# PEEB COOL

## PEEB COOL feasibility study

26/8/2022

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# 1. Introduction

### 1.1. Objective of the program

PEEB Cool aims to transform the construction sector by advancing less climate vulnerable and more energy efficient building design, construction and operation. PEEB Cool prioritises sub-sectors with significant potential for climate change adaptation and GHG reduction such as large-scale new housing schemes and commercial buildings, working with both the public and private sectors. The program will support primarily new construction, but it will also address refurbishment of existing building stock. As a cross-cutting program, objectives have been set for both mitigation and adaptation. The mitigation objective for the shift to low-emission sustainable development pathways is:

The final target for the tonnes of carbon dioxide equivalent (t $CO_2$ eq) reduced or avoided as a result of the lifetime impact of buildings constructed by the end of the program's duration is 1.56 million $tCO_2eq$ direct emissions.

The adaptation objective for reduced vulnerability is 1.133 million direct beneficiaries (561,373 females).

<u>PEEB Cool approach</u>

PEEB Cool will bridge the theory to practice gap that exists in national and international programs for transformation of the construction sector by supporting projects in which local actors will construct cool buildings while also providing technical assistance for the creation of a sustainable enabling environment for a construction sector that increases the resilience to climate change and reduces GHG emissions.

- In Component 1, the Investment Facility, PEEB Cool supports local actors in implementing more resilient and energy efficient building projects with more efficient construction methods. This is achieved through (i) technical assistance at design phase to review plans and make recommendations, (ii) provision of finance (including concessional loans) to address the financial barrier linked to higher investment costs and related debt services induced by green buildings, and (iii) technical assistance at construction phase to monitor the proper implementation of bioclimatic design and energy efficiency measures.
- In Component 2, the Enabling Facility will support the adoption of policies and regulations to perpetuate and scale up these good practices, while ensuring that capacities for implementation and enforcement are built. Activities will catalyse the replication of these new performance requirements in public procurement and sectoral investments.

### 1.2. Structure of the document

The present feasibility study is organized into eight part.

The first part is a short introduction that recalls the objective of the program and the structure of the document.

The second part set the context of the program. After defining the baseline, it justifies the relevance of energy efficiency in buildings for climate change, both in terms of adaptation and mitigation. Then, it develops on key transformative issues relating to energy efficiency in buildings (EEB): clean cooling, sustainable construction materials and private sector engagement. Finally, the context setting summarizes the climate profile of the targeted countries and the baseline of the EEB market. Climate profiles are further analyzed in the annexes of the document.

The third part focuses on the program rationale. First, it analyzes the key barriers for building sector transformation, sum up the lessons learned from the Program for Energy Efficiency in Buildings (PEEB) experience and detail the theory of change. Country specific barriers are further developed in the annexes.

The fourth part describes the program design. After recalling the objectives of the program, the part justifies the choice of intervention (in terms of programmatic approach, and interlinkage of investment and enabling facilities), describes the content of the program and the recommendations for the program.

The fifth part consists in the technical assessment of the program. It estimates the avoided carbon emissions of the program and the number of expected beneficiaries, direct and indirect. It presents mitigation and adaptation cases study that are representative of potential future PEEB Cool subprojects. Finally, it calculates the gross payback period.

The sixth part details the proposed implementation arrangements, including stakeholders, governance arrangements and program implementation structure.

The last two parts, seventh and eighth, consist respectively in the references and the annexes (country forms).

# 2. Context Setting

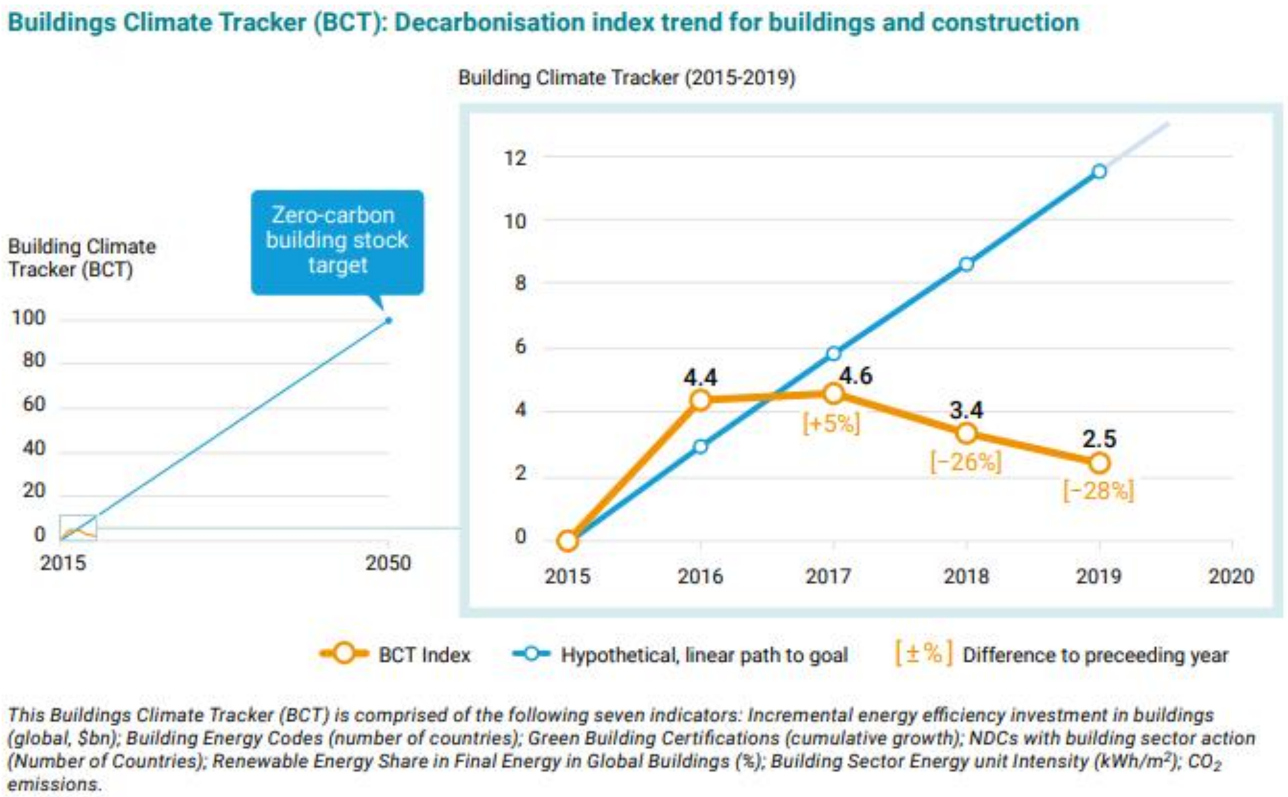
## 2.1. Baseline:

### 2.1.1. Current state of the market

Globally, USD 4.5 trillion were spent on construction and renovation of buildings in 2018. The construction and operation of buildings is responsible for around 40% of all energy-related carbon dioxide emissions and consume around 35% of the global final energy. The situation is very different from one region to another. In Africa, buildings accounted for 57% of total final energy consumption, primarily because in so many African countries the industrial and transport sectors are much less developed than in other regions of the world. Therefore, energy consumption from housing even though much smaller in absolute terms than in other regions is where the largest share of energy consumption takes place. In Asia and in Latin America, the share of energy consumption from the buildings sector is much lower at 26% and 24% respectively as the industrial and transport sectors are much more established. Finally, in the two only Balkan countries that are included in the PEEB Cool program, Albania and North Macedonia, where the industrial and transport are also very much established, the buildings sector consumes respectively 34% and 37% of final energy consumption.

Due to population growth, rapid urbanization and economic development, final energy demand from buildings is predicted to increase globally by 50% by 2050 compared with 2015 under business-as-usual scenarios. To be on track to meet global climate ambitions set forth in the Paris Agreement, the energy intensity per square meter of the global buildings sector needs to improve on average by 30% by 2030 (compared to 2015). This requires mainstreaming of highly energy-efficient new buildings in addition to the deep renovation of the existing building stock by 2050.

The Global Alliance for Buildings and Construction's new Buildings climate tracker shows that whilst the number of emission reduction actions in the building sector are growing, the rate of annual improvement is decreasing worldwide.




The growth in the construction of new buildings in emerging and developing economies is counteracting global efforts to reduce emissions in the building sector.

**Table 1: Percentage increase in floor area between now and 2050 in Asia, Latin America and Africa**

| *Continents* | *increase in floor area between now and 2050* | *Source* |
|---|---|---|
| **Asia** | 60% | GlobalABC Regional Roadmap for Buildings and Construction in Asia 2020-2050 |
| **Latin America** | 65% | GlobalABC Regional Roadmap for Buildings and Construction in Latin America 2020-2050 |
| **Africa** | 100% | GlobalABC Regional Roadmap for Buildings and Construction in Africa 2020-2050<br>Guide du bâtiment durable en régions tropicales – 2014 |

In the Balkans, the focus is primarily on renovating existing buildings.

### Energy efficiency in building codes in PEEB Cool countries

As an indicator for the current status of advancement of the buildings sector for integration of energy efficiency and resilience, an analysis of building codes was done for all PEEB Cool countries and is presented in the tables below.

In summary;

- 9 out of 11 countries have thermal regulations in force;
- 1 country out of 11 has a thermal regulation project;
- No country do not have thermal regulations (TR) or TR projects;
- The Asian countries concerned by the PEEB Cool all have a TR.

### Africa:

**Table 2: African countries in the PEEB Cool Programme and the status of energy building codes**

| *Countries* | *Energy building code* | *Enactment* | *Details and comments* |
|---|---|---|---|
| Djibouti | Under preparation | 2019 | - Included in the law on energy efficiency, draft decree on the energy efficiency of buildings and their thermal specifications<br>- Other components to this law: mandatory and periodic audit, energy performance labelling of air conditioners, refrigerators, freezers, combination appliances and light bulbs? |
| Morocco | Yes | 2014 | - Residential and tertiary buildings; specific rules according to 6 defined geographical areas;<br>- "Obligation of result" for hot and cold needs; "obligation of means" for the envelope;<br>- Not directly related to the energy building code: Energy labelling standard for electrical products and household appliances (air conditioning and household refrigerators) |
| Nigeria | Yes | 2019 | Applicable to: Group B “business and professional” (space used primarily for office work) & Group R “Residential” > 85 m² |
| Tunisia | Yes | 2008 | - Offices and residential buildings<br>- Not directly related to the energy building code: minimum performance requirements for air conditioning and energy labelling |

### South America:

**Table 3: South American countries in the PEEB Cool Programme and the status of energy building codes**

| *Countries* | *Energy building code* | *Enactment* | *Details and comments* |
|---|---|---|---|
| Argentina | Yes | - | - 1996 : V—IRAM 11605, maximum thermal transmittance values for fabric elements of residential buildings<br>- 2001 : V—IRAM 11604, maximum thermal transmittance values for fabric elements of all buildings in Buenos Aires<br>- 2017: Residential energy label (voluntary approach)<br>- 2010: Program for rational and efficient use of energy in Public Buildings |

| | | | |
|---|---|---|---|
| | | | - 2005: Minimum Performance Requirements for Air Conditioners, Lamps and Appliances |
| Costa Rica | No | - | |
| Mexico | **Yes** | 2016 | - Residential buildings (low-rise, up to 3 storeys) and Commercial Buildings<br>- Not directly related to the energy building code: minimum performance requirements and energy labelling for domestic appliances |

**Asia:**

Table 4: Asian countries in the PEEB Cool Programme and the status of energy building codes

| *Countries* | *Energy building code* | *Enactment* | *Details and comments* |
|---|---|---|---|
| Indonesia | Yes | 2011 | Voluntary approach, only "recommendations<br>New non-residential buildings<br>4 texts giving guidelines for: the envelope, air conditioning, lighting, audit procedures (all types of buildings including residential) |
| Jakarta (Indonesia) | Yes | 2012 | - Jakarta Regulation No. 38/2012 on Green Buildings, mandatory<br>- Apartments, offices, mixed-use buildings of more than 50,000 m².<br>- Commerce, hotels, health centers of more than 20,000 m².<br>- Cultural and public service buildings, education buildings of more than 10,000 m².<br>- Includes rules for existing buildings |
| Sri Lanka | Yes | 2008 | Large-scale commercial, industrial and residential buildings with one of the following four characteristics:<br>- 4 or more storeys,<br>- Floor area of 500m2 or more,<br>- Electrical power of 100 kVA or more,<br>- Air conditioning system power of 350 kW or more. |

**Europe**

Table 5: European countries in the PEEB Cool Programme and the status of energy building codes

| *Countries* | *Energy building code* | *Enactment* | *Details and comments* |
|---|---|---|---|
| Albania | Yes | In progress | - All building categories, new constructions and major renovations, with the exception of: religious buildings, temporary occupation buildings, buildings of less than 50m²)<br>- not fully enforceable as additional texts are to be voted |
| North Macedonia | Yes | 2013 (ongoing update) | English version could not be located |

The table below details the building types that fall within the scope of the energy building codes

**Table 6: Building types that fall within the scope of the energy building codes in the PEEB Cool programme**

| *Countries* | *Social housing* | *Mid-income housing* | *Health centers* | *Hospitals* | *Education* | *Does it apply to renovations?* |
|---|---|---|---|---|---|---|
| Morocco | x | x | x | x | x | No |
| Nigeria | > 85 m² | > 85 m² | clinic out-patient | No | No | No |
| Tunisia | x | x | *Under preparation* | *Under preparation* | *Under preparation* | No |
| Argentina | x | x | *Only in Buenos Aires* | *Only in Buenos Aires* | *Only in Buenos Aires* | Uncertain |
| Mexico | < 3 floors (low-rise) | < 3 floors (low-rise) | X | X | X | No |
| Indonesia | No | No | Voluntary compliance | Voluntary compliance | Voluntary compliance | No |
| Jakarta (Indonesia) | > 50 000 m² | > 50 000 m² | > 20 000 m² | > 20 000 m² | > 10 000 m² | Yes* |
| Sri Lanka | > 500 m², 4 floors | > 500 m², 4 floors | No | No | No | Yes |
| Albania | x | x | x | x | x | Yes |
| North Macedonia | x | x | x | x | x | Yes |

### 2.1.2.PEEB and results of PEEB

PEEB Cool is based on the existing "Program for Energy Efficiency in Building" (PEEB).

The climate urgency surrounding buildings gave rise to the Global Alliance for Buildings and Construction (GlobalABC). Launched at the COP 21, the GlobalABC is a voluntary partnership of national and local governments, inter-governmental organizations, businesses, associations, networks and think thanks committed to a common vision: a zero-emission, efficient and resilient buildings and construction sector. The GlobalABC network currently includes over 130 members, among which are 32 countries. Following the creation of the GlobalABC, a feasibility study was launched by AFD, financed by the Fonds Français pour l'Environnement Mondial (FFEM) to establish a French German program, with the objective of supporting developing and emerging economies to implement more energy efficient buildings and thereby contribute to the Paris Agreement's climate objectives. The Program for Energy Efficiency in Buildings (PEEB) was subsequently created in the following Conference of Parties, COP 22.

The PEEB is currently funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the French Ministère de la Transition Ecologique et Solidaire (MTES), AFD and the Fonds Français pour l'Environnement Mondial (FFEM). PEEB brings the best out of AFD's, ADEME's, and GIZ's expertise to bring about a transformation of the buildings sector in developing and emerging economies. PEEB provides partner countries simultaneous support for policy implementation, trainings and knowledge sharing as well as financial and technical assistance to implement large-scale building projects with high energy and environmental performance standards.

Below are displayed PEEB's results since it started in 2018.

- Project finance:
- Financing pipeline: over 30 projects supported representing an investment of 1.9 bn EUR.
- Preparation of 2 NAMA financing projects in Morocco and Vietnam.
- Support for private-sector projects in Mexico and Morocco.
- Policy:
- Supporting the development of energy efficiency policies in Morocco, Tunisia.
- Advice on NDC roadmaps or platforms in Mexico and Vietnam.
- Support on establishment of National Alliances for Buildings and Construction in Morocco, Mexico, and Tunisia with GlobalABC.
- Expertise:
- Capacity building and knowledge transfer to the private and public sectors.
- Trainings on financing for green buildings for over 600 policy makers and practitioners in 5 countries.
- Awareness-raising at 17 international meetings and co-organising regional workshops for Asia and North Africa in cooperation with the GlobalABC.

The annex 18b presents the main results and conclusion of PEEB and paragraph 3.2 details the lessons learned from PEEB experience.

## 2.2. Relevance of EEB for climate change

### 2.2.1. Relevance for mitigation

The construction and operation of buildings is responsible for 40% of all energy-related carbon dioxide emissions and consumes 36% of the global final energy. Due to population growth, rapid urbanization and economic development, final energy demand from buildings is predicted to increase by 50% by 2050 compared with 2015 under business as usual scenarios. To be on track to meet global climate ambitions set forth in the Paris Agreement, the energy intensity per square meter of the global building sector needs to improve by 30% on average by 2030 (compared to 2015). This requires mainstreaming of highly energy-efficient new buildings and deep renovation of the existing building stock.

The IEA has analysed building sector energy intensity at the regional level. It has scored different regions' building sector energy intensity (all starting with a score of 100 in 2000). Currently, Central and South America scores 96.6, Africa 92.1, Europe 78.0, and Asia 71.3.[1] The rate of improvement will need to increase dramatically if the world is to achieve the Paris Agreement targets. The IEA's Sustainable Development Scenario, which assumes a major transformation compared to the baseline, requires the energy intensity index to fall to 69.4 in Central and South America, 36.1 in Africa, 59.8 in Europe and 39.3 in Asia.

A significant part of GHG emissions from the building sector is due to energy use for cooling and heating. According to the International Energy Agency (The future of cooling, 2018), 2,021 TWh was used for space cooling in 2016, and in the baseline this is expected to increase to 6,200 TWh in 2050. CO2 emissions generated by space cooling will almost double, from 1,135 Mt in 2016 to 2,070 Mt in 2050.

[1] https://www.iea.org/reports/tracking-buildings-2020

Various indices are used to indicate changes in temperature that affect thermal comfort and the need for mechanical cooling. One widely used index is cooling degree days. Projections for the impact of climate change on this index are shown in the table below:

**Table 7: Projected increases in cooling degree days**

| **Increase in cooling degree days (°C)*** | **RCP4.5** | | |
|---|---|---|---|
| **Country** | **2020-2039** | **2040-2059** | **2080-2099** |
| **Albania** | 284 | 420 | 621 |
| **Argentina** | 203 | 313 | 446 |
| **Costa Rica** | 485 | 786 | 1102 |
| **Djibouti** | 572 | 934 | 1308 |
| **Indonesia** | 442 | 666 | 936 |
| **Mexico** | 487 | 731 | 1010 |
| **Morocco** | 345 | 559 | 825 |
| **Nigeria** | 605 | 918 | 1315 |
| **North Macedonia** | 239 | 379 | 565 |
| **Sri Lanka** | 454 | 678 | 996 |
| **Tunisia** | 203 | 313 | 446 |

* Calculated as the number of degrees that a day's average temperature is above 18.3°C. Ensemble median over the period. Change compared to 1986-2005. Source: World Bank, Climate Change Knowledge Portal.

### 2.2.2.Relevance for adaptation

In this chapter we start by giving background information on the effects of warmer indoor temperatures on health and productivity.

The main pathways linking increased temperatures with increased vulnerability relevant to PEEB COOL are:

- Direct vulnerability due to increased risk to adverse health effects from high indoor temperatures
- Secondary vulnerability due to stresses to the health system from
  - Increased emergency health services needs, especially during heatwaves
  - Reduced productivity of the health professionals in hospitals
- Direct vulnerability due to reduced productivity in businesses and schools.

The reduced exposure to high temperatures, through improved indoor thermal comfort, will lessen the vulnerability of the population, minimizing the risks in health, the health system, and productivity.

In this chapter we start by giving background information on the effects of warmer indoor temperatures on health and productivity.

We then show how comfort diagrams are used in quantitative studies and give examples of a few of these studies conducted within the framework of previous PEEB projects.

The following table presents the historical trends and climate projection for the countries included in PEEB Cool. All countries are expected to experience significant warming. Moreover, an important change in cooling degree days is projected across all countries compered to 1986-2005. A detailed presentation for the climatic trends in each country and a more detailed discussion of the vulnerability per sector are presented in the Annex. All relevant studies are referenced in the Annex as well.

Table 8: Summary of projected changes and vulnerability due to climate change in PEEB Cool Programme countries

| Country | Historical Data | Climate Projections (RCP4.5) | Cooling degree days (CDD)[2]* | Vulnerability for the priority sector. |
|---|---|---|---|---|
| Albania | Albania has a subtropical Mediterranean climate with dry, hot summers. Temperature has increased by around 1°C since the 1960s, with a faster rate of warming in recent decades). The number of days where temperature reaches above 35°C has also risen, with such events occurring annually now rather than every few years. | Models show temperature will rise intensely throughout the century. Projections show change in temperature of 1.6°C by mid-century and reaching up to 2.4°C for the maximum temperature. By 2100, the change will likely reach 1.8°C (on capital level). Moreover, hot days (over 35°C) are expected to increase by 5 days for the period 2020-2039 (on a national level). | Projected change in annual cooling degree days is projected to rise from 284 CDD between 2020-2039 to 420 CDD between 2040 and 2059 and 621 CDD by the end of the century | Health Services:<br><br>Significant adverse effects are expected.<br><br>Heat-related deaths, especially among the elderly, present the most immediate threat for the Balkans. The country is additionally vulnerable due to an under-developed public health system. |
| Argentina | Argentina's dense population in urban regions make it vulnerable to a variety of hazards, including extreme heat. The ND-Gain Index ranks Argentina 69th on vulnerability and 108th on readiness. Periods in recent decades. Moreover, the country has experienced a rise in the number of days with heat waves.<br><br>Argentina's mean annual temperature between 1901-2016 was 14.31°C, with significantly warmer | Projections show a change in temperature of 0.97°C by mid-century and reaching up to 1.1°C for the maximum temperature. By 2100, the change will likely reach around 1.4°C (on capital level). Moreover, hot days are expected to increase by17.35 days for the period 2080-2099 (on a national level). | Projected change in annual cooling degree days is projected to rise from 203 CDD between 2020-2039 to 313 CDD between 2040 and 2059 and 446 CDD by the end of the century. | Residential sector:<br><br>Argentina is facing increasing urbanization rates. High temperatures are expected to increase pressures in urban zones, that have already been affected.<br><br>Adapting to heatwaves should also take into consideration the aged power grid. |
| Costa Rica | The average temperature is 19.5°C. However, the country is experiencing significant warming, with temperatures having increased by between 0.2°C and 0.3°C per decade since 1960. The | Projections show a change in temperature of 1.6°C by mid-century and reaching up to 2.0°C for the maximum temperature. By 2100, the change will likely reach around 1.9°C | Projected change in annual cooling degree days is projected to rise from 485 CDD between 2020-2039 to 786 CDD between | Education:<br><br>Costa Rica has more than 25% probability that at least one period of prolonged heat exposure, resulting in |

[2] Linked to temperature projections (RCP4.5)

| Country | Historical Data | Climate Projections (RCP4.5) | Cooling degree days (CDD)[2*] | Vulnerability for the priority sector. |
|---|---|---|---|---|
| | number of warm days has increased by 2.5% and warm nights rose by 1.7% between 1961 and 2003. The number of cooler periods has also fallen, with a reduction in the number of cold nights of 2.2% and a drop in cold days by 2.4% by decade since 1961. These figures show a clear upward trend in warming over the last 60 years in Costa Rica. | and reaching up to 2.4°C for the maximum temperature (on capital level). Moreover, hot days are expected to increase by 16.64 days for the period 2080-2099 (on a national level). | 2040 and 2059 and 1102 CDD by the end of the century. | heat stress, will occur within the next five years.<br><br>The Ministry of Public Education has identified schools as a possible intervention area. Improved thermal comfort will increase the productivity and academic performance in schools. |
| Djibouti | Temperatures have been increasing quickly in recent years, at a rate of around 0.22°C per decade in the last 30 years. The climate type of the country means dry spells and hot periods are reasonably frequent, with a duration of 65 days and 9 days respectively. | World Bank expects Djibouti to see warming of 1.7°C by 2050, while the change in the maximum temperature will reach 2.00. By the end of the century the change in temperature will reach 4.2 °C (on capital level). Hot days are expected to increase by 51 days for the period 2080-2099 (on a national level). | Projected change in annual cooling degree days is projected to rise from 572 CDD between 2020-2039 to 934 CDD between 2040 and 2059 and 1232 CDD by the end of the century. | Small offices: According to ILO increased heat is expected to lead to loss in working hours in all sectors. A study in Djibouti City found that natural ventilation creates a comfortable indoor temperature and would allow buildings to benefit from cooling without the need for energy inefficient cooling. |
| Indonesia | Temperature is rising rapidly at a rate of around 0.1°C per decade since 1990 and is expected to continue this trend in the future.<br><br>Moreover, Indonesia's climate is driven, in part, by El Nino cycles. The country experiences dry and warm conditions during the El Nino periods and intense rainfall during La Nina periods. Currently, Indonesia experiences a mean dry spell duration of 9 days and a mean heat wave | Projections show a change in temperature of 1.4°C by mid-century and reaching up to 1.9°C for the maximum temperature. By 2100, the change will likely reach around 1.7°C and reaching up to 2.2°C for the maximum temperature (on capital level). Moreover, hot days are expected to increase by15.65 days for the period 2080-2099 (on a national level). | Projected change in annual cooling degree days is projected to rise from 442 CDD between 2020-2039 to 666 CDD between 2040 and 2059 and 936 CDD by the end of the century. | Residential and Education: WHO estimates a rapid rise in heat-related mortality by the end of the century under a BAU scenario. They project, an expected mortality rate of nearly 50 per 100,000 in 2080 compared to 5 per 100,000 in 1990.<br><br>Adaptation measures in the residential sector will also improve / reduce energy load.<br><br>Improved school thermal comfort will improve academic performance. |

| Country | Historical Data | Climate Projections (RCP4.5) | Cooling degree days (CDD)[2]* | Vulnerability for the priority sector. |
|---|---|---|---|---|
| | duration of 4 days, although both are expected to increase. | | | |
| Mexico | Mexico's mean annual temperature has increased by 0.6°C since 1960, at around 0.13°C per decade and up to 0.2°C in the dry, hot months. As noted in Mexico's official Climate Change Strategy, the number of cooler days has fallen while warm nights have increased. | Warming throughout the country is expected, especially in hotter urban regions. Projections show a change in temperature of 1.8°C by mid-century and reaching up to 2.2°C for the maximum temperature. By 2100, the change will likely reach around 2.4°C and reaching up to 3.0°C for the maximum temperature (on capital level). Moreover, hot days are expected to increase by45.9 days for the period 2080-2099 (on a national level). | Projected change in annual cooling degree days is projected to rise from 487 CDD between 2020-2039 to 731 CDD between 2040 and 2059 and 1010 CDD by the end of the century. | Residential, health care, schools and offices:<br><br>Increased urbanisation and low-income housing caused infrastructure deficiencies and enhanced energy demands, especially during hot periods.<br><br>A 2018 study on thermal comfort and air quality in university buildings found that mean hourly values of $CO_2$ and temperature exceeded maximum values recommended by WHO guidelines. Moreover, humidity levels were significantly higher than regulations. Such characteristics can inhibit productivity and output, especially in a learning environment. |
| Morocco | In the last half century, average temperature has risen by around 1°C, with observed average increases of 0.2°C per decade and summer months experiencing faster and greater warming. This warming trend has increased the number of days and nights classified as 'hot' by 21 and 40 respectively. | Projections show a change in temperature of 1.5°C by mid-century and reaching up to 2.1°C for the maximum temperature. By 2100, the change will likely reach around 2.0°C and reaching up to 2.7°C for the maximum temperature (on capital level). Moreover, hot days are expected to increase by 31 days for the period 2080-2099. (on a national level). | Projected change in annual cooling degree days is projected to rise from 345 CDD between 2020-2039 to 559 CDD between 2040 and 2059 and 825 CDD by the end of the century. | Residential and Schools:<br><br>The WHO estimates a rapid rise in heat-related mortality by the end of the century under a BAU scenario. They project, an expected mortality rate of nearly 50 per 100,000 in 2080 compared to 5 per 100,000 in 1990.<br><br>The ILO expects the proportion of working hours lost to heat stress in the country to fall by 0.14% in |

| Country | Historical Data | Climate Projections (RCP4.5) | Cooling degree days (CDD)[2]* | Vulnerability for the priority sector. |
|---|---|---|---|---|
| | | Warming will increase at a faster rate in the interior, where regions are drier, rather than the coastline.<br><br>. | | industry, 0.39% in construction and 0.02% in services by 2030 |
| Nigeria | Nigeria has seen an increase in mean temperature of around 0.19°C per decade over the last thirty years (around 0.60°C total warming) with a faster rate in the south. The World Bank estimates that the number of hot nights and days has increased between 1960 and 2003, with hot days rising by 73 days annually.<br><br>Dry spells and hot periods are significant, with a 17-day average duration of dry spells and 7-day average duration of heat waves. Yet, there is significant variability throughout the country. | The warming trend seen in recent years is expected to continue at a faster rate. The whole country will likely see significant warming, with those in rapidly growing urban populations at risk.<br><br>Projections show a change in temperature of 1.3°C by mid-century and reaching up to 1.6°C for the maximum temperature (on capital level). By 2100, the change will likely reach around 1.7°C and reaching up to 2.0°C for the maximum temperature. Moreover, hot days are expected to increase by 67 days for the period 2080-2099(on a national level). | Projected change in annual cooling degree days is projected to rise from 605 CDD between 2020-2039 to 918 CDD between 2040 and 2059 and 1315 CDD by the end of the century. | Residential: WHO estimates that nearly 80 deaths per 100,000 will be expected due to heat by 2080 under a high emission scenario compared to 3 deaths per 100,000 during the baseline period.<br><br>Improvement of residential thermal comfort will reduce health effects. Additional health co-benefits are expected from improved ventilation that will reduce the threat of indoor pollution. |
| North Macedonia | Average temperatures have been increasing in recent decades as estimates show up to 0.5°C of warming between 1981 and 2010.<br><br>The number of warm days has increased by 4-10 days per decade in line with a doubling of the summer heat wave length over the last century. Heat waves have been common throughout the country as over 150 | Projections show a change in temperature of 2.0°C by mid-century and reaching up to 2.9°C for the maximum temperature By 2100, the change will likely reach around 2.4°C and reaching up to 3.7°C for the maximum temperature. Moreover, hot days are expected to increase by 15.81 days for the period 2080-2099(on a national level). | Projected change in annual cooling degree days is projected to rise from 239 CDD between 2020-2039 to 379 CDD between 2040 and 2059 and 565 CDD by the end of the century. | Commercial: Heat-related deaths, especially among the elderly, present the most immediate threat for the Balkans. Moreover, increased temperatures are expected to lead to lower productivity and loss of working hours. |

| Country | Historical Data | Climate Projections (RCP4.5) | Cooling degree days (CDD)[2]* | Vulnerability for the priority sector. |
|---|---|---|---|---|
| | were recorded between 1961-2012, including 25 in Skopje and 38 in Demir Kapija. Moreover, the number has been rising in recent periods with 8 heat wave events observed in Skopje in 2012 alone. | | | Improved thermal comfort in commercial spaces will safeguard the level of productivity in the country. |
| Sri Lanka | Over the last 50 years, temperature has increased at a rate of around 0.16°C per decade, with greater increases in minimum temperature | Projections show a change in temperature of 1.1°C by mid-century and reaching up to 1.2°C for the maximum temperature. By 2100, the change will likely reach around 1.3°C and reaching up to 1.4°C for the maximum temperature (on capital level).. Moreover, hot days are expected to increase by 32.13 days for the period 2080-2099(on a national level). | Projected change in annual cooling degree days is projected to rise from 454 CDD between 2020-2039 to 678 CDD between 2040 and 2059 and 996 CDD by the end of the century | Residential: Heat-related mortality in the elderly is expected to rise to 22 deaths per 100,000 under a high emissions scenario by 2080 from 1 death per 100,000 in 1990. At the same time a number of studies have highlighted the potential for adaptation of the residential sector. |
| Tunisia | World Bank data shows a mean annual temperature of 19.4°C between 1901-2019, with a mean maximum of 25.4°C and a mean minimum of 13.5°C. However, temperatures in recent decades have risen significantly, by an average of 0.37°C per decade over the last 30 years. This combined with fewer cool periods and an increase in energy consumption on hot days threatens the health of vulnerable groups. Over the last 50 years, temperature has increased at a rate of around 0.16°C per decade, with greater increases in minimum temperature | Projections show a change in temperature of 1.4°C by mid-century and reaching up to 1.7°C for the maximum temperature. By 2100, the change will likely reach around 1.8°C and reaching up to 1.9°C for the maximum temperature (on capital level).. Moreover, hot days are expected to increase by 17.35 days for the period 2080-2099 (on a national level). | Projected change in annual cooling degree days is projected to rise from 203 CDD between 2020-2039 to 313 CDD between 2040 and 2059 and 446 CDD by the end of the century. Projected change in annual cooling degree days is projected to rise from 454 CDD between 2020-2039 to 678 CDD between 2040 and 2059 and 996 CDD by the end of the century. | Residential and Hospital:<br><br>Heat-related mortality is expected to rise from around 20 deaths per 100,000 in 2030 to 56 deaths per 100,000 by 2080 in the cohort over 65. The World Bank notes that the rise in temperatures expected is "likely to exacerbate respiratory diseases", especially the increase of heat waves and heat islands in urban areas.<br><br>Improved residential thermal comfort will reliver pressure to the healthcare system, while improved |

| Country | Historical Data | Climate Projections (RCP4.5) | Cooling degree days (CDD)[2]* | Vulnerability for the priority sector. |
|---|---|---|---|---|
| | | | | thermal comfort in hospital will improve productivity and its response to heatwaves. |

* Calculated as the number of degrees that a day's average temperature is above 18.3°C. Ensemble median over the period. Change compared to 1986-2005.
Source: World Bank, Climate Change Knowledge Portal.

2.2.2.1. Impact of high temperatures on health and productivity

We then show how comfort diagrams are used in quantitative studies and give examples of a few of these studies conducted within the framework of previous PEEB projects.

2.2.2.2. Impact of high temperatures on health and productivity

Many sources provide quantitative and qualitative information on the impact of high temperatures in the indoor environment on health and productivity.

2.2.2.2.1. Impact on health

According to the World Health Organization[3] "the room temperature should be kept below 32 °C during the day and 24 °C during the night. This is especially important for infants or people who are over 60 years of age or have chronic health conditions. Electric fans may provide relief, but when the temperature is above 35 °C, may not prevent heat-related illness. It is important to drink fluids."

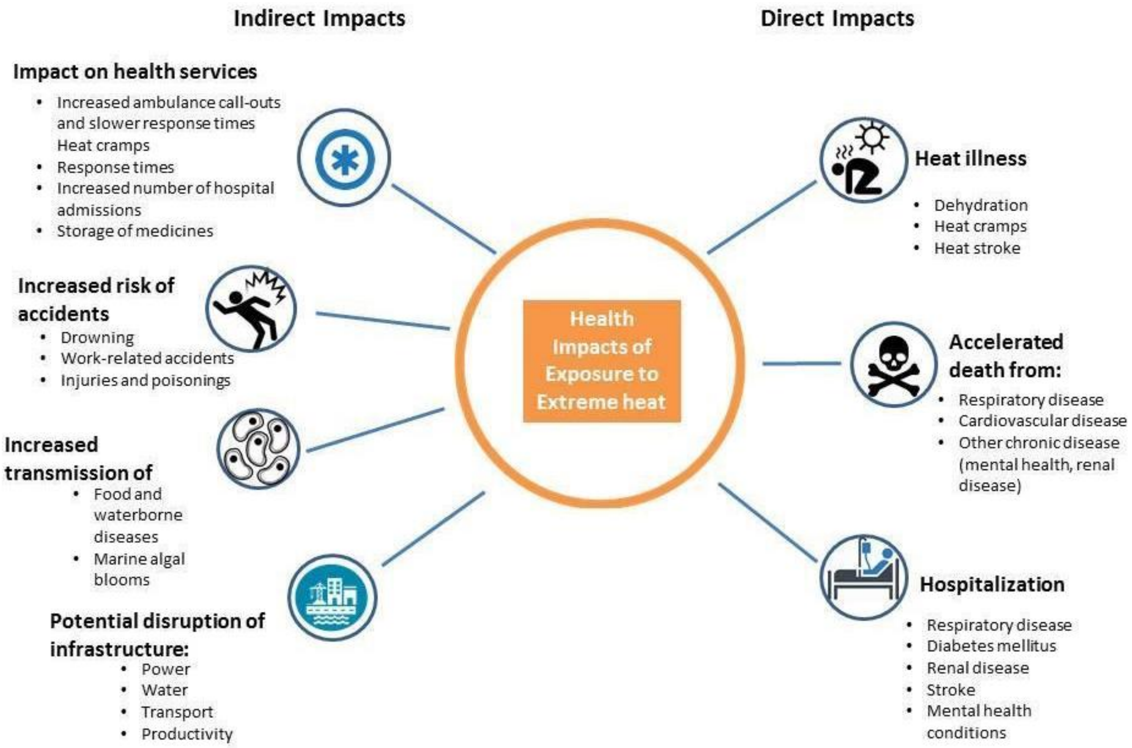



**Figure 1: Direct and indirect impacts caused by heat – Source: Information and public health advice: heat and health, World Health Organization**

According to the Ministry of Labor in Spain[4] "the hygrothermal conditions of a space are 1 of the 3 factors that influence the thermal stress of a person, which is defined as the net heat load to which a worker is

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[3] Information and public health advice: heat and health, World Health Organization. (https://www.who.int/globalchange/publications/heat-and-health/en/ )

[4] Exposición laboral a estrés térmico por calor y sus efectos en la salud, Gobierno de España, Ministerio de Trabajo Migraciones y Seguridad Social. (https://istas.net/sites/default/files/2019-04/Guia%20EstresTermico%20por%20exposicion%20a%20calor_0.pdf)

exposed, the other two are physical activity and clothing, which are difficult to address because they depend directly on the activity that takes place in space. Excess heat in the body affects health, which can manifest itself in different ways:

- *Heat-related disorders and/or illnesses, such as the following:*
    - Skin eruptions (rashes).
    - Edema (swelling in ankles, feet).
    - Cramps.
    - Exhaustion.
    - Loss of consciousness (syncope).
    - Heat stroke.
- *Effects on behavior, causing accidents or incidents.*
- *Severe dehydration.*
- *Worsening of previous conditions (chronic lung, heart conditions, kidney disorders and psychiatric illnesses).*
- *Long-term disorders.*"

In a recent systematic literature review concerning exposure to indoor high temperatures Tham et al. (2020) have found several studies providing evidence for adverse health effects of high indoor temperatures. Adverse effects groups included:

- Respiratory
- Blood pressure
- Core temperature
- Heat-related health complaints
- Blood glucose
- Mental health and cognition, and
- Physical functioning

###### 2.2.2.2.2. Impacts on the Health System

A number of studies link increased temperatures with effects to the Health System. According to Uejio et al. (2016)[5] indoor temperatures higher than 26 have been associated with increased proportion of respiratory distress calls made to paramedics. Moreover, heatwaves have been associated with increased emergency hospital admissions contributing to the stress in health systems [6]. The overall impact of heatwaves in health systems is also manifested in the overall excess mortality that takes into consideration indirect impacts of heatwaves. Several studies associate heatwaves with excess mortality e.g., Yan et al (2022) found that the 2017 exceptional heatwaves had a statistically significant association with all-cause mortality across 91 Chinese counties[7].

[5] Uejio CK, Tamerius JD, Vredenburg J, Asaeda G, Isaacs DA, Braun J, Quinn A, Freese JP. Summer indoor heat exposure and respiratory and cardiovascular distress calls in New York City, NY, U.S. Indoor Air 2016;26(4):594e604.

[6] Li, M., Gu, S., Bi, P., Yang, J., & Liu, Q. (2015). Heat waves and morbidity: current knowledge and further direction-a comprehensive literature review. International journal of environmental research and public health, 12(5), 5256-5283.

[7] Yan, M., Xie, Y., Zhu, H., Ban, J., Gong, J., & Li, T. (2022). The exceptional heatwaves of 2017 and all-cause mortality: An assessment of nationwide health and economic impacts in China. Science of The Total Environment, 812, 152371.

In addition to the direct and indirect effects of increased temperatures and heatwaves to health systems admissions, another aspect of vulnerability has to do with the productivity of the health care professionals. Increased indoor temperature leads to decreased productivity, as it is presented in the following section.

Finally, improved thermal comfort in hospitals has been associated with better recovery shown by improved vital signs, reduced cardiac stress, accelerated recuperation and greater physical activity. This protective effect was also demonstrated by a shorter hospital stay for patients with respiratory disease and a reduction of mortality for heat illness patients[8].

###### 2.2.2.2.3. Impacts on productivity

According to a study by the National Center for Biotechnology Information[9] which takes into account a variation of the indoor temperature between 18°C and 30°C:

- "Brain executive functions in high and low air temperatures are more influenced by the air temperature than the moderate air temperature, which may reduce accuracy and increase the error in sensitive work environments that required more attention.
- High and low air temperatures significantly increased the participants' HR, LF/HF and respiratory rates, which represent stress and high mental fatigue and negative long-term impact on their health.
- Undesirable high and low air temperatures caused significant changes in the SDNN and RMSSD indices, which have not been uniformly changed at different air temperatures.
- In moderate air temperatures (22°C), the LF/HF ratio, which represents the sympathetic and parasympathetic equilibrium to the vagal one, is approximately close to one, indicating that, in this temperature, the participants had a better thermal comfort, so that they had a good performance (accuracy)."

NB: The acronyms used above are: HR (Heart rate), LF/HF (Low/High frequency), SDNN (standard deviation of normal-to-normal intervals), RMSSD (root mean square of successive differences between normal heartbeats).

According to another article of the same source[10], in a study that evaluates the performance of office workers:

- "The effect of indoor temperature has 38.56% of contribution on the performance of a person in a space."
- "The performance measurement was taken by recording reaction time and errors made in the test".

According to a study conducted by four American universities analyzing the test results of 10 million high school students over 13 years in the United States[11] "Researchers calculated that for every 0.55°C increase

[8] Lenzer, Benedikt; Rupprecht, Manuel; Hoffmann, Christina; Hoffmann, Peter; Liebers, Uta (2020). Health effects of heating, ventilation and air conditioning on hospital patients: a scoping review. BMC Public Health, 20(1), 1287–. doi:10.1186/s12889-020-09358-1

[9] The effect of indoor office environment on the work performance, health and well-being of office workers, National Center for Biotechnology Information (NCBI) (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6377698/).

[10] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4591743/.

[11] 30 May 2018, Hotter years 'mean lower exam results', British Broadcasting Corporation, this Study was conducted by the Harvard, the University of California Los Angeles (UCLA) and Georgia State University, which analyzed the test results of 10 million high school students over 13 years in the United States, (https://www.bbc.com/news/business-44288982)

in average temperature over the year, there was a 1% fall in learning. Colder days did not seem to damage achievement - but the negative impact began to be measurable as temperatures rose above 21°C. The reduction in learning accelerated once temperatures rose above 32°C and even more so above 38°C."

According to a study performed in African countries[12]:

"Occupational heat strain is defined in the paper as "the physiological consequences of environmental heat stress," which involves working in an environment with an air temperature between 91.4 (33°C) and 101.6 (38,7 °C) degrees Fahrenheit. The physiological effects of heat strain include dehydration, fainting, kidney injury and hyperthermia."

"30 percent of people working under heat stress reported productivity losses"

"The effects of heat stress compound with the frequency of exposure – 15 percent of people who worked under heat stress for at least six hours a day, five days a week, for two or more months of the year experienced kidney disease or acute kidney injury."

"Flouris explained that the effect of heat strain is likely to exacerbate global economic inequalities. Hotter regions of the world tend to be poorer, and these economies will face additional challenges as global temperatures rise. Developing economies tend to rely more on manual labor, which further contributes to the risk of occupational heat strain."

According to a document of the International Labour Organization[13]:

"Heat stress refers to heat received in excess of that which the body can tolerate without suffering physiological impairment. Such excess heat increases workers' occupational risks and vulnerability; it can lead to heatstroke and, ultimately, even to death."

"Excessive heat during work creates occupational health risks; it restricts a worker's physical functions and capabilities, work capacity and productivity. Temperatures above 24–26°C are associated with reduced labour productivity. At 33–34°C, a worker operating at moderate work intensity loses 50 per cent of his or her work capacity. "

"Heat stress is projected to reduce total working hours worldwide by 2.2 per cent and global GDP by US$2,400 billion in 2030".

In a recent systematic literature revies, Bueno et al. (2021) studying the thermal comfort and the productivity in buildings While performance/productivity can be attained within an ample temperature range, several studies have linked higher temperatures with decreased performance in businesses and school environments[14].

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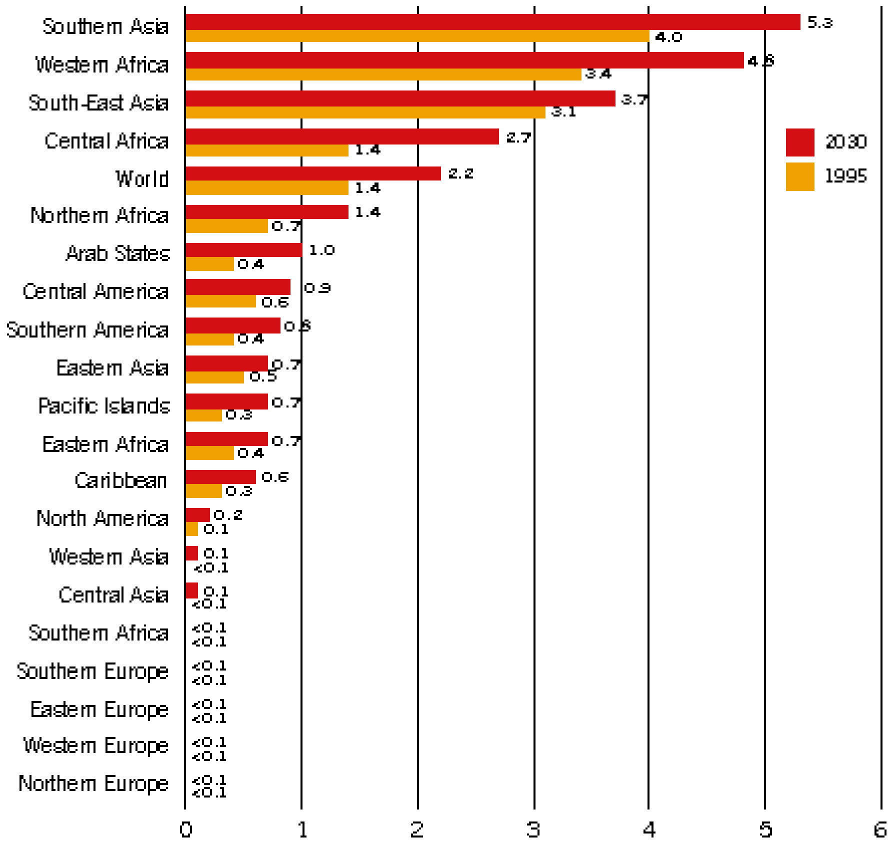
[12] 2018, Heat makes workers less productive, impacts health, The Journalist's Resource, The included studies involved 447 million workers in over 40 different occupations, including outdoor and indoor jobs. (https://journalistsresource.org/environment/heat-productivity-health-climate-change/), in the study South Africa, Angola and Egypt are included.

[13] Working on a warmer planet: The impact of heat stress on labour productivity and decent work – International Labour organization, 2019

[14] Bueno, A. M., de Paula Xavier, A. A., & Broday, E. E. (2021). Evaluating the connection between thermal comfort and productivity in buildings: a systematic literature review. Buildings, 11(6), 244.




Source: ILO estimates based on data from the ILOSTAT database and from the HadGEM2 and GFDL-ESM2M climate models (using as input the RCP2.6 climate change pathway, which envisages a global average temperature rise of 1.5°C by the end of the century).

**Figure 2: Working hours lost to heat stress by sub-region, 1995 and projections for 2030 (percentages)**

Finally, another study predicts the productivity losses by region in the developing countries, due to global warming[15]:

“Results showed that climate change between 1975 (as the median year of the period 1961–1990 for which climate data were used) and 2050 would reduce the available work hours in all regions. The estimated reductions at the population level varied between 0.2% for Australasia and 18.6% for Central America. Other highly affected regions were Southeast Asia (18.2%), West Africa (15.8%), Central Africa (15.4%), Oceania (15.2%), the Caribbean (11.7%), and South Asia (11.5%). A shift in the workforce distribution away from physically demanding jobs to less ardent service jobs will make these reductions smaller, and use of heat-protection methods (adaptation) will reduce them further; however, in some countries, significant reductions in labor productivity will likely remain.”

#### 2.2.2.3. Mortality and heat waves

According to the WHO[16], “Population exposure to heat is increasing due to climate change, and this trend will continue. Globally, extreme temperature events are observed to be increasing in their frequency,

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[15] "Mapping Occupational Heat Exposure and Effects in South-East Asia : Ongoing Time Trends 1980-2011 and Future Estimates to 2050"  Tord Kjellstrom, Bruno Lemle and Matthias Otto, 2012

[16] Information and public health advice: heat and health, World Health Organization. (https://www.who.int/globalchange/publications/heat-and-health/en/ )

duration, and magnitude. Between 2000 and 2016, the number of people exposed to heat waves increased by around 125 million. In 2015 alone, 175 million additional people were exposed to heat waves compared to average years.

Single events can last weeks, occur consecutively, and result in significant excess mortality. In 2003, 70,000 people in Europe died as a result of the June-August event, in 2010, 56,000 excess deaths occurred during a 44-day heatwave in the Russian Federation."

On December 19, 2019, Pan American Health Organization (PAHO) and World Health Organization urged southern hemisphere countries to prepare for heat waves[17]:

"Over the past 12 months, 24 countries in the Americas were affected by heatwaves. These include Argentina, Bahamas, Barbados, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, the United States, Honduras, Guatemala, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Venezuela and Uruguay."

In another document of PAHO[18], it is mentioned that "Variations of one or two degrees above normal, depending on the average temperature of the place of residence can generate adverse effects. Adverse heat effects have been seen from temperatures of 27 to 29ºC. The heat wave that affected Europe showed that not only the diurnal temperature peaks and humidity variations should be monitored, but also the nocturnal ones, especially the presence of sustained high temperatures above normal at night, since in addition to causing discomfort and malaise, they contributed to an increase in mortality, by not allowing a return of body temperature to baseline levels." (Page 8, Ola de Calor y Medidas a Tomar - Revisión Preliminar).

An American study evaluated the health impacts and mortality rates of various heat waves in different cities[19]. It shows that mortality is increased during heat waves and that ambient heat exposures, primarily indexed by temperatures, are positively associated with mortality.

**Table 9: Results from descriptive studies analyzing risk factors for increases in mortality following heat waves**

| Study population (reference no.) | Exposure | Outcome | Results |
| --- | --- | --- | --- |
| Three September heat waves in Los Angeles, California, 1939, 1955, and 1963 (29) | Daily temperature ≥100°F; compared with 1947 "normal" temperatures | Daily no. of deaths | Death counts were higher with increasing temperature and age; lag time between maximum temperature and maximum mortality was ~1 day |

[17] https://www.paho.org/hq/index.php?option=com_content&view=article&id=15650:paho-who-urges-southern-hemisphere-countries-to-prepare-for-heatwaves&Itemid=1926&lang=en

[18] Ola de Calor y Medidas a Tomar – Revisión Preliminar, Pan American Health Organization / World Health Organization, (https://www.paho.org/hq/index.php?option=com_docman&view=download&alias=48467-heat-wave-and-measures-to-take-preliminary-review-spanish&category_slug=detection-verification-risk-assessment-1226&Itemid=270&lang=en)

[19] Relation between Elevated Ambient Temperature and Mortality: A Review of the Epidemiologic Evidence, Rupa Basu and Jonathan M. Samet From the Department of Epidemiology, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD

*The continuation of the table is in the following link (https://academic.oup.com/epirev/article/24/2/190/535042#8418116), with a detailed list of cases by cities worldwide and the reference corresponding to each case investigated.*

**Table 10: Results from studies of heat-related mortality specific to cardiovascular and respiratory diseases**

| Study population (reference no.) | Exposure | Outcome | Results |
|---|---|---|---|
| England and Wales (years not available) (70) | Temperature indicators | Respiratory disease, arteriosclerotic disease, and total no. of deaths | Temperatures above 68°F increased CVD (cardiovascular disease) mortality by 0.5–15.1%, depending on age and specific disease; no gender difference; stronger in elderly |

The continuation of the table is in the following link (https://academic.oup.com/epirev/article/24/2/190/535042#8418116), with a detailed list of cases by cities worldwide and the reference corresponding to each case investigated.

### 2.2.3.Technological solutions selected

The following table set technological solutions selected for the program. It sets criteria to provide a clear guidance to project owners. Though, a feasibility/market study might be carried out in each relevant country to refine those criteria. Complementary opportunities might be identified or specified to be captured lists of eligible activities, based on climate change trends and sector business as usual practices. This list is not exhaustive and may evolve in the course of the program.

**Table 11: Eligible technologies for the PEEB Cool Programme**

| Project type | List of technologies eligible to the program |
|---|---|
| Building construction/ renovation | • Building envelope (material, insulation, colours)<br>• Limitation of solar gain (overhangs, windows)<br>• Heat or cold production system<br>• Lighting equipment<br>• Ventilation system<br>• Drop ceiling<br>• Electric equipment<br>• Solar water heaters<br>• Roof photovoltaic power generation system (or other renewable energy system if applicable)<br>• Green space management<br>• Water management system |

| | |
|---|---|
| Efficient heating/ cooling infrastructure | • Heating or cooling network<br>• Recover waste heat infrastructure<br>• Solar cooling storage equipment<br>• Cooling equipment (HVAC, storage) |
| Green building ecosystem actor | • Processes and equipment involved in the production and/or distribution of the technologies listed above under Building construction/renovation and under Efficient heating/cooling infrastructures<br>• Services and equipment required for the installation, operation and/or maintenance of the technologies listed above under Building construction/renovation and under efficient heating/cooling infrastructure |

## 2.3. Key transformative issues relating to PEEB

Three of the main prominent issues underpinning energy efficiency in buildings in developing and emerging economies, which PEEB Cool will specifically target include:

- Clean cooling as a majority of the countries with developing and emerging economies are located in hot climates, both dry and humid;
- Sustainable building construction materials that make the most out of locally sourced materials and construction techniques;
- Private sector involvement which must be spearheaded by the national public authorities.

### 2.3.1. Clean cooling

Maintaining thermal comfort in buildings in locations with hot climates is expected to present an increasing challenge as a result of climate change, both due to the rise in average temperatures and the increased frequency and severity of heat waves. This climate hazard affects both the efforts to mitigate climate change and the resilience of vulnerable populations. On the one hand, high temperatures harm health. In the absence of air conditioning, people are exposed to an increased risk of high indoor temperatures during periods of high outdoor temperature. The World Health Organization recommends that in populations exposed to high ambient temperatures, strategies to protect people from excess indoor heat should be developed and implemented.[20] On the other hand, globally, energy consumed by air conditioning already equals 2000 TWh every year and is expected to triple by 2050.

In fact, among buildings energy end-uses, space cooling and appliances and other plug loads are the fastest-growing energy end-uses. The IEA found that Global sales of air conditioning (AC) systems per year have nearly quadrupled since 1990. Moreover, according to the IEA report “the future of cooling”, the anticipated growth in cooling demand in coming decades may cause a “cold crunch”. According to this report, standards for the bulk amount of the coming new air conditioning units are much lower than what they should be.

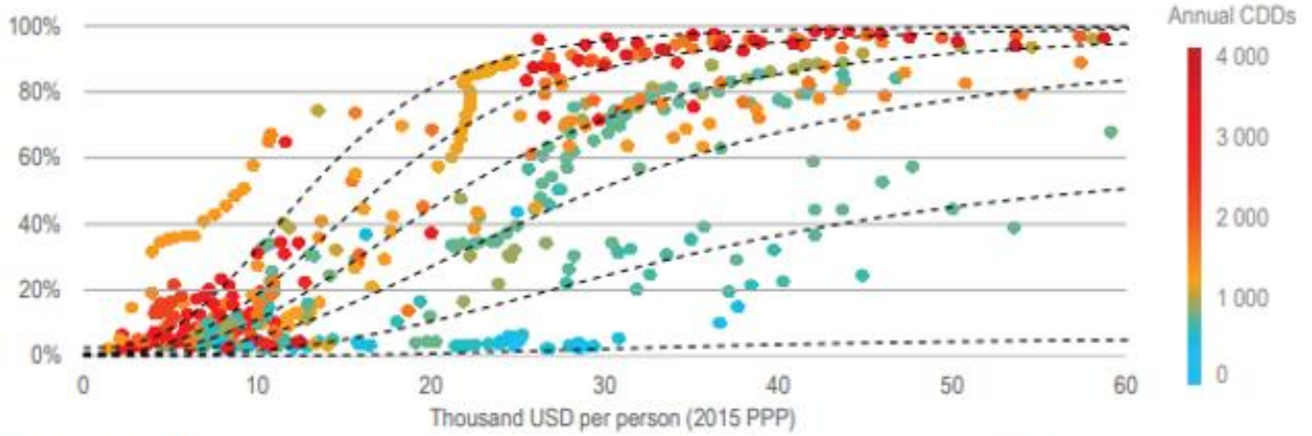
As for now, cooling still is not the biggest building energy use, compared to heating. However, of the approximately 2.8 billion people who live in places with average daily temperatures above 25°C all year, only 8% of them are estimated as having AC (GlobalABC 2018, IEA 2018). Population in hot climates will specifically

[20] WHO Housing and Health Guidelines. Geneva : World Health Organization ; 2018. 5, High indoor temperatures. Available from: https://www.ncbi.nlm.nih.gov/books/NBK535285/

contribute to this increase in demand. Demand for cooling in Indonesia is for instance expected to increase 13-fold during this period. Rapid increase in demand is also expected in countries such as Mexico as well as significant growth throughout Africa (IEA, 2018).

The IEA has found that:

- in hot climates (typically in countries with 3000 or more hours during the year when the temperature is above 18°C), there is a very strong correlation between increase in income and increase in cooling demand,
- passed a certain income threshold, sales of ACs in hot climates take off.




Notes: The dotted lines shown here are illustrative pathways for a typical place or country according to CDDs adjusted for relative humidity (see Box 2.1 for an explanation of how the heat index is calculated); PPP = purchasing power parity.

**Figure 3: Per capita Income and rate of household ownership of air conditioning**

It is in these same places that we expect huge increase in new buildings following strong population growth. These new constructions must be thoroughly designed to limit the impact on cooling demand and associated GHG emissions.

By incorporating passive (bioclimatic) measures to maintain cooler temperatures than conventional buildings, cool buildings can increase the resilience to temperature increases of inhabitants and users of buildings which are not mechanically cooled. Such building design also reduces cooling demand (on average 20 to 30% reduction in hot climates). Typical strategies include:

- optimizing the building main orientation (according to sun path and prevailing winds);
- minimizing east/west glazed area, minimizing the window/wall area ratio;
- maximizing solar shading devices (integrated in architectural project and completed by mobile shades such as blinds);
- promoting light color coatings on roofs and walls, forbidding horizontal glazing (typically roof glazing);
- promoting landscaping around the building to cool down the micro climate around the building and reduce local surfaces temperatures;
- integrating natural ventilation and indoor air fans coupled to an adjunction of indoor thermal mass when it is useful, and of course;
- training occupants on how these passive buildings must be used.

A second set of strategies consists in integrating energy efficiency requirements on the cooling systems and if possible, using renewable energy to power these systems. In many of the PEEB Cool countries, cooling systems often mean simple split units, except in Asia where cooling demand is higher and urban fabric is denser, implying more district cooling networks potential projects as well as other technologies for electricity-based cooling (water-cooled chillers...). When dealing with split units, efficiency depends on part load ratio, outdoor temperature, and rated efficiency. On-site measurements often show a very low efficiency. This can be explained by the fact that local cooling units' markets do not include energy efficiency labeled units and that the designers often oversize the cooling systems. Energy efficiency labels and inverter technology must be promoted (only 10 African countries have energy efficiency programs for appliances). Regulation devices may also be prescribed. Lastly, indoor air temperature set points should be adjusted to reasonable comfort requirements, as it is common to see indoor spaces at temperatures below 20°C when outdoor temperature is at 40°C. Energy efficiency requirements can further reduce the consumption of passive buildings by 30 to 40%.

Another advantage of this second set of strategies is that by improving the efficiency of the Air Conditioning (AC) units through an energy labelling program, one also pushes out of the market AC units which still use R-22 refrigerants although they are forbidden by the Montreal protocol. While most countries have instituted regulations to assist the phase out of HCFCs, few have regulations to control the import of ACs that use HCFCs. In Africa for instance, only South Africa has implemented HCFC regulations that cover AC units. ACs containing HCFCs, in particular R-22, can still be found in some African countries, like Kenya and Tunisia.

The third set of strategies consists in selecting systems that reduce GHG emissions related to cooling. We can distinguish two cases: the district cooling networks and the electricity-based cooling. Electricity-based cooling is the common approach. Once the two previous set of strategies have been implemented, the third aspect is to install PV panels to reduce the carbon content of the electricity used for cooling. This might not be relevant in all countries since one must first look at the carbon content of the national electricity grid. However, many sites will be off-grid and their GHG emissions will be better with PV panels than with a fuel generator. In all the PEEB Cool countries, the solar resource is abundant, and many projects are low rise buildings, making it possible to cover close to 100% of cooling related electricity use and others (provided the building's demand has been reduced thanks to the two previous strategies).

In the case of district cooling networks, one opportunity is eco-districts projects where the district cooling system is built along with the whole district. If a low carbon source of cold is identified (typically hydrothermal energy), then a very efficient system can be designed that also mutualizes investment among the whole district developers (public and private). Low carbon district cooling networks may yield as low as 10 to 20 $gCO_2/kWh$ of cooling whereas the average carbon content for electricity among the program's countries is 428$gCO_2/kWh$. Knowing that the average cooling efficiency is roughly 2, this gives an average carbon content of 214$gCO_2/kWh$ of cooling. The benefit of a district cooling network can be as high as a factor of 10!

Lastly, for centralized cooling systems and for local split units, it is important to remember that cooling systems GHG emissions are also due to their refrigerant types and that great differences exist (from GWP 0 for ammoniac to GWP 1430 for R134a, a very common refrigerant). Associated institutional work may include capacity building, improvement of policies, standards and labelling, understanding the locks for manufacturing capacity of efficient equipment as well as the dynamics of access to cooling.

Some countries already have started the institutional work with regards to cooling efficiency. The Kigali cooling efficiency program provides a good overview of the current progresses. The Argentinian example is a program that works on the potential for improving energy efficiency of the produced manufacturing refrigeration equipment in domestic industries. In Indonesia, the program's objective was to integrate a cooling efficiency award category into the established sustainable business awards and raise awareness of cooling efficiency in the country. In Nigeria, the program aimed at integrating energy efficiency into the room air-conditioning sector, transforming the market of inefficient room air conditioning equipment and developing a national efficiency cooling plan. Often, these programs come along with an F-gases phase-out program.

In terms of institutional work, passive design strategies must be integrated in building design and construction codes. Energy efficiency cooling systems can be normalized in building energy efficiency codes as well as cooling equipment standards requirements. PV electricity generation can be promoted or blocked due to local legislation with regards to on-site consumption, often related to discussions between the State and the national electricity supplier. Lastly, district scale cooling can also be promoted through urban planning requirements such as quotas of GHG emissions or renewable energy cover rates in the context of eco-districts.

As long-lived assets, inefficiently constructed new buildings today provoke future thermal discomfort or will require future costly refurbishment. Cool buildings therefore reduce vulnerabilities that would otherwise continue to exist for decades, and ensure reduced emissions for the duration of their lifetimes.

### 2.3.2.Sustainable construction materials

Another important factor when looking at buildings' carbon footprint is embodied carbon – the carbon emission associated with material and construction processes throughout the whole lifecycle of a building. Carbon emissions released before the building begins to be used will be responsible for half of the entire carbon footprint of new construction between now and 2050.[21] Hence, the use of low carbon construction materials can have a significant impact on buildings' overall carbon footprint.

According to the GHG emission reduction estimates of this feasibility study (5. Technical assessment), the emissions reduction relating to materials could amount to half of the total emissions reduction of the proposed PEEB Cool program. This ratio can be greater for buildings with low energy intensity such as social housing.

Moreover, locally sourced and low carbon materials are a source of local jobs, economic development and local natural resources promotion. There is a strong relation between locally sourced materials and local construction practices. Such materials include, but are not limited to, compressed earth bricks, straw, wood or bamboo.

However, despite multiple benefits, including (if locally sourced) on local economic development, low carbon materials are still rarely used at scale.

Normative requirements have insurance impacts and can therefore be a severe obstacle. One typical barrier is that contractors specialized in such construction techniques are considered small and unreliable by local stakeholders. The latter usually feel more at ease by consulting large contractors although they know that these actors do not have this special skill.

Typical criteria that must therefore be considered when designing activities to encourage the use of sustainable construction materials include:

- Norms and standards found in tenders;
- Industrialization and normalization of the materials production;

[21] Bringing embodied carbon upfront – coordinated action for the building and construction sector to tackle embodied carbon. World Green Building Council, 2019. Available from: https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf

- Perception by market stakeholders;
- Qualified labor;
- Costs.
- Impact on construction schedule (seasonality of some eco-materials)
- Impact on construction schedule (seasonality of some eco-materials)

Institutional work is definitely needed to promote local materials, especially regarding normalization works. For example, public projects should promote local materials. Another aspect of this work is to promote and support the locally sourced / low carbon materials market players. Those can be NGOs, local companies, and institutions.

### 2.3.3. Private sector engagement

In developing and emerging economies, the private sector involvement in energy efficiency projects is real although generally limited to low-hanging fruit. Energy efficient buildings represent for the vast majority of private sector actors in the countries targeted by the program a deviation from business-as-usual practices. Therefore, there is a financial risk for private sector actors to implement energy efficient buildings tied both to the incremental cost of energy efficiency measures and to innovating away from business-as-usual practices.

In order to leverage the private sector in contributing to the transformation of the building sector towards more energy efficiency, PEEB Cool will incentivize private sector pioneer stakeholders of the building value chain (i.e. construction companies, local architects, private sector project owners, private developers, banks) to implement improved standards regarding energy and environmental performance of buildings. This will be supported through a combination of project and policy level activities.

At the project level, this will involve offering to cover part of the extra-cost related to the improved energy and environmental performance of buildings, thereby directly incentivizing private sector pioneers to adopt these improved practices within their projects. Simultaneously, by supporting the improvement of the policy framework through for instance establishing building design and construction guidelines, advice on improvement or creation of a building energy efficiency code, training civil servants to control and enforce such codes and advice on setting up public incentives, the program will also contribute to rewarding those energy efficiency private sector pioneers of the building value chain.

Private sector actors that will be targeted by the PEEB Cool program will be the same types of actors currently involved in projects financed by the AFD Group and supported by PEEB. They include:

- Construction companies, architectural and engineering firms as well as private sector developers involved in large-scale public-sector projects financed by AFD,
- Households and private sector developers as beneficiaries of affordable green finance through financial intermediaries financed by AFD,
- Private sector project owners across various sectors (health, education, industry, etc.) financed by Proparco.

<u>Stimulating the private sector through large scale public buildings construction/renovation projects</u>

It is understood that in many of the PEEB Cool countries, public procurement can be one of the main drivers of private sector innovation.

Because most projects financed through PEEB Cool will be very large in scale, the stakeholders of the building value chain (i.e. construction companies, local architects) that will be pioneering improved standards in the building construction/renovation projects, will then be able to apply such new practices in future private sector projects in a more cost-effective way. Many projects currently supported by the PEEB fall into this category. The hospital project in Tunisia (described in section 3.2), currently supported by the PEEB, is a good example of such project and its intention to make hospital building practices more energy efficient in Tunisia as a whole since the hospital building code currently being updated as a result of this project will impact private and public hospitals alike and the scale of programmed hospital construction (13 large regional hospitals) in the coming ten years will allow private sector actors of the building value chain to gain new skills and knowledge.

Another way of engaging the private sector is through large scale public housing development projects. Such projects are often implemented either by a ministry (ministry of housing or ministry of construction) or by a national public housing planner (such as is the case with some of the projects currently financed by the AFD Group and supported by PEEB). The national housing planner sets the building construction and urban planning requirements (including criteria relating to the energy and environmental performance of buildings) and the private sector housing developers apply for projects through a competitive bidding process. This set up describes a project currently supported by the PEEB in Morocco which aims to construct more than 7000 residential buildings.

Stimulating the private sector through financial intermediation

Both AFD and Proparco (AFD Group), have been working with financial intermediaries, both public and private, for a long time by allowing investment flows to address climate change issues by leveraging the resources and capabilities of the local financial sector. It has experience in lowering market barriers by combining adapted financing to technical assistance to develop a pipeline of bankable projects and build capacities of banking actors.

In complementarity with the work to support public policies in favour of energy efficiency (political/institutional signal) and the necessary accompaniment of economic operators and project owners (demand side), the actors of the financial system have a key role to play in financing investments that best integrate energy efficiency technology in all sectors (construction, industry, tertiary sector, infrastructure projects).

This integration of the energy efficiency topic by the actors of the financial systems is not self-evident. It requires in-depth work on raising the awareness of financial actors, on their capacity building on the subject and on the partnership that they can develop to enhance their financing approach in this market segment (institutional partnership, with consultants, etc.).

Based on this approach and on AFD Group’s experience, PEEB has been working on several programs promoting green affordable buildings through local banks involvement. On those projects, credit lines are combined with technical assistance to support actors of financial system. Additional instruments, such as green investment bonuses can be added for final beneficiaries to enhance incentives. With PEEB Cool, AFD and GIZ aim to push this activity further by working with additional actors and capitalizing on PEEB’s experience.

Examples of such project include a SUNREF Housing scheme financed by AFD in India. In this project AFD provides a green credit line along with grant resources for technical assistance and investment grant to the National Housing Bank, which then on lends to Housing finance companies, which themselves on lend to public and private developers as well as individual homebuyers. The project aims to build a total of 420’000 m2 of affordable Green Housing. Many such projects are in the PEEB Cool pipeline and are currently being identified and studied.

Stimulating the private sector through direct financing

Lastly, Proparco regularly finances through a variety of financing tools various private sector actors, who also have the potential to bring about a transformation of building and/or energy management practices in the health, education, tourism, retail and industrial sectors.

Most developing economies targeted by the PEEB Cool are considered frontier markets for retail and industrial development, meaning that both GDP and the percentage of people with disposable income is growing, thereby fueling a demand in consumer goods. In the retail sector, Proparco is for instance financing the construction of a large shopping mall in an equatorial climate. Many such malls are being built throughout emerging and developing economies. Setting the impact of COVID aside, even those emerging economies such as Indonesia continue to experience growth in the retail sector. Therefore, there is a significant potential for replicating improved standards regarding the energy and environmental performance of these large shopping malls and retail buildings in general.

The same can be said about the industrial sector, for which as it grows in developing and emerging economies, opportunities to invest in optimizing industrial production in addition to expanding it become more apparent. Proparco is for instance financing (or intends to finance) and supporting private sector actors to improve their energy and environmental performance in the textile sector in Asia, in the telecommunications sector in Africa and in the pharmaceutical sector in the Middle East and Africa among other types of projects. In many cases, these are very energy intensive buildings for which there aren't at the country or at the regional level many building guidelines or standards.

In the health sector, Proparco is for instance financing a Foundation to build a hospital in East Africa. PEEB has supported efforts to improve the energy and environmental performance of the hospital in the design phase. As the Foundation is a large international network of close to 100'000 workers and volunteers in 30 countries that has completed over 9000 building projects, the potential for replicability with such actors is huge. In the health sector specifically, the Foundation is widely seen as a reference among health providers in East Africa and central Asia as they are running 15 hospitals and over 450 health centers.

In the education sector, Proparco finances private sector providers of education in countries where the share of private sector providers is significant. For instance, in Kenya, 33% of primary schools and 15% of secondary schools are private. These shares are set to increase as data from the Kenya National Bureau of Statistics has shown a much larger growth between 2003 and 2017 of private schools compared to public schools. Some of these private sector education providers have become significant in size, thereby increasing the potential impacts at project level as well as the replicability of actions aimed at improving the energy and environmental performance of such schools.

The impact of PEEB Cool project level support in the private sector can be replicated through setting guidelines to be shared through federations and associations of professionals.

PEEB Cool's policy level will also majorly contribute to making sure the impact of the projects is replicated beyond the projects themselves. For instance, in Morocco, even though the building code has been in force since 2015, its application by the private sector is lacking. The absence of technical capacities, financial incentives and effective conformity checks prevent the private sector from complying with current regulations. Therefore, one of the ways PEEB is working to overcome these barriers in Morocco has been by setting up a National Alliance of Buildings professionals lead by the ministry of housing which offers training opportunities for its members and implements awareness raising activities for the sector and the greater public among other activities. Other policy level activities including for instance improving the energy building regulation, training civil servants to better enforce it and studying financial incentives for energy efficiency in buildings among others, are described in the following chapter. The capacity to support the identification of synergies between the policy level and the project level activities is one of the main factors for the success of the program.

## 2.4. Target countries

### 2.4.1. Climate profile

#### 2.4.1.1. Overview of the impacts of high indoor temperatures

The World Health Organisation (WHO) notes the importance of indoor temperatures on human health (WHO, 2018). While high outdoor temperatures have long been associated with heat-related illnesses, the impact of indoor temperatures is less studied.

Heat-related risks can be affected by various climatic parameters such as the frequency of hot days, hot nights and heatwaves. Globally, the IPCC has stated that it is virtually certain that in future there will be more frequent hot temperature extremes on most land areas on daily and seasonal timescales, and that it is very likely that heat waves will occur with a higher frequency and longer duration. Increases in heat load and a rising body core temperature can lead to a range of health effects, the worst of which is life-threatening heatstroke (McGregor, 2015). Exposure, in this case, can be thought of as the location of people or activities in places that can potentially be affected by heat. In urban areas, climate trends are projected to increase the risks from heat stress. These risks are amplified for those lacking essential infrastructure and services (IPCC, 2014). Vulnerability to the health effects of heat depends on the social, economic and political setting, but the nature of a person's dwelling, can play a role.

Factors that affect specifically indoor thermal loads include building thermal mass and orientation, as well as ventilation. WHO explains that "air conditioning, insulation, wall thickness, shading from direct sunlight, natural ventilation (especially during night time), and increased air motion (fans) to cool indoor temperatures can help protect people against heat and heat-related illness." (WHO,2018).

Cities and urbanised areas are especially vulnerable to the heat island effect which causes infrastructure (such as buildings) to absorb more heat than natural environments. This then creates 'islands' of significantly warmer temperatures in areas with less green and blue space. Without the necessary adaptation measures, populations within cities can suffer severe heat stress. Moreover, given the links between higher outdoor temperature and warmer indoor temperature in regions where air conditioning is uncommon, methods for thermal regulation are key characteristics of effective housing.

Below we provide an overview of the impact of climate change on vulnerabilities related to high indoor temperatures in the PEEB Cool countries, separating between the impacts on health (mortality and morbidity) and economic exposure to risks. To better understand the impacts of high temperatures on the target countries within the program, it is useful to consider which countries have similar climates. The seven climate zones according to which countries are classified in the feasibility study are the following:

**Table 12: Climate zones of the PEEB Cool countries**

| **Climate zone:** | **PEEB Cool countries that mainly fall in this climate zone:** |
|---|---|
| 1. Equatorial climate | Indonesia, Sri Lanka |
| 2. Tropical climate | Nigeria, Mexico (part), Costa Rica |

| | |
|---|---|
| 3. Desert or arid climate | Djibouti, Mexico (part), |
| 4. Humid subtropical climate (or “Chinese climate”) | Argentina |
| 5. Mediterranean climate | Morocco, Tunisia, Albania |
| 6. Continental climate | North Macedonia |

Where studies specific to target countries are lacking, those available in neighbouring countries with a similar climate are included to illustrate similar climate risks.

For some countries data on vulnerability is more extensive than for others, with data availability being better for larger and wealthier countries. Overall, the picture is clear. In regions with warm or hot climates average temperatures as well as the various climatic variables related to hot weather (such as warm night, cooling degree days and heatwaves) are all expected to increase, and unless investments are made in cool buildings, the adaptive capacity of the population to these climate impacts will remain low. In view of this, buildings that are adapted to high temperatures will be increasingly important for resilience to climate change of the population of these countries.

##### 2.4.1.2. Climate change and economic exposure to the impacts of high indoor temperatures

Increasingly warm temperatures can have profound impacts on a country’s economy. There are strong links between rising temperatures and exhaustion, decreased energy and focus, risk of heatstroke and more. So, a rapidly warming climate will yield significant disruptions to the economy, resulting in losses. The 2019 ‘Working on a Warmer Planet’ report published by the International Labour Organization (ILO) found that even under a conservative estimate of 1.5°C of warming by the end of the century, 2.2% of total working hours worldwide will be lost by 2030 due to higher temperatures – with construction, services and industry accounting for 40% of this total (ILO, 2019). This is equivalent to a global loss of 80 million full-time jobs and an economic loss of US 2,400 billion.

These results were echoed by The Journal of Labour Economics, which studied how people allocate their time based upon the weather. They concluded that people work fewer hours on warmer days, therefore reducing productivity (Zivin, 2014). It is expected that in some hot areas, up to 30-40% of annual daylight hours could become too hot to work at all, causing losses of over 20% to global GDP by 2100 (Kjellstrom, 2016). Moreover, a 2015 study on economic production expects a reduction in average global incomes of 23% by 2100 under the assumption that future adaptation mimics past adaptation and based on the RCP 8.5 (high emission) pathway (Burke and Hsiang, 2015).

Equally, higher temperatures create a variety of socio-economic risks that worsen but do not cause an immediate financial burden. Studies on the effect of temperature on academic performance have shown strong correlations between higher temperatures and a fall in achievement (Hyunkuk, 2017). One 2019 study in the U.S. found the performance of psychological tests and school tasks can increase an average of 20% if classroom temperatures are lowered from 30°C to 20°C, with the optimal temperature for performance being less than 22°C (Wargocki et al, 2019).

As is often the case regarding climate vulnerabilities, the most significant losses fall on developing countries despite their minimal contributions to global greenhouse gas emissions. A study of annual industrial value-added output across 125 countries between 1950-2003 found a loss of 2% for every 1 degree Celsius warmer in poorer countries (defined by level of national income), though without the same impact in richer countries

(Dell, 2012). This suggests that countries with limited adaptive capacity to warmer climates and smaller economies suffer more.

Available literature on the broad impacts of increasing temperatures on the economy agrees on the trend: hotter temperatures lead to higher economic exposure at a level remarkably consistent around 2% per 1 degree Celsius of warming. This can be through a loss of working hours, heat stress and fatigue, lack of concentration, limited academic achievements, and more. Equally, many of the same studies point to the possibility of these impacts being avoided, or at least significantly reduced, with effective regulation of heat and thermal comfort.

Upscaling the PEEB Cool program would, therefore, limit the economic exposure and stress due to climate change in developing countries.

#### 2.4.1.3. Country level data

For each country covered by the Program, information on the relevant climate impacts will be provided in the following sections. In addition to selected country specific information, the following data is provided:

- *The ND-GAIN index ranking*. This is a measure of a country's vulnerability and readiness to climate change. Those with a high ranking are typically less vulnerable and most ready and those with a low ranking are more vulnerable and less ready (e.g Norway is 1st and Chad is 181st). The index allows governments and decision-makers to better understand priority areas.
- *The Climate Risk Index ranking*. The Global Climate Risk Index, produced by Germanwatch, analyses to what extent countries and regions have been affected by impacts of weather-related loss events (storms, floods, heat waves etc.).
- Relevant information from the country fact sheets produced by the Climate Service Center Germany (GERICS).

Moreover, climate parameters for establishing the current climate situation were based on 30-year data-sets downloaded from the Climate Information portal for the country's capital city (or where the capital city is in a relatively cool area, for a large city with a warmer climate):[22]

1. *Tropical nights:* Tropical nights are calculated as the number of days when daily minimum temperature is above 20°C, presented as an absolute change against the baseline period 1981-2010.
2. *Temperature change*: calculated as the mean annual values of daily mean averaged over a 30-year period compared to the baseline.
3. *Max. temperature*: calculated as the maximum yearly values of daily temperatures averaged over a 30-year period
4. *Min. temperature*: Same method, for minimum temperatures

All projections are based on the annual mean, have been adjusted for bias and are the median change within the ensemble mean.

Where relevant data is available, projections of the following parameters from the World Bank's Climate Change Knowledge Portal have also be included:

1. Hot days: calculated as the change in total count of days over the time period where daily maximum temperature rose above 35°C compared with the baseline period 1986 – 2005.

[22] https://climateinformation.org/ - this source provides historic meteorological data over the course of a 30-year period.

2. Heat index: representing the change in the total count of days considered to be ‘extremely uncomfortable’.
3. The probability of heat wave: defined as the daily probability of a sudden period of heat lasting three or more days when temperature remains above the 95th percentile.
4. Cooling degree days: measuring changes in demand for energy based upon high temperatures over the course of a year. When temperatures rise above the threshold (18.3°C), power demand for cooling rises. This indicator measures the total number of degrees that temperatures remain above the threshold.

Where available, information is provided on the impact of high temperatures on health and economic vulnerability of the country to high temperatures. **The country data is provided in the annex of the Feasibility Study.**

### 2.4.2.Baseline of the EEB market

The below tables present an overview of the housing, education and health infrastructure sectors for of the program’s countries. The baseline will be calculated on a project by project basis according to the methodology described in the chapter 4.3.1.2 of the present study. An indicative baseline per climate and per building type is provided below.

As explained in Annex 22a, the mitigation impact was assessed based on a database of projects. The table below shows the expected climate additionality of the programme in tCO2 avoided.

**Albania**

| | |
|---|---|
| Housing | The average household size is 3.7 for a population of 2.8 million inhabitants, 61% of which are urban. With the assistance of the UNDP, a law “On Social Housing” was drafted and approved in 2018 to regulate the sector and organize existing or new programs (Social Housing Rental, Enhance the Conditions of Existing dwellings or construction of new ones, Affordable Dwelling Unit, Area Development for Housing purposes, Temporary Shelter (accommodation), Specialized Housing). A certain number of design requirements are already in place (minimum areas in DCM 626, 15.07.2015, see below for energy performance).<br>The National Housing Agency (NHA) focuses on financing, construction, sales, and allocation of low-cost houses to the priority categories. The municipalities are responsible for assessing housing needs, designing housing programs and projects; they tend however to lack adequate tools and methodologies to provide clear projections (including for new constructions). A 2019 EU report indicates that, in order to meet the goal of improving the living conditions of 25,000 households by 2025, an average 2 983 household per year should benefit from a new social housing. However, only 1 545 among 12 095 applications were met in 2019. |
| Health | The primary healthcare system, run by the regional directorates of health and public health, is composed of:<br>- Key health centers: 415 in 2019, in towns and centers of communes, covers all basic primary health services. Each covers on average 8 to 10,000 persons.<br>- Satellite health centers / ambulances: 1,801 in 2019, in villages.<br>The country has a lower health expenditure as percentage of its GDP in comparison to its neighbors, with Albania at almost 5.26% and others 6.5% and higher (2018). Quantified plans for new constructions have not been identified. |
| Education | The basic and secondary education stages consist in:<br>- Kindergarten: pre-primary education (3 years, not compulsory)<br>- Primary schools: 5 compulsory years<br>- Lower secondary schools: 4 compulsory years |

| | |
|---|---|
| | - Gymnasium and vocational institutions: 3 to 4 secondary education (not compulsory)<br>The current mandated maximum class size in Albania is 26 to 30 students for the first grade, and 30 to 35 students for grades two to five and the lower and upper secondary level. The observed average class size was 21 student per class (17 in rural areas, 2019), 27% of classrooms were larger than 30 students in 2015-2016. Net school enrolment rates are 95% for the primary level and 87% for the secondary level (2018). |

### Argentina

| | |
|---|---|
| Housing | The average household size is 3.3 people (44.49 million inhabitants, 92% urban population).<br>100% of the population had access to electricity in 2017.<br>The country lacked 2.5 million homes in 2010. The government plans to reactivate the PROCREAR program, which supported the construction of nearly 40,000 homes between 2012 and 2015 but was subject to a policy of austerity for the next 4 years. Studies are underway to revive support for 11,000 housing units from 2020.<br>In a typical house, the use of energy (electricity and gas) is approximately 35% heating, 17% cooking, 16% DHW, regarding air conditioning and lighting, its participation corresponds to 3% and 2% respectively. |
| Health | Information on the types of health centers, the average coverage and the upcoming construction planned was not identified. Statistical yearbooks between 2017 and 2019 indicate an average increase of approximately 700 new operational centers per year. |
| Education | Between 2007 and 2017, the country has carried out three school construction programs financed by the Inter-American Development Bank (IDB) that have resulted in the construction of 2,544 facilities. |

### Costa Rica

| | |
|---|---|
| Housing | The average household size is 3.2 people (5.0 million inhabitants, 63% urban population). 60% of the homes are independent (60%), followed by row dwellings (34%) and in a condominium or closed residence (3%).<br>99.4% of the population had access to electricity in 2017.<br>In the second quarter of 2018, the number of people employed in construction activity increased by 38% (47,724 people), compared to the same period in 2017.<br>In 2019, 22,167 new homes were built in Costa Rica, which represented a slight increase of 1.3%, compared to the 21,882 houses built in 2018. The highest number of construction permits for residences was extended in Alajuela with 5,381, followed San José with 3,398 and Puntarenas with 3,128 authorizations. |
| Health | Costa Rica provides universal health care coverage. The first level of health coverage is provided by Basic Provision Units of Integrated Healthcare (EBÁIS, 947 units in 2009) and some peripheral and deconcentrated clinics. Each EBAIS serves a population of 3 500 to 4 000 residents.<br>In the 2019-2022 period, ¢ 956 638 million will be invested in infrastructure and equipment, the portfolio includes the construction of at least 50 EBÁIS headquarters, 34 health areas and the hospitals of Turrialba, Puntarenas and Carthage. |
| Education | Pre-primary, primary and upper secondary education is compulsory. Class sizes are small in public primary school (16 students in average in 2018) but increase in secondary schools (35 students in average in 2018).<br>In 2012, through a loan of US $ 167 million to the Inter-American Development Bank, the construction of 79 new educational centers was financed, as well as the creation of 24 cultural and sports spaces.<br>In 2019, the Ministry of Public Education (MEP) awarded three contracts for ¢ 6.8 billion for the construction of two new schools and a college. At that time, the three educational centers faced serious infrastructure problems and overcrowding. |

### Djibouti

| | |
|---|---|
| Housing | The average household size is 6.3 persons in 2002. Electricity access rate is 60.2% (70% for the urban population) in 2017. The Government estimates the need for housing between 35,000 and 50,000 units with an annual increase of 3,000 units. The Agency for Urban Rehabilitation and Social Housing (ARULoS) is in charge of developing public projects. In 2018, it had 3 ongoing projects (184 housing units) and 4 under identification (1965 housing units, financing Gulf countries, FADES, China). |

| | |
|---|---|
| Health | The health facilities in Djibouti are organized as follows:<br>- Health posts: managed by a health technician (care, prevention, education), 9 in rural areas in 2017.<br>- Health centers: managed by a doctor (care, treatment, prevention, education), 14 in urban areas in 2017.<br>- Intermediate Health Centers (IHCs): cover health sub-districts (hospitalization, prevention, education, maternity, medical services)<br>- Regional hospital centers: 1st level services + specialties and emergencies, regional coverage (8 in 2017)<br>The PNDS 2018-2022 estimated the average radius of action of these facilities to be 9.36 km (the standard is 5 km) with strong geographical disparities in the regions (6.91 to 16.1 km), the need for new centers has not been quantified nor is it associated with a programing effort at this stage. Based on a density of 41.4 inhabitants/km², the average coverage of a health center can be estimated at approximately 11,400 inhabitants. |
| Education | According to the Education Action Plan 2017-2020:<br>- The average number of students per class is 50 in 2016 at the primary level, with 161 schools for 61,755 students (or 383.6 students/school). The need for new classrooms is estimated at 357 in 2017-20 to reach an average class size of 40 students without double flow (127 classrooms built in 2014-15).<br>- Middle and secondary school enrolments in 2016 will be 55,405 students in 85 schools (651.8 students/school), and the need for new classrooms is estimated at 439 in 2017-20.<br>- The investment effort involves the expansion of existing establishments rather than the construction of new ones, even if the regional network is insufficient. |

### Indonesia

| | |
|---|---|
| Housing | The average household size is 4 people (267.7 million inhabitants, 55% urban population).<br>98.1% of the population had access to electricity in 2017 (100% urban).<br>Taking together the private and public sectors produce 550,000 to 600,000 housing units per year, which does not cover the annual need of more than 820,000 units per year.<br>The penetration of air conditioning in households was 9% in 2016 |
| Health | Basic services are provided by (2017):<br>- 9,700 primary health centers: 30,000 inhabitants<br>- 23,875 Auxiliary Health Centers: 3,000 inhabitants<br>- Village maternity: 1 or a few villages<br>- Village post: 1 or a few villages<br>- Integrated health post: 120 households<br>- District hospitals: 1 district up to 100 beds |
| Education | In 2007-08, class size of primary schools averaged 27 pupils, 38 in middle school and 37 in high school.<br>The number of schools and the pace of new construction have not been identified. |

### Mexico

| | |
|---|---|
| Housing | The average household size is 3.7 persons (162.2 million inhabitants, 80% urban population).<br>100% of the population had Access to electricity in 2017.<br>The construction of social housing is managed by cities and states with a central government subsidy fund. |
| Health | The health system is managed at the state level, data on the capacity, distribution and construction planning of health facilities has not been identified. We note only that for the State of Mexico, over the period 2004-2020:<br>- 72 health centers were built/reconstructed.<br>- The replacement of 6 centers (community hospitals) is currently suspended. |
| Education | The central government finances the majority of schools, but the states manage them and plan capacity building. |

### Morocco

| | |
|---|---|
| Housing | The average household size is 4.2 persons (36.03 million inhabitants, 62% urban population).<br>100% of the population had access to electricity in 2017. |

| | |
|---|---|
| | Since 2010, the government has been conducting a program for the construction of housing from 50 to 80 m² for a maximum price of 250,000 dh excluding VAT, by granting subsidies to buyers and tax benefits to developers who commit to building at least 500 homes over 5 years. Morocco has set itself the objective of developing 300,000 units over 5 years and has exceeded this objective (376,900 completed). A new framework is being developed to meet the changing demand (maintaining "social" housing units and developing a "social +" offer) from 2021. The current deficit is estimated at 400,000 units. |
| Health | Public Primary Health Care and Primary Health Facilities (PHCFs) are made up of urban (838) and rural (1,274) Health Centers and Rural Dispensaries (776). The ratio of inhabitants per facility averages 12,264 (variations by regional province from 2,015 to 43,750, with strong tensions in the urban centers of the northern and coastal provinces).<br>The Health Plan 2025 (2018) provides for the construction of 51 new PHCFs between 2019 and 2021, 7 of which have been completed as of June 2019. |
| Education | In 2018/19, the country counted the following public schools:<br>- Primary: 7,789 schools (64 new schools opened/year on average since 2010/11), with an average of 470.3 students/school and 27.2 students/classroom.<br>- Colleges: 2,007 colleges (43 new openings/year on average since 2010/11), with an average of 779.7 students/institution and 35.3 students/classroom<br>- High School: 1,236 high schools (39 new openings/year on average since 2010/11), with an average of 741.9 students/school and 31.2 students/class<br>Despite the disparities between regions and between urban/rural areas, overcrowded classrooms do not appear to be a problem as of yet. The proximity of schools remains an area for improvement in rural areas. |

**Nigeria**

| | |
|---|---|
| Housing | The average household size is 4.9 people (195.9 million inhabitants, 50% urban).<br>54.4% of the population had access to electricity in 2017 (86.8% urban).<br>According to the World Bank, the annual needs are about 700,000 homes per year, with production capacity in the formal sector between 100,000 and 200,000 homes. The government set up the Family Homes Funds in 2017-18 with a production target of 500,000 units in 4 years. Less than 5,000 units have been achieved to date. |
| Health | The private sector provides 60% of health services while representing 30% of the institutions. The number of public primary and secondary health facilities is about 23,000 in 2015, a target of 10,000 new functional facilities has been set in the 2018-22 development plan. Details of planning or progress have not been identified. |
| Education | The construction standards for public facilities are as follows:<br>- Primary: maximum 40 students per class (target of 30). There were 67 students on average per class in 2016<br>- College: There were 68 students on average per class in 2016<br>- Secondary: maximum 45 students per class (target of 40). There were 62 students on average per class in 2016<br>The Education 2018-22 (federal) plan calls for the construction of at least 30 schools and 71,875 new classrooms in existing facilities. |

**North Macedonia**

| | |
|---|---|
| Housing | The average household size is 3.7 for a population of 2.1 million inhabitants, 58% of which are urban. The country suffers from a large deficit in housing stock, with an average 342 dwelling per 1 000 inhabitants in 2011 (compared to 531,9 in France in 2019). The home ownership rate is also very high, with only 5% of the properties registered as rental. The government policy focuses more on providing subsidies to buyers than on building affordable housing to bridge the gap. |
| Health | The public primary healthcare facilities consist in 34 health centers and 5 health stations<br>The extensive net of health care institutions makes it possible for around 90% of the population to reach a health service within 30 minutes. The construction of new facilities is therefore less an issue than the upkeep, upgrade, and efficiency improvement of the existing structures. 9 reconstruction projects were planned in the 2017-2020 Programme for Work of the Government |

| | |
|---|---|
| Education | The compulsory pre-tertiary education facilities consist in:<br>- Elementary schools: 9 years (primary and lower secondary education), 989 institutions in 2017/2018 with an average 17 student per class<br>- Secondary, technical or vocational schools: 4 years, 131 institutions in 2017/2018 with an average 21 student per class<br>The need for new infrastructures is limited with only 4 new high schools planned in the 2017-2020 Program for Work of the Government. |

**Sri Lanka**

| | |
|---|---|
| Housing | In 2014, the construction sector was growing at an annual rate of 20% involving mainly office and residential buildings (IFC, 2018). Although this trend seems to have slowed down in recent years with the slowdown in GDP, the fact that the supply of housing is struggling to meet demand is a sign that the construction sector has good years ahead (Global Property Guide, 2019).<br>Indeed, according to some private real estate developers, the need for housing amounted to 100,000 units for 12,500 units produced in 2018 (Opportunity Sri Lanka, 2018). In fact, the Sri Lanka Chamber of Construction Industry predicted in 2017 a sustained growth in the construction sector over the next 15 to 20 years.<br>According to businesswire, the penetration rate of air conditioning in Sri Lanka was 10% in 2018 (businesswire, 2018) while 99% of the population is connected to the power grid. |
| Health | Health services are provided by a network of 1,118 government institutions operating at three levels :<br>- 996 Primary Medical Care Units (PMCUs) and Divisional Hospitals (DHs) staffed by one or more medical officers<br>- 98 District general hospitals and base hospitals<br>-24 Tertiary-level hospitals (national hospitals, teaching hospitals, and provincial general hospitals) |
| Education | The provinces are divided into about 98 zones. An education zone has an average of around 100 schools.<br>Currently, in Sri Lanka:<br>- 17,000 Early Childhood Development Centers enroll a total of 475,000 children aged 3-5<br>-10,000 public primary and secondary schools that enroll about 4 million students.<br>- 15 public universities that enroll about 180,000 students. |

**Tunisia**

| | |
|---|---|
| Housing | The average household size is 3.9 persons (11.57 million inhabitants, 69% urban population).<br>100% of the population had access to electricity in 2017. The number of households equipped with air conditioners is expected to reach 70% in 2020.<br>2 public companies and housing departments in some ministries ensure the production of social and medium standing housing. At the end of 2019, projects were being planned over the medium term for at least 750 units. |
| Health | The public structures of the 1st level of health care were in 2018:<br>- 110 District Hospitals (+2 in 4 years)<br>- 28 Basic Health Groups (stable in 4 years)<br>- 2,161 Basic Health Centers (+38 in 4 years)<br>The average number of people covered by a basic health center in 2018 was 5,345 persons. |
| Education | The public schools at the beginning of the 2017/2018 school year were:<br>- 4,576 primary school (+59 in 6 years) with an average of 228 students and 23.4 students per class (regional variations from 16.4 to 29.4)<br>- 1,424 middle and high schools (+74 in 6 years) with an average of 571 students and 25.5 students per class (regional variations from 17.2 to 27.7)<br>- 86 technical colleges (-2 in 6 years) with an average of 120 students and 23.9 students per class<br>The 2016-2020 sector plan identifies as a strategic objective the development of a new school map to reduce overcrowding in some major cities. The number of schools to be built has not yet been determined, but it can reasonably be assumed that it will be about the same as was planned in the previous period (around 20 schools per year). |

### 2.4.3. Total emissions from the building sectors in the PEEB Cool countries

Energy consumption in buildings results in a significant portion of the greenhouse-gas emissions in all of the relevant countries of the programme. The table below shows estimates of overall emissions from the buildings sector (residential and commercial) based on calculations carried out using energy balances and standard IPCC emissions factors for fuels, and grid emissions factors from The IFI Dataset of Default Grid Factors v.2.0 (2019). In most of the countries in PEEB Cool, energy use in the building sectors represents between 20 and 50% of all annual emissions.

**Table 13: Annual GHG emissions from buildings in the PEEB Cool countries (MtCO2eq)**

| | Annual emissions from buildings (MtCO2eq) |
|---|---|
| Albania | 1.4 |
| Argentina | 54.0 |
| Costa Rica | 2.8 |
| Djibouti | 1.3 |
| Indonesia | 125.8 |
| Mexico | 82.5 |
| Morocco | 26.1 |
| Nigeria | 24.2 |
| N. Macedonia | 4.3 |
| Sri Lanka | 16.3 |
| Tunisia | 11.3 |
| **Total** | **419.0** |

*Source: Based on calculations using energy balance data from the most recent years available for each country and standard emissions factors for fuels. More detail is available in the spreadsheet in Annex 22c of the project submission*

# 3. Program Rationale

## 3.1. Problem and barrier analysis

### 3.1.1. Problem

**Financing of energy efficiency in buildings remain limited**

Despite the importance of improving energy efficiency in buildings in the fight against climate change, the financing for energy efficiency in buildings remains marginal. Even though world energy investments amounted to 1850 billion $ in 2018, energy efficiency investments only amounted to around 250 billion $ of which 150 billion was for buildings (International Energy Agency, 2019). In comparison, investments in renewable energies amounted to around 310 billion $ in 2018. Once again, the situation varies significantly from one region to another. The table below shows investment data from the IEA that date back to 2017.

**Table 14: Total investment in energy supply and energy efficiency in Asia, Latin America and Africa**

| *Continents* | *Total investment in energy supply* | *Total investment in energy efficiency* |
|---|---|---|
| **Asia** | 602 billion USD | 99 billion USD |
| **Latin America** | 49 billion USD | 2 billion USD |

| | | |
|---|---|---|
| **Africa** | 84 billions USD | 3 billions USD |

A report published by IRENA showed that in order to meet the objective of the Paris Agreement of staying below an increase of 2°C in global average temperature, investments in energy efficiency would have to amount to 37 trillion $ over the 2016-2050 period (IRENA, 2019), which is the equivalent of 1090 billion $ per year. A comparatively lower total investment amount in renewable energies is needed over the same period.

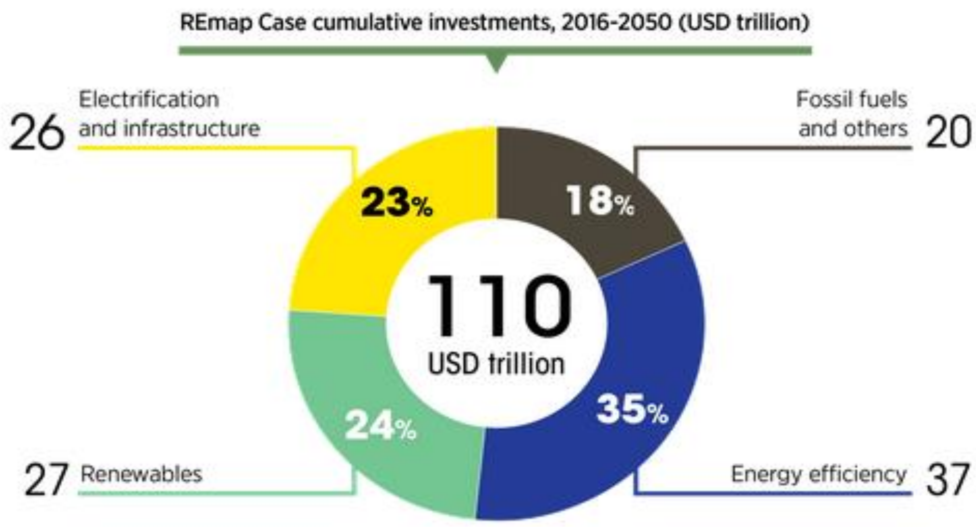



**Figure 4: Investments needed over the 2016-2050 period to be in line with the Paris Agreement**

*Source: (IRENA, 2019)*

**Regulations alone are not enough**

The experience built up since the 1980s shows that market dynamics alone do not naturally direct actors towards improving energy efficiency, including when the energy costs are not subsidized. Public policies are essential in order to impose a framework to ensure that energy resources and the climate are preserved. However, the experience of countries that have had a building energy code for a while now shows that it often takes years before most actors are able to comply with the new code. While in developed economies, energy building codes were usually put in place to formally establish existing energy efficient practices, in many of the countries that have recently adopted a building energy code, the know how necessary for complying with the code is often not generalized enough throughout the construction sector.

In particular, energy efficiency is still not well integrated into the specifications at the project development phase and is often perceived, and sometimes wrongly so, as an additional short-term cost which, although it generates savings in the medium and long term, is not financed. Moreover, real estate developers do not necessarily have the skills to properly integrate energy efficiency specificities. This is also often the case with administrations. Thus, it is difficult to build an appropriate contractual framework for the emergence of bankable projects for energy efficiency in buildings even in the presence of a building energy code.

In the context of developing and emerging economies, it therefore appears necessary to balance the top-down approaches that have been implemented over the past few years with a more bottom-up approach. Work on the definition of a regulatory framework for energy performance in buildings should therefore be balanced by strategies to implement this regulatory framework. The role of public authorities as well as the financial and technical support of development agencies are crucial to the development of energy efficiency in buildings.

The causes for this persisting low investment in energy efficient and resilient buildings can be classified according to three main barrier types – technical, financial and institutional/regulatory – which are detailed in the following chapters.

Detailed barriers per countries are presented in the country forms in the annex of the Feasibility Study.

### 3.1.2. Technical barriers

The following general technical barrier was identified:

- **Project stakeholders lack technical knowledge and experience in planning and implementing energy efficient and resilient building projects based on bioclimatic design principles and efficient cooling technologies.** Projects are not well designed, and the impact of projects is not optimized. This barrier concerns the entire buildings sector value chain, from project idea to design, planning, engineering, construction, operation and end of life recycling. In particular, energy efficiency is still not well integrated into the specifications at the project development phase and is often perceived, and sometimes wrongly so, as an additional short-term cost which, although it generates savings in the medium and long term, and is thus not financed. Moreover, real estate developers do not necessarily have the skills to properly integrate energy efficiency specificities. This is also often the case with administrations. Thus, it is difficult to build an appropriate contractual framework for the emergence of bankable projects for energy efficiency in buildings even in the presence of a building energy code.

### 3.1.3. Financial barriers

The following three main financial barriers were identified:

- **Building owners are reluctant to invest in the higher upfront cost of energy efficient, low carbon and resilient buildings, especially with the economic crisis caused by the COVID-19 pandemic.** Energy efficient buildings and efficient cooling systems are still perceived by project owners as complex and unattractive and the environmental advantage and wider benefits of more resilient buildings and practices is not well understood. This results in an incremental investment cost and risk premium for EE investments, making a project's cost higher. In addition, energy efficiency investments are often subject to split incentives when the entities making the investments in buildings are different from the entities using the building (and experiencing the benefits of reduced energy bills and increased comfort). In case of renovations, there is a lack of willingness from building owners to undertake major (necessary) energy efficiency retrofits. Although it is too soon to have detailed data on the economic impact of the Covid crisis, it is reasonable to assume that it has further burdened the sovereign debt of PEEB Cool countries, making it harder for these countries to borrow.

- **Due to lack of experience with such projects, banks are reluctant to expand their portfolios towards green building finance. Tailored financial solutions are missing and/or too restrictive to be widely used.** Banks prefer commercial risk over technical risk. Indeed, banks often have little knowledge of technology or experience with assessing the level of risk associated with energy efficiency technology and therefore tend to be conservative in their evaluation. Financial institutions prefer asset-based financing over cash flow project-based financing. Bank officers at the implementing level lack the required technical know-how for the development and implementation of incentive and financing schemes for projects improving energy performance of buildings. Energy efficiency projects are still perceived as risky.

- **Industry actors are reluctant to adapt their services for the construction and operation of energy efficient (EE), low carbon and resilient buildings, specifically in times of economic crisis.** The transformation of the buildings sector relies heavily on the innovativeness and delivery capacity of the private sector. However, due to limited market demand and/or unclear national strategies and regulations, as well as often unfavourable start-up environments, the potential in the market is not exploited in the PEEB Cool countries. This means that industry actors find it difficult and risky to introduce new products in the market, i.e. in the low carbon building material sector, or for building operation services. In case of renovation projects, companies do most often not propose sufficiently integrated and deep energy efficiency measures. Cash-constraints following the current economic crisis only re-enforce this reluctance.

### 3.1.4. Institutional and regulatory barriers

The following institutional and regulatory barriers were identified:

- **National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions).** An important share of PEEB Cool countries have integrated energy efficiency in buildings in their national strategies, however, often without clear targets or an idea for a way forward. A perfect example can be found in non-operationalized NDC targets that give no guidance to the sector actors on the future strategies taken by the government, and which could orient the market and support the investment decisions of national and international financiers. The below figure shows that many countries still do not explicitly mention the building sector in their NDC.

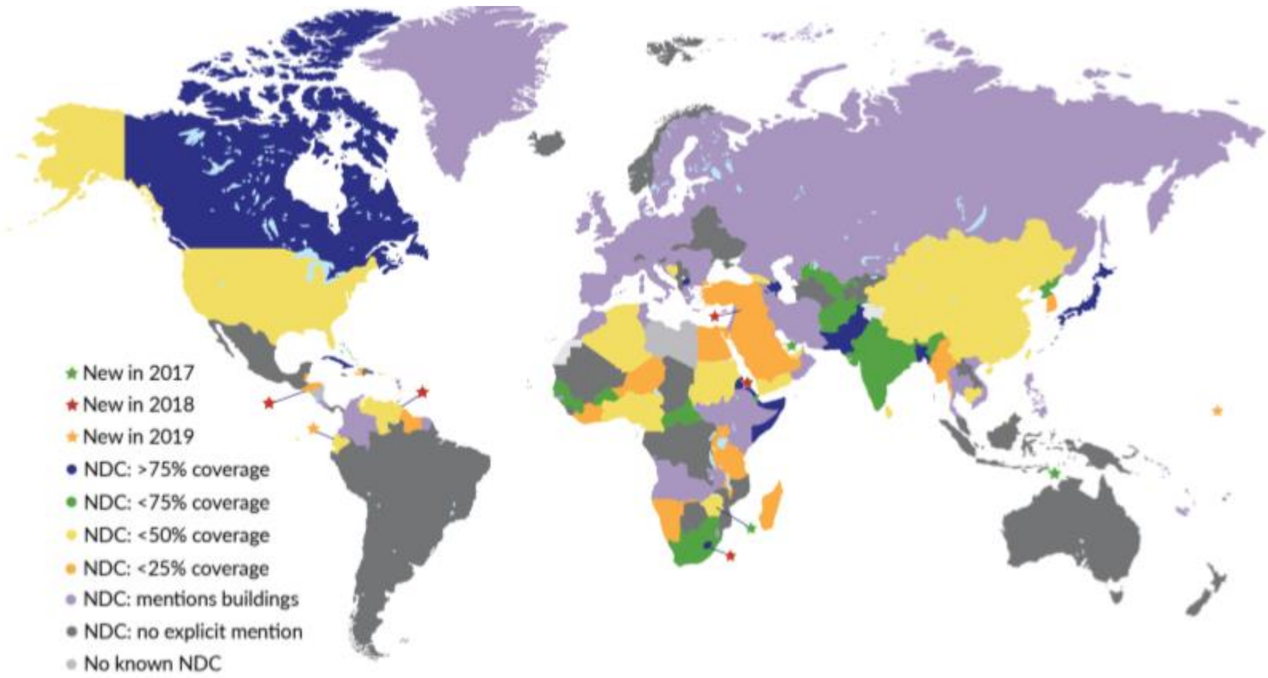



**Figure 5: Building sector emissions coverage in NDCs, 2018-2019 (IEA, 2019)[23]**

[23] Emissions coverage is estimated based on specific mentions of measures related to the buildings sector, building end uses and technology with respect to 2018 building sector CO2 emissions. Country NDC's that do not explicitly mention

This often still reflects a lack of political buy-in on behalf of some governments that have not recognized the importance and potential of the buildings and construction sector for climate change mitigation and adaptation, as well as sustainable economic development. Where they do exist, strategies are often also outdated or lack a sound data basis. The experience built up since the 1980s shows that market dynamics alone do not naturally direct actors towards improving energy efficiency, including when the energy costs are not subsidized. Clear public policies (i.e. national or sectoral strategies) are essential in order to impose a framework to ensure that energy resources and the climate are preserved.

- **Building codes lack specific requirements for energy efficiency in buildings and enforcement is often weak, mandatory for certain types of buildings only, or still under discussion.** The experience of countries that have had a building energy code for a while now shows that it often takes years before most actors are able to comply with the new code. While in developed economies, energy building codes were usually put in place to formally establish existing energy efficient practices, in many of the countries that have recently adopted a building energy code, the know how necessary for complying with the code is often not generalized enough throughout the construction sector. Governments severely struggle with enforcement – be it through unclear integration into general construction codes and practices of energy efficient practices, unresolved liability questions, insufficient capacities for on-site random verification, or simply lack of awareness on behalf of the civil servants involved in permitting. In the social housing sector, dwellings or house prices are sometimes capped by law, preventing the implementation of energy efficiency measures.

- **Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented.** The buildings and construction sector is highly fragmented with a multitude of actors involved – from small and medium sized companies to large multinationals, from individual homeowners or renters to large national housing corporations. It is therefore exceptionally difficult and resource-intensive to rally those actors behind the common goal of transitioning to energy efficient and resilient buildings. Across the buildings value chain along its entire life cycle, the involved parties speak different jargon and mostly only look at a small section of the project instead of contributing to a larger picture. Their formal (and often, also, informal) education did not convey the principles of energy efficiency. No uniform way of strengthening, updating and institutionalizing knowledge related to energy efficient and resilient buildings exists, resulting in very different knowledge and awareness levels.

## 3.2. Lessons learned from PEEB experiences

PEEB provides partner countries simultaneous support for policy implementation, trainings and knowledge sharing as well as financial and technical assistance to implement large-scale building projects with high energy and environmental performance standards.

**The originality of PEEB, and the key of its success is to work simultaneously on the national policy level (GiZ, ADEME) as well as on the level of transformational program and project financing (AFD Group).** As a result, PEEB supports improvements to the regulatory framework whilst at the same time providing the

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measures or actions for buildings, for example the economy-wide targets in the European Union, have not been counted in emissions coverage. Source: United Nations Environment Programme (2020). 2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi. Available from: https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf needed incentives to the energy efficiency pioneer stakeholders of the building value chain to implement those improved standards.

**In the first 5 PEEB partner countries, which are Mexico, Morocco, Senegal, Tunisia and Vietnam, PEEB is supporting and financing 6 projects amounting to EUR 600 million.** Working in synergy with the financing, PEEB has supported the development of policies and codes relating to energy efficiency in buildings as well as the establishment of national alliances for buildings and construction. PEEB has also advised on NDC roadmaps or platforms and trained over 500 policy makers and practitioners in Morocco, Tunisia, Senegal, Vietnam and Mexico. Internationally, PEEB has also raised awareness in many international meetings and co-organized regional workshops for Asia and North America in cooperation with the Global Alliance for Buildings and Construction (GlobalABC).

**One of the PEEB's main successes, which was not foreseen in the initial feasibility study, has been the fact that the program has become a tool for mainstreaming the topic of energy efficiency in building projects (new construction or renovation) financed by the AFD Group.** Before the existence of the PEEB program, most energy efficiency projects in buildings financed by the AFD Group consisted of projects implemented by the public energy ministries or energy efficiency agencies of AFD partner countries. This 'energy efficiency sector' approach ruled out all other building projects financed by the AFD Group such as schools, hospitals, health care centers, social and mid income housing units among other types of buildings.

The PEEB's innovation is to implement an approach reflecting the cross-sector nature of energy efficiency. The PEEB's Secretariat based in AFD's headquarters works across all of AFD Group's technical divisions to identify large scale building construction/renovation projects and provide support to optimize the energy and environmental performance of these projects. This implies projects most often implemented by sectoral actors (ie: ministry of health, ministry of education or private sector actor such as housing developers) rather than by the ministry of energy. Furthermore, the PEEB Secretariat's support extends to the policy level activities, even though the PEEB budget for such activities is currently earmarked for the first 5 partner countries.

Another aspect that was perhaps not fully captured by PEEB initial feasibility study are the synergies between the policy and project level activities. Having staff within the PEEB Secretariat, located in the headquarters as well as in the countries, dedicated to both project and policy level activities and working together as part of the same team, increases the synergies between those two levels of intervention. Examples of such synergies include Tunisia where AFD is financing the construction of 2 large scale regional hospitals (30 000m$^2$ each). PEEB provides project level technical assistance to the ministry of health leading to a 20% improvement compared with the baseline scenario. At the same time, drawing from the lessons learned from the project, PEEB provides policy level support in the form of a guide for the construction of energy efficient hospitals, trainings for building energy efficiency managers and an update to the current energy efficiency code for hospitals and health buildings, at a time when Tunisia is planning the construction of 11 additional large-scale hospitals. Many other similar examples of synergies between PEEB policy and project level activities exist in the four other first PEEB partner countries.

**To date, PEEB has identified over 30 large scale building construction/renovation projects in more than 20 countries worldwide which will be financed by AFD.** However, most of these projects take place outside the first 5 partner countries where current PEEB resources for project level support are limited and policy level support nonexistent.

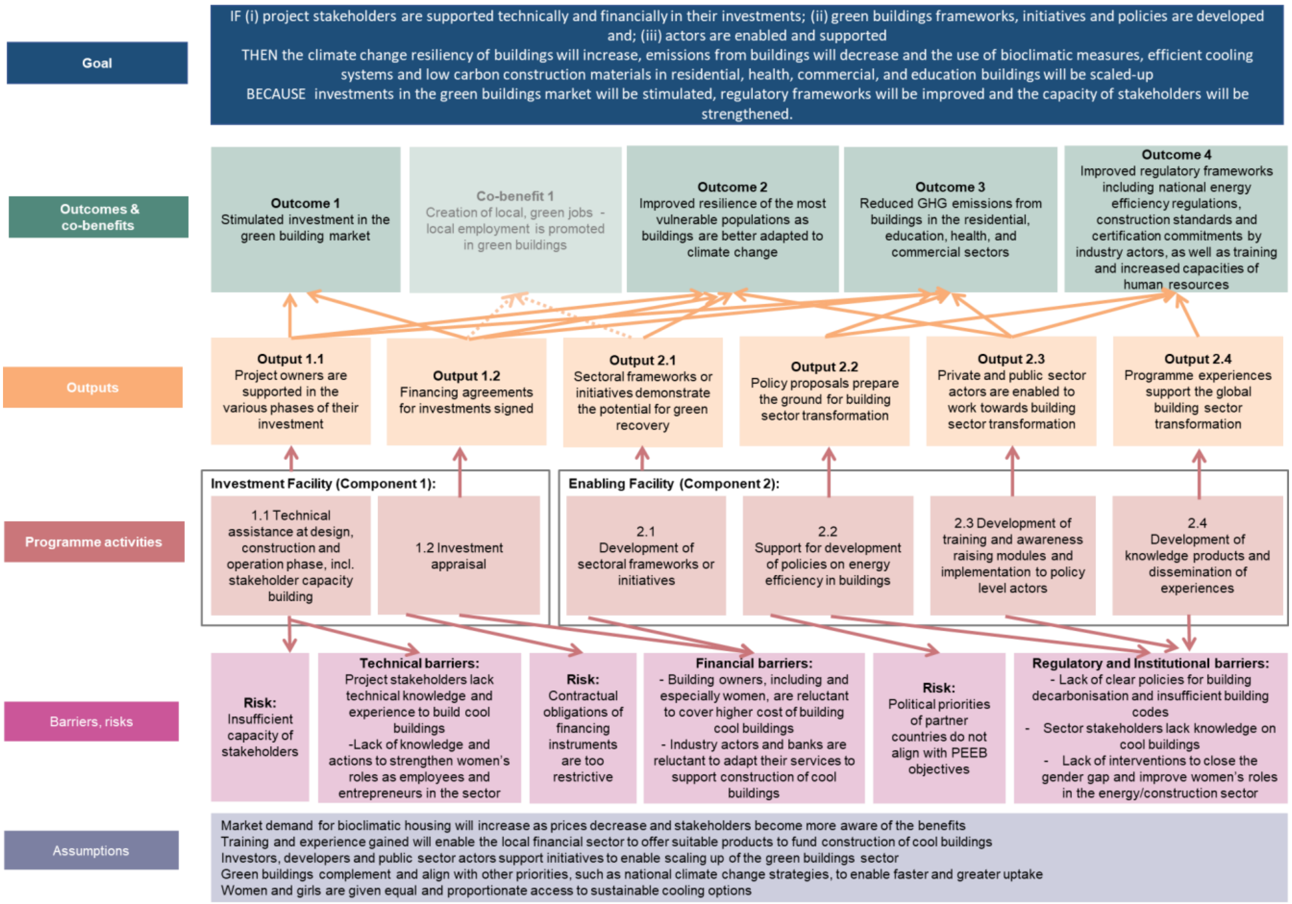
**The purpose of PEEB Cool is therefore to extend the current scope of PEEB, both geographically and technically.** Geographically, PEEB Cool will target countries where PEEB has already identified a need for project and policy level support in order to bring about a change of dynamics regarding energy efficiency in the building sector. Technically, PEEB Cool will go further than the current PEEB program by focusing on some of the more prominent issues underpinning energy efficiency in buildings in developing and emerging economies, namely the issue of clean cooling, the use of sustainable low carbon building materials as well as private sector involvement.

**The basis for coordination among partners has already been established under PEEB and has been successful to date**. A secretariat, staffed by the GIZ and AFD, has been successfully functioning for the past three years. The Secretariat ensures communication is fluid among PEEB implementing entities and manages the program's activities. At least one local PEEB coordinator is present in each of the first five PEEB partner countries. This coordinator ensures communication between the country agencies of the implementing entities (GIZ and AFD) and with local partners (ministries and project promoters). Communication and knowledge exchange among countries can be facilitated through the GlobalABC.

### 3.3. Theory of change

Buildings are critical to delivering climate change mitigation and adaptation action. On the one hand, current building infrastructure lacks the necessary resilience to cope with future temperature increases and with the expected increase in the frequency, intensity and duration of extreme heat periods, meaning hundreds of millions of people in the PEEB Cool countries could face indoor heat stress. On the other hand, energy use for cooling is a large and increasing fraction of building energy use.

The PEEB Cool Investment Facility and the Enabling Facility activities complement and reinforce each other, addressing the *technical, financial, as well as regulatory and institutional barriers for investments in energy efficiency in buildings* in an integrated and holistic manner. Through this combined approach, low-carbon buildings are constructed or renovated and, based on the experience gained and on the improvement of policy frameworks, national transformations of the construction sector are initiated. As a result, national public and private actors are able to implement effective mitigation and adaptation actions in the building sector. The PEEB Cool methodology focuses strongly on the replicability and transferability of the policy, regulatory and financial solutions to other countries.




**PEEB Cool addresses the technical barriers** by providing technical project assistance to the subproject owners in partner countries on the feasibility, design and construction of energy efficient, low carbon and resilient buildings (for instance social housing, schools, and health facilities). This assistance will be provided through the two Program Facilities. The Investment Facility will conduct feasibility studies to identify and prepare subprojects implemented by partner countries and private sector (i.e. private construction such as universities or building materials manufacturing). The Investment Facility will also assist the subproject implementation through direct supervision and monitoring activities during the construction and operation phases. It will provide onsite capacity development for completed subprojects to ensure a low carbon operation and sustainability. Only subprojects that demonstrate at the design phase that they are targeting a minimum energy performance criteria will be eligible for PEEB Cool financing, thus raising technical capacities of implementing actors. Measures recommended will be adapted to the different building types and climate zones as well as the investment budget. Low tech solutions will be prioritized. An assessment of the subprojects' further technical assistance needs will be undertaken during the design phase, this technical assistance may also be provided through the construction phase to ensure that measures initially recommended are implemented. The Enabling Facility provides trainings and disseminates the acquired knowledge to the wider ecosystem of stakeholders (e.g. developers, planners, builders, and facility managers) on the design and construction of energy efficient, low carbon and resilient buildings as well as meeting the building code requirements.

**PEEB Cool addresses the financial barriers** at the subproject level and at the country/project level. The Investment Facility supports the subproject stakeholders in securing concessional financing to partly offset the higher debt service costs of green building. The concessionally offered by GCF will contribute to softening the borrowing conditions for these countries. The provided financing stimulates green construction activities, thus contributing to the economic recovery from the effects of the COVID-19 pandemic. Based on the project implementation experiences, the Enabling Facility supports the development of sectoral frameworks for the broader transformation of the building and construction sector in the partner countries, leading to the mobilization and de-risking of further investment. By developing action plans or roadmaps to improve the level of a given service in the market, the Enabling Facility fosters the development of a local offer.

PEEB Cool addresses the **regulatory and institutional barriers** by improving the policy framework. The Enabling Facility supports the building and construction sector stakeholders of the partner countries through the proposal and development of relevant policies (e.g. national cooling strategies for buildings, cooling action plans) and the improvement and enforcement of energy efficient building codes. It provides trainings to policy level actors (e.g. national and local governments, energy agencies, building sector associations) on the development and implementation of national building policies and energy efficient building codes. The Enabling Facility will also support the establishment and activities of national public-private alliances for energy efficient buildings to support the national scaling and replication of the low carbon and resilient building efforts from the subproject levels.  It also raises awareness by showcasing good examples of successful projects and focusing on the long-term benefits of investments (economic, financial, social, etc.).The enabling facility also disseminates good practice knowledge of PEEB Cool within countries and internationally to strengthen institutional and regulatory systems for mitigation and adaptation in the building sector and contribute to scaling and replicating the solutions. This raising of awareness and promoting peer review processes happens at the highest political level, as is currently done within the PEEB through the GlobalABC.

The results of PEEB Cool will contribute to the transformation of the buildings and construction sector towards low-emission, efficient and resilient buildings compatible with the Paris Agreement. Its mitigation and adaptation impacts will be as follows: 1.6 million $tCO_2e$ avoided and 1.133 million direct beneficiaries.

# 4. Program Design

## 4.1. Objectives of the project

PEEB Cool aims to transform the construction sector by advancing energy efficient and resilient building design, construction and operation in 11 countries through both policy level (enabling facility) and subproject level (investment facility) activities. In its work, PEEB Cool aims to prioritize sub-sectors with significant potential for GHG reduction potential and climate change adaptation such as, for example, large-scale new housing schemes and commercial buildings. PEEB Cool works with both the public and private sectors, and while it primarily targets new built, it will also address refurbishment of the existing building stock.

Throughout its activities, PEEB Cool intends to have a special transformative focus on three key thematic areas:

- Efficient cooling solutions: smart building design and low-tech approaches to avoid overheating, as well as efficient cooling technologies. This area also includes efficient cooling and heating networks in cities, urban design to avoid heat island, and the transformation of the market for air conditioning and refrigeration systems. It will promote high performance standards in terms of both efficiency and safety of refrigerant gases with regard to the greenhouse effect.

- Sustainable construction materials: decarbonisation of construction materials and transformation of the market through the promotion and financing of low carbon and local construction materials, with improved energy efficient production methods in order to further reduce the carbon footprint of the buildings.

- Private sector involvement: this area includes the development and strengthening of the local green construction ecosystem, targeting key actors involved at complementary levels in construction and/or renovation of buildings projects. Improvement of local ability to deliver products and services needed to enhance adoption of bioclimatic and energy efficiency measures (for example through local banks willing to develop a climate finance activity).

## 4.2. Choice of intervention

### 4.2.1. Programmatic approach

The “programmatic” approach as understood by the PEEB Cool implementing agencies is characterized by the following aspects:

- Aggregating subprojects by sector/type on a global scale, with local implementation teams that have access to these global resources;
- Approaching the building sector challenges in countries systematically, thanks to high expertise concentration made available flexibly locally – both from an investment subproject preparation and enabling environment creation perspective;
- Assuring coordinated intervention and implementation globally instead of implementing isolated country by country activities;
- Building on and ensuring cross-country information and experience flow.

This “standardization” with local flexibility allows for maximum resource efficiency.

### 4.2.2. Interlinkage of investment and enabling facilities

PEEB cool was designed to rely on two components that are mutually dependent and complementary: the investment facility and the enabling facility.

To implement the programmatic approach, the approach of the facilities is as follows:

1. Through discussions with partner countries, potential investment subprojects are identified that could be targeted by the investment facility.
2. In parallel, the adequate level of support from the enabling facility is estimated (see operations manual for details).

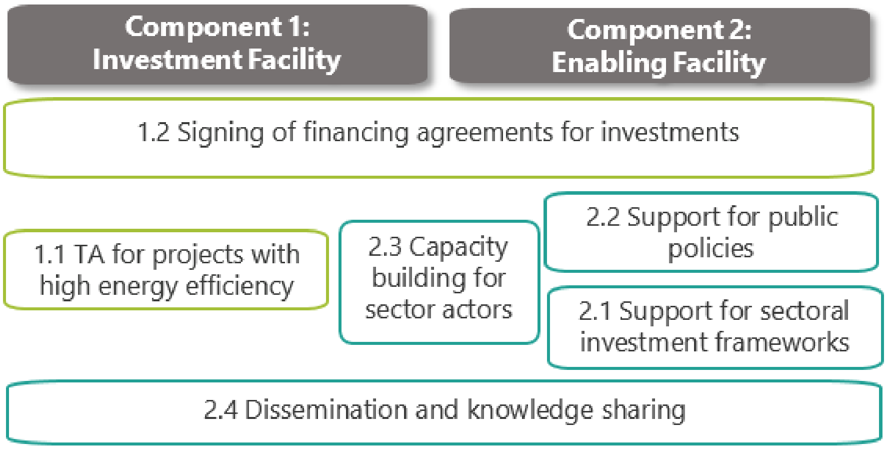
The investment facility represents the core of PEEB Cool as its sets up and provides the necessary financing to implement sustainable building practices through green building projects.

The investment facility relies on the enabling facility to provide further sectoral investment opportunities (output 2.1), improve the regulatory framework (output 2.2.), and increase capacities of sectoral and national stakeholders (output 2.3). The enabling facility furthermore represents an essential aspect of PEEB Cool to deliver climate impact for the following reasons:

- It enables national governments to build their own climate finance-related pipelines (output 2.2. and 2.3).
- It enables local industry actors to develop value chains, to open up new business opportunities and to increase capacity to deliver on projects (output 2.1. and 2.3).
- It improves the overall investment climate for buildings through clear regulations and standards (output 2.2. and 2.3).

As a consequence, viable investment pipelines and better regulatory framework will attract further public and private capital. In particular, public investment programs (accompanying and enlarging lead AFD/GCF investment) will crowd in significant private capital and, through its multiplier effect on the local economy, increase public revenue (through income tax, corporate tax, avoided unemployment costs …) and contribute to job creation. This strengthens the overall financial situation and capabilities of national governments and local industrial actors to finance their transition to a low carbon economy.

The project activities feed into both respective facilities, as demonstrated in the graphic below.




## 4.3. Project description

### 4.3.1. Eligibility criteria

The following section presents the conditions under which subprojects or stakeholders can benefit from PEEB Cool tools and the scope of support offered under component 1: technical assistance (output 1.1) and investment financing (output 1.2).

**Technical Assistance at the design phase** aims to review identified subprojects in PEEB Cool countries and characterize their potential for climate impacts. PEEB Cool provides the expertise to identify the measures that can be taken to improve the energy and environmental performance of buildings or cooling/heating infrastructure. The outputs of the technical assistance will describe the recommended measures and the expected climate impacts of these measures compared to the baseline (section 4.3.1.2) as well as the related financing requirements compared to the business-as-usual initial budget of the subproject (section 4.3.1.2).

Selected subprojects will also be offered **technical assistance at the construction and operation phases**.

Technical assistance will also be provided to **green construction ecosystem actors** and **financial intermediaries**.

**Investment financing:** Some subprojects that have received TA will subsequently be fully funded by AFD group investment financing, after a positive appraisal of the financial operation following AFD or PROPARCO internal procedures. **Co-financing by a GCF concessional loan** will be offered to selected subprojects, as described below.

Additionally, while not the primary focus for the programme, AFD will fund subprojects which reduce leakage of coolants. AFD is currently developing a proposal with the Fonds Français pour l’Environnement Mondial (FFEM) to support “innovative” actions within buildings cooling (with studies and investments) – including related to “clean refrigerants” with no global warming potential nor ozone impacts as part of these innovative actions.

Subproject and credit line's end-beneficiary project criteria are defined as follows:

a) Overall eligibility criteria for a subproject to receive any support under the programme. These address the following aspects of a subproject and credit line's end-beneficiary project:
    a. Country
    b. Subproject or credit line's end-beneficiary project type
    c. Within each subproject type, targeted sub-sector, technologies or actors
    d. Exclusion list
    e. E&S category
b) Additional eligibility criteria for intermediated projects
c) Technical assistance eligibility criteria
d) Investment financing eligibility criteria:
    a. Eligibility for financing from AFD Group
    b. Eligibility for GCF concessional loan co-financing in addition to the financing from AFD group

For each of those eligibility criteria, both direct financed subprojects and intermediated subprojects cases will be addressed.

###### 4.3.1.1.1. Overall eligibility criteria

When AFD Group identifies a new subproject, PEEB Cool PMU will apply the following criteria to assess whether the subproject can benefit from the program support:

a. ***Eligible country(ies)***: the countries are part of PEEB Cool program.

b. ***Subproject type***: the subproject and credit line's end-beneficiary project belong to one of the following types:
    i. Building(s) construction / renovation;
    ii. Efficient cooling / heating infrastructure;
    iii. In the case of intermediated financing, the subproject is a credit line to a public financial institution headquartered in one of the eligible countries that allows for the financing of one or several end-beneficiary projects of type i. or ii. as defined above.

c. ***Targeted building sectors*** (non-exhaustive):
    i. Housing - social (i.e. lower income) and middle income housing;
    ii. Education (school, universities, classrooms in rural areas, science complex, training centres);
    iii. Health (health centres, hospitals);
    iv. Public buildings and commercial buildings (public buildings, markets, shopping malls, offices);
    v. Industrial buildings
    vi. Transportation (train and bus stations);
    vii. Tourism (hotels).

***d. Technology types***

- Architectural solutions boosting natural ventilation and/or comfort inertia, thus passive cooling, and therefore the reduction of energy consumption linked to the cooling of buildings (e.g.: "Canadian system", "Solar tower", "natural ventilation openings, use of biosourced materials with good thermal properties, etc.)
- Sub-trade equipment (technical trades) promoting cooling with low energy consumption (air handling units with energy recovery, smart ventilation units, cold loops & sharing, etc.).

- "Clean" active cooling using systems with an excellent coefficient of performance (compared to systems used in PEEB Cool countries), using clean coolants and, if possible, an low and renewable energy supply

e. ***Eligible active cooling / heating infrastructure*** (supported technologies include, but are not limited to)
    - District cooling and heating
    - Recover waste heat infrastructure
    - Development of solar cooling storage solutions
    - Access to cooling equipment that are consistent with EIA's Pathway to Net-Zero Product List report[24].

f. ***Exclusion list***: subprojects and credit lines' end-beneficiary projects activities are not included in AFD Group Exclusion list.

g. ***E&S category****:* subprojects and credit lines' end-beneficiary projects belong to E&S category B or C. Subprojects and credit lines' end-beneficiary projects A are excluded.

In addition to technical assistance offered to specific construction projects, technical assistance is also offered to selected green construction ecosystem actors. These actors include the following:

- Manufacturers of local, low-carbon building materials
- Construction material suppliers and retailers
- Construction or renovation services providers
- Manufacturers or distributors of equipment (including cooling, renewable energy, water management device)
- Service providers for the operation and maintenance of buildings including equipment and green surrounding areas

In addition and in the case of intermediated subprojects, the following eligibility criteria apply:

*Eligibility criteria for Local Financing Partners (LFPs):*

a) The LFP is a public or private financial institution existing under the laws of any Host Country and/or which has funding activities in any Host Country;

b) The LFP satisfies with the Executing Entities' (AFD or Proparco) financial, governance, risks management and compliance due diligences procedures;

c) The LFP has sufficient internal procedures and core capacities to be able to implement the subproject with a Technical Assistance support (where relevant);

d) The LFP is capable of complying with the AFD Group's procurement procedures;

e) The LFP has AML/CFT risk management approach that are satisfactory to AFD Group; and

f) The LFP has an E&S risk management approach that is satisfactory to AFD Group as per the E&S Framework.

*Typology of subproject owners:*

[24] Pathway to Net-Zero: Cooling Product List - EIA (eia-international.org)

The scope of eligible end-beneficiary projects will be defined for each project by AFD Group in close coordination with each LFP. Depending on the local context, the project may target the following project owners:

a) Size and legal structure: large corporate, SMEs, micro enterprises, cooperatives, entrepreneurs, households/individuals, Government or other types of agencies/entities;
b) Typology: public and/or private;
c) Geography: eligible countries.

#### 4.3.1.1.2. Technical assistance (TA) eligibility criteria and scope

Five types of technical assistance are provided:

a) Technical assistance at the design phase of a construction/renovation subproject
b) Technical assistance at the construction and operation phases of buildings
c) Technical assistance for efficient cooling/heating infrastructure
d) Technical assistance to green construction ecosystem actors
e) Technical assistance for intermediated subprojects

Below we describe the eligibility, scope and outputs of each of type of TA.

*a) Technical assistance at the design phase of a construction/renovation subproject*

*Eligibility:*

Any subproject meeting the above-mentioned ***Project eligibility criteria*** can receive Technical Assistance at the design phase from PEEB Cool.

*Scope*:

The objective of the technical assistance at the design phase is to assess the potential for climate impacts, defining energy efficiency and bioclimatic measures for buildings, and to confirm the eligibility for further PEEB Cool support. The scope of TA activities at this phase is described in the section 4.3.1.3.

*Outputs:*

The following outputs are mandatory to confirm eligibility of the subproject for GCF concessional:

- Baseline for climate impacts
- Business-as-usual budget;
- Feasibility studies where energy energy efficiency and bioclimatic measures are defined, establishing potential impacts compared to the baseline and financing requirements compared to the business-as-usual budget.

In cases in which these outputs are provided by the subproject owner and not directly produced by PEEB Cool TA activities, Climate Performance TA will be used to assess the methodology and findings of the documents provided by the subproject owner to confirm alignment with the program.

Considering Technical Assistance is often provided at a very early stage of the subproject appraisal performed by AFD Group, so as to ensure recommendations are well taken into consideration, it might occur a small number of beneficiaries from the TA support will not subsequently receive investment financing from AFD Group.

*b) Technical assistance at the construction and operation phases of buildings*

*Eligibility:*

Any subproject that has benefited from the ***Technical assistance at the design phase*** and whose financing AFD Group has approved can receive Technical Assistance at the construction and operation phases from PEEB Cool.

*Scope:*

The objective of the technical assistance is to ensure the proper implementation of the energy efficiency and bioclimatic measures that were defined in the feasibility study. The TA will implement the training activities according to the needs that were identified at the design phase and carry out the monitoring and evaluation activities. The technical assistance at the construction and operation phases are described in the section 4.3.1.3.

*c) Technical assistance for efficient cooling/heating infrastructure*

*Eligibility:*

Any subproject meeting the above-mentioned ***Project eligibility criteria*** can receive Technical Assistance at the design or operational phase from PEEB Cool.

*Scope:*

The technical assistance for efficient cooling/heating infrastructure will assess the feasibility and the climate impact of subprojects that target primarily efficient cooling or heating solutions. Among the types of subprojects that benefit from technical assistance are the construction or retrofitting of cooling or heating network, access to efficient cooling equipment (including refrigeration), development of solar cooling storage solutions or recovery waste heat infrastructure.

At design phase, the technical assistance activities will include the preparation of the feasibility study, the environmental and social studies, and the climate impact assessment. At the operation phase, the technical assistance will provide, but is not limited to, training activities and support the monitoring and evaluation of the subprojects.

*d) Technical assistance to green construction ecosystem actors:*

*Eligibility:*

Any subproject meeting the above-mentioned ***Project eligibility criteria*** can receive Technical Assistance at the design or operational phase from PEEB Cool.

*Scope:*

The objective of such technical assistance it to better appraise the potential for improving the energy and bioclimatic performance of key actors from the local green construction sector. Instead of looking at measures specific to a building construction or renovation subproject, improvements within important market players processes would benefit to the value chain downstream, having a leverage effect on any future subprojects using the improved products or services of such targeted ecosystem actors. The support will emphasis on the identification of potential area for improvements, whether it is related to better raw material supply, the improvement of internal processes, or making available new products or services in the local market. Expected benefits downstream would either be (a) to reduce grey energy by lowering carbon intensity of the subproject from the material and construction activities, (b) to reduce energy consumption in building through the availability of more efficient or passive equipment, including adapted operation and maintenance services, or (c) to make available products and services to increase the resilience of buildings.

Technical assistance will focus on exploring opportunities and defining practical recommendations that should be encouraged, thus covering:

- Reviewing processes and assessing the impact in the value chain of improving or making available products or services, including research on sectorial best practices and fostering the production of local low-carbon construction materials;

- Formulating recommendations for improvements that would result in positive climate impacts in buildings projects using products and services;

- Proposing methodologies to estimate positive climate impacts downstream.

e) Technical assistance for intermediated subprojects

For intermediated subprojects, the Climate Performance TA will be composed of support to local financial partners (LFPs) and support to subproject owners.

Support to LFPs

The types of TA provided to LFP can be categorised in five sub-components:

- Support for the definition of technical requirements for eligible credit lines' end-beneficiary projects. Based on TA feasibility study and minimum performance targets for the credit lines' end-beneficiary projects, the technical assistance will define along with the LFP the technical requirements to be met by credit lines' end-beneficiary projects to be eligible for the subproject. Those technical requirements can consist of eligible technologies or measures to be undertaken by project owners. The technical requirements will be assessed on a project by project basis.
- Support for marketing and communication activities for the climate finance offer: supporting the LFP in structuring its climate finance offer, defining a related marketing plan, providing communication tools to promote its offers, etc. with the aim to develop the visibility of LFPs' climate offers among the targeted public and stimulate the demand for such offers.
- Gender analysis and support in the implementation of a gender action plan according to the gender analysis and gender action plan of PEEB Cool
- Assistance in the management of environmental and social risk: supporting the LFP in the establishment of a E&S risk management system is needed and reducing the risk of environmental and social non-compliance.
- Training activities in order to help the LFPs in improving their competencies in assessing and financing energy efficiency in buildings investments.

Support to subproject owners

TA will also benefit subproject owners and include support for better designing credit lines' end-beneficiary projects:

- How to respect the technical specifications required by the subproject
- Capacity reinforcement for bioclimatic design in a given climate

4.3.1.1.3. Investment financing eligibility criteria and scope

Any financial operation meeting ***Project eligibility criteria*** can receive financing from AFD Group, provided it ***successfully pass the project appraisal***. Not all subproject that receive financing from AFD Group will also receive the GCF concessional loan instrument. Those subprojects that do receive concessional financing from GCF will be subject to stricter conditions. Both options will be accounted under PEEB Cool in terms of overall program financing, and in terms of impacts indicators.

*a. Eligibility for direct investment financing using GCF concessional loan co-financing*

Three types of subprojects are distinguished with regards to investment financing: 1. Subprojects with an adaptation focus; 2. Renovation subprojects with a mitigation focus; and 3. Construction subprojects with a mitigation focus.

PEEB Cool will mobilise GCF concessional loan co-financing under the following conditions:

- ***Subproject type***: Building(s) construction / renovation only;
- The subproject meets the ***Minimum performance targets***:
    - On Adaptation for both renovation or new construction = The subproject addresses a specific climate vulnerability compared to the baseline for new construction or to the existing situation for renovation. The target will be for building users (male/female) to have experienced an improvement in their indoor thermal conditions of at least 20% compared to the baseline or existing situation (in buildings that are not mechanically cooled, an increase in 20% thermal comfort is a reduction in 20% of the hours of discomfort resulting from improvements brought to the building);
    - On Mitigation for renovation = 40% GHG emissions reduction or 40% energy consumption savings compared to the existing situation before renovation;
    - On Mitigation for new construction = 20% GHG emissions reduction compared to the baseline; and/or 20% energy consumption savings compared to the baseline; and/or 20% water consumption savings compared to the baseline (a minimum of 2 out of 3 criteria).

The GCF contribution terms and conditions will be adjusted for each subproject according to the PEEB Cool approach for GCF concessionality for climate improved buildings (section 4.3.1.3). According to this approach the share of GCF cofinancing is adjusted for each subproject, while the interest rate is fixed for pre-defined subproject categories. The aim is that the GCF cofinancing (a) only covers eligible Climate Costs, and (b) is capped so that the debt service is not reduced below what it would have been for the business-as-usual budget.

*b. Eligibility for intermediated financing using GCF concessional loan co-financing*

GCF concessional loan will be available for credit lines' end-beneficiary projects that meet the eligibility criteria of subprojects financed under direct financing using GCF concessional loan (paragraph a. above):

- Credit line's end-beneficiary project ***type***: Building(s) construction / renovation only;
- The credit line's end-beneficiary project meets the ***Minimum performance targets***:
    - On Adaptation for both renovation or new construction = The credit line's end-beneficiary project addresses a specific climate vulnerability compared to the baseline for new construction or to the existing situation for renovation. The target will be for building users (male/female) to have experienced an improvement in their indoor thermal conditions of at least 20% compared to the baseline or existing situation (in buildings that are not

mechanically cooled, an increase in 20% thermal comfort is a reduction in 20% of the hours of discomfort resulting from improvements brought to the building);
  - On Mitigation for renovation = 40% GHG emissions reduction or 40% energy consumption savings compared to the existing situation before renovation;
  - On Mitigation for new construction = 20% GHG emissions reduction compared to the baseline; and/or 20% energy consumption savings compared to the baseline; and/or 20% water consumption savings compared to the baseline (a minimum of 2 out of 3 criteria).

Technical specifications of credit lines' end-beneficiary projects will be defined for each subproject in order to ensure that the credit lines' end-beneficiary projects meet the above criteria, thus are eligible for GCF concessional co-financing. The GCF contribution terms and conditions will be adjusted for each subproject according to the PEEB Cool approach for GCF concessionality.

*c. Eligibility for investment financing not using GCF concessional loan co-financing*

Subprojects not eligible for GCF concessional loan co-financing will solely be financed by AFD or Proparco (and potential other co-financer(s)). The subproject will still be accounted for as a PEEB Cool subproject, provided it delivers climate impacts as established through the TA activities.

#### 4.3.1.2. Business as usual and baseline

When AFD Group identifies a potential subproject (new construction or renovation of buildings) an initial business as usual subproject budget shall be provided by the project owner and a baseline for climate impacts shall be established, using PEEB Cool upstream Technical Assistance if needed.

**Baseline**

The baseline is the starting point of the resource reductions. It describes the expected building energy performance (which could be expressed in kWh/m2/year) and/or the expected building thermal performance (which could be expressed in percentage of discomfort hours during occupation hours) following typical building practices as well as national/local performance codes if they exist and are being enforced.

In order to assess the baseline for building energy performance the technical assistant will resort to two solutions:

- The technical assistant will model the building using the EDGE tool which gives baseline energy performance data for over 170 countries based solely on data regarding the building type, location, floor area, number of rooms, floors, occupancy and whether the building includes an AC or a heating system. Based on this data, the EDGE tool makes its own assumptions regarding how the floor area is divided among the various uses (bathroom, living room, kitchen, etc.), the building envelope dimensions and composition and equipment as well as the energy efficiency of the equipment. If more detailed assumptions are available, the technical assistant has the possibility to manually modify some of the EDGE assumptions (floor, wall and roof area information as well as types of fuel used, fuel and water costs and emission factors). Detail of EDGE simulation results is provided in the annex of the Feasibility Study for each type of building and each climate.

  In countries with an existing and effectively implemented building energy code the technical assistant will check if the EDGE baseline is consistent with the energy performance requirements of the building energy code. The technical assistant will assume that the baseline for building energy performance is the one set by the building energy code (which could be expressed in kWh/m2/year). PEEB Cool will then encourage to exceed them.

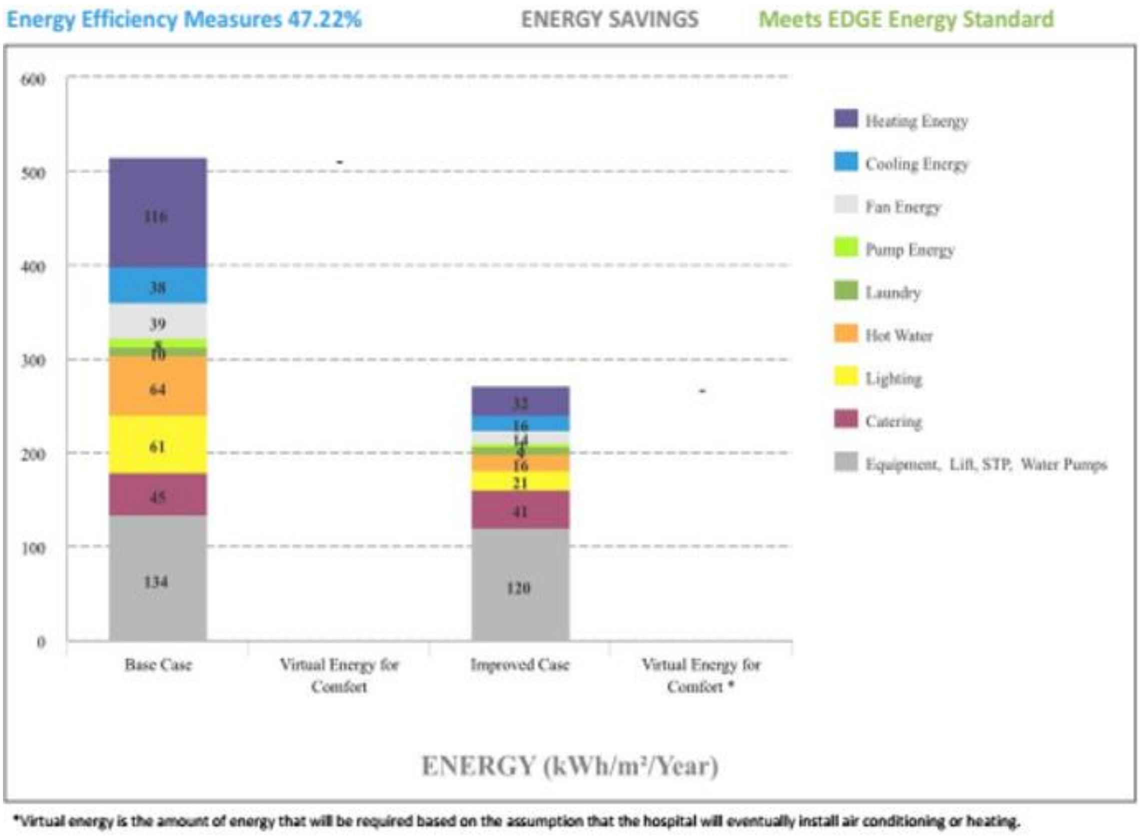



**Figure 6: EDGE results for a hospital project in Tunisia**

- For more detailed analyses, the technical assistant will model the building using a thermal dynamic simulation software and using as input data the plans (at basic or detailed preliminary design level) provided by the subproject owner. Additionally, the technical assistant will input assumptions regarding composition of the building envelope (material properties), type of equipment used, occupancy hours over the course of day, and occupancy schedule throughout the year, etc.) provided and/or verified by the subproject owner. If the subproject is built according to existing standard plans, those plans can be used as well as the assumptions related to existing buildings built according to these standard plans. The energy performance resulting from the dynamic thermal simulation of the building, before any improvements have been recommended, is the baseline.

If the subproject is in a country without an effective building code and if the building is not a standard design then the TA will use their knowledge of standard practice in the country (for instance by visiting several buildings of a similar use in the country) to verify that the design provided by the subproject developer has thermal performance and costs that are typical of the location and type of building.

For a building refurbishment subproject, the baseline of the subproject is the current energy performance of the building before any improvement were made.

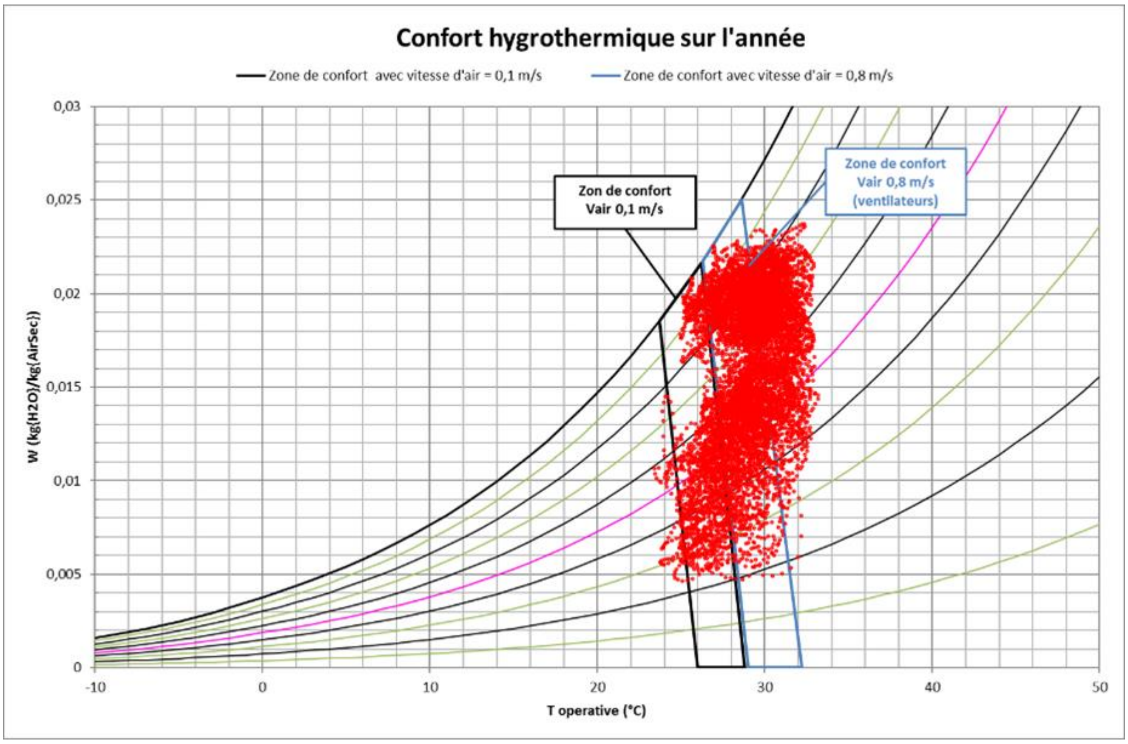



**Figure 7: Baseline results in one the rooms of a health center in a tropical climate**

**Business as usual**

The technical assistance assesses the business as usual (BAU) budget which is the budget of the baseline subproject.

Building construction subproject

To determine the BAU subproject cost as well as the incremental cost (both of which could be expressed in EUR /m2), the technical assistance will follow these steps:

- TA will start his analysis with cost data provided by the subproject and coming from the subproject's preliminary design.
- If the subproject is built according to existing standard plans, TA will also ask for data coming from existing buildings that are based on those plans.
- Finally, the cost data for this subproject is cross checked for consistency with the cost data from the following sources:
    - Past PEEB subprojects built in the same country
    - Other building subprojects in the country
    - Estimates from architects and engineers that are not part of the subproject
    - Estimates from EDGE.

Building refurbishment subproject

For a building refurbishment subproject, the BAU budget is zero.

#### 4.3.1.3. Subproject level TA

| **Output 1.1 Subproject stakeholders are supported in the various phases of their investment** | |
|---|---|
| Contribution to GCF outcome and impacts | *A7.0: Strengthened adaptive and reduced exposure to climate risks*<br>*M3.0 Reduced emissions from buildings, cities, industries and appliances*<br>*A3.0 Increased resilience of intrastructure and the built environment to climate change* |
| Contribution to subproject outputs | This output contributes to the indicator 1.1 (number of subprojects that receive support at identification |
| Envisaged result | The public and private subproject owners are supported throughout the implementation of green building subprojects. They gain experience and benefit and technical knowledge.<br>The output addresses the technical barrier: subproject stakeholders lack technical knowledge and experience to build cool buildings. |

| **Activity 1.1.1 Technical assistance support at identification and design phases** | |
|---|---|
| Description | Technical Assistance at the design phase aims to review identified subprojects and characterize their potential for climate impacts. PEEB Cool provides the expertise to identify the measures that can be taken to achieve adaptation or mitigation targets. The technical assistance will describe the recommended measures and the expected climate impacts of these measures compared to the baseline (reference to methodology to define the baseline) as well as the related financing requirements compared to the business-as-usual initial budget of the subproject.<br>Support provided depends on the type of subprojects:<br>1. Building construction/renovation subproject<br>2. Efficient cooling/heating infrastructure<br>3. Green construction ecosystem actors<br>4. Intermediated subprojects<br><br>Some activities are **common to all subproject types**. They include:<br>- Scoping study, pre-feasibility study<br>- Technical, legal, economic feasibility study of the subproject, including<br>    o Market study<br>    o Review of the regulatory framework<br>    o Carbon footprint assessment<br>    o Review of cooling technology and proposal for efficient cooling systems<br>    o Promotion of low-carbon materials<br>    o Revision and suggested modifications to tender documents for contracting building designers and/or construction firms<br>    o Economic and financial analysis of the subproject<br>- Assessment of the climate impact of the subproject<br>- Environmental and social analysis<br>- Gender analysis and gender action plan<br>- Diagnosis of the need for training activities at implementation phase |

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|---|---|
| | Other TA activities **depend on the type of subproject** that is supported. They include:<br><br>1. <u>Building construction/renovation subproject</u><br>The TA activities that could be carried out by subproject TA include but are not limited to:<br>- Definition of the baseline for climate impact and business as usual subproject<br>- Identification of energy efficiency and bioclimatic measures to be undertaken<br>  o For building construction, this may include reviewing plans and performing thermal dynamic simulations;<br>  o For building renovation, this may include carrying out walk-in-audits and energy audits;<br>- Definition of the improved subproject taking into account energy efficient and bioclimatic measures recommendations<br>- Assessment of the climate co-benefit of the improved subprojects according to the AFD methodology (section 4.3.1.5).<br>- Scoring study in case of building certification<br><br>2. <u>Efficient cooling/heating infrastructure</u><br>- Reviewing the initial design of the subproject<br>- Formulating recommendation to improve the climate impact of the investments<br><br>3. <u>Green construction ecosystem actors</u><br>- Reviewing processes and assessing the impact in the value chain of improving or making available products or services, including research on sectorial best practices and fostering the production of local low-carbon construction materials;<br>- Comprehensive energy audits of both buildings and industrial processes, providing recommendations of measures to improve the energy efficiency of the facility as a whole, including the industrial processes;<br>- Formulating recommendations for improvements that would result in positive climate impacts in buildings subprojects using products and services;<br>- Proposing methodologies to estimate positive climate impacts downstream.<br><br>4. <u>Intermediated subprojects</u><br><br>Support to Local Financial Partners (LFP) include:<br><br>- Support for the definition of technical requirements for eligible credit lines' end-beneficiary projects. Based on TA feasibility study and minimum performance targets for the credit lines' end-beneficiary projects, the technical assistance will assess the business as usual design a baseline for climate impacts.<br>- The technical assistance define along with the LFP the technical requirements to be met by credit lines' end-beneficiary projects to be eligible for the subproject. Those technical requirements can consist of eligible technologies or measures to be undertaken by project owners. The technical requirements will be assessed on a project by project basis.<br>- Assessment of the climate co-benefit of the improved subprojects according to the AFD methodology (section 4.3.1.5).<br>- The technical assistance define a set of criteria to be met by all credit lines' end-beneficiary projects to respect the performance targets set for the project. |

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|---|---|
| | The **recommendations** in the feasibility studies will aim to achieve the following targets for each subproject type. The performance targets are simulated for the next 30 years.<br><br>- Adaptation, either renovation or new construction: The subproject addresses a specific climate vulnerability compared to the baseline for new construction or to the existing situation for renovation. The target will be for building users (male/female) to have experienced an improvement in their indoor thermal conditions of at least 20% compared to the baseline or existing situation (in buildings that are not mechanically cooled, an increase in 20% thermal comfort is a reduction in 20% of the hours of discomfort resulting from improvements brought to the building);<br><br>- Mitigation, renovation subproject: 40% GHG emissions reduction or 40% energy consumption savings compared to the existing situation before renovation;<br><br>- Mitigation, new construction: 20% GHG emissions reduction compared to the baseline; and/or 20% energy consumption savings compared to the baseline; and/or 20% water consumption savings compared to the baseline (a minimum of 2 out of 3 criteria).<br><br>For intermediated financing, technical assistance will review the design of the targeted investments and formulate bioclimatic and energy efficient recommendations. The measures to be implemented to achieve the minimum performance targets for the credit lines' end-beneficiary projects will be integrated to the technical specifications defining the modalities of eligible investments under the subproject. The technical assistance will also assess the revised budget of the investments.<br><br>The output of the technical assistance shall be a revised design and budget for the subproject that include measures leading to the required climate impact. The revised budget of the subproject therefore can translate in an increased upfront budget and higher debt service for the subproject owner. |
| Results | 25 requests for subproject TA are sent by subproject owners<br>25 purchase orders are signed for TA interventions<br>25 TA reports are available |
| Justification | This activity contributes to increase capacity of subproject owners and is key to design energy efficient and resilient buildings. |
| Institutions involved | The activity will be implemented by subproject technical assistants under the supervision of the PMU. |

| **Activity 1.1.2 Technical assistance at construction and operation phase** | |
|---|---|
| Description | All subprojects that receive investment financing using GCF concessional loan co-financing (see Output 1.2) will receive technical assistance to support implementation. The TA will ensure that the adaptation and mitigation measures agreed on between PEEB Cool and the subproject owner are effectively implemented at construction phase. The following technical assistance activities that could be provided include: |

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| | - Project management assistance for the implementation of the recommended measures to improve the performance of the subproject.<br>- Support for performance verification<br>- Support for certification<br>- Evaluation of the subproject at mid-term and at the end of the subproject<br>- Support in the implementation of the gender action plan<br><br>For **intermediated financing** subprojects, the technical assistance activities that could be provided include:<br><br>- Support for marketing and communication activities for the climate finance offer: supporting the LFP in structuring its climate finance offer, defining a related marketing plan, providing communication tools to promote its offers, etc. with the aim to develop the visibility of LFPs' climate offers among the targeted public and stimulate the demand for such offers.<br>- Assistance in the management of environmental and social risk: supporting the LFP in the establishment of a E&S risk management system is needed and reducing the risk of environmental and social non-compliance. |
| Results | ● 10 request from subproject owner for TA monitoring support<br>● 10 TA reports<br>● 10 subproject completion reports |
| Justification | This activity contributes to ensure the proper implementation of the suggested measures following the activity 1.1.2 in the subprojects |
| Institutions involved | The activity will be implemented by subproject technical assistants under the supervision of the PMU. |

| **Activity 1.1.3 Capacity reinforcement to subproject stakeholders** | |
|---|---|
| Description | In addition to the TA to support construction implementation of financed subprojects that is offered under activity 1.1.2, capacity reinforcement for subproject owners, financial intermediary and contractors will also be offered where this can result in significant value added in terms of the capacity for climate change adaptation and mitigation.<br><br>Based on the diagnosis that was established at design phase and on the potential additional needs that have emerged since, from subproject owner or from contractors, the technical assistance will prepare a training program to be implemented with the subproject.<br><br>For instance, construction firms involved in the subproject could benefit from training in the implementation of construction methods that are adapted to the climate context and local materials. This contributes to the upscaling of local actors and the development of a local offer of energy efficiency services.<br><br>In addition and according to the Programme Gender Action Plan, capacity building on gender related topics will be provided in each subproject to identified staff from the subproject owner.<br><br>More comprehensive capacity development activities to favour local upscaling beyond the direct subproject stakeholders for sectors in which financing subprojects |

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| | are identified, financed, or assisted in the construction phase will be provided through Output 2.3 in Component 2.<br><br>For **intermediated financing** subprojects, training activities could be organized to help the LFPs in improving their competencies in assessing and financing energy efficiency in buildings. |
| Results | ● 70 training presentations<br>● 500 attendance record |
| Justification | This activity contributes to ensure the proper implementation of the suggested measures following the activity 1.1.2 in the subprojects |
| Institutions involved | The activity will be implemented by subproject technical assistants under the supervision of the PMU. |

#### 4.3.1.4. Investment

| **Output 1.2 Sectoral investment frameworks demonstrate potential for economic recovery** | |
|---|---|
| Contribution to GCF outcome(s) | *M/A7: Strengthened institutional and regulatory systems for low-emission, climate-responsive planning and development*<br><br>*M3.0 Reduced emissions from buildings, cities, industries and appliances*<br><br>*A3.0 Increased resilience of intrastructure and the built environment to climate change*<br><br>*M7.0: Lower energy intensity of buildings, city and appliances*<br><br>*A7.0: Strengthened adaptive capacity and reduced exposure to climate risks* |
| Contribution to program outputs | This output contributes directly to indicator 1.2. |
| Envisaged result | Within this output, the green building subprojects that have been identified in the output 1.1 are financed.<br><br>The AFD Group will request Concessional Loan from the GCF to co-finance its investments covering new construction or renovation of buildings under PEEB Cool. Eligible subprojects shall achieve minimum climate impacts targets compared to the baseline established for each subproject in its specific country and sector, on adaptation or mitigation. The extra costs of bioclimatic and energy efficiency measures in the improved subproject leads to an additional debt service for the subproject owners. GCF co-financing will only be offered to subproject that comply with stringent criteria that are defined below. PEEB Cool builds on those safeguards to ensure additionality and minimum concessionality of the GCF contribution at all time.<br><br>For the sake of clarity, not all subprojects benefiting from PEEB Cool Technical Assistance support will also receive a GCF concessional loan. Below we describe the selection criteria for subprojects to be offered the loans. |

| Activity 1.2.1 Development of sectoral frameworks or initiatives | |
|---|---|
| Description | When AFD Group identifies a potential subproject (new construction or renovation of buildings) an initial business as usual subproject budget shall be provided by the subproject owner and a baseline for climate impacts shall be established, using PEEB Cool Technical Assistance if needed.<br><br>For intermediated financing, technical assistance identify the business as usual design that will be the investment target of the Local Financial Partner (LFP). It calculates the baseline of this business as usual design.<br><br>To encourage and allow adoption of the bioclimatic and energy efficiency measures, PEEB Cool offers to mobilize GCF concessional loan as co-financing of AFD Group debt investment. Minimum concessionality of the GCF contribution is ensured through the following considerations:<br><br>a. *Determination of GCF level of blended finance based on the calculation of a grant-equivalent concessionality:* The grant equivalent of the GCF contribution is defined as the difference in financial costs (interest and repayments) between GCF financial terms (see proposed terms below) and AFD Group financial terms (or commercial terms available local). The grant-equivalent concessionality provided to each subproject will be capped based on calculation of the debt service for the subproject owner to avoid any unjustified use of this financial incentives. The proposed mechanism aims to reduce the debt service related to the financing of the cool building to un-lock the investment. It shall however never become lower than the initial debt service the owner would have covered for a standard building before improvements to green building standard. This will size the GCF blended contribution for each subproject. In other words, the GCF debt contribution will be calculated so as to strictly off-set the additional debt service which is due to the incremental costs of bioclimatic and energy efficient measures without the support of the investment facility.<br><br>b. *GCF debt contribution will be capped based on AFD Group climate finance principles for energy efficiency in buildings:* AFD Group has developed a detailed, stringent and ambitious methodology to evaluate the share of its financings bearing a climate co-benefit for buildings. It is more ambitious than the MDBs methodology as high level of energy efficiency shall be achieved to be classified as climate finance. It is proposed that the share of GCF debt financing shall never be higher than the share of climate co-benefit of the subproject financings.<br><br>The conditionalities described above will be maintained by adjusting the share of co-financing from the GCF contribution, while offering applicable fixed interest rates, based on whether the country is an LDC and whether the loan is sovereign, a public entity or a private-owned entity (the proposed rates are listed below). |

| | |
|---|---|
| | End-beneficiaries are the clients or prospects of the LFPs (public or private-owned MSMEs, leasing companies, microfinance institutions, …).<br><br>For intermediated financing, the allocation of the funds to final beneficiaries are decided upon two possible ways: ex-post and ex-ante decisions.<br><br>- In ex-ante, the credit line's end-beneficiary projects pipeline is decided during formalization process, as in direct financing. The LFI has to comply with the credit line's end-beneficiary projects pipeline.<br>- In ex-post, the investment process fully belongs to the LFP. The LFP is audited during appraisal process regarding E&S aspects, procurement, gender inclusion, ..., and the eligibility criteria of credit line's end-beneficiary projects is formalized. During implementation, the LFP reports a complete information of projects financed under the credit line to AFD (with impacts, projects owners, etc...). On the base of these reports, the LFP has to submit an allocation request to the EE for every credit line's end-beneficiary projects. The EE either gives a "no-objection" to the allocation of the credit line to the credit line's end-beneficiary projects which financing is required by the LFP to the EE, or refuses to finance the credit line's end-beneficiary projects. In case a potential end-beneficiary project proposed by the LFP is declared non-compliant with the subproject's eligibility criteria, this proposed end-beneficiary project is financed by other funds made available by the LFP. The EE funds are not directly financing the credit line's end-beneficiary projects; the EE funds are financing the LFPs, which are financing the credit line's end-beneficiary projects. The LFP is entirely managing the financing of credit line's end-beneficiary projects.<br><br>Voluntary prepayment is going to be allowed. In case the funds are not invested within a certain amount of time (decided by the LFP), the prepaid amount will be deployed a second time on eligible financings.<br><br>Only the share of the financing bearing climate co-benefit, as defined by AFD Group climate methodology for building (section 4.3.1.5), are eligible for the concessional loan co-financing, and GCF could only cover up to 100% of those climate share as far as the cap on the grant-equivalent concessionality remains valid. The remaining debt will be provided either by AFD for public-led subprojects or by Proparco for private-led subprojects.<br><br>PEEB Cool proposed fixed interest rates on the GCF co-financing are:<br>● Least Developed Countries, sovereign loan = 0%<br>● Least Developed Countries, non-sovereign loan for public-owned entity = 0.25%<br>● Other countries, sovereign loan = 0.25%<br>● Other countries, non-sovereign loan for public-owned entity = 0.5%<br>● Any country, non-sovereign loan for private-owned entity = 1.5%<br><br>For **intermediated financing**, technical assistance will determine the GCF contribution necessary for the subproject owner using the same criteria as above.<br><br>AFD Group and LFPs may agree when relevant on a set of financial criteria applicable to sub-loans:<br>- A minimum maturity and grace period for the loans extended to end-beneficiaries, to ensure alignment with the lifecycle of the targeted investments. |

| | |
|---|---|
| | - A maximum interest rate of the loan to be extended to the final borrower, or any agreed mechanism evidencing adequate improvement of lending conditions to final borrower compared to LFP's and/or local applicable standards.<br>To evidence compliance with such financial criteria, LFPs will provide regular reporting to AFD Group with the list of credit line's end-beneficiary projects financed and respective financial conditions. |
| Results | ● 10 subprojects approved by AFD or Proparco board<br>● 10 financing agreements signed<br>● 10 financing agreements include GCF concessionality |
| Justification | This activity enables the financing of eligible investments. |
| Institutions involved | The activity will be implemented by AFD and Proparco. |

#### 4.3.1.5. AFD Climate methodology and eligibility requirements for specific building projects

The following outlines the benefits methodology and eligibility requirements for new construction subprojects which are mitigation-focused.

| **MITIGATION** | |
|---|---|
| **Eligibility Requirements** | **1) Improvement study based on baseline situation.**<br>• must consider 2050 temperature projections in its performance calculations<br>**2) If study not available, the Project Note to Board must:**<br>• state clear improvement objectives for energy performance<br>• make first work disbursement conditional on the completion of the study and the integration of the measures recommended in the feasibility study.<br>**3) The subproject targets reductions / baseline for at least 2 of the following items:**<br>20% GHG 20% energy 20% water |
| **Eligible Actions** | **The subproject value with deduction of land and special equipment.** |
| **Baseline** | • **Thermal regulations if they exist and are applied** by the majority of constructors.<br>• **Otherwise a recent counterfactual building of the same type or**<br>• **theoretical counterfactual building (EDGE)** |
| **Accounting Scale** | • **Eligibility requirements met: 40%**<br>• **Low-Carbon Materials and/or Certification Very Good/Gold/Silver: + 10%**<br>• **GHG Reductions 40% beyond Baseline: +30%** |

The following outlines the benefits methodology and eligibility requirements for new construction subprojects which are adaptation-focused.

| ADAPTATION | |
|---|---|
| **Eligibility Requirements** | **1) The Project Note to Board must showcase :**<br>• The existence of a climate vulnerability<br>• Explicit subproject objective to address this vulnerability<br>• Subproject investments related to this objective<br>**2) Adaptation study addressing at least one type of climate vulnerability.**<br>• Must integrate 2050 temperature projection if study addresses extreme heat.<br>**3) If study not available, the Project Note to Board must:**<br>• articulate clear objectives addressing climate vulnerabilities<br>• make first work disbursement conditional on the completion of the study and the integration of the measures recommended in the feasibility study. |
| **Eligible Actions** | **The subproject value with deduction of land and special equipment.** |
| **Baseline** | • **Recent counterfactual building of the same type or**<br>• **Building as defined in pre-feasibility study** |
| **Accounting Scale** | **Flat-rate approach: 40% if certification at Very Good / Gold / Silver levels**<br>**Approach by risks addressed:**<br>**+15%** for the improvement of **thermal comfort by 20%** compared to baseline<br>**+15% for water savings of 20%** compared to baseline<br>**+15% per additional risk** taken into account (Sea level rise, Floods or drought or ground movements, Cyclones)<br>**Low-energy buildings: 40% if all relevant risks are addressed** |

Light renovation subprojects

The following outlines the benefits methodology and eligibility requirements for light renovation subprojects which are mitigation focused.

| MITIGATION | |
|---|---|
| **Eligibility Requirements** | **1) Improvement study** based on baseline situation.<br>• must **consider 2050 temperature projections** in its performance calculations<br>**2) If study not available, the Project Note to Board must:**<br>• state clear improvement objectives for energy performance<br>• make the first work disbursement conditional on the completion of the study and the integration of the measures recommended in the feasibility study.<br>**3) Definition of targeted EE objectives in technological choices:** lighting / air conditioning / heating - domestic hot water / refrigerator / washing machine. |

| | |
|---|---|
| **Eligible Actions** | **Works, engineering and TA related to EE improvement.** |
| **Baseline** | **The building before renovation.** |
| **Accounting Scale** | "Factual" approach:<br>**Only expenses related to eligible actions are accounted.** |

The following outlines the benefits methodology and eligibility requirements for light renovation subprojects which are adaptation focused.

| **ADAPTATION** | |
|---|---|
| **Eligibility Requirements** | **1) The Project Note to Board must showcase:**<br>• The existence of a climate vulnerability<br>• Explicit subproject objective to address this vulnerability<br>• Subproject investments related to this objective<br>**2) Adaptation study** addressing at least one type of climate vulnerability.<br>• Must integrate **2050 temperature projection** if study addresses extreme heat.<br>**3) If study not available, the Project Note to Board must:**<br>• articulate clear objectives addressing climate vulnerabilities<br>• make first work disbursement conditional on the completion of the study and the integration of the measures recommended in the feasibility study. |
| **Eligible Actions** | **Works, engineering and TA specific to climate adaptation.** |
| **Baseline** | **The building before renovation.** |
| **Accounting Scale** | "Factual" approach:<br>**Only expenses related to eligible actions are accounted.** |

The following outlines the benefits methodology and eligibility requirements for heavy renovation subprojects which are mitigation focused.

| **MITIGATION** | |
|---|---|
| **Eligibility Requirements** | **1) Improvement study based on baseline situation.**<br>• must **consider 2050 temperature projections** in its performance calculations<br>**2) If study not available, the Project Note to Board must:**<br>• state clear improvement objectives for energy performance<br>• make first work disbursement conditional on the completion of the study and the integration of the measures recommended in the feasibility study. |

| | | |
|---|---|---|
| **Eligible Actions** | **Works, engineering and TA related to EE improvement.** | |
| **Baseline** | **The building before renovation.** | |
| **Accounting Scale** | **If observed EE improvement < 40%:**<br>“Factual” approach:<br>**Only expenses related to eligible actions are accounted.** | **If observed EE improvement > 40%:**<br>“Flat-rate” approach:<br>**70% of total renovation value (similar to New Construction)** |

The following outlines the benefits methodology and eligibility requirements for heavy renovation subprojects which are adaptation focused.

| **ADAPTATION** | | |
|---|---|---|
| **Eligibility Requirements** | **1) The Project Note to Board must showcase :**<br>• The existence of a climate vulnerability<br>• Explicit subproject objective to address this vulnerability<br>• Subproject investments related to this objective<br>**2) Adaptation study** addressing at least one type of climate vulnerability.<br>• Must integrate **2050 temperature projection** if study addresses extreme heat.<br>**3) If study not available, the Project Note to Board must:**<br>• Articulate clear objectives addressing climate vulnerabilities<br>• make first work disbursement conditional on the completion of the study and the integration of the measures recommended in the feasibility study. | |
| **Eligible Actions** | **Works, engineering and TA specific to climate adaptation.** | |
| **Baseline** | **The building before renovation.** | |
| **Accounting Scale** | **If observed EE improvement < 40% :**<br>“Factual” approach:<br>**Only expenses related to eligible actions are accounted.** | **If observed EE improvement > 40% :**<br>**Expenses related to adaptation actions are added to the 70% lump sum related to mitigation.** |

### 4.3.2.Enabling Facility

Component 2 consists of **four output areas** (sectoral investment framework, public policies, capacity building and international dissemination) that are closely interlinked with the Investment Facility and will run for five years. The activities in this component ensure that the investment subprojects find a frame that enables the implementation of these subprojects. The sector actors are enabled to create the framework conditions necessary to deliver the services and products and thus de-risk the investments in the subprojects for private and public stakeholders, as well as individual households. They also contribute to extending the impact of PEEB Cool beyond the program's duration because further projects will be added to an ever-growing green buildings investment pipeline.

While many possibilities for de-risking exist, "de-risking" in the sense used in the enabling facility refers to the reduction of risk of stranded assets and even default of the borrower side through better company performance through Paris-alignment of activities and investments (this means that their assets keep their value even in the wake of increasing climate risks). The enabling facility will support this through the development of sectoral frameworks and industry commitments (e.g. developers are supported to base their portfolio and services on certain Paris-aligned standards and labels).

Developers (generally, all investors, including households) that invest today in buildings/apartments with high energy consumption are in danger of investing in potentially stranded assets. Such buildings are prone to climate related risks in two ways: so called "physical risks" because they tend to overheat (and in cold areas to cool down drastically) and are vulnerable to the raise of energy prices or energy cuts. Such buildings/apartments are also carrying "transitional risks". That means, due to the low standard they are built, they are in danger of quickly losing value in times of changes in regulations where higher standards are and will be demanded. PEEB Cool anticipates such developments and, by promoting energy efficient and resilient buildings, contributes to maintaining and improving the value of these built assets, thus de-risking investments in buildings.

**Beneficiaries of the activities in component 2 include:**

- Sectoral actors such as national federations, alliances or other public-private interest groups that will be supported in developing sectoral frameworks or other initiatives such as market assessments, labels or a decarbonisation pathway
- Public sector representatives who receive support in designing and implementing regulations, standards, and programs.
- Local experts and consultants on green buildings, who will see a rise in demand for their services
- Actors at all levels (buildings and construction sector professional, policymakers, including low carbon material suppliers) who receive trainings and strategic support to develop further business activities on green buildings
- Sectoral stakeholders as well as the wider public, who will benefit from developed knowledge products
- Interested stakeholders in other countries, who will have access to the knowledge products developed
- Households benefiting from improved buildings and building quality through better national regulations and implementation capacity of the sector.

An **example of interlinkage between the enabling and investment facility** is presented as follows. For example, if the investment facility targets residential buildings through direct or intermediate financing,

- The sectoral investment framework activity will support construction industry actors (e.g. building developers, construction material/equipment providers) to develop voluntary industry standards for their products or services integrating climate mitigation and adaptation impact measures and thus increase further (climate) investment potential of these actors (see description of activity 2.1.1.);
- The policy proposals activity will assist with enforcing, updating or developing the necessary national public policies and regulations that will create a market environment favourable for climate mitigation and adaptation actions in the primary sector of intervention (see description of activity 2.2.1);

- The capacity building activities will train developer or real estate organizations regarding financial evaluation of efficient and resilient buildings including measures (see description of activity 2.3.2.).

#### 4.3.2.1. Sectoral investment frameworks (Output 2.1)

| **Output 2.1 Sectoral investment frameworks demonstrate potential for economic recovery** | |
|---|---|
| Contribution to GCF outcome(s) | *M/A7: Strengthened institutional and regulatory systems for low-emission, climate-responsive planning and development*<br>*M3.0 Reduced emissions from buildings, cities, industries and appliances*<br>*A3.0 Increased resilience of intrastructure and the built environment to climate change* |
| Contribution to program outputs | This output contributes directly to indicator 2.1 and is highly relevant for output 1.2.<br>Sectoral frameworks or initiatives notably also ensure that project stakeholders and market participants are able to provide the necessary products and services for the financing projects (Output 1.2.) while developing future business opportunities. |
| Envisaged result | Within this output area, public and private investment towards energy efficiency and resilience in buildings is strengthened through support in the development of sectoral and private sector led roadmaps, investment plans, and initiatives in sectors targeted by the Investment Facility. These support future-oriented economic recovery in the PEEB Cool partner countries by laying out investment opportunities and associated job creation potential.<br>The output area contributes to removing the<br>- Financial barriers of high perceived risk, lack of market information, and limited experiences with efficient and resilient building design, finance and implementation;<br>- Reluctance of industry actors to adapt their services for the construction and operation of energy efficient, low carbon and resilient buildings, specifically in times of economic crisis.<br>To illustrate this result with an example from the current PEEB, in Mexico, PEEB supported private hotel developers to technically improve their projects and thus elaborated hotel-sector specific energy efficiency guidelines, which contributed to the improvement of the national norm for hotels. These activities resulted in a significant financing pipeline for energy efficient new hotel constructions with increased thermal comfort. |

| **Activity 2.1.1 Development of sectoral frameworks or initiatives** | |
|---|---|
| Description | Within this activity, the development of sectoral investment frameworks or initiatives with industry commitments will be supported.<br>The sectoral frameworks and initiatives in the form of roadmaps, with milestones and commitments facilitate identification of significant investment pipelines, help construction industry stakeholders (e.g. developers, material and equipment providers) to decarbonize their products and services, increase information about |

| | |
|---|---|
| | business risks of "conventional" buildings or building sector products or services (thus help to avoid stranded assets), point out necessary innovations in industry processes to anticipate expected market demand and ensure future competitiveness, demonstrate viability of business models and related investments, contribute to job creation, and increase commitment for climate action. This will also bring concrete actions into national mitigation and adaptation planning in the countries' NDCs.<br><br>The sectoral frameworks or initiatives that will be supported depend on the type of financing project supported. Preliminary activities in this output area for each country are already identified in the respective country form, but only the most promising sectoral investment frameworks will be supported. An overview over the preliminarily identified activities is given below. |

| Country | Tentative activities 2.1 (Sectoral frameworks) |
|---|---|
| Albania | • Investment roadmap to decarbonize the hospital sectors including relevant technology & services (commitments with industry partners to be defined) |
| Argentina | • Investment roadmap to decarbonize the construction industry (commitments with industry partners to be defined) |
| Costa Rica | • Investment roadmaps for building segments which are targeted under the Investment Facility (commitments with industry partners to be defined) |
| Djibouti | • Investment roadmap for public sector actors and enterprises |
| Indonesia | • National green building strategies for green housing and educational buildings<br>• Investment roadmap for sectors targeted by the investment facility (commitments with industry partners to be defined) |
| Mexico | • Investment roadmaps for building segments targeted by the investment facility |
| Morocco | • Action plan for strengthening industry labels (commitments with industry partners to be defined) |
| Nigeria | • Investment roadmap for the construction industry (commitments with industry partners to be defined<br>• Investment roadmap for student housing projects (commitments with industry partners to be defined |
| North Macedonia | • Investment roadmap for public buildings |
| Sri Lanka | • Investment roadmap for mitigation targets and adaptation measures in the building sector (in particular regarding insulation, commitments with industry partners to be defined) |
| Tunisia | • Investment roadmap for social housing or district cooling sectors (commitments with industry partners to be defined) |

**Sub-Activities:**

- Decision on sector(s) to be targeted according to investment subprojects in a respective country: Starting with the pipeline and feasibility study stage of the financing subprojects, the sectoral stakeholders and socio-economic context will be mapped and analysed in order to identify the potential for additional

| | |
|---|---|
| | investment, job creation, and decarbonization possibilities in this sector in the near to mid-term future and to understand how these could be furthered by coordinated sectoral action and industry commitments. General appetite and conditions for investments in the sector will also be gauged. At the end of this sub-activity stands the confirmation of collaboration with the industry sector partner federation, association, alliances etc.<br><br>- Support in investment roadmap or industry initiative development: Based on the potential identified, the proposals for appropriate actions will be elaborated jointly with the federations, alliances, or other groups that represent a significant share of the respective industry through studies, interviews, and further consultations. For example, if the building material sector is identified for support, this sub-activity will help the industry actors to develop joint (voluntary) industry standards such as the disclosure of climate footprint of their products. If an owner of a large building stock is supported, this sub-activity would analyse the mitigation and adaptation as well as financial optimization potential in the existing and future buildings stock and develop an investment pipeline, with a more detailed business case preparation of the most promising and ambitious green projects for further financing. The outcomes of the support in the development of the initiative or framework will be presented in a national workshop co-organized with the national partner organizations. Relevant national and international financiers will equally be invited to this workshop, with the aim of early stage setting up of contacts that could lead to financing of projects. Private sector companies building a business around the potential identified will equally be invited. |
| Baseline | A few PEEB Cool countries are already elaborating elements of investment roadmaps (i.e. for renovation of public buildings in Mexico), but the majority do not have any clear sectoral vision that is laid out in a format that could encourage further business and investment. |
| Results | 10 sectoral frameworks or initiatives are developed. The format of the deliverables is chosen to cater to the potentially different sectoral needs and opportunities. They will take the form of:<br>● Investment roadmap for sectoral decarbonisation, including sectoral future market assessment or green investment plans for large built asset owners and labour market effects, or<br>● Voluntary sectoral initiative (e.g. industry standard, product or service label, green building certification) based on internationally recognized methods and private sector commitments such as the Science Based Target initiative |
| Justification | This activity contributes to materialising investments in the subprojects financially supported by PEEB Cool but also in future decarbonisation projects. It is therefore absolutely necessary for market transformation. |
| Institutions involved | The activity will be implemented by GIZ in close coordination with AFD/Proparco and the stakeholders of the sectors. The decision on the type of sectoral framework or initiative to support will be taken following national stakeholder consultation meetings – in concertation with national governments and industry alliances, based on the priority sectors to be targeted within PEEB Cool by both the Investment and Enabling Facilities. |

#### 4.3.2.2. Policy proposals (Output 2.2)

| **Output 2.2 Policy proposals prepare the ground for building sector transformation** | |
|---|---|
| Contribution to GCF outcome(s) | M/A7: Strengthened institutional and regulatory systems for low-emission, climate-responsive planning and development<br><br>M3.0 Reduced emissions from buildings, cities, industries and appliances<br><br>A3.0 Increased resilience of intrastructure and the built environment to climate change |
| Contribution to project outputs | This output directly contributes to indicator 2.2.<br><br>This output further supports partner countries with advice on public policies in sectors in which the Investment Facility intervenes with financing projects to anchor the project in an enabling framework and to deliver climate impact beyond the project duration (output 2.1) |
| Envisaged result | The experiences from the financing of construction projects will feed into the development of policy proposals and their integration into the national contexts, providing valuable "on the ground" experiences for better public policies, national incentive mechanisms, and improved public procurement criteria. The improved policy framework will expand existing and create new markets for services or products and stimulate investment.<br><br>The output contributes to removing regulatory barriers such as lack of clear policies for building decarbonation and incomplete or non-existing building codes as well as lack of knowledge on green buildings.<br><br>To illustrate this result with an example from the current PEEB, AFD and GIZ are collaborating with the government of Morocco and with the financial support of the NAMA Facility to launch an ambitious national incentive program to improve energy performance in households through competitive allocation of incentives to public and private real estate developers as well as appliance retailers. Beyond the first 7,000 housing units that are directly targeted, this will create a ripple effect through the entire sector, while the program itself is set to transition into a fully nationally managed structure and incentive program. |
| Budget/co-finance | 12.3 million EUR funding, of which 2 million EUR co-financing from the German government. |

| **Activity 2.2.1 Support for development of policies on energy efficiency in buildings** | |
|---|---|
| Description | Public policies will be developed (or updated), especially in sectors in which subprojects are financed by the Investment Facility in order to deliver long-term climate impact.<br><br>PEEB Cool local teams, benefiting from access to global resources of the PEEB Cool program management unit, will accompany and consult national partner authorities in these processes and in necessary steps preparing adoption of regulations in national legislative procedures. Thanks to the "programmatic" approach and the transfer of knowledge and experiences across countries in supporting different policy types, a very efficient use of resources is ensured. |

Policy proposals may concern one or several of the following list of areas:

- National action plans for energy efficiency in buildings
- National green building standards and building codes (i.e. general or sectoral energy regulation for new constructions or retrofitting);
- Minimum energy performance standards (i.e. for cooling and refrigeration appliances);
- Certification requirements (e.g. for architects, auditors, or engineers),
- Labels (e.g. building energy performance certificates/passports);
- Public procurement standards;
- Fiscal policies (e.g. tax reductions);
- Non-monetary incentives (e.g. preferential building permit processing);
- National incentive programs (e.g. national incentive mechanisms for energy efficient buildings, promotional programs for materials and technologies).
- Enforcement of policies (e.g. revisions of the current legislative texts or increased collaboration with sub-national authorities)
- Integration of adaptation aspects into building sector policies (e.g. revised national territory and urban planning policies to include adapted flood zoning plans, avoidance of urban heat islands, early weather warning systems in vulnerable zones, etc.)

In individual cases, support with data collection or estimation may also be offered within this activity, as this is a necessary preparatory activity for the preparation of effective policies – especially in the PEEB Cool countries with limited statistical data on building stock, types, energy consumption profiles, and projected future evolution.

An overview over preliminarily identified policy proposals is given below. These give an indication of the potential policy areas to be supported but will undergo further selection at program start.

| **Country** | **Tentative activities 2.2 (Policies)** |
|---|---|
| Albania | • Regulation for energy performance in buildings in the health sector |
| Argentina | • Energy certification of residential buildings |
| Costa Rica | • Improvement and enforcement of energy efficiency building codes and regulations<br>• Development of energy performance systems<br>• Policy development for low carbon construction |
| Djibouti | • Implementation of building codes<br>• Standards for efficient cooling appliances |
| Indonesia | • Improvement and enforcement of regulation for residential buildings<br>• Energy performance systems for specific building types<br>• Energy efficient and low carbon policies for large energy consuming buildings |
| Mexico | • Energy Performance Systems for building segments targeted by the investment facility<br>• Improvement and enforcement of energy efficiency policy in buildings<br>• Policy development for low carbon construction |

| | |
|---|---|
| Morocco | • Minimum Energy Performance Standards and energy efficiency labels<br>• Regulation and control for self-assisted construction |
| Nigeria | • Building code improvement<br>• Certification of residential and commercial buildings<br>• Market framework development for local building materials |
| North Macedonia | • Renovation policy strategy for all buildings<br>• Renovation plan for building used by public sector entities<br>• Feasibility of renewable energy cooperation business model for collective building residents |
| Sri Lanka | • Revision of the Code of Practice for Energy Efficient Buildings<br>• National Regulations and energy performance label system<br>• Update and adaptation of Green Building Certification requirements to the private sector<br>• Roadmap for the implementation of green building certification and registry scheme for the private sector |
| Tunisia | • Update of the energy building code for priority sub sectors such as social housing<br>• Introduction of energy certification of buildings<br>• Labeling for air conditioners<br>• Building label for heritage buildings |

**Sub-activities:**

- Agreement on support areas: National meetings among all project stakeholders will confirm the previously identified policy gaps in each of the countries and sectors and prioritise intervention as well as assess concrete steps. This may be done through a checklist based on the WB RISE scores, and own experiences.

- Provision of support: The PEEB Cool enabling facility team will set up a pool of consultants and mobilize expertise from the pool as requested and needed for the implementation of the identified support areas. This will complement their own expertise. For two "policy" types, necessary background steps that will be included in the PEEB Cool support are explained below.

  - Support with enforcement of a building code: analysis of the most important obstacles (including through market stakeholder survey), review of existing legislative texts and potential unclarities, proposal for legislative enforcement mechanisms, development of internal guidelines for line authorities such as municipalities delivering the permits, etc.

  - Preparation of national investment incentive programs: this requires estimating the current demand and supply for efficient and resilient buildings, analysing types of potential incentives, the cost-optimal incentive level that would lead to a higher uptake of a set of pre-identified measures (which also have to be validated in the context of this activity), as well as the type of beneficiary (i.e. end customer, intermediary, etc.), incentive pay-out or tax recovery options, administration of the national program, approval by the relevant fiscal government authorities etc.

| | |
|---|---|
| Baseline | While some of PEEB Cool countries have a mandatory or voluntary building code already in place in at least parts of the sector, in others, relevant regulation remains in preparatory stages or the regulatory context is otherwise incomplete. See context section of this feasibility study as well as country forms for more details. |
| Results | As a result of this activity, 24 policy proposals relating to efficient and resilient buildings will have been prepared and be at the hands of the national partner governments for implementation and enforcement. This will particularly contribute to improving already existing building codes, and/or support the enacting of new ones. |
| Justification | Putting the buildings sector on a low emission and resilient development pathway absolutely requires strong local anchoring of policies enabling this transition. However, existing regulations and capacities in PEEB Cool partner countries are not enough to change the current status quo in the buildings sector. Governments will further benefit from structured and tested international experiences in the design of policies fitting the respective local context, offered by the programmatic approach of PEEB Cool. |
| Institutions involved | This activity is led by GIZ in cooperation with AFD/Proparco, and national counterparts. |

4.3.2.3. Trainings (Output 2.3)

| **Output 2.3 Private and public sector actors are enabled to work towards building sector transformation** | |
|---|---|
| Contribution to GCF outcome(s) | M/A7: Strengthened institutional and regulatory systems for low-emission, climate-responsive planning and development<br>M3.0 Reduced emissions from buildings, cities, industries and appliances<br>A3.0 Increased resilience of intrastructure and the built environment to climate change |
| Contribution to project outputs | This output directly contributes to indicator 2.3. (number of persons trained), indicator 2.1 (sectoral investment frameworks), indicator 2.2 (policy proposals). It also strengthens indicators 1.1 (TA at project level) and 1.2 (investments) on a sectoral/national level. It is therefore an essential crosscutting output with important inputs in all project outputs. |
| Envisaged result | The capacity development by PEEB Cool helps partner governments and sector stakeholders in achieving long-term climate impacts beyond the direct effects of financing project interventions. It also makes sure that investment roadmaps (output 2.1.) or policies supported (output 2.2) are implementable by both civil servants and building sector professionals; and that capacities required for the implementation of investments (output 1.2) supported by PEEB Cool are available at the sectoral/national level.<br>The output contributes to removing the following barriers:<br>- Regulatory and institutional barriers, such as weak enforcement capacities in governments and insufficient buildings codes, as well as a lack of awareness of the benefits of energy efficient and resilient buildings; |

- Financial barriers of reluctance of the private sector to adapt their services to support the construction of cool buildings, and of building owners to cover higher cost of cool buildings;
- Technical barriers such as low availability of innovative skills in the local construction industry or lack of knowledge about passive design principles.

Capacity building measures will also be directed to civil society organizations, in the form of participation in public hearings / consultations for policies. In general, this output builds capacities for communication efforts around regulation to CSOs. Local authorities are targeted notably with trainings related to their authority of enforcement of national buildings regulation (i.e. through issuance and controlling of building permits). Representation of all genders will be assured in the setting up of the consultations, together with partner institutions

**Activity 2.3.1 Development of training and awareness raising modules**

Description

The PEEB Cool trainings, specifically targeted at the intersection of finance, architecture, engineering and politics, are truly unique. They are not intended to replace national and international long-term further learning opportunities but provide an entry point for sector actors through short and concise programs.

The key principles for the development of the trainings are:

1. All PEEB Cool trainings are implementation-oriented and serve specific identified needs for local market development, that ensure long-term climate impacts beyond the Investment Facility's reach
2. All PEEB Cool trainings are accompanying measures to other outputs within Components 1 and 2, which are essential for delivering long-term climate impact.

Each training module will be linked to other PEEB Cool outputs, tailored to the target group, and be conceived as interactive and practice oriented.

An overview over the preliminarily identified training needs is given below:

| Country | Tentative activities 2.3 (Trainings) |
|---|---|
| Albania | • Extension of existing trainings (i.e. for hotel buildings) to health establishments. |
| Argentina | • Financing for energy efficiency in buildings for the sector actors benefiting from public policy support or financing projects.<br>• Extension to national scale of existing energy efficiency certification of residential housing units trainings<br>• Bioclimatic building design |
| Costa Rica | • Low-carbon building and the air conditioning<br>• Design and construction of energy efficient, climate-adapted and low-carbon cool buildings.<br>• Eligibility criteria and verification procedures for the financing of low-carbon building based on energy performance system |
| Djibouti | • Financing, technical solutions, building codes, users' best practices, as well as joint efficiency and cooling efforts.<br>• Efficient building and appliance operation (air-conditioning, lighting, etc.) |

| | |
|---|---|
| Indonesia | • Eligibility criteria and verification procedures for financing of low-carbon residential and other buildings, facilitating a large-scale deployment of a potential housing financing mechanism.<br>• Design and construction of energy efficient, climate-adapted and low-carbon cool buildings, to ensure homogenous quality of constructed housing units.<br>• Energy efficient design, construction and operation of buildings for private sector actors |
| Mexico | • Design and construction of energy efficient, climate-adapted and low-carbon cool buildings, in sectors targeted by the Investment facility<br>• Eligibility criteria and verification procedures for the financing of low-carbon building based on energy performance systems, for sectors targeted by the Investment facility |
| Morocco | • Management of energy efficiency construction projects.<br>• Self-assisted construction |
| Nigeria | • Urban zoning and master plan development, bioclimatic building design to policy options and financing for energy efficiency in buildings linked to existing or future financing projects<br>• Energy efficiency building design, building energy code compliance, energy audits and building energy simulations, specifically for the housing sector |
| North Macedonia | • Low-carbon construction financing and eligibility criteria, evaluation and verification criteria and procedures covering the part for energy efficiency in buildings, industry and transport. |
| Sri Lanka | • Implementation of energy efficiency and green buildings standards<br>• Building and cooling technologies, with a special emphasis on maintenance requirements and procedures.<br>• Enforcement of standards and regulations on technical and managerial levels in key municipal and/or ministerial divisions, closely linked to component 1 and 2 activities. |
| Tunisia | • Application and enforcement of the thermal regulation nationwide<br>• Implementation of new regulation for large AC units or systems, for cooling system design and energy auditing for cooling installations, as well as technical know-how for district cooling systems.<br>• Building certificate introduction |

**Sub-activities**

- Continuous coordination with investment projects and updating of relevant sectoral/national training offer: Taking into account the diversity of participating countries and sectors in PEEB Cool, the existing training needs analysis will be continuously updated and clustered in order to provide a useful and relevant training offer to the participating countries, linked to the sectors of intervention of the Investment Facility.

- Development of 10 new training modules. Based on the continuous monitoring of the training needs, tailored trainings will be developed with internal and external expertise. The trainings will be developed with international best-practises and benchmarks, but will leave designated room for additional content to be adapted to country specific circumstances. Where useful, international standards such as DGNB, HQE, LEED will be taken into consideration for use or adaptation into the national context. Examples from specific PEEB Cool investment subprojects that lead by example and apply i.e. HQE standards will be included, thus create practical learning opportunities for the sector.

An indicative list of (working) titles of trainings expected to be developed, the specific target groups, and the objectives is given in the below table.

| **(Working) title of training (examples)** | **Target group** | **Objectives (supporting output areas 1.2, 2.1. and 2.2.)** |
|---|---|---|
| New regulations or certificate requirements for green business procedures or protocols | Stakeholders in the buildings and construction value chain | Participants are able to comply with national and/or international certifications or building standards |
| Financing of energy efficiency and resilience in buildings | Banks, financial intermediaries | Participants understand, evaluate and price in energy efficiency in their projects. They are able to accompany the sectoral investment pipelines identified with appropriate financing solutions. |
| Enforcement of public policies (legal) | Public sector officials (e.g. municipal agents in cities, representatives of national authorities …)<br>Third-party verification bureaus | Participants understand incentive and/or sanctioning mechanisms for good practices / violations. They are able to implement necessary steps to enforce existing and new regulations. |
| Market development for energy efficient and resilient buildings | Representatives from private sector stakeholders in the buildings and construction value chain | Participants understand the opportunities changing market demand brings for their own business activities and are able to orient their services and goods to a more climate-friendly mode of delivery and quantify necessary investments. They are able to |

<table>
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<tr><td></td><td></td><td>deliver the investments identified in the sectoral investment framework activities.</td></tr>
</table>
The following table describes the already developed trainings by PEEB.
<table>
<tr><th>Existing training modules</th><th>Target group</th><th>Objectives (supporting output areas 1.2, 2.1. and 2.2.)</th></tr>
<tr><td>Financing of energy efficiency and resilience in buildings</td><td>Policy makers, senior government officials</td><td>Participants are aware of the role and potential of energy efficiency in buildings. They understand the way public policy support can be useful to create economic activity and are able to advocate for appropriate policies.</td></tr>
<tr><td>Financing of energy efficiency and resilience in buildings</td><td>Building sector professionals (architects, developers, real estate owners…)</td><td>Participants understand how to build the business case for energy efficient and resilient building projects. They have acquired the necessary skills to present attractive projects for financing.</td></tr>
</table>
<ul>
<li><u>Transfer of some training modules to national authorities/institutions:</u> Since all training modules will be developed in an “open-source” mode, the training content will be, where possible, handed-over to interested and relevant national authorities to continue offering trainings beyond PEEB Cool. They could also be used as starting points for more elaborate training programs or developed further by technical and vocational training activities that are ongoing in the respective country and sector.</li>
</ul>
</td>
</tr>
<tr>
<td>Baseline</td>
<td>Within the current PEEB, 2 trainings were already developed regarding the financing of energy efficiency in new construction: one training oriented towards policy makers, and one oriented towards practitioners (see table in section above for details).</td>
</tr>
<tr>
<td>Results</td>
<td>As a result of this activity, a further 10 trainings for flexible use across PEEB Cool partner countries will be developed, including different language versions. Trainings are integrated into national training institutes where possible, to ensure sustainability of the trainings.</td>
</tr>
<tr>
<td>Justification</td>
<td>The development of further trainings is justified because of the novelty of the topics and the unique cross-cutting nature of the subject, which means that traditional (national and international) training programs do not grasp the complexity of the issue and/or are simply not available. Furthermore, given the diversity of the target audience (developers, architects, engineers, policy makers, bankers, etc.), the trainings need to be tailored to speak the relevant sector language.</td>
</tr>
<tr>
<td>Institutions involved</td>
<td>This activity will be implemented by GIZ, in cooperation with AFD/Proparco as well as PEEB Cool partner countries. In addition to these trainings at sectoral or national level,</td>
</tr>
</table>

| | |
|---|---|
| | ad-hoc capacity building at the subproject level (i.e. on environmental and social safeguards compliance, or technical subproject monitoring strengthening), will be provided through technical assistance of AFD/Proparco. The harmonization and usage of the training content across both components is ensured by a close collaboration at headquarter and country level. |

| **Activity 2.3.1 Implementation of training and awareness raising measures:** | |
|---|---|
| Description | The implementation of the developed trainings follows the logic defined by each country intervention and the most pressing market needs. In most PEEB Cool countries, training will only start once sectors of intervention are identified and policy support is defined. Some early stage countries may require more initial support on the relevance of the topic from different angles (i.e. public finance, energy supply and security, social justice, technology availability, calculation methods, etc.). In these countries, these introductory training and awareness raising sessions, in particular for public sector representatives, will open up further program activities.<br><br>**Sub-activities:**<br><br>- Setting up of a training schedule: A training schedule will be agreed upon with the partner organisations for implementation in accordance with the investment projects, investment roadmaps, and public policies to be supported.<br><br>- Local adaptation: While the overall modules will be developed from an international best practice standard point of view, a number of content elements will have to be adapted by the national/regional/international consultants that will implement the trainings, with the support of the local PEEB Cool teams.<br><br>- Implementation of trainings: The trainings will be implemented locally in a face-to-face setting where possible. Online formats may complement but not replace certain trainings if the circumstances are favourable. Due to past experiences on the effectiveness and learning outcomes of participants, trainings are scheduled to have relatively small training groups of 15-20 persons per training. This allows for very tailored learning but requires a careful selection of participants. This selection of participants will be done in collaboration with the partner governments and managed by the PEEB Cool team locally. Evaluation sheets, that in particular look at relevance of the training for market development of energy efficient and resilient buildings, will be administered and evaluated. |
| Baseline | In the current PEEB countries, roughly 600 policy makers and building sector professionals in five countries have participated in trainings relating to financing of energy efficient buildings, building code enforcement, or awareness raising for national regulations. |

| | |
|---|---|
| | In a few PEEB Cool countries, national education authorities offer secondary or tertiary technical training for energy efficiency in buildings. However, no specific trainings on financing energy efficient and resilient buildings from design stage exist. |
| Results | As a result of this activity, 1350 additional persons will have completed a training at sectoral/national level and filled out the evaluation questionnaire demonstrating the perceived relevance of the training for market development of energy efficient and resilient buildings. |
| Justification | Currently existing capacities in public and private sector actors in PEEB Cool countries are not sufficient to sustainably put the buildings sector on a low emission pathway, be it through structuring and financing of investment projects or public policies design and enforcement. The number of trainings / persons trained is thus the absolute minimum needed to provoke a mindset change and strengthened capacities. |
| Institutions involved | This activity will be implemented by GIZ. In addition to the trainings at sectoral or national level, trainings will be implemented directly at the project level, through technical assistance administered by AFD/Proparco. Additionally, it is foreseen to transfer training content to interested and capable national institutions for integrating into national training curricula. |

#### 4.3.2.4. Dissemination (Output 2.4)

| **Output 2.4 Program experiences support the global building sector transformation** | |
|---|---|
| Contribution to GCF outcome(s) | *M/A7.0: Strengthened institutional and regulatory systems for low-emission, climate-responsive planning and development*<br>*M3.0 Reduced emissions from buildings, cities, industries and appliances*<br>*A3.0 Increased resilience of intrastructure and the built environment to climate change* |
| Contribution to project outputs | This output contributes to the indicator 2.4 (number of events/methods disseminated and uptake by sector actors). |
| Envisaged result | This output will build upon the program's experience and make information available regionally and internationally to speed up building sector transformation. This output covers knowledge transfer and dissemination at the level of the entire program (components 1 and 2).<br>Another envisaged result is an increase in the availability of information regarding the identification and financing of energy efficient and resilient buildings investment projects, as well as information about financial models and de-risking and upscaling tools.<br>An additional welcome result is the raising of further constituencies' interest for buildings sector climate action – as has been the case due to the communication around the current PEEB. |

| **Activity 2.4.1 Development of knowledge products** | |
|---|---|
| Description | PEEB Cool activities in both the investment and enabling facilities will generate a wealth of experiences that will be channelled in different knowledge products and thus made accessible to a wider audience. |

| | |
|---|---|
| | The type and quality of products developed in the current PEEB has been widely appreciated by the international sectors; in particular, the feedback from on-the ground implementation has garnered interest far beyond the initial PEEB countries. The aim of this activity is thus to build upon the successful series of publications to further build up the international knowledge base on climate mitigation and adaptation in the buildings sector.<br><br>In the context of PEEB Cool, it is envisaged to put a focus on experiences that successful de-risk investment in energy efficient and resilient buildings, and to present the variety of financial instruments available to national governments and development finance institutions at the example of concretely implemented investment projects and their structuring (as much as publicly possible).<br><br>Where applicable, these knowledge products may also be developed jointly with other international building sector actors to further enlarge the experiences base.<br><br>**Sub-activities:**<br><br>- Continuous monitoring of project results and experiences worth transforming into knowledge products: regular meetings at HQ at PMU level will serve to consolidate local PEEB Cool experiences and to establish a knowledge product pipeline.<br><br>- Development of knowledge products: The knowledge products will be developed based on the different program activities. These build the foundation for making project experiences available within and beyond PEEB Cool. |
| Baseline | Within the current PEEB, 8 knowledge products have been developed based on PEEB implementation results and made available at a global level through PEEB communication activities and feeding-in into GlobalABC activities.<br><br>The existing knowledge products are:<br><br>● A publication concerning business models for new green buildings;<br>● A guide for digital solutions for energy efficiency in buildings;<br>● A publication showing passive building measures to reduce cooling demand in buildings;<br>● A guide for energy efficiency in hotels, based on PEEB Mexico experience;<br>● An overview over energy efficient national building program from different countries;<br>● A video demonstrating an innovative business model as well as a profitability calculation tool for planning and energy efficient building;<br>● A publication regarding experience and recommendations for establishments of national alliances for buildings and climate, based on the experience of PEEB donor countries France and Germany as well as PEEB implementing countries Morocco, Mexico, and Tunisia;<br>● A technical brochure for energy efficiency in the buildings sector, based on PEEB Morocco experience. |
| Results | 20 additional knowledge products are developed, where a knowledge product could be a best practice paper on different PEEB Cool experiences, a sectoral publication, or similar. |

| | |
|---|---|
| | It is expected to develop knowledge products from all PEEB Cool countries, as well as transversal products. These products are expected to be used within PEEB Cool for transfer of knowledge and for external communication of the PMU. |
| Justification | The efforts of pioneering PEEB Cool countries need to be shown and recognized at the global level, in particular to provide examples on buildings sector climate mitigation and adaptation action from developing and emerging countries.<br><br>These experiences serve to transfer much needed implementation knowledge among PEEB Cool partner countries and beyond. |
| Institutions involved | This activity will be led by GIZ but relies heavily on input from AFD/Proparco from all program activities. |

| **Activity 2.4.2 Dissemination of experience** | |
|---|---|
| Description | PEEB Cool will feed its implementation experience into the joint effort to decarbonise the buildings and construction sector at the national and international level by making its knowledge products accessible to project implementers and investors, and a wider audience via regional and/or global platforms (e.g. GlobalABC, UNFCCC events, COPs, websites, social media).<br><br>This activity also notably includes presenting the PEEB Cool program at international online and offline sector conferences or seminars, i.e. to provide good examples of how to concretely implement mitigation and adaptation commitments in the buildings sector; and to raise further financing on national and international financial markets. This could be for example through the Work Area Finance of the GlobalABC, of which the current PEEB is the co-chair, and the construction sector members of the GlobalABC. Experience dissemination will also be included in peer exchange formats of financial institutions, such as the International Development Finance Club; and be made available to further potential additional financiers.<br><br>Experiences may also feed into the efforts spearheaded by the International Platform for Sustainable Finance (IPSF), initiated by the European Commission, to move the financial sector towards alignment with the Paris Agreement and SDGs. This may contribute to facilitating application of elements of the EU taxonomy (classification of sustainable economic activities) application beyond EU borders, or its adaptation, as far as it concerns the buildings sector.<br><br>**Sub-activities:**<br><br>- Monitoring of dissemination occasions: This will be a continuous activity in order to identify the most impactful events and formats in which PEEB Cool experiences and knowledge products could be presented.<br><br>- Preparation and presentation of inputs in diverse formats: The PEEB Cool PMU or local staff will regularly participate in relevant formats and disseminate relevant experiences throughout the entire duration of PEEB Cool. |
| Baseline | So far, in the current PEEB, experiences have been disseminated in an average of 10 events annually (sectoral, regional and global climate conferences, webinars, etc.) |

| | |
|---|---|
| Results | PEEB Cool investment and enabling facility experiences are disseminated globally at least at an additional 20 occasions, picked for their relevance. |
| Justification | PEEB Cool as a unique program with a huge potential for replication and a wealth of concrete and very sought-after investment experience should use its weight and influence to move more countries and financial market participants towards climate mitigation and adaptation in the buildings sector. |
| Institutions involved | This activity will be led by GIZ with input from AFD/Proparco. |

#### 4.3.3. Program duration

The overall program duration is estimated to be 10 years. The enabling facility will provide support for the first five years. Within the investment facility, this duration extends to the construction and commissioning of the buildings. It is expected that the finance facility will be fully disbursed within 10 years. The estimated mitigation potential will be achieved over a 15-year building lifespan.

### 4.4. Recommendations for the program

The recommendations are largely based on PEEB's experience over the last 4 years.

**Lack of political buy in**

All countries have included energy efficiency in buildings in their national strategies.

Of the current PEEB countries all of them have an active building energy code.

Out of the additional countries targeted by the PEEB Cool program, the feasibility study confirmed that the institutional environment was favorable for implementing the program. 3 countries already have an existing building energy code or Green building code, namely Sri Lanka, Nigeria and Indonesia. Djibouti's building energy code is currently under preparation. Argentina and Djibouti have already joined the Global Alliance for Buildings and Construction and Nigeria has already expressed interest in receiving policy level support from PEEB.

Recommendations:

- Raising awareness and promoting peer review processes at the highest political level as is currently done within the PEEB through the GlobalABC.
- Raising awareness by showcasing good examples of successful projects and focusing on the long-term benefits of investments (economic, financial, social, etc.).
- Just as it is currently done through the PEEB program, put in place a local PEEB coordinator in each of the PEEB Cool countries, who will be the program's focal point for working with the ministries' that have the mandate for energy efficiency in buildings.

**Project and financing opportunities are few and far between**

Financing of large-scale building projects have been identified in all 11 countries targeted by the PEEB Cool program. Although, it is too soon to have detailed data on the economic impact of the COVID crisis, it is reasonable to assume that it has further burdened the sovereign debt of PEEB Cool countries, making it harder for these countries to borrow.

Recommendations:

- The concessionality offered by GCF will contribute to softening the borrowing conditions for these countries.
- Any grant or concessional resources should be prioritized for low and lower-middle income economies.

| **Countries** | Existing building energy code | GlobalABC member | Project financing opportunities identified |
|---|---|---|---|
| Tunisia | **Yes** (current PEEB support for enforcement) | **Yes** | **Yes** |
| Morocco | **Yes** (current PEEB support for enforcement and application) | **Yes** | **Yes** |
| Mexico | **Yes** | **Yes** | **Yes** |
| Djibouti | Under preparation | **Yes** | **Yes** |
| Nigeria | **Yes** (but limited in scope) | **No** | **Yes** |
| Indonesia | **Yes** (but limited in scope) | **No** | **Yes** |
| Sri Lanka | **Yes** (but limited in scope) | **No** | **No** |
| Argentina | **No** | **Yes** | **Yes** |
| Costa Rica | **No** | **No** | **Yes** |
| Albania | **Yes** | **No** | **Yes** |
| North Macedonia | **Yes** | **No** | **Yes** |

**Lack of coordination among partners**

The basis for coordination among partners has already been established under PEEB and has been successful to date. A secretariat, staffed by the GIZ and AFD, has been successfully functioning for the past three years. The Secretariat ensures communication is fluid among PEEB implementing entities and manages the program's activities. At least one local PEEB coordinator is present in each of the first five PEEB partner countries. This coordinator ensures communication between the country agencies of the implementing entities (GIZ and AFD) and with local partners (ministries and project promoters).

Recommendations:

- The same coordination structure should be kept for PEEB Cool.

**Subprojects are not well designed and the impact of subprojects is not optimized**

Recommendations:

- Only eligible subprojects shall be financed by PEEB Cool, meaning that they demonstrate at the design phase that they are targeting a minimum energy or comfort improvement of 20% as compared with the baseline scenario. PEEB Cool studies will be undertaken to demonstrate this or propose measures for achieving the targeted energy and environmental performance.

- As is currently the case with PEEB:
    - A request for PEEB Cool's support should always be asked to encourage ownership.
    - An assessment of the subprojects' technical assistance needs shall be undertaken during the design phase.
    - If needed additional technical assistance during the entire design phase as well as the construction phase is provided by PEEB Cool to ensure that the measures initially recommended are actually implemented.
    - Measures recommended with be adapted to the different building types and climate zones as well as the investment budget. Low tech solutions will be prioritized.

# 5. Technical assessment of the mitigation impact

This section analyses the intended impact of the PEEB Cool program both in terms of climate mitigation and adaptation potential as well as the payback period of the main investments. A brief outline of the public policy framework in each of the 13 countries in also presented in annex.

**Key findings regarding the program's mitigation impact**

The key findings of the mitigation impact assessment are summarized in the table below:

**Table 15: Key outputs of the mitigation impact assessment**

| Indicators | Based on the subproject pipeline studied (1,083 MEUR of building infrastructure investment) | Extrapolated to the PEEB Cool program amount (1287 MEUR) |
|---|---|---|
| Total surface area built (m2) | 3,645,757 | 4,270,239 |
| Total avoided direct GHG emissions for a 30% energy saving package (tCO2eq over 15 years) | 1,334,220 | 1,562,759 |

Based on a planned disbursement of 60% of investment by the end of year 6 of the subproject, and 100% disbursement by the end of year 14, the following projections can be made for the impact of of the programme at mid-term and end-of project.

| | **Mid-Term** | **End of project** |
|---|---|---|
| Target for disbursement | 52% | 100% |
| Total budget (MEUR or MUSDeq) | €691.37 | €1,338.50 |
| GCF contribution (MEUR or MUSDeq) | €113.64 | €220.00 |
| GCF grant (MEUR or MUSDeq) | €22.73 | €44.00 |
| **Mitigation** | | |
| GCF allocation for mitigation | 35% | 35% |
| Direct emissions reductions (tCO2eq - lifetime) | 807,208 | 1,562,759 |
| Total project cost per tCO2eq reduced (lifetime) | | €299.77 |
| GCF contribution per tCO2eq reduced (lifetime) | | €49.27 |
| GCF grant per tCO2eq reduced (lifetime) | | €9.85 |
| **Buildings with interventions** | | |

| | | |
|---|---|---|
| Residential | 17,543 | 33,964 |
| Hospital | 7 | 14 |
| Education | 4 | 8 |
| Small scale office | 7 | 14 |
| Retail | 42 | 82 |
| Total | **17,604** | **34,081** |

The mitigation impact assessment was undertaken on the basis of a subproject pipeline provided by AFD Group and amounting to 1,099 MEUR of building infrastructure cost. We then extrapolated to reach 1,287 MEUR, which is the PEEB Cool amount relating to the project investment activities.

The avoided GHG emissions estimated cover emission reduction derived from both the construction phase particularly through the use of low carbon materials as well as from the energy savings during the operational phase of the buildings (the use of the buildings). The construction phase ranges significantly from 2% to up to 46% of the 15-year lifetime emissions amongst the buildings examined. This large range is due to significant differences in energy consumption and emissions factors for fuel consumption (e.g. grid emissions factors ranging widely amongst countries). Regardless, the analysis shows that low carbon materials can play a significant part, and represent short-term GHG emission reductions; whereas operational phase emission reductions are spread over a period of 15 years (a conservatively low number).

**Key methodological features of the analysis**

Given the fact that the PEEB Cool is a multi-country program, its impact in terms of both mitigation and adaptation was analyzed following a portfolio approach. The analysis is based on an existing portfolio of large-scale building construction/renovation subprojects currently financed or to be financed by the AFD Group. Even though some of the subprojects in this subproject portfolio are not intended at this stage to be included in the PEEB Cool program, the subproject portfolio is intended to reflect the variety of building types and climates that are likely to be found within the PEEB Cool program.

The building types included in the analysis include housing, healthcare centers, hospitals, schools, small office buildings, hotels and retail. Each of the 11 countries was assigned one of seven main climate zones (equatorial, tropical, humid subtropical, arid, Mediterranean, mountain climate and semi-continental). GHG emission reductions were estimated for the construction (low carbon materials and material re-use) and operational phases (energy use reduction due to passive design strategies, energy efficiency of equipment and low carbon cooling systems as well as rooftop solar energy among other types of measures).

A 15-year building lifespan was initially chosen to be consistent with GCF recommendations for accounting (section 4.3.1.5) the mitigation co-benefits of the subprojects it finances. A 15-year lifespan is also consistent with the average lifespan of the technical equipment typically found in buildings such as HVAC equipment – though it is shorter than the normal cycles of refurbishment / renovation of buildings. However, given that buildings are generally built to last much longer, some say an average 60 years for modern buildings and 120 years for conventional buildings, a longer lifespan could potentially be justified later during monitoring and reporting in order to the full potential of energy savings and GHG emissions reduction over the entire lifespan of the buildings.

The analyses were carried out following three main steps:

1) Estimation of energy consumption using climate parameters from the last 30 years for each climate type with energy consumption calculated using the EDGE tool[25]. The energy consumption was calculated also into the future using in the baseline case (without measures), then with measures to achieve 20% savings and with measures to achieve 40% savings.

[25] Climate parameters for energy consumption calculations for mitigation were taken from https://climateinformation.org/ which provides historic meteorological data over the course of a 30-year period.

2. Using a portfolio approach to assume that on average, the interventions involved would achieve 30% savings, the energy consumption in the baseline case and in the energy savings cases (20% and 30%) was multiplied by appropriate emissions factors for fuel – in most cases either natural gas or electricity or a mix of the two. Specific grid emissions factors for each country were used.

3. The annual energy savings / GHG reductions in the 30% case (average of 20% and 40% cases) were multiplied by 15 years to reflect the lifetime of investments.

4. The GHG emissions for the materials used were also calculated under the "baseline" and "improved" cases.

5. The total emissions reduced was calculated as the sum of GHG reductions over the lifetime of investments for operation (see step 3) and the reductions from improved materials usage.

6) Estimation of m² built and associated investment amounts were based on data provided by the AFD regarding its current buildings project portfolio and following various exchanges with local AFD agencies to try to finetune the data. This work has allowed a more accurate estimation of project surface areas and costs.

Related to investments, based on project cost estimations, we estimated the investment amounts for energy efficiency improvements and use of low carbon materials.

Given that the subproject portfolio provided by AFD represents a proportion of the total investment amount of the PEEB Cool program, a linear extrapolation was then applied to determine the total investment amount, surface area and volume of avoided GHG emissions of the PEEB Cool program.

This report also details the calculation of the number of direct and indirect beneficiaries as well as the calculation of the gross payback period of the investments.

It should be noted that for housing, the concept of suppressed demand is applied when calculating avoided greenhouse gas emissions. This means that we consider current comfort levels in some housing types, such as social housing, to be at a level which is currently inadequate for proper human development. This may be for a variety of reasons such as lack of infrastructure or low level of income. Therefore, the baseline scenario includes a minimum level of energy consumption relating to the demand for cooling. This minimal amount of cooling is what is needed to reach an acceptable indoor comfort level. The calculations of avoided emissions in this feasibility study account for this.

It should also be noted that, as there is insufficient data to assess the impact of activities pertaining to the cross - cutting transformative issues outlined in chapter *2.3 Key transformative issues relating to EEB* such as district cooling systems, subprojects focusing solely on equipment (cooling systems, fridges, solar water heaters or other appliances) or industrial subprojects, the estimation of the mitigation and adaptation impact undertaken in this feasibility study relates only to the buildings subprojects.

Lastly, it should be noted that potential GHG emissions reductions due to decreased leakage of coolants with high global warming potentials (GWP) were not estimated in the analysis – though there may be scope for including such investments within PEEB Cool to address this issue (see Section 4.3.1).

## 5.1. Methodology for calculating avoided emissions in the 11 PEEB Cool countries

### 5.1.1. Carbon footprint related to the operational phase of buildings

The building types used for calculating the avoided emissions are based on concrete cases of buildings already studied and supported as part of the PEEB program or other previous AFD programs. The EDGE software was then used to model the impact. We applied a sampling logic in terms of climate zoning in order to calculate typical improvements by building type and climate zone.

#### 5.1.1.1. Grouping countries according to their main climate zone

The PEEB Cool climate zones are (*source: Wikipedia*):

- Equatorial climate
- Tropical climate
- Desert or arid climate
- Humid subtropical climate (or "Chinese climate")
- Mediterranean climate
- Continental climate

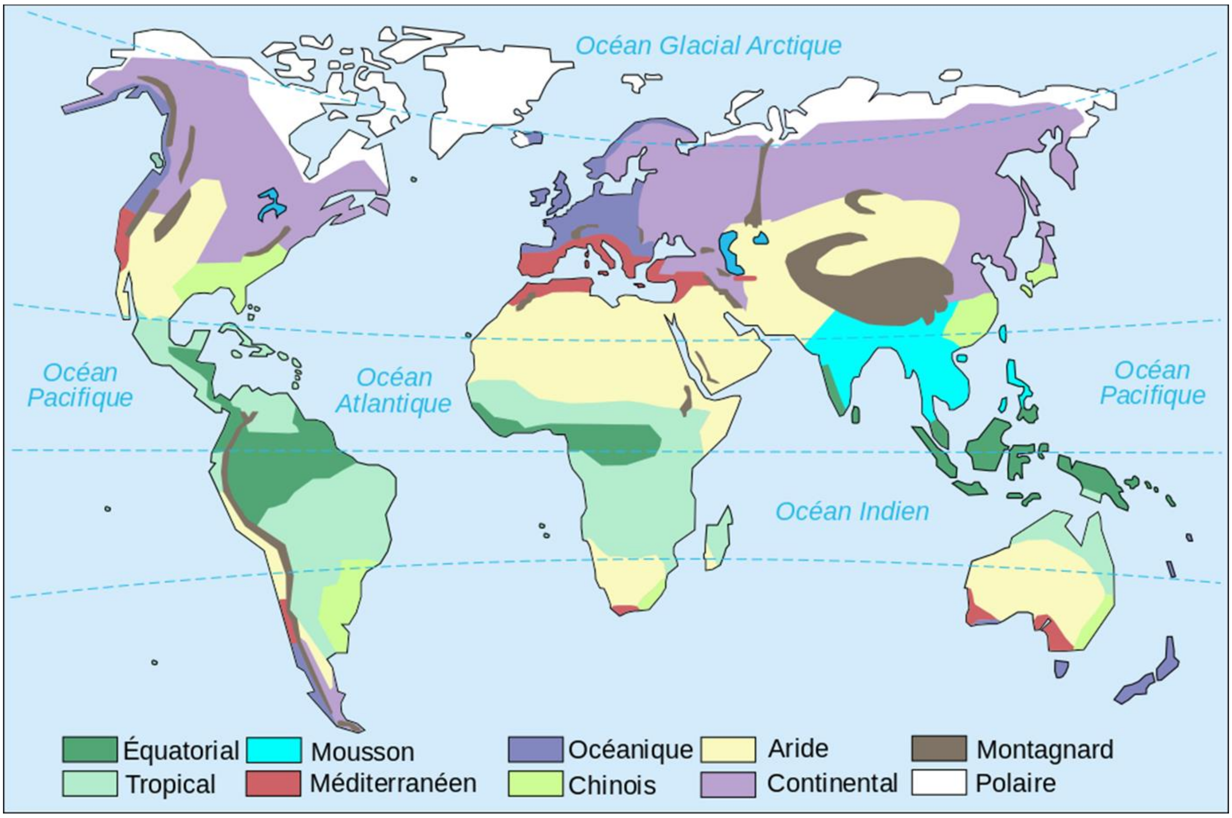



Figure 8: Main climate zones (Wikipedia, 2020)

The list of countries involved in the PEEB Cool program is as follows:

Table 16: PEEB Cool countries according to their main climate zones

**Africa:**

| *Countries* | *Main climate zones* |
|---|---|
| Djibouti | Desert |
| Morocco | Mediterranean |
| Tunisia | Mediterranean |
| Nigeria | Tropical |

**Latin America:**

| *Countries* | *Main climate zones* |
|---|---|

| | |
|---|---|
| Argentina | Subtropical humid |
| Mexico | Tropical in half of the country, arid in the other half |
| Costa Rica | Tropical |

**Asia:**

| *Countries* | *Main climate zones* |
|---|---|
| Indonesia | Equatorial |
| Sri Lanka | Equatorial |

**Europe:**

| *Countries* | *Main climate zones* |
|---|---|
| Albania | Mediterranean |
| North Macedonia | Semi-continental |

The selected climatic zoning is the following (each climate zone is matched with a reference weather station):

**Table 17: Representative weather station for each climate zone**

| **Climate zone** | **Weather station** |
|---|---|
| Equatorial climate | Abidjan (Côte d'Ivoire) |
| Tropical climate | Ziguinchor (Senegal) |
| Desert climate | Djibouti (Republic of Djibouti) |
| Subtropical humid climate | Buenos-Aires (Argentina) |
| Mediterranean climate | Tunis (Tunisia) |
| Semi continental climate | Skopje (North Macedonia) |

Since there is obviously a certain level of uncertainty at this stage regarding the PEEB Cool subproject portfolio (as most subprojects are under identification), the climate zone assumptions are limited to one zone per country. However, it should be noted that during the implementation of the PEEB Cool program, just as is currently done in the PEEB program, each subproject will be studied according to its climatic specificities, a country generally comprising several climate zones.

#### 5.1.1.2. Building types studied

The building types studied for all the countries of the PEEB Cool program are the following:

- Small multi-family residential
- Health centers
- Hospitals
- Schools

- Small office buildings
- Retail

Finally, based on the subproject portfolio, we have added the small office buildings type for Djibouti.

#### 5.1.1.3. Baseline definition and energy savings calculation

The project baseline for each of the building types in each of the climate zone were modeled using the EDGE software. When more sophisticated energy simulations from previous PEEB supported subprojects were available for a given building type, the EDGE model assumptions were updated accordingly.

Once again, using the EDGE software, we then calculated for each building type and climate zone the energy savings and associated emissions avoided distinguishing between two different levels:

- The « -20% » package
- The « -40% » package

It should be noted that the « -20% » and « -40% » levels of energy savings were simulated using a set of real measures (which are described below) for each building type and in each climate zones. Therefore, depending on the building type and the climate zone, the actual savings simulated through the use of the different combinations of measures put forward, do not exactly achieve « -20% » and « -40% » but approximate those values.

We then applied the same results for all countries belonging to the same climate zone.

For each type of building, we chose an existing project to serve as a reference case for the building type using realistic parameters. The majority of these reference cases were drawn from projects currently supported under the PEEB program. A minority of projects were drawn from projects unrelated to the PEEB program but with similar characteristics.

The table below summarizes for each building type the different energy saving strategies that were applied for the « -20% » and « -40% » energy saving packages:

**Table 18: Definition of energy and environmental improvement packages for each building type**

| | **Small multi-family residential** | **Health centers** |
|---|---|---|
| **Baseline** | Insulated flat roof with 6 cm EPS<br>Air conditioning (EER = 2) | Non-insulated ventilated roof with 1.5 m eaves overhang<br>WWR equal to 15%.<br>SG Aluminum joinery and float glass<br>Split with EER of 1.7 |
| **20% package** | Insulated flat roof with 8 cm EPS<br>WWR = 20%.<br>DG low E with PVC joinery<br>More efficient air conditioning (EER 2.8)<br>High efficiency heating<br>High-performance household appliances | Roof with 1.5m eaves overhang<br>High reflectivity roof paint<br>Roof slab insulation 4 cm EPS<br>WWR equal to 15%.<br>SG Aluminum joinery float glass<br>Louvers<br>Split with EER of 2.5 |
| **40% package** | 20% package measures + solar thermal collectors for DHW (1.9 m2/household) | 20% package measures + PV collectors for 25% of the electrical demand (66 kWp) |

| | Hospitals | 2 storey schools |
|---|---|---|
| **Baseline** | Roof insulation (U=0.3) and wall insulation (U=0.4) DG low E (U=3.3) + air-cooled CU (COP = 3.3) | WWR=30% |
| **20% package** | Baseline measures + double flow exchanger 60% + solar thermal collectors for 50% of the DHW demand (510 m2) | Baseline measures + High reflectivity paint + air blowers in classes |
| **40% package** | 20% package measures + reinforced roof and wall insulation + Uw = 1.95+ air conditioning with water-cooled condensers (EER = 6.1) + PV covering 10% of the electrical demand (730 kWp) | 20% package measures + roof insulation (U=0.44) + PV for 10% of the electrical demand (2.5 kWp) |

| | Small office buildings | Hotel | Retail |
|---|---|---|---|
| **Baseline** | Light color roof, light color walls, WWR=0.28, splits with average EER of 1.5 | WWR = 20%, Roof insulation (U=0.5), DG (U=3.2), EER=2.7, gas boiler for DHW | WWR = 50%, Roof insulation, wall insulation, SG, EER=6.1 |
| **20% package** | High reflectivity roof paint (0.7), light colored walls, WWR=0.28, external shading devices, roof insulation (U=0.44), splits with average EER 2.5 | EER=6.0, heat recovery on condensing loop for DHW, dual-flow exchanger, variable speed circulators, presence detection for lighting in circulation systems | Baseline measures +low consumption lighting, dual-flow exchanger, variable speed circulator |
| **40% package** | 20% package measures + PV solar collectors covering 20% electricity consumption (91 kWp) | 20% package measures + outdoor solar protections + lower solar factor (0.4) + solar thermal collectors covering 50% DHW (360m²) + PV to covering 10% of electrical needs (870kWp) | 20% package measures + reflective roof cladding + Clear walls + low emissivity double glazing (U = 3.2, SHGC = 0.4) + PV covering 20% of the electrical needs (1240 kWp) |

<u>Acronyms used in the tables above:</u>

EPS: Expanded polystyrene

WWR: Window to Wall Ratio

EER: Energy Efficiency Ratio (amount of cooling produced for a given electricity consumption)

COP: Coefficient of performance (amount of heating produced for a given electricity consumption)

SG: Single Glazing

DG: Double Glazing

DHW: Domestic Hot Water

Low E: low emissivity glazing

CU: Cooling Unit

PV: Photovoltaics

These energy saving strategies give a fairly accurate picture of the types of measures that will be recommended as part of the PEEB Cool program. However, given that each subproject will be specifically studied on a case-by-case basis, these measures will vary according to the technical specificities of each subproject.

The detailed results for the health center building type in an equatorial climate are illustrated below:

**Table 19: Example of energy consumption results using the EDGE software for a health center in an equatorial climate**

| | *Baseline* | *20% EE scenario* | *40% EE scenario* |
|---|---|---|---|
| **Energy consumption (kWh/m².an)** | | | |
| Final energy consumption (total) | **162** | **139** | **104** |
| Cooling (mechanical + fans + pumps) | 56 | 24 | 18 |
| Laundry | 13 | 13 | 10 |
| DHW | 20 | 17 | 12 |
| Lighting | 17 | 17 | 13 |
| Other equipment | 68 | 68 | 51 |

The detailed results for each of the other buildings types in each climate zone can be found in the annexes.

The following table gives an overview of the energy consumption results for each scenario according to each building type and each climate zone:

**Table 20: Overview of energy consumption results, in kWh/m2fa**

| Building type | Scenario | Equatorial (Abidjan) | Tropical (Ziguinchor) | Desert (Djibouti) | Subtropical (Buenos Aires) | Mediter. (Tunis) | Semi-continental (Skopje) |
|---|---|---|---|---|---|---|---|
| **Small multi-family residential** | Baseline | 106 | 111 | 106 | 134 | 129 | 156 |
| | 20%EE | 79 | 81 | 76 | 102 | 98 | 117 |
| | 40%EE | 67 | 68 | 68 | 78 | 77 | 87 |
| **Health centers** | Baseline | 162 | 169 | 171 | 162 | 164 | 178 |
| | 20%EE | 139 | 140 | 141 | 145 | 146 | 168 |
| | 40%EE | 104 | 106 | 107 | 110 | 110 | 126 |
| **Hospitals** | Baseline | 356 | 416 | 404 | 394 | 393 | 525 |
| | 20%EE | 304 | 342 | 330 | 292 | 293 | 334 |
| | 40%EE | 248 | 276 | 268 | 255 | 253 | 290 |
| **Schools** | Baseline | 34 | 37 | 44 | 32 | 35 | 28 |
| | 20%EE | 24 | 24 | 28 | 26 | 27 | 25 |
| | 40%EE | 21 | 22 | 24 | 19 | 20 | 23 |
| **Offices** | Baseline | 169 | 200 | 197 | 125 | | 118 |
| | 20%EE | 111 | 125 | 125 | 91 | | 95 |
| | 40%EE | 88 | 99 | 100 | 73 | | 75 |
| **Hotels** | Baseline | 253 | | | 249 | | 266 |
| | 20%EE | 212 | | | 219 | | 232 |
| | 40%EE | 179 | | | 176 | | 182 |
| **Retail** | Baseline | 217 | | | 241 | | 228 |
| | 20%EE | 168 | | | 181 | | 186 |
| | 40%EE | 129 | | | 137 | | 139 |

The energy savings achieved were then obtained by simply subtracting the total energy consumption of each package from the total energy consumption of the baseline scenario.

The graphs below show for each of the two packages, the energy savings averaged over all building types and climate zones:

**Package -40%: Energy savings by climate zone averaged over all building types**

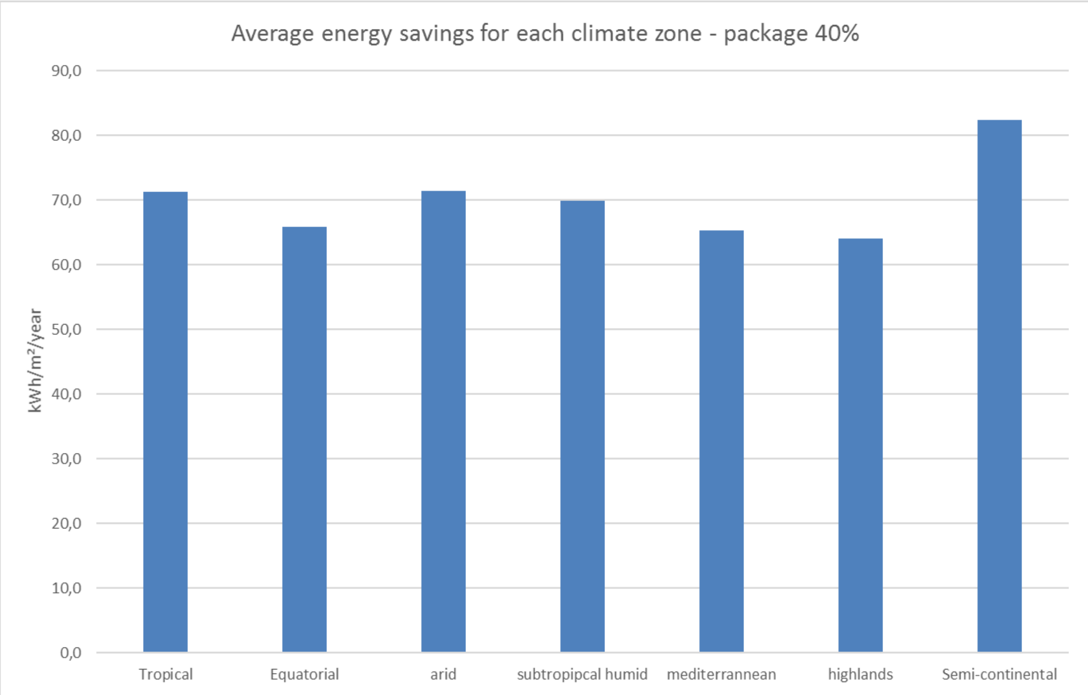



Figure 9: average energy saving by climate zone - package -40%

We notice that energy savings are highest in the semi-continental climate. The difference in energy savings between climate zones is however limited.

**Package -40%: Energy savings by building type averaged over all climate zones**

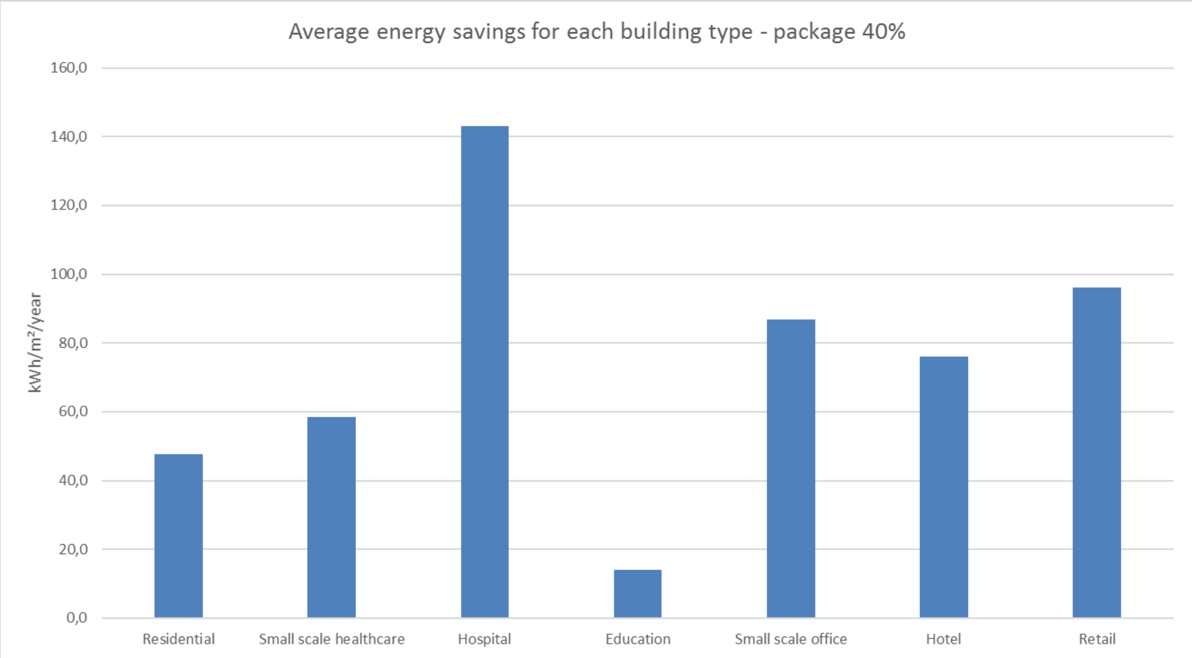



Figure 10: average energy saving by building type - package -40%

**<u>Package -20%: Energy savings by climate zone averaged over all building types</u>**

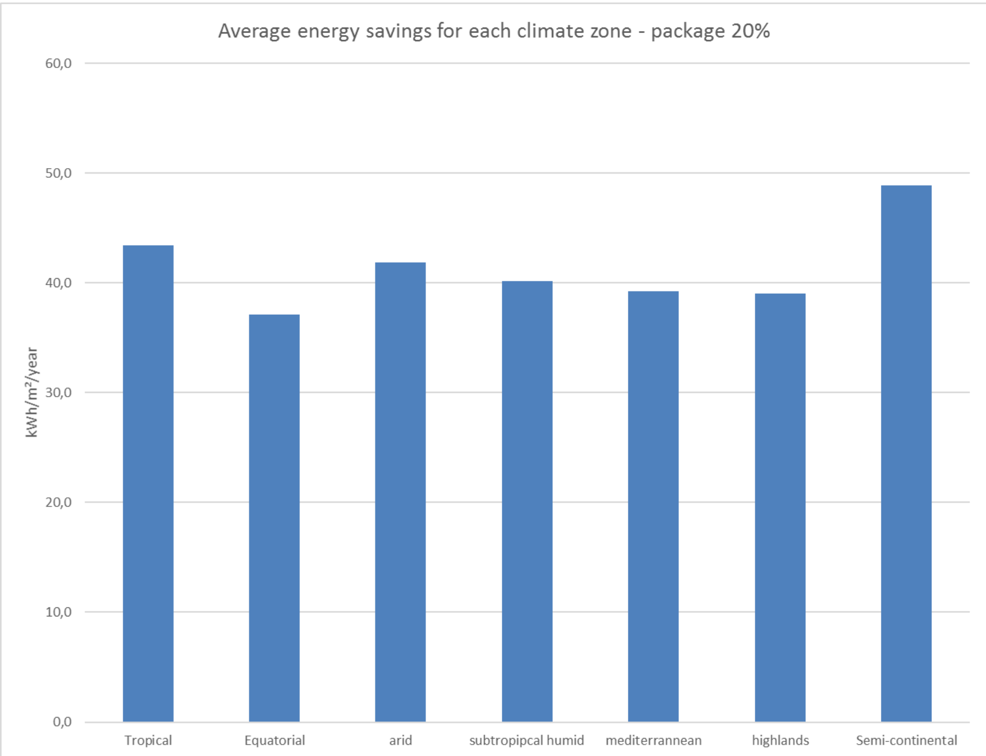



Figure 11: average energy savings by climate zone - package -20%

The same observations made for the 40% package are true for the 20% package.

**<u>Package -20%: Energy savings by building type averaged over all climate zones</u>**


**Figure 12: Average energy saving by building type - package -20%**

For this package, we find similar differences in energy savings as for the 40% package, with schools saving on average 10kWh/m²/year and hospitals 90kWh/m²/year.

#### 5.1.1.4. CO2 coefficients for electricity and gas

We assumed natural gas and/or liquefied petroleum gas (LPG) for heating/DHW uses and electricity for other uses. Generally speaking, the need for DHW is low in hot climates because the water from the network is distributed at a temperature close to the average annual temperature. In climates with little heating needs in winter (Mediterranean climate, humid subtropical climate), a boiler fuelled by fossil fuels (gas when the network exists or fuel oil) usually provides both heating and domestic hot water production. Of course, this is not always the case, but the error margin related to using the emission factor of gas rather than the emission factor for heating and DHW (which is not quite the same) is not significant.

The emission factors of electrify of each country are based on the IFIs dataset for harmonized grid emission factors. A single emission factor of gas is used for all countries.

The graph below shows the emissions factors chosen for the 11 countries:

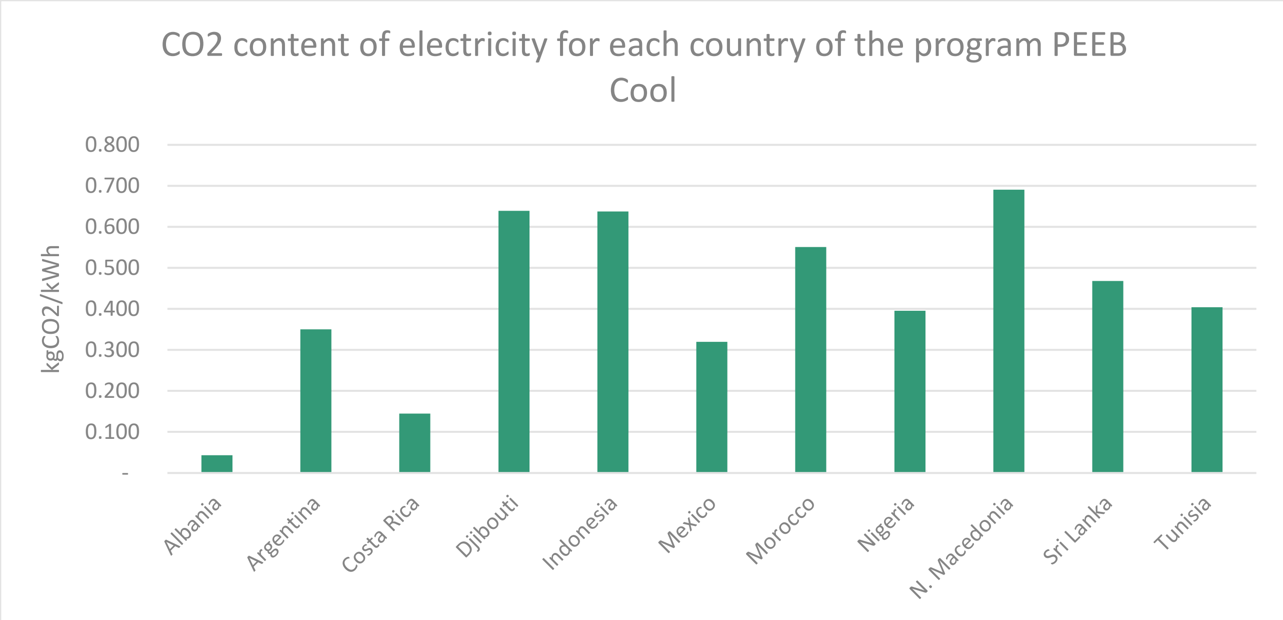



**Figure 13: Grid emissions factor in the PEEB Cool countries**

*Source: The IFI Dataset of Default Grid Factors v.2.0 (2019)*

For natural gas, we used a single value of 231gCO2eq/kWh as natural gas is always made up of 90% methane and therefore the CO2 content does not vary much from country to country.

5.1.1.5. Calculation for avoided emissions during the buildings' operation

Based on the energy savings and the carbon content of energy, we determined the annual emissions avoided and expressed them in kgCO2/m²/year for each of the two packages.

**<u>CO2 Emissions avoided by climate zone – package -40%:</u>**

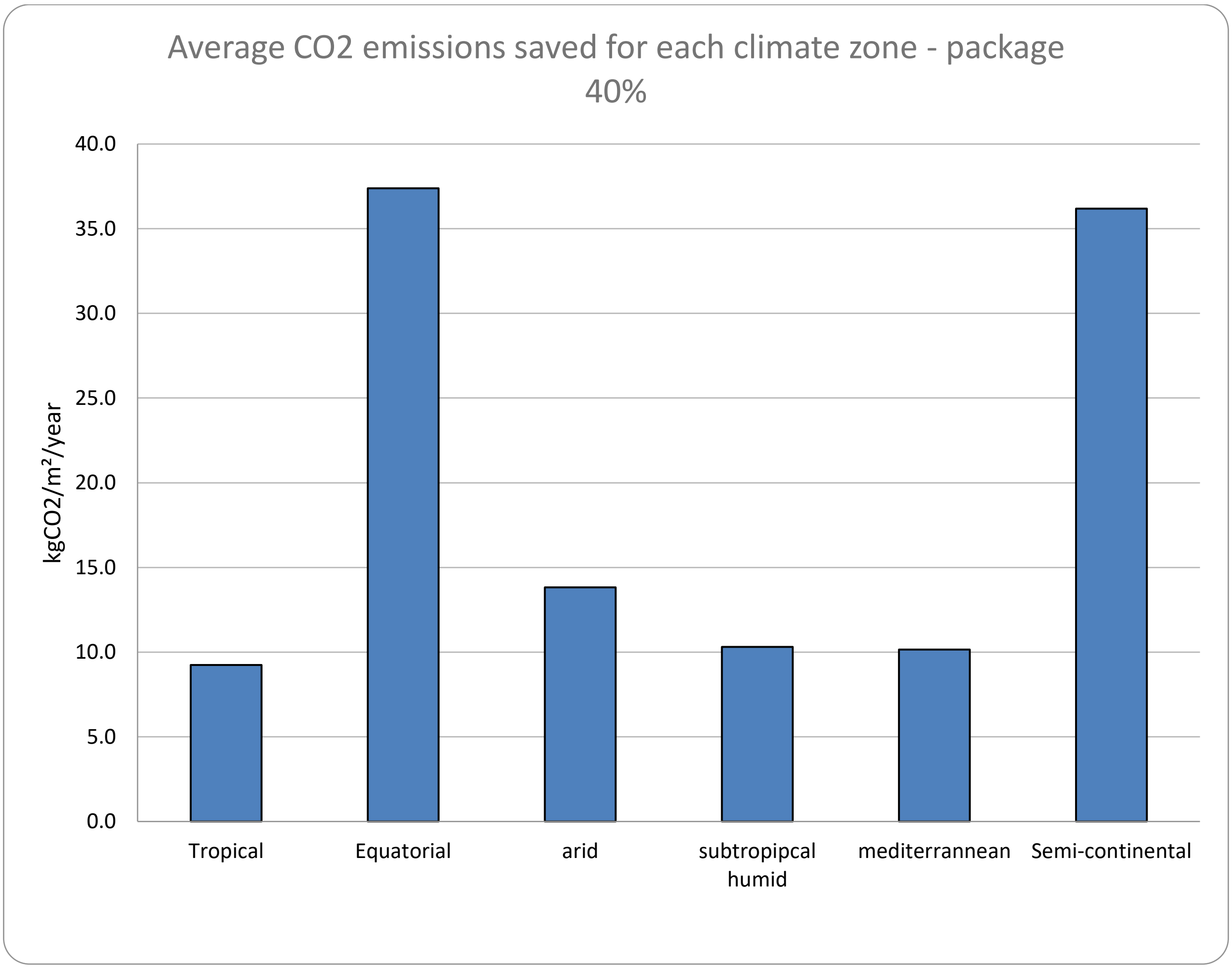



Figure 14: Emissions reduction relating to the buildings' operation for each climate zone and averaged over all building types - 40%

We notice that there is a high emission reduction potential in the desert (arid), equatorial and semi-continental climates of the program.

**Avoided CO2 emissions by building type (averaged over all countries) – package -40%:**

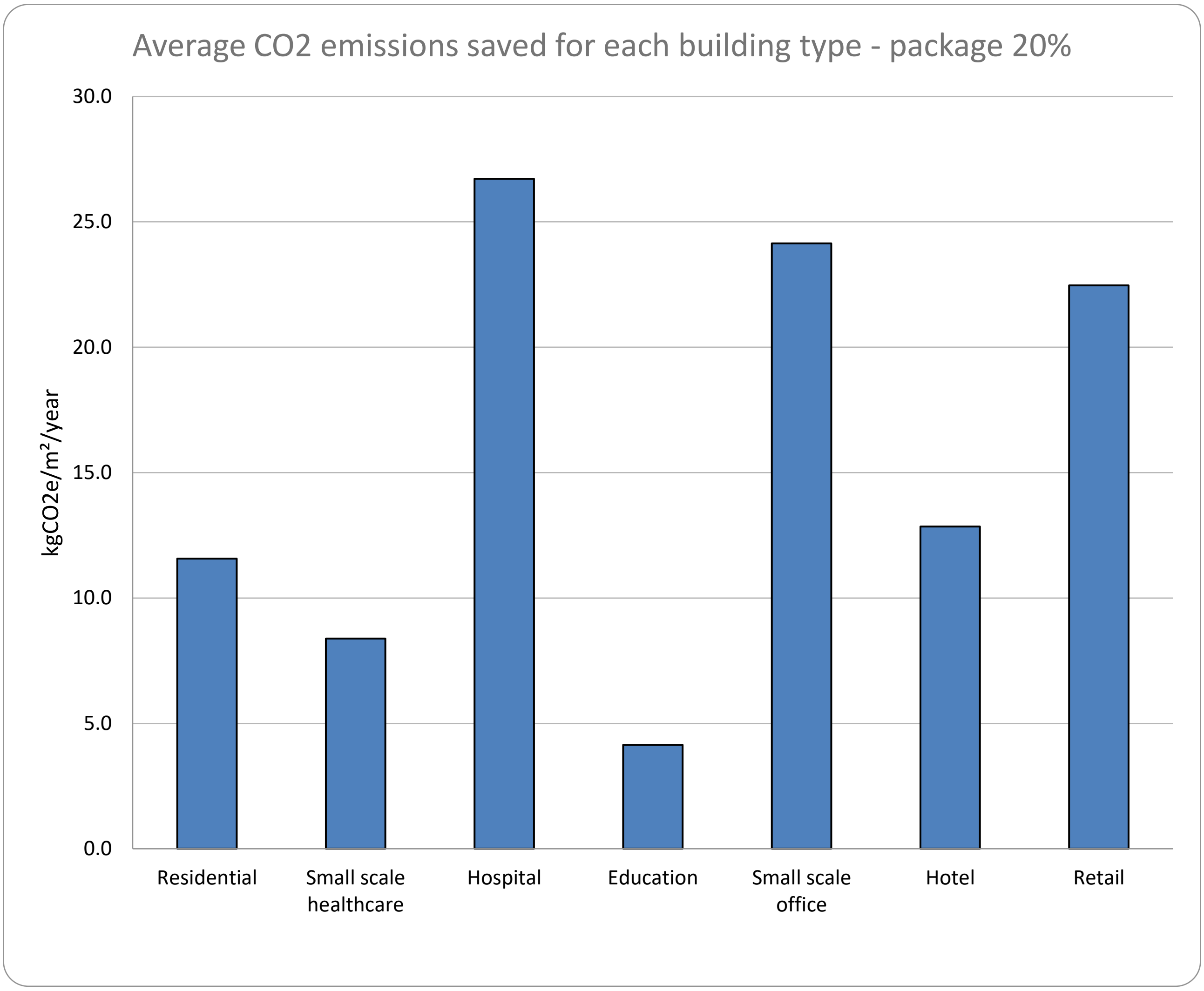



**Figure 15: Avoided emissions during the buildings' operation by building type package -40%**

Just as was the case when comparing the energy savings potential of each building type, when comparing the avoided emissions of each building type, we notice strong differences between building types, with 6kgCO2eq/m²/year for schools and 51kgCO2eq/m²/year for hospitals. The energy savings difference is not as pronounced between hospitals and the other building types (offices/hotels/retail). This is because the subproject portfolio shows that the latter building types are exclusively located in countries of the PEEB Cool program with a relatively high carbon content of electricity. The average carbon content of electricity throughout the program for the « -40% » package is 31.3kgCO2eq/m²/year.

**Avoided CO2 emission by climate zone – package -20%:**

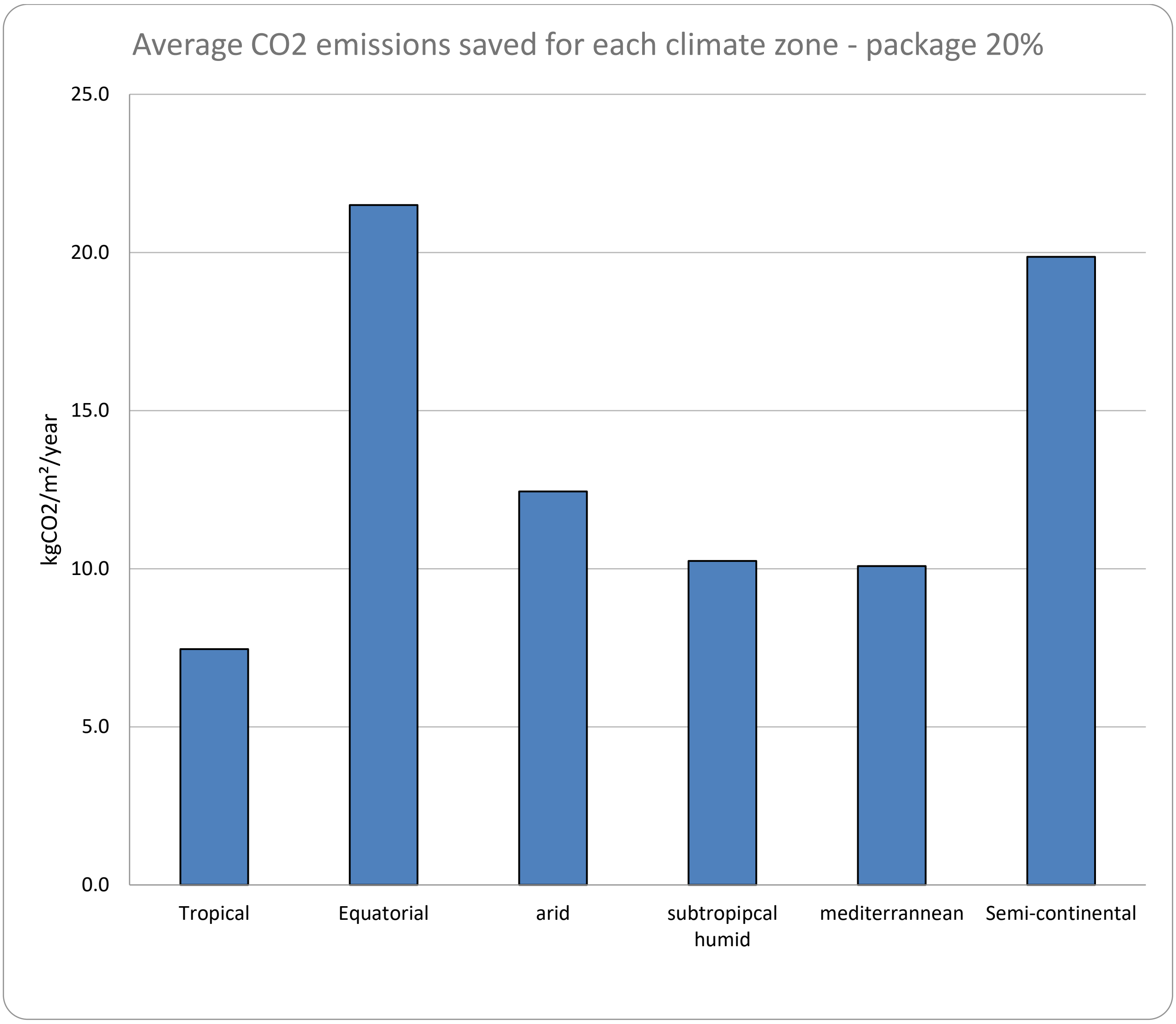



Figure 16: Avoided emissions during the buildings operation by climate zone and averaged over all building types -20%

The same observations made for the « -40% » package are true for the « -20% » package.

**Avoided CO2 emissions by building type (averaged over all countries) – package -20%:**

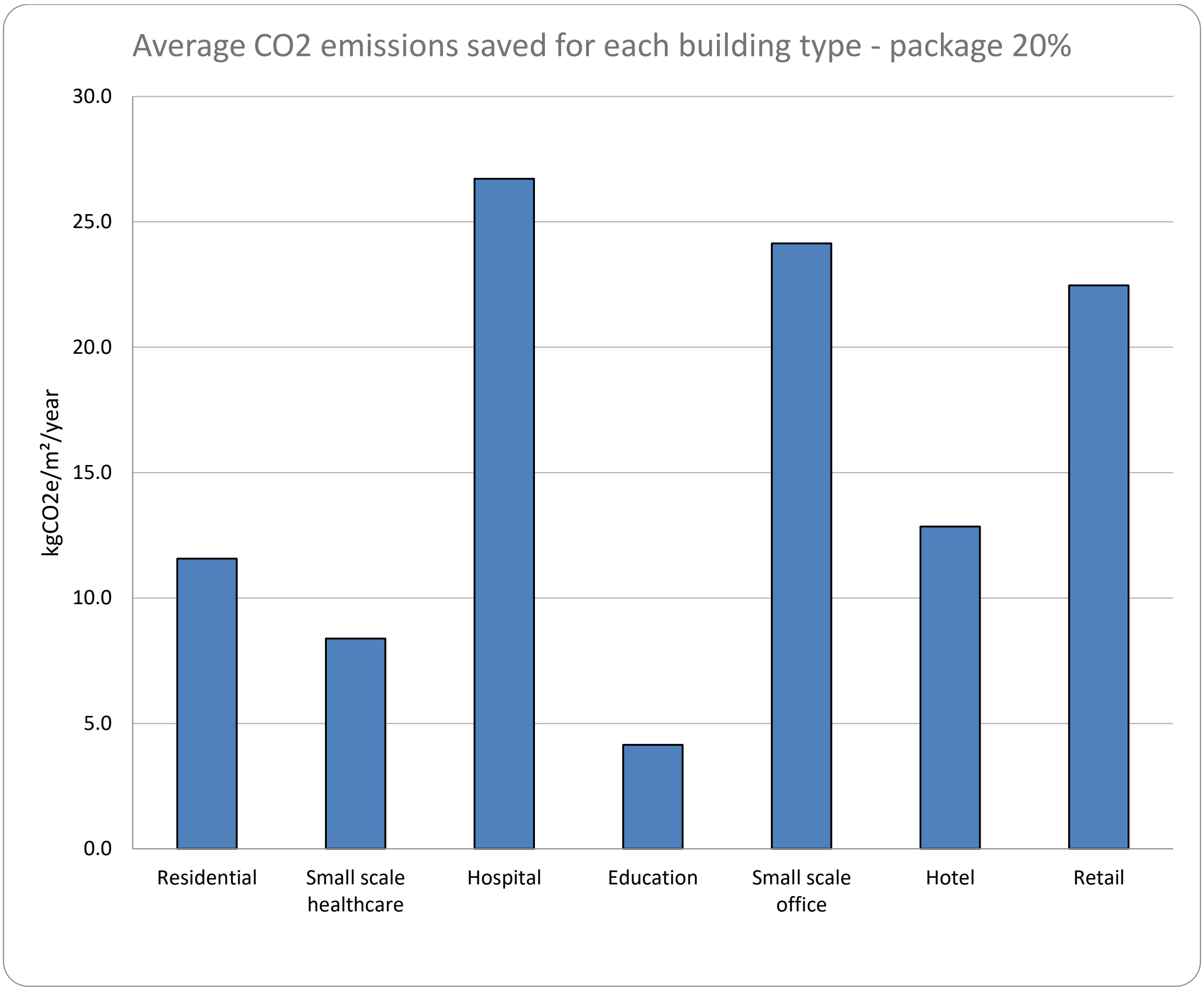



**Figure 17: Avoided emissions during the buildings' operation by building type package -20%**

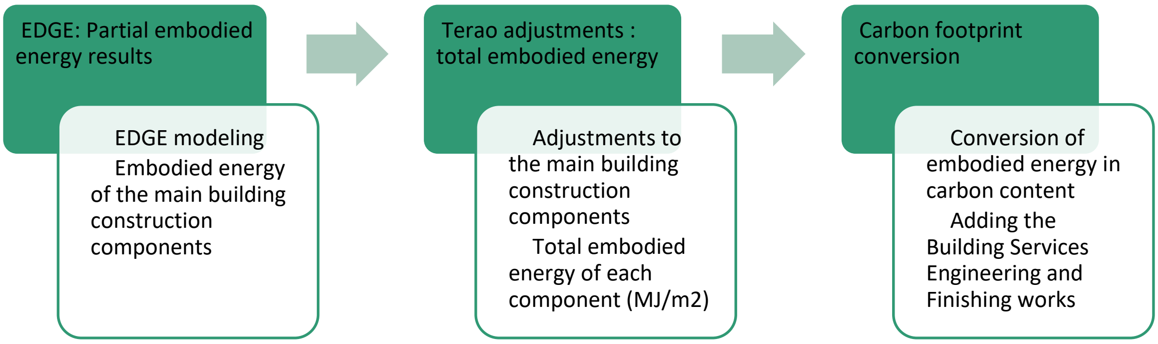
We observe similar differences in avoided emissions between building types for the « -20% » package as was previously observed for the « -40% » package. The average avoided emissions throughout the program for the « -20% » package is 18.3kgCO2eq/m²/year.

#### 5.1.2. Avoided emissions relating to construction

We opted for a methodology tailored to the level of information as well as to the types and number of variables (building types and climate zones) based on the following steps:

1) We first used the EDGE software to give us the quantity of embodied energy in the construction process for each building type;
2) We finetuned the data based on our experience from PEEB and other similar projects we worked on;
3) We then used a French tool called E+C- to give us a more precise picture of the carbon content of each construction component;
4) We adjusted the values from the E+C- tool based once more on experience from PEEB and other similar projects we worked on;
5) Using a Terao tool, we included additional carbon gains for low tech solutions, reuse, local materials and eco-materials;
6) Finally, we evaluated the impact over 15 years taking into account the carbon footprint linked with the renewal of the finishing works and building services engineering works.

The diagram below illustrates the process that was followed:




5.1.2.1. EDGE calculation of the embodied energy of the structural elements of the buildings

The table below illustrates an example of the embodied energy results using EDGE for a health center:

**Table 21: Example of embodied energy calculation relating to the structural elements of a health center using the EDGE software**

| | **Baseline** | *Scenario 20% EE* | *Scenario 40% EE* |
|---|---|---|---|
| **Embodied energy (MJ/m²)** | | | |
| Total embodied energy | **2835** | **2669** | **2669** |
| Floor | 1148 | 1148 | 1148 |
| Roof | 1148 | 1148 | 1148 |
| Exterior walls | 62 | 6 | 6 |
| Interior walls | 216 | 106 | 106 |
| Ground | 199 | 199 | 199 |
| Windows and joinery | 62 | 62 | 62 |

The results are considered identical for all climates but differ depending on the building type.

The next step was to simulate improvements to the structural elements of the building. The following table summarizes all the assumptions made regarding the construction materials as part of the embodied energy calculations using EDGE. Note that not all of these examples are from countries to be involved in the programme, but their building characteristics are reflective of the types of buildings in similar geographies.

**Table 22: Definition of the low carbon material specifications for the structural elements by building type**

| | **Small multi-family residential** | **Health centers** |
|---|---|---|
| **Climate zones** | Mediterranean | Tropical |
| **Floor area (Fa)** | 7000 m$^2$ | 3175 m$^2$ |
| **Baseline** | Reinforced concrete slab floor<br>Reinforced concrete slab roof<br>Exterior brick walls<br>Interior brick walls | Reinforced concrete slab floor<br>Reinforced concrete slab roof<br>Exterior walls made of hollow concrete blocks |

| | | |
|---|---|---|
| | Ceramic tile floor coverings<br>SG windows with aluminum frame<br>Roof insulation with 6 cm Polystyrene<br>Air conditioning | Interior brick walls<br>Ceramic tile floor coverings<br>SG windows with aluminum frame<br>Partial air conditioning |
| **20%EE scenario** | Reinforced concrete slab floor<br>Reinforced concrete slab roof<br>Exterior walls made of hollow concrete blocks<br>Interior walls with plaster partitions on metal rails<br>Ceramic tile floor coverings<br>DG windows with PVC frame<br>Roof insulation with 8 cm Polystyrene<br>Air conditioning | Reinforced concrete slab floor<br>Reinforced concrete slab roof<br>Exterior walls in Compressed Earth Bricks 20 cm<br>Interior walls with plaster partitions on metal rails<br>Ceramic tile floor coverings<br>SG windows with aluminum frame<br>Roof insulation with 4 cm of polystyrene<br>Partial air conditioning |
| **40%EE scenario** | Ditto 20% EE scenario<br>Solar Hot Water system (1,9 m2/housing unit) | Ditto 20%EE scenario<br>PV system (66 kWp) |

| | Hospitals |
|---|---|
| **Countries serving as point of reference for the data** | Tunisia |
| **Fa** | 35679 $m^2$ |
| **Baseline** | Reinforced concrete slab floor<br>Reinforced concrete slab roof<br>Exterior walls made of hollow concrete blocks<br>Interior brick walls<br>Ceramic tile floor coverings<br>DG windows with aluminum frame<br>Wall insulation with 6 cm EPS<br>Roof insulation with 10 cm mineral wool<br>Air conditioning |
| **20%EE scenario** | Reinforced concrete slab floor<br>Reinforced concrete slab roof<br>Exterior walls made of hollow concrete blocks<br>Interior walls made of plaster partitions on metal rails with acoustic insulation<br>Ceramic tile floor coverings<br>DG windows with aluminum frame<br>Wall insulation with 6 cm EPS<br>Roof insulation with 10 cm mineral wool<br>Air conditioning<br>Solar collectors for DHW (434 m2) |
| **40%EE scenario** | Ditto 20% EE scenario + wall insulation with 8 cm EPS and roof insulation with 20 cm mineral wool<br>Air conditioning<br>Solar collectors for DHW (434 m2)<br>PV collectors (680 kWp) |

| | Small office buildings |
|---|---|
| **Countries serving as point of reference for the data** | Djibouti |
| **Fa** | 5211 $m^2$ |
| **Baseline** | Reinforced concrete slab floor<br>Reinforced concrete slab roof<br>Poured concrete exterior walls<br>Interior brick walls<br>Ceramic tile floor coverings<br>SG windows with aluminum frame<br>Air conditioning |
| **20% EE scenario** | Ditto baseline + roof insulation with 8 cm of mineral wool |
| **40% EE scenario** | Ditto 20%EE scenario + PV panels (91 kWc) |

#### 5.1.2.2. Total embodied energy calculation for the structural elements of the buildings

We then used a tool from the French E+C- label (E+C- meaning Energy plus – Low Carbon label), in addition to the lessons learned from previous studies relating to in depth lifecycle analyses, to finetune the results. This led us to opt for a systematic 30% increase of the embodied energy values relating to the structural elements of the buildings calculated by the EDGE software.

#### 5.1.2.3. Carbon footprint conversion

In order to determine the carbon footprint of the embodied energy relating to the structural elements of the buildings, we researched appropriate conversion factors. The E+ C- French label lays out 6 indicators in addition to carbon, including embodied energy:

**Table 23: Environmental indicators of the E+C- label (Fa means "floor area")**

| Global warming potential | Total use of primary energy resources | Total use of non-renewable primary energy resources | Exhaustion of resources | Net use of freshwater | Non-hazardous waste | Hazardous waste |
|---|---|---|---|---|---|---|
| kg CO2eq/m2Fa | **MJ/m2Fa** | **MJ/m2Fa** | **G Sb eq/m2/Fa** | **L/m2 Fa** | **Kg/m2/Fa** | **Kg/m2 Fa** |

We notice that there is a significant disparity between the carbon emission and primary energy results. The difference comes from the carbon content of the embodied energy of the main building construction components.

Data on the carbon content is taken from the Environmental Product Declaration (EPD) provided by the manufacturers of the building construction materials. These are used to determine the life cycle assessment of the construction materials.

Looking at the carbon content of each of the main building construction components, we see that the manufacturing of some building components such as the foundations and structural elements of the buildings are more carbon intensive than other building components, that is to say that they emit more carbon for the same amount of energy required. This is shown if the figure below:

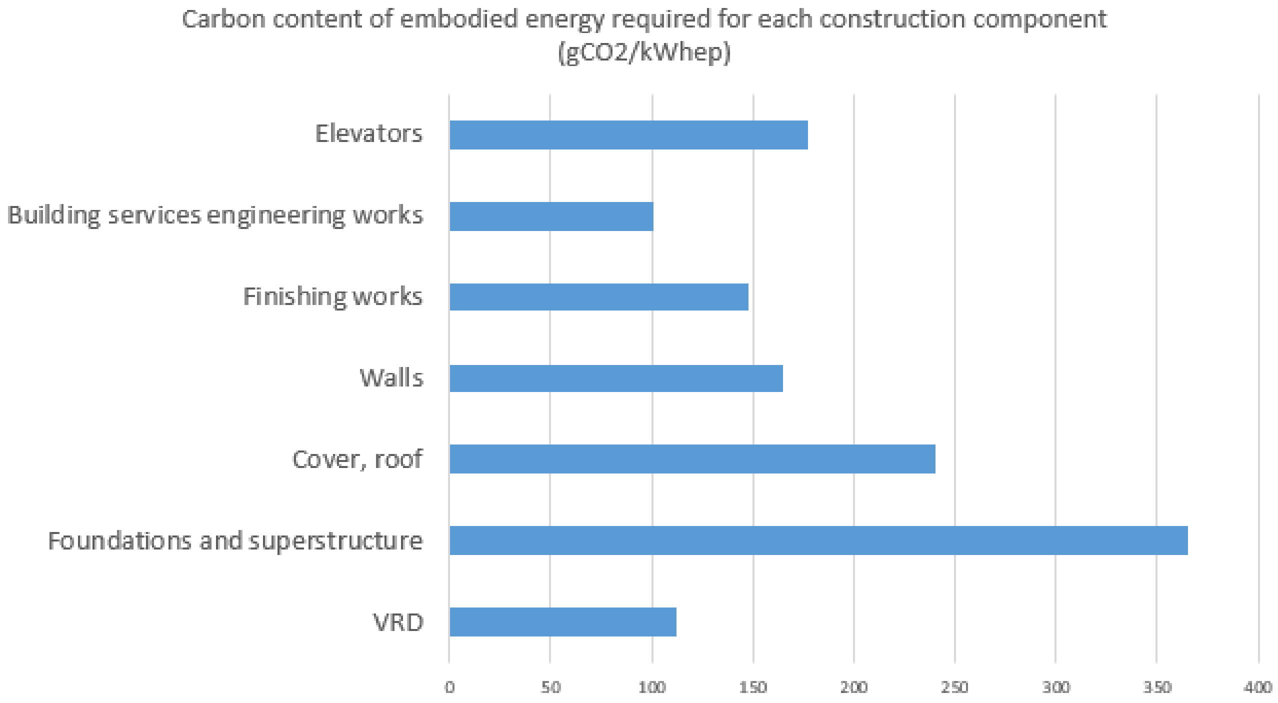



**Figure 18: Carbon content of primary energy by main construction component**

Since it is extremely complicated to take into account geographical variations for each country and for each construction component, we make the simplifying assumption that the carbon content values of the different construction components, described above, should be applied identically to all countries.

When applied in our case to the construction components relating to the structural elements of the buildings, we find the following values:

- Foundation and superstructure: 100gCO2/MJ
- Cover, roof: 70gCO2/MJ
- Windows: 50gCO2/MJ
- Finishing works relating only to the floor covering: 40gCO2/MJ

In the case of the building services engineering works and other finishing works, we assumed carbon footprint values similar to those found in France, given the serious work carried out in recent years in this field, at the instigation of the E+C- label.

a. Finishing works excluding floor covering: 110 kgCO2/m²
b. building services engineering works: 70 kgCO2/m²
c. Elevators: 20 kgCO2/m²
d. Suppression of the component relating to roads and networks

Drawing from the lessons learned from PEEB projects and/or projects similar to PEEB, we identified adjustment factors for the carbon values found above. These adjustment factors were determined according to the complexity as well as the low carbon nature of the buildings.

Table 24: Factors for adjusting the carbon footprint relating to the finishing works, building services engineering works and elevator components by building type

| Building type | Finishing works | Building services engineering works component | Elevators |
|---|---|---|---|
| Small multi-family residential | 70% | 50% | 70% |
| Health centers | 100% | 50% | 0% |
| Hospitals | 100% | 120% | 100% |
| 2 storey schools | 50% | 50% | 0% |

The graph below shows the results using these values compared with the values used by the French E+C- label:

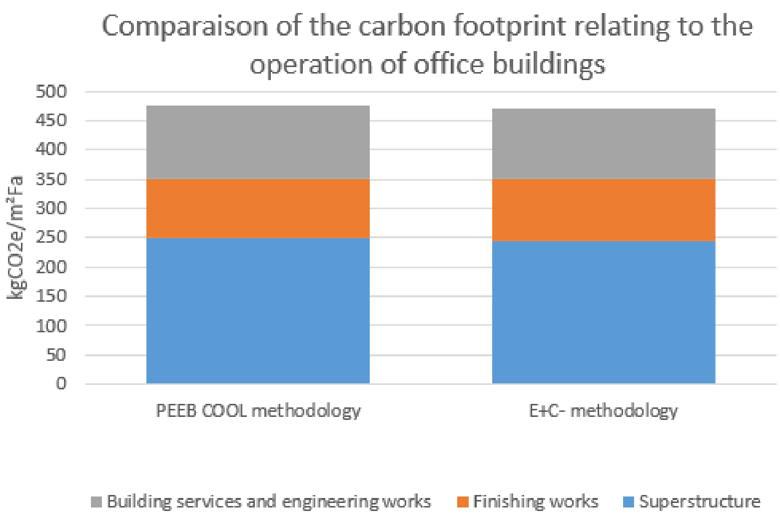



Figure 19: Comparison of the PEEB Cool carbon footprint results with a detailed approach based on the E+C- label

#### 5.1.2.4. Calculation of the avoided emissions relating to construction

The method used to calculate the avoided emissions relating to construction involves modeling the carbon footprint improvements for the structural elements of the building, the finishing works and building services engineering works and comparing, for each building type, those improvements to the baseline.

To determine the carbon gains relating to the structural elements of the buildings, we first simulated the carbon gains using the EDGE software for the « -20% » and for the « -40% » packages of measures. We then used the TERAO tool to add additional carbon gains relating to finishing works and structural works as follows:

**Table 25: Calculation of the carbon gains in addition to those calculated by EDGE for the structural elements of the buildings**

| **Low carbon solutions** | **Carbon impact** |
|---|---|
| Low tech (absence of air conditioning) | - 30% for the building services engineering works component |
| X% of reusable materials<br><br>(X between 0% and 20% to remain conservative about the possibilities of construction material reuse) | - X% for the finishing works component |
| Y% Local materials<br><br>(Y between 0% and 30% to remain conservative about the possibilities of sourcing local materials for the finishing works) | - Y%*20% for the finishing works component |
| Z% Low carbon / bio-sourced materials<br><br>(Z between 0% and 30% to remain conservative about the possibilities of sourcing low carbon materials for the finishing works) | - Z%*40% for the finishing works component |

Furthermore, we considered that some countries were already "low tech" due to their stage of economic development as well as the lack of standards and that it was therefore easier to achieve material carbon gains in those countries than in countries already influenced by "high tech". This assumption was translated into coefficients for adjusting carbon gains.

**Table 26: Carbon gain adjustment factors according to the building type and whether it is a low tech or high-tech country**

<table>
<tr><th></th><th colspan="2">Potential Low-tech (1)</th><th colspan="2">Reuse (2)</th><th colspan="2">Rate of local sourcing (3)</th><th colspan="2">Rate of low carbon materials (4)</th></tr>
<tr><th></th><th>LT country (5)</th><th>HT country (6)</th><th>LT country</th><th>HT country</th><th>LT country</th><th>HT country T</th><th>LT country</th><th>HT country</th></tr>
<tr><td>Health centers</td><td>100%</td><td>50%</td><td>20%</td><td rowspan="4">0%</td><td colspan="2" rowspan="4">20%</td><td rowspan="4">30%</td><td rowspan="4">20%</td></tr>
<tr><td>Housing units</td><td colspan="2">0%</td><td>0%</td></tr>
<tr><td>Hospitals</td><td colspan="2">0%</td><td>0%</td></tr>
<tr><td>Schools</td><td>100%</td><td>50%</td><td>20%</td></tr>
</table>

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Offices | 100% | 50% | 20% | | | | |
| Hotels | 50% | 0% | 0% | | | | |
| Retail | 50% | 0% | 0% | | | | |

1. Depending on the amount of energy equipment already planned and the possible gains: 0%: no gain, 100% = 30% reduction in the carbon impact of the construction components relating to the building services engineering trades
2. Depending on whether the building is 'high end' or not, typically there is minimal reuse in housing or hospitals
3. We multiply the % of local materials for the finishing works by 20% to obtain the carbon gains relating to the finishing works component
4. We multiply the % of low carbon materials used in the finishing works component by 40% to obtain the carbon gains relating to the finishing works component.
5. « LT countries »: low-tech, countries other than the HT countries
6. « HT countries »: high-tech, Asia + Argentina + Tunisia + Morocco

This gives us the following matrix for determining the carbon gains from construction materials:

**Table 27: Carbon gains from construction by building type in countries with a prevalence for low tech and high tech**

| Building type | « High tech » countries | % savings compared with the baseline | « Low tech » countries | % savings compared with the baseline |
|---|---|---|---|---|
| | Carbon gains (kgeqCO2/m2) | | Carbon gains (kgeqCO2/m2) | |
| Housing units | 86 | 22% | 88 | 22% |
| Health centers | 38 | 9% | 61 | 14% |
| Hospitals | 16 | 4% | 19 | 4% |
| Schools | 12 | 4% | 28 | 8% |
| Small office buildings | 20 | 5% | 48 | 11% |
| Hotels | 8 | 2% | 27 | 7% |
| Retail | 8 | 2% | 27 | 7% |

##### 5.1.2.5. Calculation of global avoided emissions

Finally, we take into account the transformational effect of the PEEB Cool program in countries that already have a building energy code. This is the case for Morocco, Nigeria, Tunisia, Nigeria, Mexico, Indonesia, Sri Lanka, Albania and North Macedonia. In order to highlight the impact of the policy level component of the PEEB Cool program and the leverage effects it aims to achieve, we consider a multiplier effect of 4 in the case of countries that have a building energy code for all sectors. This is a conservative assumption which assumes that the favorable regulatory environment of those countries makes it easier to replicate a project meeting the PEEB Cool specifications.

Based on this assumption, we can define the avoided CO2 emissions for each building type in each country as follows:

$$
\begin{aligned}
&\mathit{Avoided\ emissions}\ \left(\frac{kgCO2eq}{m^2}\right) \\
&\qquad = \mathit{Avoided\ emissions\ due\ to\ energy\ savings}\left(\frac{kgCO2eq}{m^2.an}\right) \times 15 years \\
&\qquad \times (1\ \mathit{or}\ 4\ \mathit{depending\ on\ whether\ there\ is\ a\ building\ energy\ code}\ ) \\
&+ \mathit{Avoided\ emissions\ relating\ to\ embodied\ energy\ during\ construction}\left(\frac{kgCO2eq}{m^2}\right)
\end{aligned}
$$

## 5.2. Estimation of the surface areas and investments relating to the PEEB Cool program

### 5.2.1. Piecing together the surface area and cost of the subprojects

Based on the pipeline of subprojects provided by AFD, we were able to make estimates of the surface area and subproject cost for some countries and made assumptions for others. At this stage, we have been able to piece together approximately 3.65 million m² for a total building infrastructure subproject cost of 1.099 million EUR.

Considering the fact that the PEEB Cool program amounts to an estimated EUR 1.287 billion of investment, the total surface area of buildings to be constructed or renovated in the framework of PEEB Cool will be 4.27 million m².

As it stands, this is equivalent to an average construction cost of 261 €/m². These values seem consistent with the fact that some of the subprojects are located in Africa and that the majority of the surface areas relate to low-income housing.

The following graph shows the surface areas by building type:

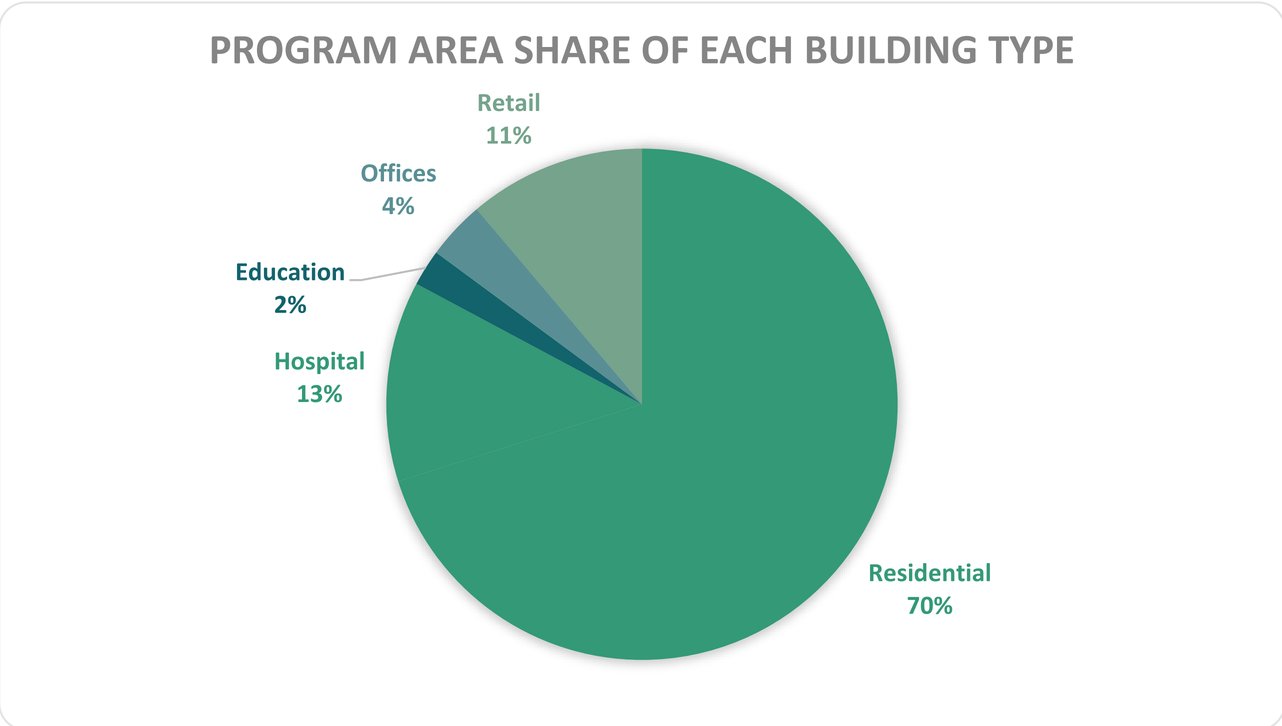



**Figure 20: Share of surface areas by building type in the pipeline**

We notice that in terms of built surface area, housing is the most prevalent building type (70%).

The results of scaling up the investments to the entire portfolio are provided at the beginning of Section 5.

### 5.2.2. Calculation of the overall cost of low carbon measures for the PEEB Cool program

#### 5.2.2.1. Estimation of the extra-cost of energy-saving and low-carbon actions

In order to calculate the cost per ton of CO2 avoided, we have estimated the additional investment costs (which is a share of the project construction cost) related to the following packages of measures for each building type:

- The « -40% » energy saving package
- The « -20% » energy saving package
- The low carbon material package

Our method consisted in searching through our PEEB mission reports for information on the costs of the baseline buildings and the cost of buildings which included the different improvement packages.

Whenever we could not find accurate data for the cost and extra cost for a given building type, we then used the extra cost as estimated by the EDGE software. Note that not all of these examples are from countries to be involved in the programme, but their building characteristics are reflective of the types of buildings in similar geographies.

**Table 28: Additional costs of emission reduction actions in relation to the cost of construction**

| | **Small multi-family residential** |
|---|---|
| **Countries** | Tunisia and Morocco |
| **Year** | 2010 |
| **Surface area** | 80 $m^2$/housing unit |
| **Baseline cost** | 282 €/m2 |
| **Extra cost of the 20%EE package in % of the overall construction cost** | 4.6 % rounded up to 5% |
| **Extra cost of the 40%EE package in % of the overall construction cost** | 10% |

| | **Hospitals** |
|---|---|
| **Countries** | Tunisia |
| **Year** | 2020 |
| **Surface area** | 36712 m2 |
| **Baseline cost** | 1850 €/m2 |
| **Extra cost of the 20%EE package in % of the overall construction cost** | 0.5% rounded up to 1% |
| **Extra cost of the 40%EE package in % of the overall construction cost** | 1.7% rounded up to 2% |

| | **Small office buildings** |
|---|---|
| **Countries** | Djibouti |
| **Year** | 2019 |
| **Surface area** | 8072 m2 |
| **Baseline cost** | 800 €/m2 |
| **Extra cost of the 20%EE package in % of the overall construction cost** | 3.1 % rounded up to 3% |
| **Extra cost of the 40%EE package in % of the overall construction cost** | 10.1% rounded up to 10% |

**Table 29: Building energy renovation cost by building type and energy performance package**

| **Building type** | **Cost of building energy renovation (€/m2)** | |
|---|---|---|
| | **Package 20%** | **Package 40%** |
| **Small multi-family residential** | 28€/m2 | 40€/m2 |
| **Hospitals** | 89€/m2 | 127€/m2 |
| **Small office buildings** | 61.25€/m2 | 87.5€/m2 |
| **Retail** | 89€/m2 | 127€/m2 |

It is worth noting that for any given building type, the cost per m2 of building energy renovation is higher than for new buildings because for new buildings it is possible to integrate early on in the building design phase bioclimatic design measures (building orientation, optimizing window to wall surface area, improving shading, etc.). To achieve the same level of energy performance with existing buildings, increased building insulation and more energy efficient equipment have to compensate for the absence of bioclimatic design measures, which is costlier.

It should also be noted that the cost/m$^2$ ratios for building energy renovation subprojects will vary substantially depending on the baseline energy performance.

In addition to the extra costs identified above, we added the following extra costs relating to low carbon materials:

- 1% extra cost for housing, health centers and schools,
- 0.5% extra cost for the other building types.

#### 5.2.2.2. Package -40%

The graph below gives the % of the project cost (or additional cost) related to energy saving and low carbon actions by building type:

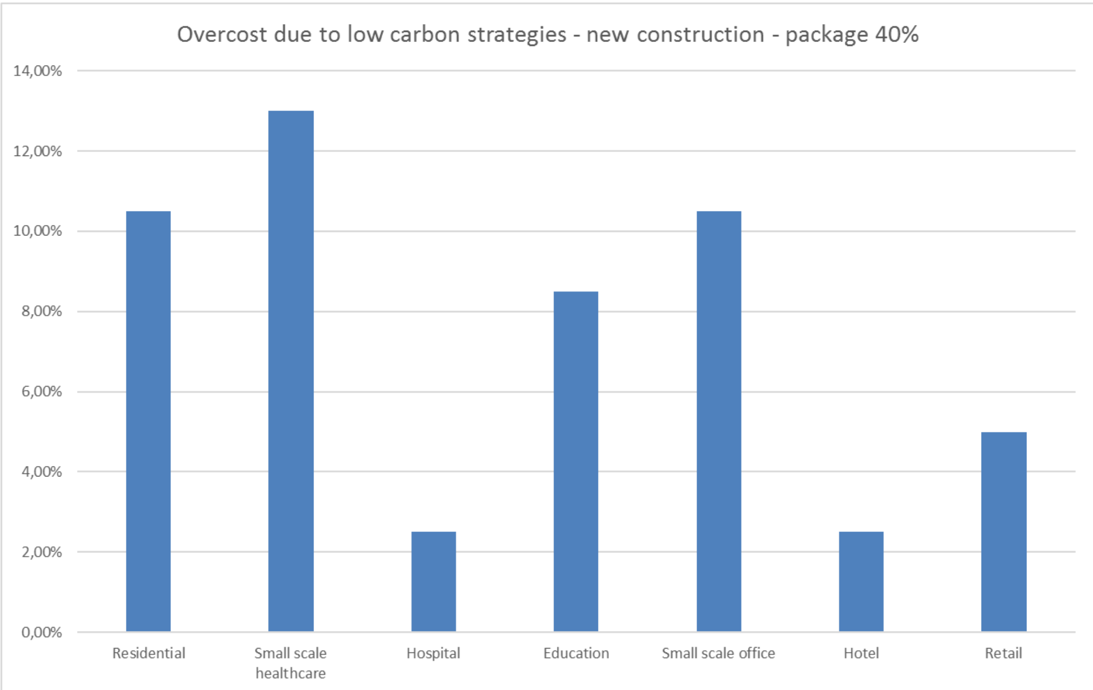



**Figure 21: Extra cost of the emissions avoiding actions by building type expressed in % of the construction cost - package 40%**

For building energy renovation subprojects, the extra cost of the 40% package is 100% of the building energy renovation cost.

On this basis, the extra cost related to these emissions avoiding actions is given below by building type:

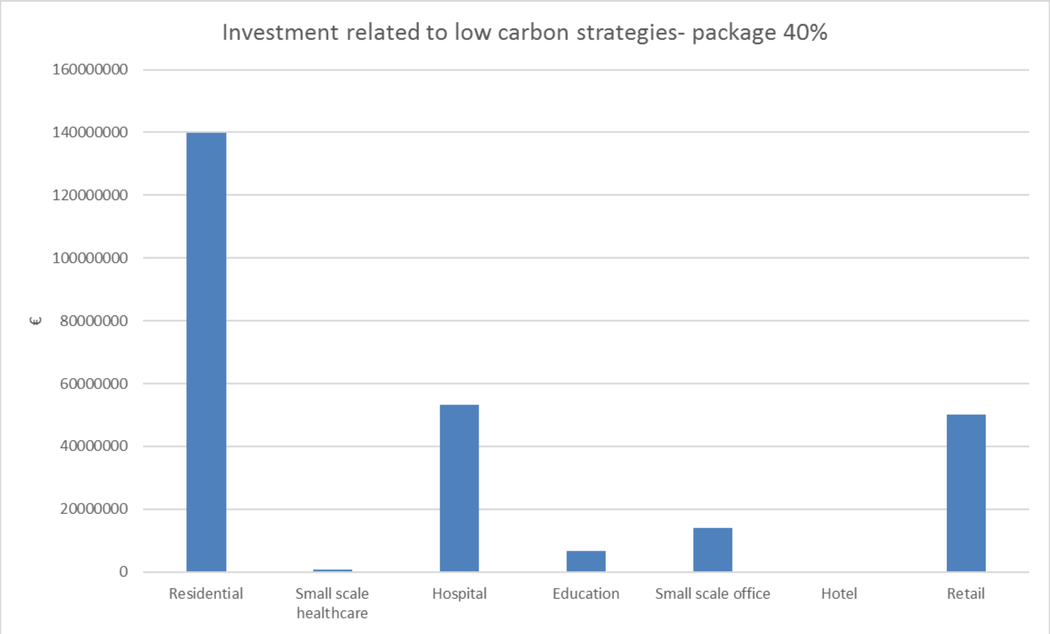



**Figure 22: Extra cost of emissions avoiding actions by building type in € - package 40%**

#### 5.2.2.3. Package -20%

The graph below gives the % of the project cost related to emissions avoiding actions by building type:

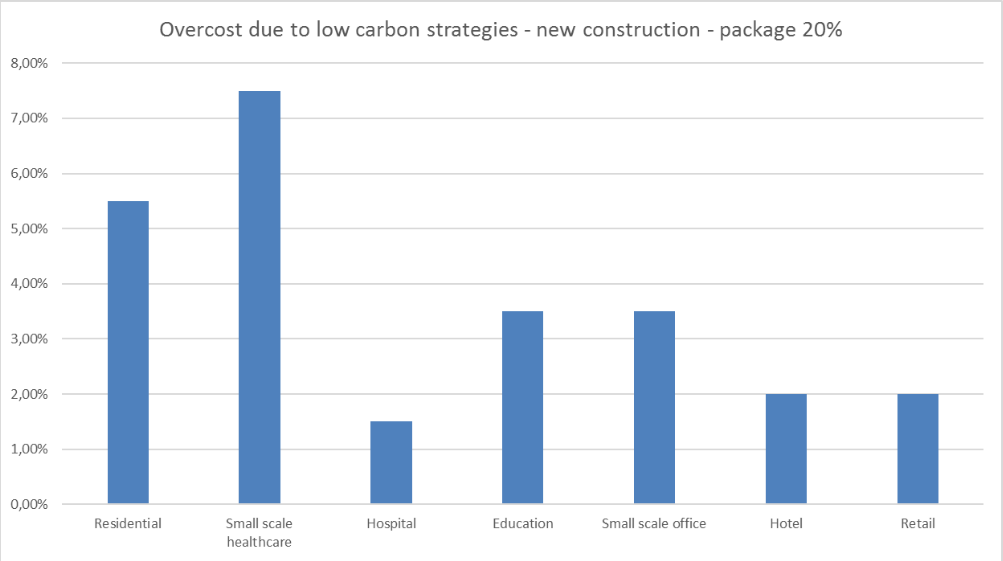



**Figure 23: Extra costs of emissions avoiding actions by building type and expressed in % of overall construction costs - package - 20%**

For building energy renovation subprojects, the extra cost of the 20% package is 70% of the building energy renovation cost.

The extra cost related to these emissions avoiding action is given below by building type:

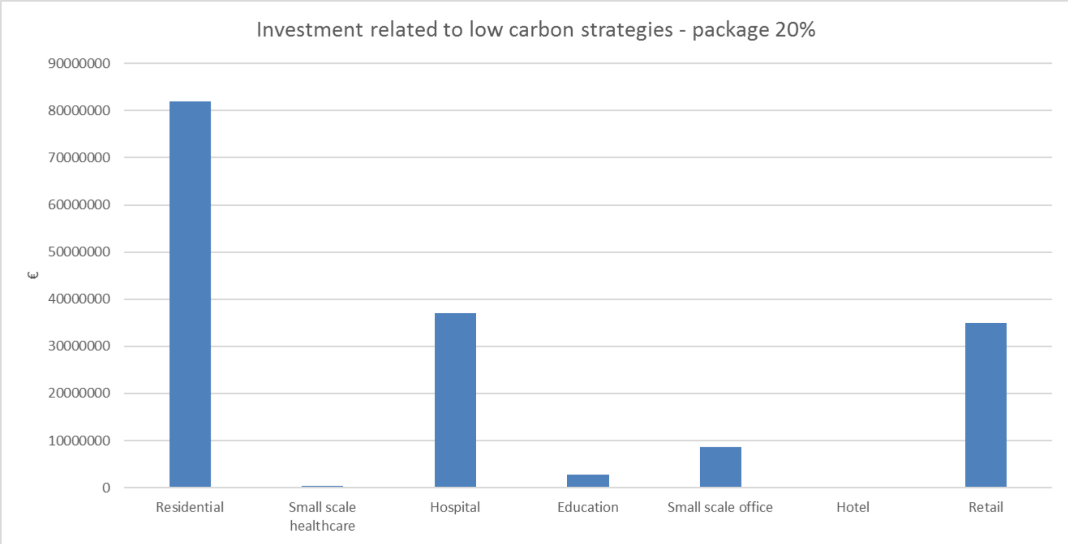



**Figure 24: Extra cost of emissions avoiding actions by building type in € - package -20%**

## 5.3. Mitigation case studies

Each building construction/renovation subproject that complies with the PEEB Cool eligibility criteria will be studied to identify the relevant package of measures to recommend in order to reach the targeted energy and environmental performance.

The case studies below provide examples of excerpts from such studies undertaken as part of the PEEB program.

In each case study, there is a brief description of the subproject or the type of building being studied, the baseline construction features and the recommended improvement, the baseline investment cost and incremental cost as well as the energy saving and mitigation impacts.

It is important to note that the Business As Usual (BAU) investment costs and the extra investment related to the recommended improvements differ significantly from one subproject to another. There are many drivers that account for the differences in BAU investment between subprojects. Here are a few of them:

1) The function of the building

Hospitals for instance will generally cost more per m2 than schools because they usually must be built to a higher standard than schools and require more expensive equipment, much of which is for medical purposes but also electrical and hot water equipment, backup power options and so on. A school on the other hand, in many developing and emerging economies, can be quite basic.

2) The quality of construction

Middle income housing units will generally include much better finishing works and equipment than social housing. They might include double glazing windows, some amount of insulation, cooling and hot water whereas social housing will typically be very basic constructions. Generally speaking, social housing units and buildings that provide basic social services to the public such as schools or health centers, will be built at minimum investment cost as there is often a political will to provide access to basic services to as many people as possible, the problem is that this is often to the detriment of thermal comfort or energy consumption during the buildings' lifetime.

3) Construction cost in the country or region

The unit cost of materials and the labor costs will vary widely from one country or one region to the next.

Moreover, for a given building function, quality of construction and construction cost in the country or region, the incremental cost of the improvements will also vary depending on the following factors:

1) the baseline level of energy and environmental performance

If the baseline level is low, then comparatively cheaper measures will be needed to reach the same percentage of improvement. In countries that already have a building energy code in place, the baseline must comply with the building energy code so the baseline level may be higher in those countries than in others.

In some cases, the building may be entirely glazed. As a result, reducing the window to wall ratio will improve the energy performance of building whilst saving on cost. These types of situations are rare but have happened in past projects supported by PEEB.

2) The package of measures recommended

This will undoubtedly have an impact on the incremental cost. The package of measures will also vary significantly from one subproject to another due to:

- The targeted level of energy and environmental performance. This can depend on the client, its capacity and willingness to achieve a higher level.
- The local climate and its future evolution. Some climates are extremely harsh and require more expensive measures to achieve a given level of energy performance and thermal comfort improvement. In temperate climates it is typically cheaper to reach a given level than in continental hot or cold climates. Some geographical areas will also be more susceptible to future rise in temperatures, thereby requiring more expensive measures in the present to make the building resilient in the future.
- The specific cost of the solution in the local context. Some solutions may be very expensive in the local context and can drive cost up.

The factors described above explain why it is important that each subproject be studied on a case-by-case basis and not to generalize the findings from any one subproject or case study.

### 5.3.1. Renovation of existing Public buildings in Djibouti

Djibouti is a country that is almost totally dependent from petroleum imports and hydro-electricity from Ethiopia for its energy needs. Moreover, electricity, which represents almost 100% of final energy consumption in public buildings, costs 2 to 3 times more than in France (0,35EUR/kWh) and as the standard of living is increasing so is cooling demand.

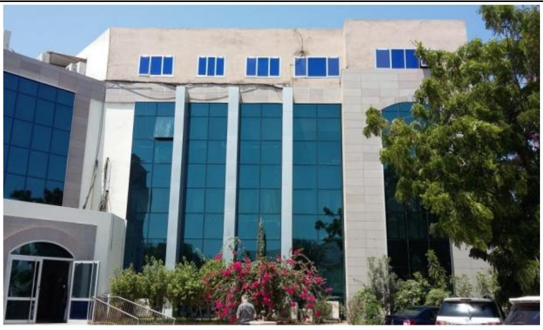
Following a request from the government of Djibouti, AFD contracted a consortium made up of TERAO and BURGEAP through the PEEB program, to undertake an analysis of the potential for energy savings in existing public buildings in Djibouti. The analysis looked at a total of 11 buildings representing 8 different building types and 6% of the overall energy consumption of public building in Djibouti.

This project is presently in the PEEB Cool pipeline of subprojects.

Djibouti has a hot desert climate. The average yearly temperature is 30.2°C and average precipitation is 380mm. There is a large day/night temperature differential, between 8°C and 15°C, meaning that buildings can potentially benefit from night-time ventilation.

The following buildings were analyzed:

| Building type | Buildings analysed |
|---|---|
| Small office buildings | Headquarters of the ADME and ODPIC (government agencies) |
| Large office buildings | New and old ministerial buildings<br>Headquaters of the EDD (national energy supplier) |
| Hospital | Hôpital Peltier |
| Walk in clinic | Polyclinique Farah Had |
| High school and middle school | Lycée Balbala |
| Primary school | Ecole Balbala II |
| Mosque | Mosquée Osman Ben Affan |
| Community center | CDC du Quartier 5 |

| New Ministerial building | Old ministerial building |
|---|---|
|  |  |

The following potential for energy saving and emission reduction was identified:

**Table 30: Energy savings and emissions reductions for example buildings in Djibouti**

| Building | Surface area ($m^2$) | Measures | Investment (€/$m^2$)* | Energy saving (%) | Energy saving in (kWh/year) | Expected emission reduction (KgCO2/year) |
|---|---|---|---|---|---|---|
| **Ministerial buildings (new and old)** | 8 061 | Roof insulation + replacement of window cooling units by split systems with EER of 3,5 + 2390 $m^2$ of rooftop PV | 81.6 | 49.5 | 485 400 | 515 034 |
| **EDD headquarters** | 2 500 | Roof insulation + replacement of window cooling units by split systems with EER of 3,5 + 650 $m^2$ of rooftop PV | 153 | 73.5 | 417 500 | 266 783 |
| **ADME headquarters** | 180 | Light color painting + 60 $m^2$ of rooftop PV | 133.3 | 54 | 14 200 | 10 480 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **ODPIC headquarters** | 180 | Light color painting + 54 m$^2$ of rooftop PV | 120 | 56 | 11 900 | 9 074 |
| **Osman Ben Affan Mosque** | 1 550 | Roof insulation + optimizing the settings of the current cooling system + 300 m$^2$ of rooftop PV | 131 | 66 | 140 000 | 89 460 |
| **Quartier 5 community development center** | 500 | Roof insulation + optimizing the settings of the current cooling system + 30 m$^2$ of rooftop PV | 60 | 57 | 10 000 | 6 390 |
| **Balbala high school** | 4 700 | 950 m$^2$ of rooftop PV | 80.9 | 49.5 | 220 000 | 140 580 |
| **Balbala primary school** | 1 800 | 95 m$^2$ of rooftop PV | 21.1 | 48.0 | 22 000 | 14 058 |
| **Peltier hospital** | 18 500 | Roof insulation + replacement of window cooling units by split systems with EER of 3,5 + 5106 m$^2$ of rooftop PV | 182 | 58.6 | 2 535 000 | 1 619 865 |
| **Farah Had clinic** | 1 012 | Roof insulation + 289 m$^2$ of rooftop PV | 138.9 | 54.9 | 119 400 | 76 297 |
| **TOTAL** | **38 983** | | **134,6** | | **3 975 000** | **2 540 281** |

**Investment excluding engineering cost*
*Currency conversion ratio used: 200 francs Djibouti =1 €*

The study showed that the energy renovation investments would create 3 975 MWh of electricity savings, which is equivalent to an average of 53% energy savings across all buildings. If we add the engineering costs as well as putting in place an energy consumption monitoring platform and providing the necessary training for its use, the total investment is estimated at around 7 M€.

It should be noted however that whilst this case study is limited in scope to the 11 buildings listed above and amounting to a total floor area of about 39,000 m2, a total investment amount excluding engineering costs of 5.25 MEUR and an average of 53% of energy savings across all buildings, the final subproject that is included in the PEEB Cool program will target 60,000m2 of floor area. Moreover, as the cost/m2 increases the more energy is saved, in the mitigation impact assessment chapter of the feasibility study, we considered a lower cost/m2 for achieving the 40% package as well as an even lower cost/m2 for achieving the 20% package.

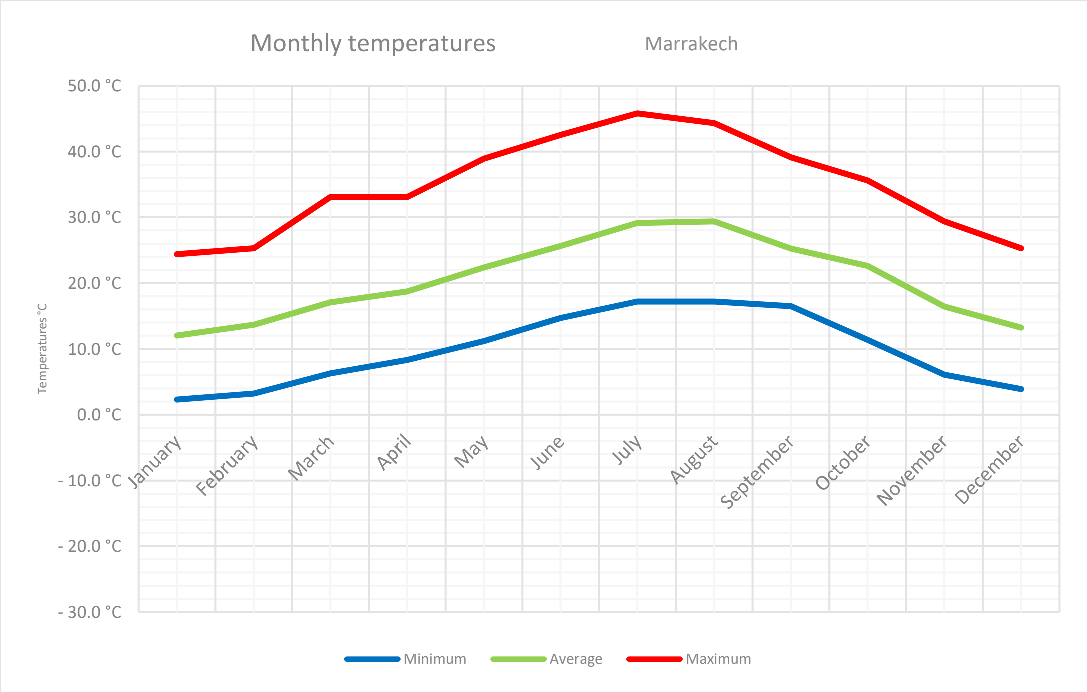
### 5.3.2.Construction of mid-income housing in Morocco

The government of Morocco intends to implement a large housing construction program. Within the framework of PEEB, AFD asked TERAO to carry out a technical and economic feasibility study aiming at energy savings and carbon emissions reductions for this program.

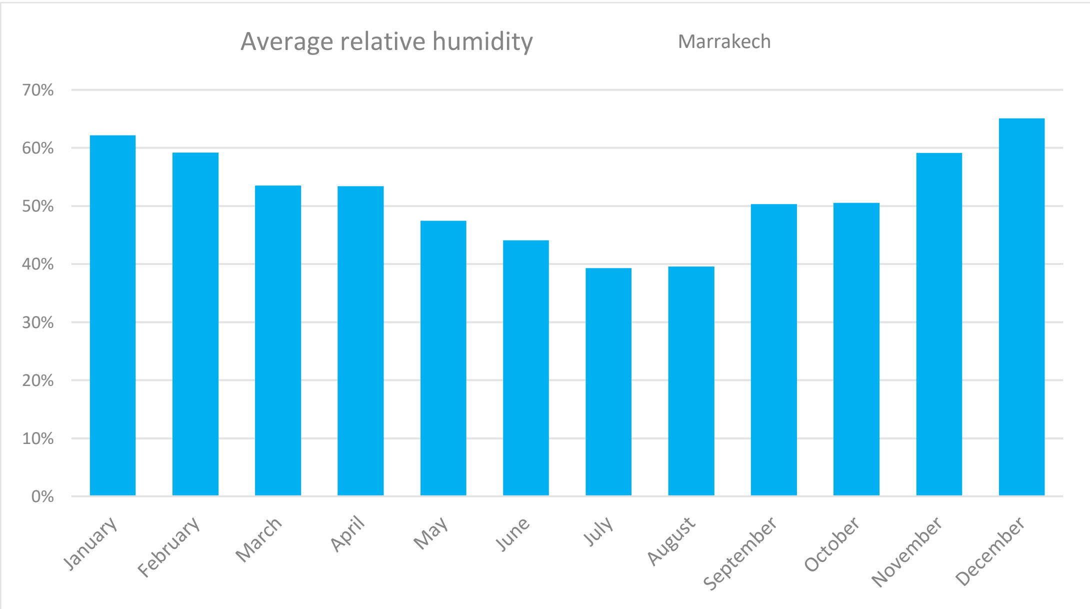
This project is presently in the PEEB Cool pipeline of subprojects along with many other similar housing construction subprojects. Since the adaptation chapter already includes a case study for social housing in Ecuador, we will focus in this case study on the mid income housing segment of this subproject, which compared with social housing is the one that has the most mitigation impact potential.

Morocco’s thermal regulation identifies 6 different climate zones. Whereas the full study looked at all 6 climate zones of Morocco, we have selected in this case study the results for mid income housing in Morocco’s climate zone N°5, represented by the climate of Marrakech.

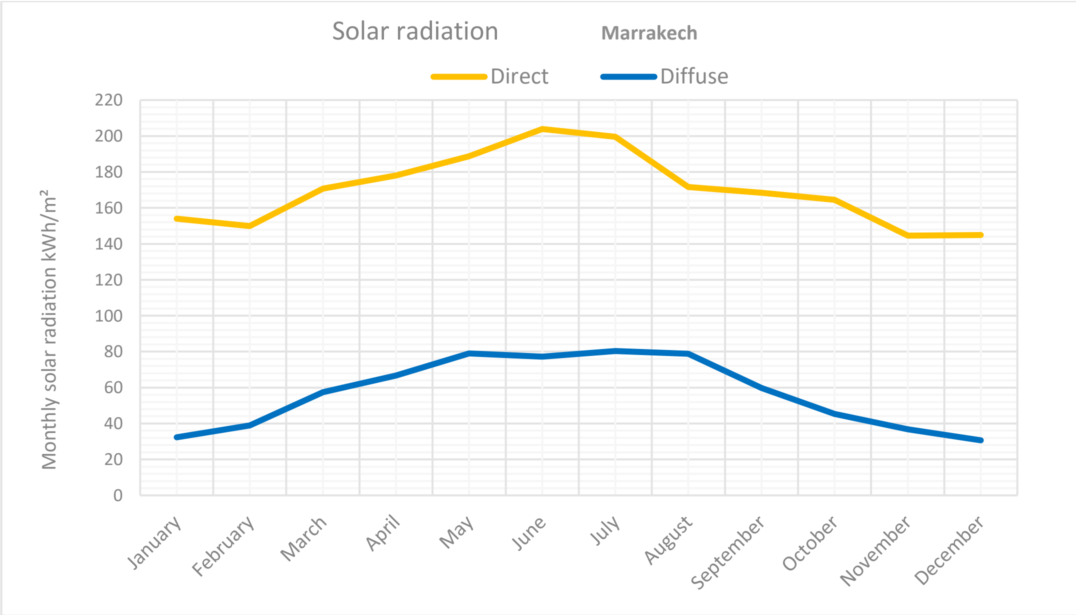
Marrakech is a hot semi-arid climate. The hot season extends from March to November. From November to March temperatures remain mild.




*Monthly outdoor temperatures*




*Monthly relative humidity*




*Monthly solar radiation (direct and horizontal diffuse)*

**Figure 25: Climate parameters for Morocco**

The building house simulated is 948m$^2$ composed of 12 housing units of 70m$^2$ each (5 rooms). It is representative of the type of mid income housing units that are to be built as part of the program.

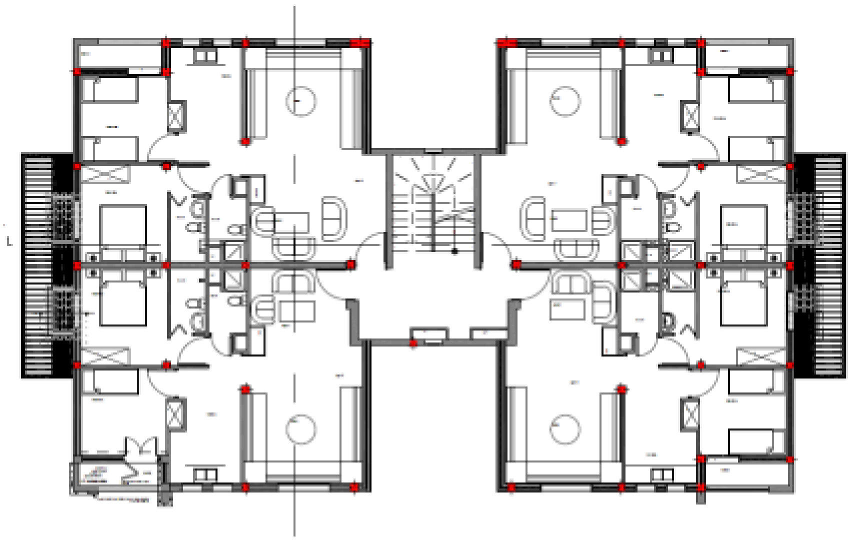


**Figure 26: Mid income housing building as part of the housing project in Morocco – Layout of the apartments**

There are 5 occupants. The housing units have cooling and electrical domestic hot water systems in place as well as washing machines, gas cooker, electric oven, fridge and other typical household equipment.

All assumptions for the baseline building and for the improved building were checked and validated by Al Omrane, Morocco's national public developer who would be the main entity implementing the program.

The baseline building has the following construction features:

- Walls with 6cm insulation, roof with 5cm insulation, floor with 2cm insulation,
- Double glazing window with solar control film,
- Building envelope is not very airtight.

To save on energy, findings show that the best results were obtained by combining the following measures:

- 8cm of insulation on walls, 10 cm on the roof, 4cm on the floor,
- Split cooling system with higher efficiency (class A)
- Highly efficient fridge (class A++)
- Nighttime natural ventilation 2 vol/h
- DHW solar production by individual thermosiphon

The incremental cost estimate of implementing such measures is given below:

| Indicator | Cost estimate (€/m2)* |
|---|---|
| **Baseline** | **573** |
| **Improved building** | **607** |
| **% increase** | **5.8%** |

**Investment excluding engineering cost*

*Currency conversion ratio used: 10.75 Moroccan dirhams =1 €*

In the 2020 climate, the following results were obtained:

| | Scenarios | Results |
|---|---|---|
| **Energy consumption ($kWh/m^2/y$)** | **Baseline** | **73.1** |
| | **Improved building** | **42.8** |
| | **% reduction** | **-41%** |
| **Emissions CO2 during building operation ($kgCo2eq/m^2/y$)** | **Baseline** | **32** |
| | **Improved building** | **19** |
| | **% reduction** | **-40%** |

We then studied the results from applying the same measures under 2050 climate conditions. Meteonorm weather files projected to 2050 in accordance with the RCP 2.6 scenario were used.

In the 2050 climate, the following results were obtained:

| | Scenarios | Results |
|---|---|---|
| **Energy consumption ($kWh/m^2/y$)** | **Baseline** | **73.8** |
| | **OPTIMUM PACKAGE** | **44** |
| | **% reduction** | **-40%** |
| **Emissions CO2 during building operation ($kgCo2eq/m^2/y$)** | **Baseline** | **32** |
| | **OPTIMUM PACKAGE** | **19.5** |
| | **% reduction** | **-39%** |

### 5.3.3. Construction of a shopping mall in an equatorial climate

Proparco is financing the construction of a shopping mall in an equatorial climate country.

The climate is similar to many other countries that are part of the PEEB Cool program and it is likely that some of the subprojects financed through PEEB Cool will involve similar building types.

Excluding the parking lot, the total floor area of the building is 25,000 $m^2$.

Figure 27: Computer Generated Image of the Shopping Mall

The assumptions made for the baseline and improved buildings are based on the same assumptions made in the chapter (of the PEEB Cool feasibility study) regarding the technical assessment of mitigation impact potential.

The following assumptions were made for the baseline scenario:

- Window to wall ratio of 50%,
- Reinforced concrete slab floor,
- Reinforced concrete slab roof with insulation,
- Poured concrete exterior walls with insulation,
- SG Windows with aluminum frame,
- Airconditioning system with an EER of 6.1.

To save on energy, findings show that the following combination of measures achieved 23% energy savings:

- Low energy lighting,
- AHU sensible cooling recovery,
- Use of variable speed fans and pumps.

Adding the following measures achieved 40% energy savings:

- Highly reflective roof coating,
- White color painting used on walls,
- Low E double glazing windows,
- Use of rooftop solar PV to cover 20% of electricity demand.

The incremental cost estimate for 23% energy savings is given below:

| Indicator | Cost estimate (€/m2)* |
|---|---|
| **Baseline** | **1700** |
| **Improved building** | **1777** |
| **% increase** | **4.5%** |

**Investment excluding engineering cost*

The energy saving and emission reduction results are summarized below:

**Table 31: Energy saving and emissions reductions for a shopping mall in a tropical country**

| | *Baseline* | *20% EE scenario* | *40% EE scenario* |
|---|---|---|---|
| **Energy consumption (kWh/m². year)** | | | |
| Total final energy consumption | **217** | **168** | **129** |
| Heating | NA | NA | NA |
| Air conditioning (including fans and pumps) | 48 | 34 | 25 |
| DHW | 14 | 14 | 8 |
| Lighting | 62 | 26 | 21 |
| Refrigeration | 11 | 12 | 9 |
| Catering | 45 | 45 | 36 |
| Other equipment | 37 | 37 | 30 |
| **CO2 Emissions** | | | |
| $kgCO_2/m^2/year$ | **75** | **46** | **35** |

## 5.5. Calculation of adaptation impact, including the number of beneficiaries

### 5.5.1.Comfort diagrams

In order to evaluate if a building is properly adapted to the hotter climate which will prevail in the future, we use international standards of comfort, we then compute by thermal dynamic simulations in a given climate the number of uncomfortable hours during occupancy for both the base case building and the improved building and we compare the results. If the improved building is well adapted to a hotter climate, the number of uncomfortable hours should significantly decrease, when compared to the base case.

The thermal comfort assessment method chosen for the feasibility study is based on the 'ASHRAE 55-2017 Thermal Environmental Conditions for Human Occupancy 'standard[26]

The thermal comfort of the occupants of a room is directly linked to the level of balance of thermal exchanges with their environment, and to psychological and cultural acceptability factors.

The thermal exchanges between the occupant and his environment depend on:

- Characteristics of the indoor environment:
- Air temperature: heat exchange by conduction and convection
- Surface temperature of the walls (radiant temperature): radiative exchanges
  The average of these temperatures is the operating temperature of the room
- Relative air humidity: cooling by evapo-transpiration or sweating
- Air speed: promotes exchange by convection and evapotranspiration. However, it is recommended not to exceed 0.8 m/s in order to maintain mechanical comfort (otherwise light papers on a table start to move)

The characteristics of the occupant:

- Metabolism: level of activity and associated heat production
- Clothing: provides thermal resistance

On the basis of statistical data, the international standard establishes, for an occupant (metabolism, clothing) and a given air speed, the operating temperature and relative humidity limits of the indoor air in which at least 90% of the occupants are satisfied with their thermal environment. In some cases, such as hot climates and naturally vented buildings, this limit can be pushed to 80% of occupants being satisfied.

These comfort zones can be represented on psychrometric diagrams as below:

[26] Thermal Environmental Conditions for Human Occupancy – ANSI/ASHRAE Standard 55-2017

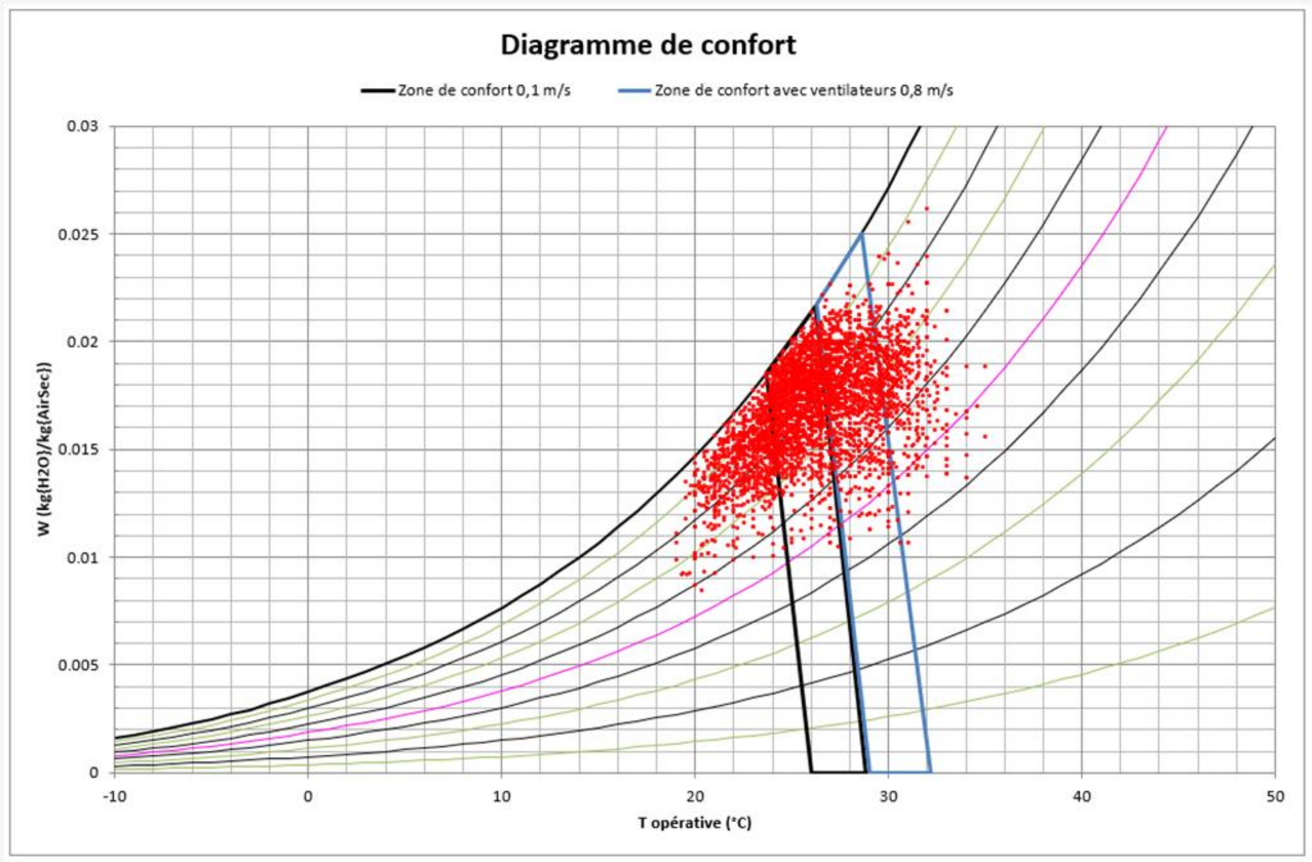



**Figure 28: Comfort zones for occupants in summer clothing, with a moderate activity, for 2 air speeds according to Ashrae 55-2017**

*Note: Within the polygons 90% of occupants are satisfied - Example of a tropical zone. The y axis represents the absolute humidity of the air. The curves represent the relative humidity of the air starting from 10% at the bottom to 100% (saturated air) at the top.*

In the example above, each red point represents the hourly outdoor conditions according to the weather data used for the simulations.

The black polygon shows the points that meet the comfort criteria without air movement, with a low speed of 0.1m/s. The blue polygon indicates the additional amplitude given to the comfort zone thanks to the use of fans enabling the air speed to reach 0.8 m/s.

The bottom group of points represents lower humidity conditions, the top points higher humidity. For each air speed (0.1m/s - black polygon, 0.8m/s - blue polygon), the points to the right of the corresponding polygon represent hours of discomfort related to high temperatures.

Dynamic thermal simulations make it possible to determine the temperature and humidity conditions during the hours of occupancy for the premises under study and to estimate the number of hours of discomfort during occupancy.

### 5.5.2. Case studies

The following three case studies come from previous PEEB studies. They are relevant for this feasibility study as they concern climatic zones which are relevant for the PEEB Cool program.

To study the projects in the 2050 climate, we used projected weather files from Meteonorm according to the RCP 2.6 scenario up to the year 2050 as explained above (section 5.3.2).

#### 5.5.2.1. A school in a tropical zone

Comoros has a tropical climate similar to the one in the coastal area of Ecuador. There is a short "dry" season in May-June-July but most of the year is humid.

We have used a climatic file for the year 2020 from the Moroni/Iconi Airport weather station, provided by Meteonorm.

The average yearly temperature is 27°C and the average relative humidity is 76%.

Table 32: Monthly outdoor temperature data for Comoros (tropical zone)

| Month | Minimum | Average | Maximum |
|---|---|---|---|
| January | 23,1 °C | 28,0 °C | 33,5 °C |
| February | 23,4 °C | 27,9 °C | 32,9 °C |
| March | 23,1 °C | 28,3 °C | 34,7 °C |
| April | 22,2 °C | 27,8 °C | 33,9 °C |
| May | 21,4 °C | 27,5 °C | 33,3 °C |
| June | 19,6 °C | 26,0 °C | 32,6 °C |
| July | 17,6 °C | 25,5 °C | 32,3 °C |
| August | 18,5 °C | 25,3 °C | 31,5 °C |
| September | 18,9 °C | 25,3 °C | 31,1 °C |
| October | 20,3 °C | 26,7 °C | 32,8 °C |
| November | 22,9 °C | 27,3 °C | 34,0 °C |
| December | 23,0 °C | 28,1 °C | 33,9 °C |
| **Yearly** | **17,6 °C** | 27,0 °C | **34,7 °C** |

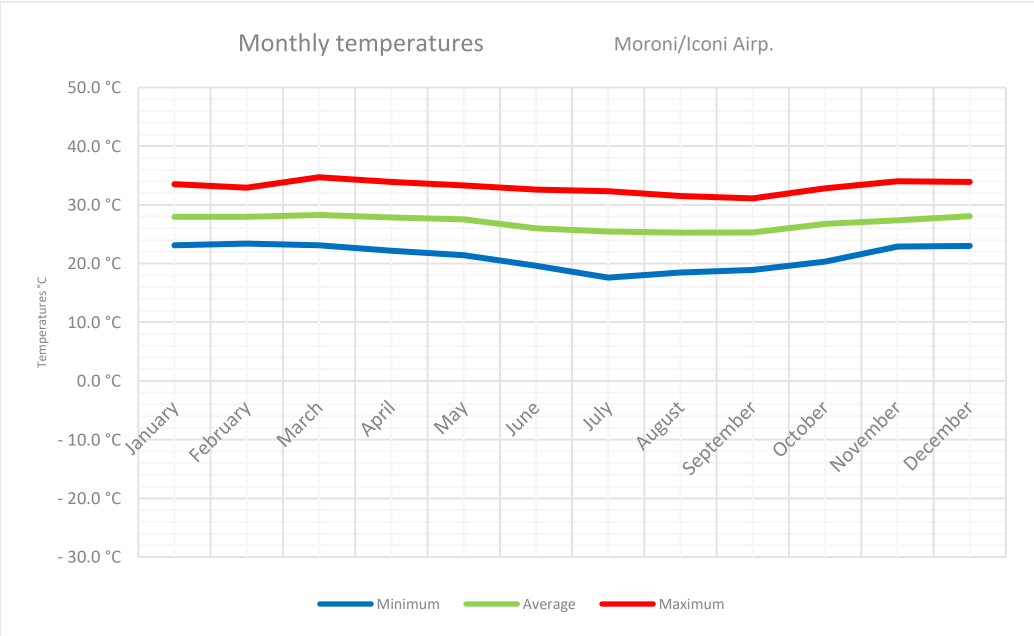



Figure 29: Monthly outdoor temperatures for Comoros (tropical zone)

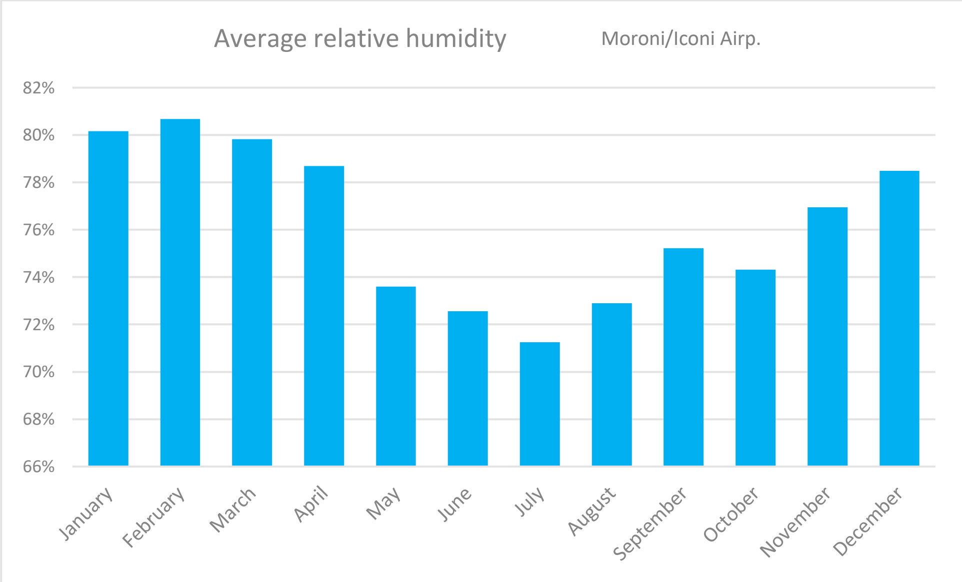



**Figure 30: Monthly relative humidity level for Comoros (tropical zone)**

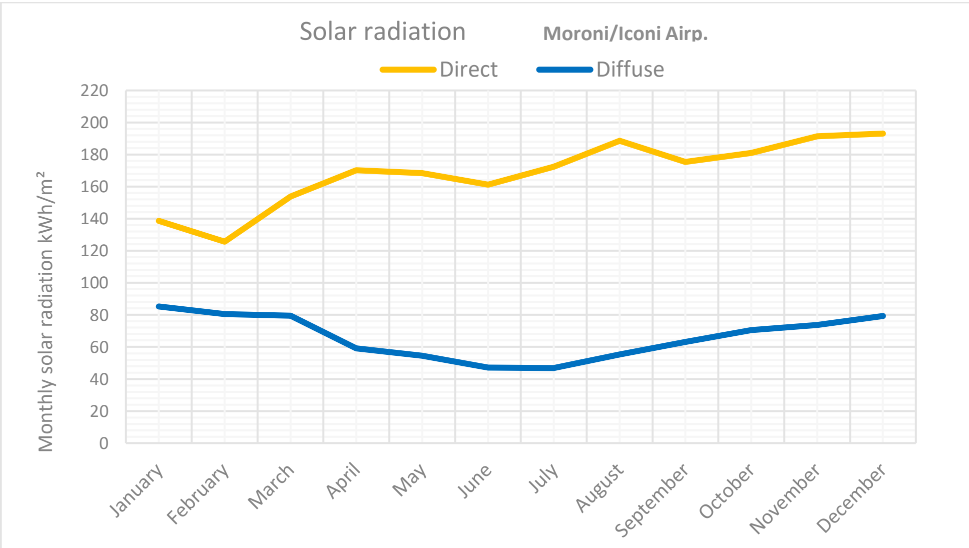
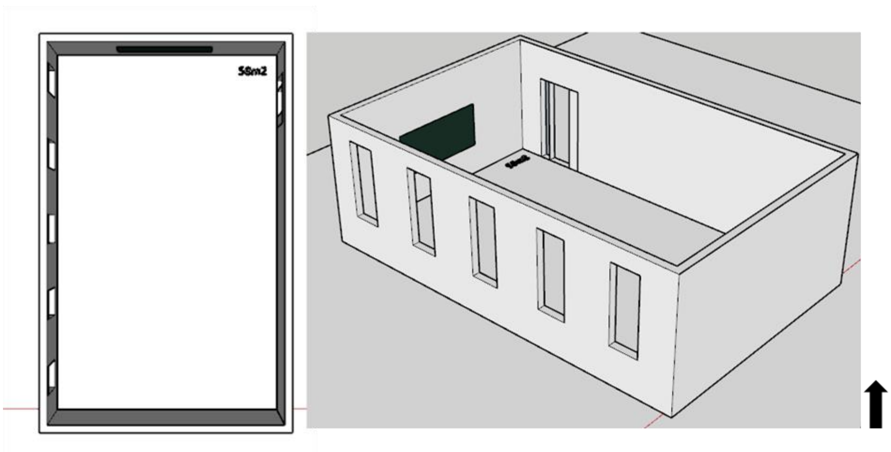



**Figure 31: Monthly solar radiation for Comoros (direct and horizontal diffuse)**

A typical modular classroom has been studied and modelled with the software Design Builder/Energy+.



We made assumptions for the baseline building and for the improved building.

The baseline building has the following construction features:

- cement blocks
- sheet metal roof
- single glass metallic frame windows.

The improved building has the following construction features:

- external walls made of raw earth
- light-colored over-roof protecting the ceiling from sunshine
- deep overhangs to protect the external walls and windows from sunshine.

The windows make it possible to have an important natural ventilation.

In the 2020 climate, the baseline case has **89% of its occupancy hours (occupancy hours are the hours when students are in the building) outside of the comfort zone** (the one set for an internal air velocity of 0.8 m/s), with a maximum indoor operative temperature reaching 52°C.

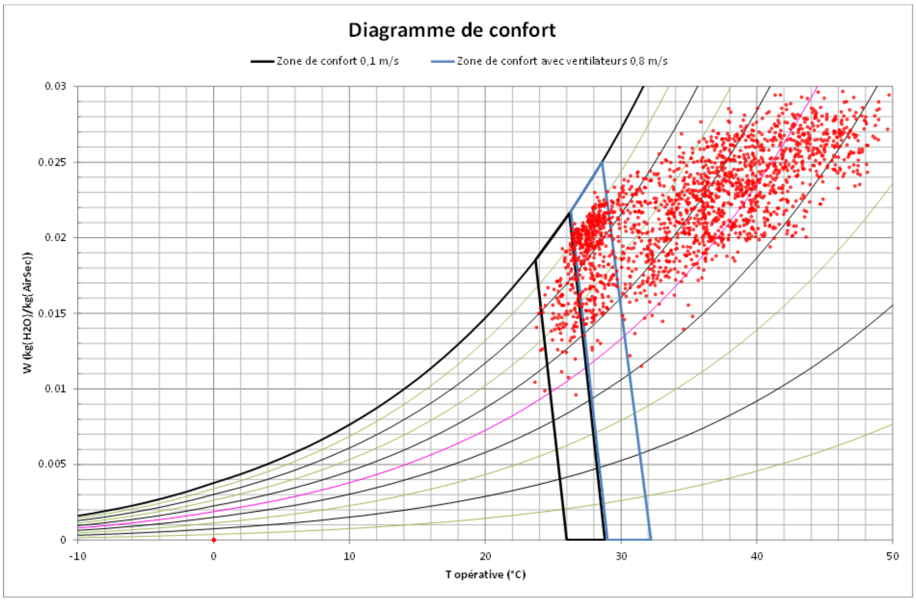



**Figure 32: Occupancy hours within and outside the comfort zones in a school in a tropical zone**

*Note: Each red dot represents an hourly indoor condition) – Baseline case – 2020 Climate)*

In the same 2020 climate, the improved case has **53% of its occupancy hours outside the comfort zone**, with a maximum indoor operative temperature reaching 34°C, **a drop of 18°C** as compared to the baseline case.

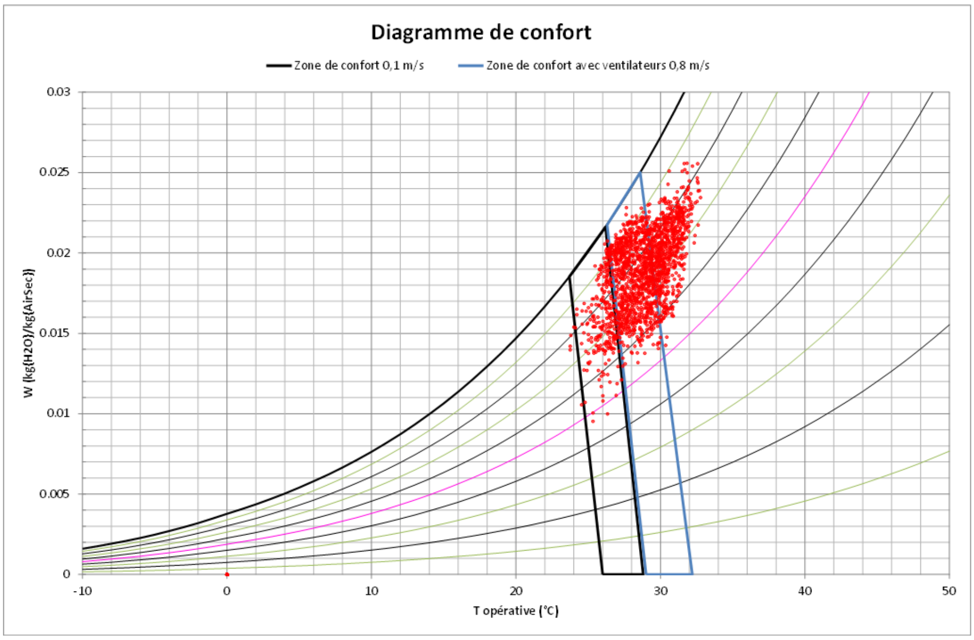



**Figure 33: Occupancy hours within and outside the comfort zones in a school in a tropical zone**

*Note: Each red dot represents an hourly indoor condition – Improved case – 2020 Climate*

The improved case has been simulated in a 2050 climate (RCP 2.6 scenario). The number of uncomfortable hours **rose to 67%** but the indoor operative temperature **remained under or equal to 34°C at all times, thereby substantially limiting the number of hours with very high temperatures which studies have shown can lead to reduction in learning (study referenced in chapter 2.2.2.2.3)**.

The cost of the baseline classroom has been evaluated in Comoros at 370 €/m$^2$.

The cost of the improved case has been evaluated at 485 €/m$^2$which has been deemed acceptable in the context of the overall project, due to the large decrease of uncomfortable hours and the benefit brought to the students.

#### 5.5.2.2. Social housing in tropical climate (Ecuador)

Within the framework of PEEB, AFD has engaged TERAO for a support mission to the Ministry of Housing of Ecuador (MIDUVI) and to the public company "Casa para Todos (CPT-EP)" which concerns a social housing project financed by AFD in order to:

- Analyze and revise standard plans;

- Analyze and revise the specifications for the construction of houses;

- Propose strategies to improve energy and environmental performance.

Figure 34: Single family house “Casa para todos”

The climatic file used is that of the Guayaquil meteorological station which is in the coastal area of Ecuador.

Ecuador has a tropical climate. It is humid with high temperatures and significant diffuse and direct solar radiation.

Table 33: Monthly outdoor temperature data for Guayaquil (tropical zone)

| Month | Minimum | Average | Maximum |
|---|---|---|---|
| January | 21,5 °C | 26,6 °C | 33,1 °C |
| February | 21,4 °C | 26,4 °C | 33,3 °C |
| March | 21,6 °C | 27,0 °C | 33,8 °C |
| April | 22,4 °C | 26,7 °C | 33,4 °C |
| May | 21,2 °C | 26,4 °C | 33,7 °C |
| June | 19,5 °C | 24,8 °C | 32,7 °C |
| July | 19,3 °C | 24,4 °C | 32,8 °C |
| August | 19,0 °C | 24,1 °C | 32,6 °C |
| September | 19,7 °C | 24,1 °C | 33,0 °C |
| October | 19,3 °C | 24,5 °C | 32,2 °C |
| November | 19,3 °C | 24,7 °C | 32,6 °C |
| December | 21,0 °C | 26,5 °C | 33,9 °C |
| **Yearly** | **19,0 °C** | 25,5 °C | **33,9 °C** |

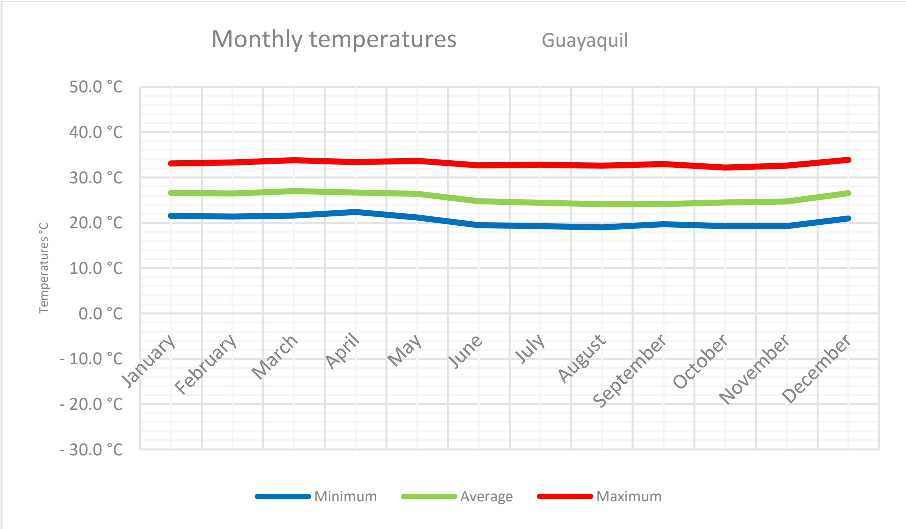



Figure 35: Monthly outdoor temperatures for Guayaquil (tropical zone)

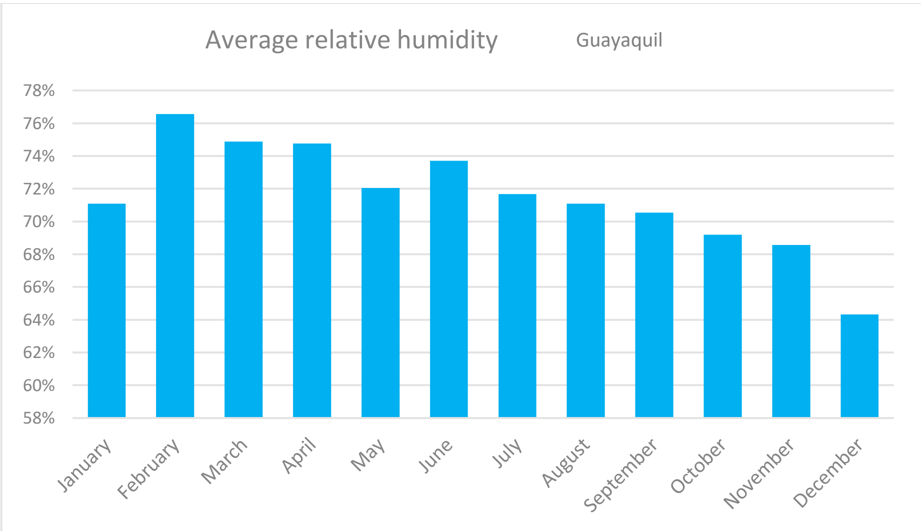



Figure 36: Monthly relative humidity level for Guayaquil (tropical zone)

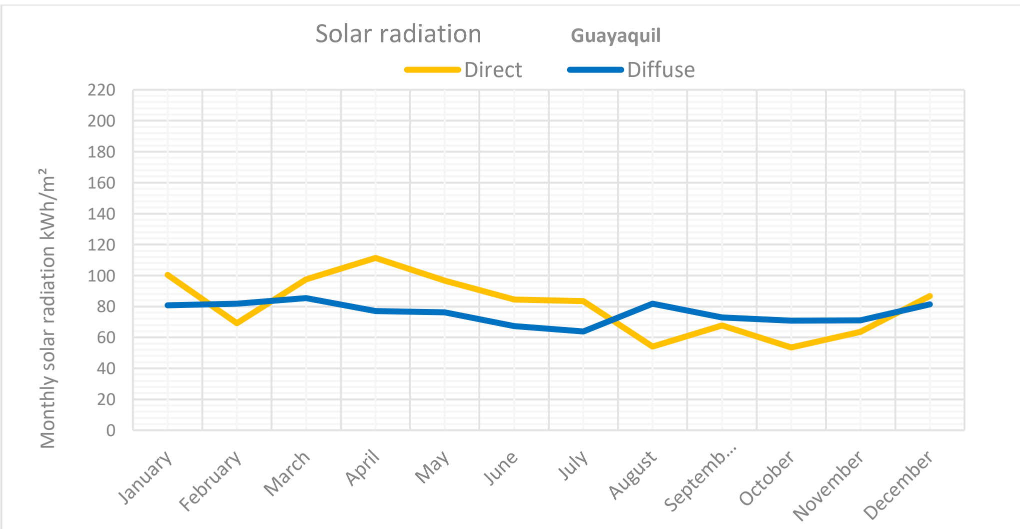


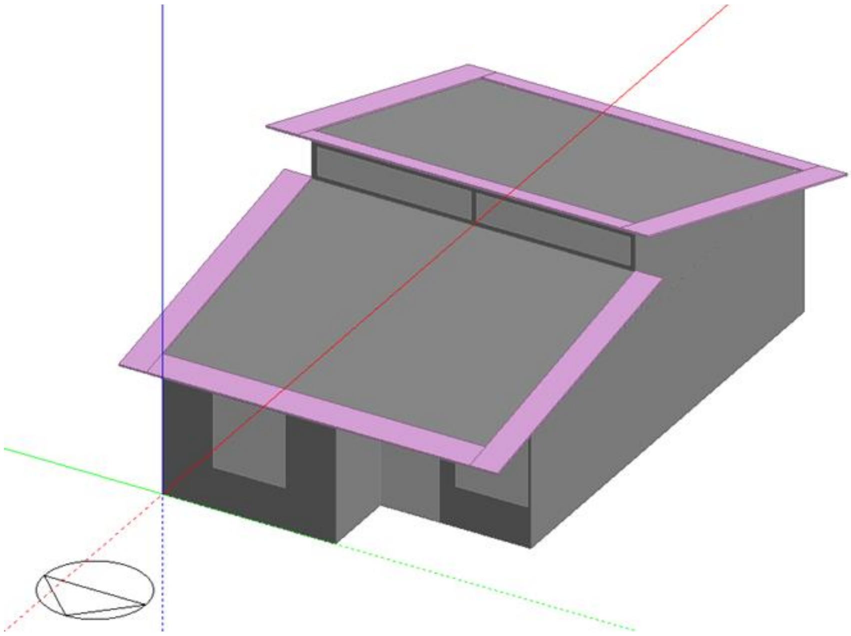

Figure 37: Monthly solar radiation for Guayaquil (direct and horizontal diffuse)

In 2050, according to the RCP 2.6 scenario, the average temperatures will be 0.7°C higher.

**Table 34: Monthly outdoor temperature data for Guayaquil (tropical zone)**

| Month | Minimum | Average | Maximum |
|---|---|---|---|
| January | 21,7 °C | 27,2 °C | 33,7 °C |
| February | 22,6 °C | 27,1 °C | 33,4 °C |
| March | 22,8 °C | 27,8 °C | 34,1 °C |
| April | 23,2 °C | 27,4 °C | 34,1 °C |
| May | 21,4 °C | 27,1 °C | 34,2 °C |
| June | 20,7 °C | 25,4 °C | 33,5 °C |
| July | 20,6 °C | 25,0 °C | 31,5 °C |
| August | 19,5 °C | 24,6 °C | 31,5 °C |
| September | 20,2 °C | 24,7 °C | 31,3 °C |
| October | 20,0 °C | 25,1 °C | 33,5 °C |
| November | 20,2 °C | 25,3 °C | 34,5 °C |
| December | 21,6 °C | 27,1 °C | 34,0 °C |
| **Yearly** | **19,5 °C** | 26,2 °C | **34,5 °C** |

The reference house has been modeled using Design Builder/Energy +.



*Architectural model (Design Builder)*

The house is composed of a porch, a living room, a kitchen, a bathroom and three bedrooms. Its total floor area is 57.3 $m^2$. There are 5 occupants.

We made assumptions for the baseline house and for the improved house.

The baseline house has the following construction features:

- cement blocks
- sheet metal roof
- single glass metallic frame windows.

The house has openings that enable natural ventilation. But the climate of Guayaquil is very hot, generating many hours of discomfort when the house is occupied.

The use of fans is necessary to expand the comfort ranges. Users need to be trained on the proper use of fans to limit associated energy consumption.

To improve comfort inside the house, findings show that the best results were obtained by combining the following measures:

- replacing envisaged roof by 4cm recycled tetra pack roof (λ = 0.22 W/m.K)
- adding 12 cm of insulation with rock wool under the roof (λ = 0.036 W/m.K)
- increasing the roof overhangs by 50 cm in all directions.
- adding a drop ceiling 1 cm thick.

In the 2020 climate, the baseline case has **40% of its occupancy hours (occupancy hours are defined as the hours when at least one occupant is inside the house) outside of the comfort zone** (the one set for still air), with a maximum indoor operative temperature reaching 40.4°C.

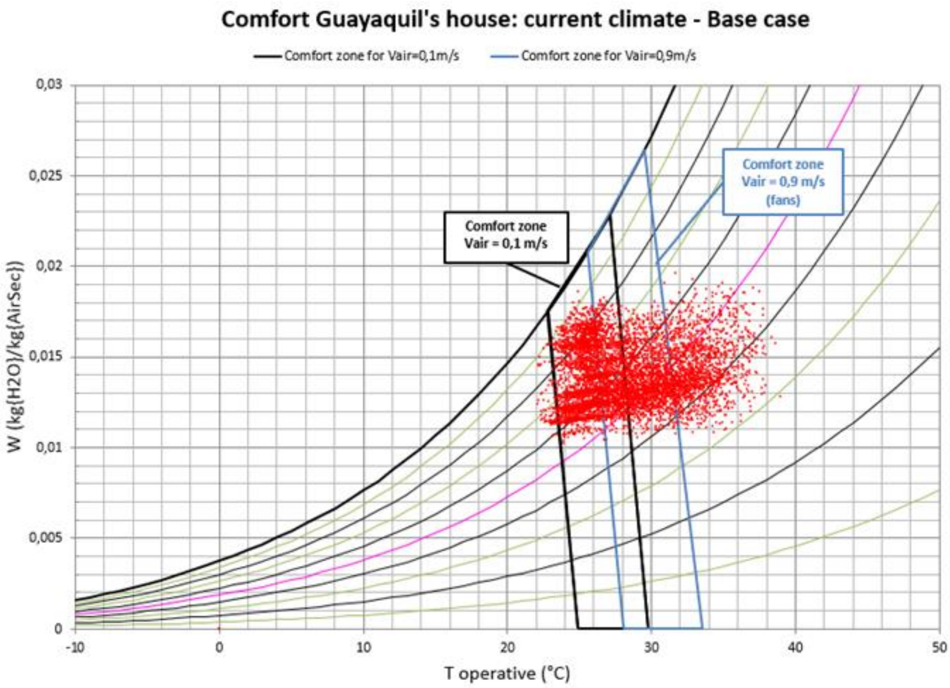



**Figure 38: Occupancy hours within and outside the comfort zones for a social house in Ecuador**

*Note: Each red dot represents an hourly indoor condition – Baseline case – 2020 Climate*

In the same climate, the improved case has **4% of its occupancy hours outside the comfort zone**, with the use of fans, with a maximum indoor operative temperature reaching 33.6°C, **a drop of 6.8°C** as compared to the baseline case. For this comparison we used comfort zones defined for a limit of 20% dissatisfied people.

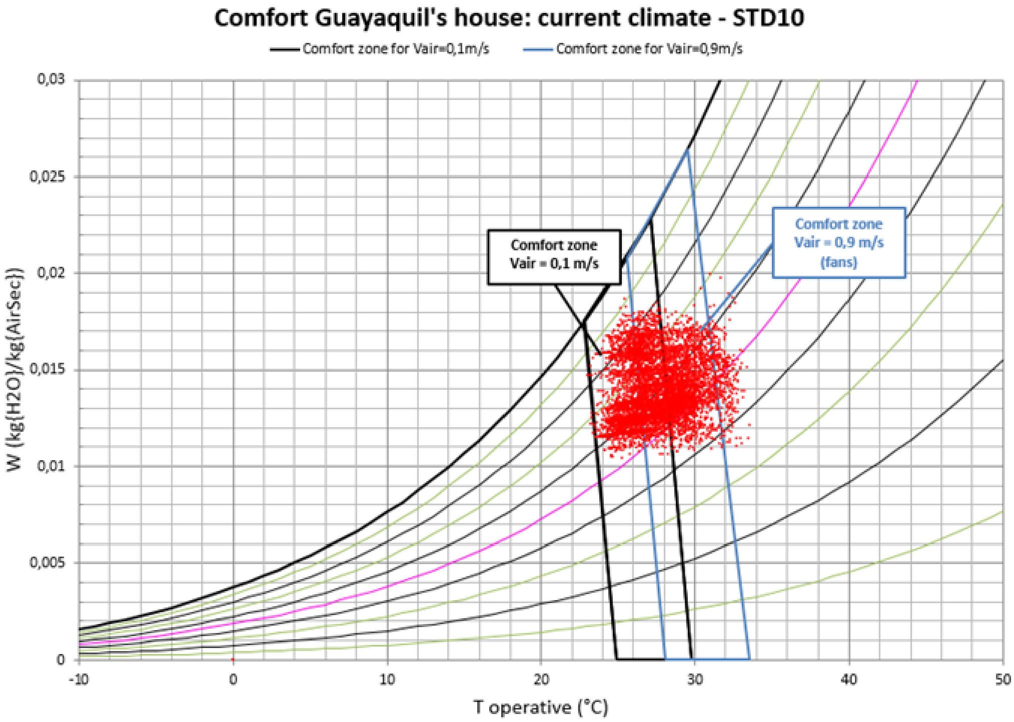



**Figure 39: Occupancy hours within and outside the comfort zones for social housing in Ecuador**

*Note: Each red dot represents an hourly indoor condition) – Improved case – 2020 Climate*

Both the baseline case and the improved case have been simulated in a 2050 climate (RCP 2.6 scenario).

The baseline case has **47% of its occupancy hours outside of the comfort zone** (the one set for still air), with a maximum indoor operative temperature reaching 39.2°C.

In the same climate, the improved case has **9% of its occupancy hours outside the comfort zone**, with the use of fans, with a maximum indoor operative temperature reaching 34.7°C, **a drop of 4.5°C** as compared to the baseline case.

Although the improved case behaves much better than the baseline case, the situation probably means that the occupants will mechanically cool at least one bedroom in order to remain under 32°C during the extreme heat waves. In such a case, when comparing baseline scenario and improved case, it is important to take into account "suppressed demand" for cooling.

The construction cost of the baseline case is 285 USD/m$^2$, a very low cost.

The improved case has a cost of 355 USD/m$^2$, i.e. an additional cost of 24% which is justified by the improved indoor conditions.

### 5.5.2.3. Health center in tropical climate (Sénégal)

Within the framework of PEEB, AFD has engaged TERAO for a support for the design of a health center in a tropical climate, specifically located in Bounkiling, south of Senegal. The work consisted in :

- Analyzing the design proposed by the architect;

- Proposing strategies to improve energy and environmental performance.

*Health Center studied*

The climatic file used is that of Ziguinchor meteorological station which is in the southern region of Senegal, not far (116 km) from Bounkiling. The climate is typical of a tropical climate with an alternance of dry and wet seasons.

**Table 35: Monthly outdoor temperature data for Ziguinchor (tropical zone)**

| Month | Minimum | Average | Maximum |
|---|---|---|---|
| January | 14,9 °C | 25,2 °C | 37,3 °C |
| February | 16,0 °C | 26,6 °C | 39,6 °C |
| March | 16,7 °C | 28,0 °C | 42,5 °C |
| April | 17,5 °C | 27,7 °C | 42,2 °C |
| May | 19,7 °C | 28,5 °C | 41,0 °C |
| June | 21,8 °C | 28,6 °C | 38,3 °C |
| July | 21,9 °C | 27,8 °C | 37,9 °C |
| August | 21,4 °C | 27,1 °C | 35,2 °C |
| September | 20,6 °C | 27,0 °C | 35,9 °C |
| October | 21,5 °C | 28,5 °C | 36,8 °C |
| November | 19,4 °C | 27,2 °C | 37,5 °C |
| December | 15,2 °C | 25,4 °C | 37,0 °C |
| **Yearly** | **14,9 °C** | 27,3 °C | **42,5 °C** |

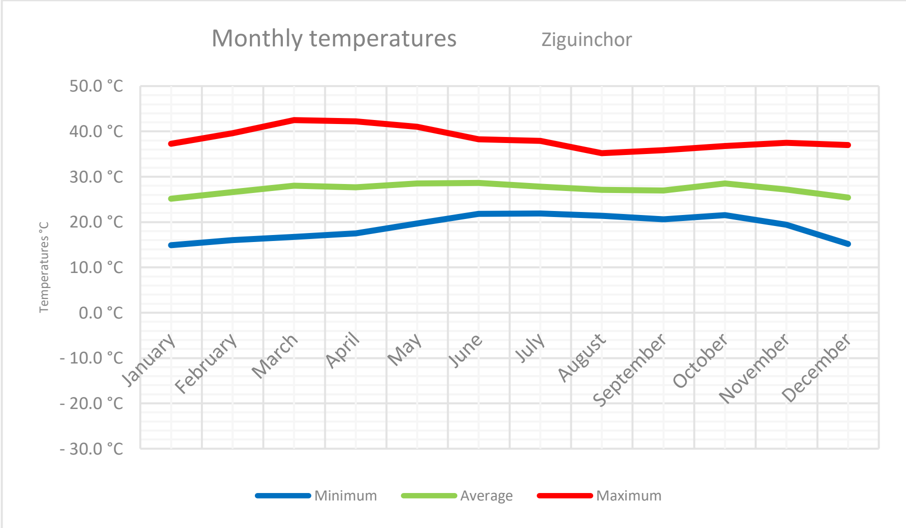



**Figure 40: Monthly outdoor temperatures for Ziguinchor (tropical zone)**

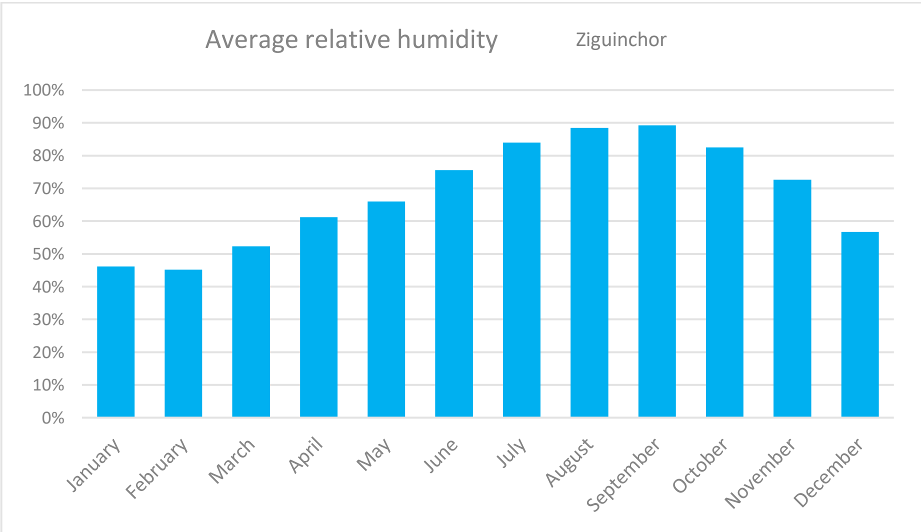



**Figure 41: Monthly relative humidity level for Ziguinchor (tropical zone)**

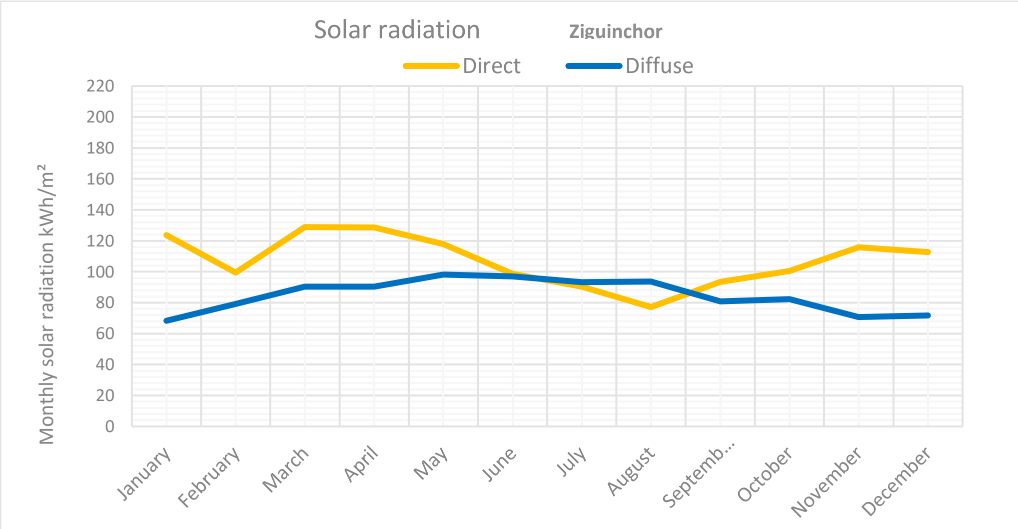



Figure 42: Monthly solar radiation for Ziguinchor (direct and horizontal diffuse)

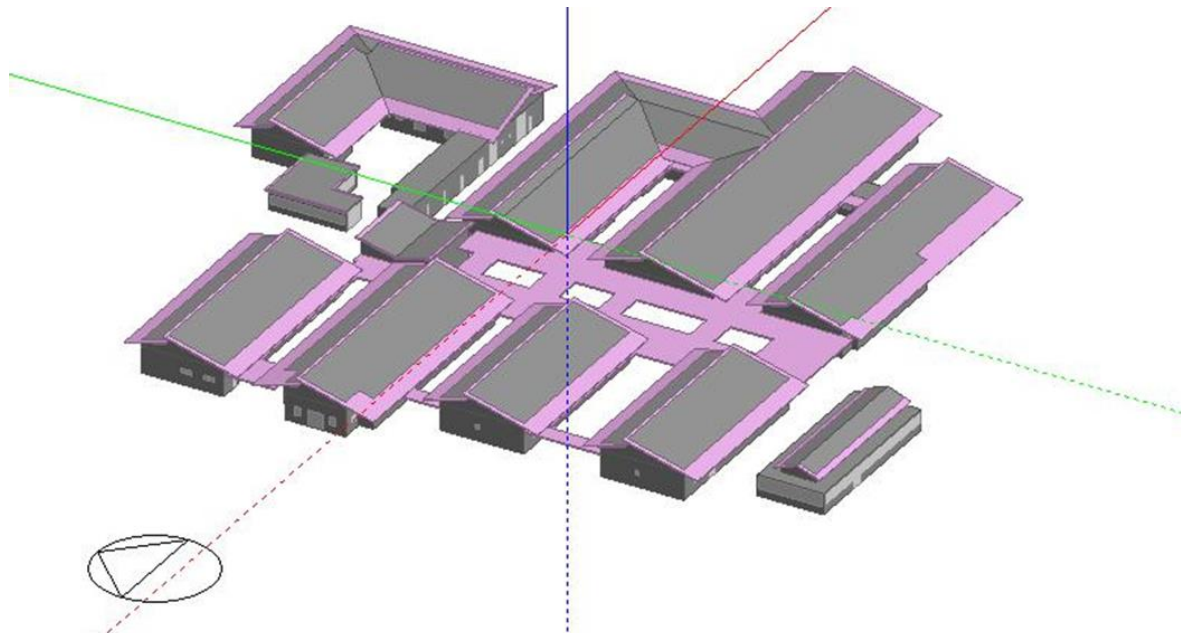
*Note: Direct and horizontal diffuse (kWh/m2.month)*

In 2050, according to the RCP 2.6 scenario, the average annual temperature will be 0.5°C higher.

Table 36: Monthly outdoor temperature data for Ziguinchor in 2050 (tropical zone)

| Yearly | Minimum | Average | Maximum |
|---|---|---|---|
| January | 15,4 °C | 25,7 °C | 38,2 °C |
| February | 15,5 °C | 27,0 °C | 40,6 °C |
| March | 17,2 °C | 28,5 °C | 42,9 °C |
| April | 18,0 °C | 28,1 °C | 42,6 °C |
| May | 20,4 °C | 29,0 °C | 41,5 °C |
| June | 22,3 °C | 29,1 °C | 38,4 °C |
| July | 22,1 °C | 28,4 °C | 38,7 °C |
| August | 22,2 °C | 27,7 °C | 34,9 °C |
| September | 21,2 °C | 27,6 °C | 36,4 °C |
| October | 22,4 °C | 29,0 °C | 37,7 °C |
| November | 19,7 °C | 27,9 °C | 37,4 °C |
| December | 16,4 °C | 26,1 °C | 37,5 °C |
| **Yearly** | **15,4 °C** | 27,8 °C | **42,9 °C** |

The health center has been modeled using Design Builder/Energy +.



*Architectural model (Design Builder)*

The center has a total area of 3200 m$^2$. 49% of the spaces are mechanically cooled. The remaining spaces are naturally ventilated. The occupancy ratio varies during the day. At its peak value there are 124 occupants, i.e an occupancy ratio of 0,039 persons/m$^2$.

We made assumptions for the baseline project, as proposed by the architect and for the improved project.

The baseline project has the following construction features:

- cement blocks
- sheet metal vented over-roof protecting a concrete slab roof
- single glass metallic frame windows.

The windows enable natural ventilation.

The use of fans is necessary to expand the comfort ranges in the rooms which are not mechanically cooled.

To improve the energy performance of the center and the indoor comfort in non-mechanically cooled spaces, findings show that the best results were obtained by combining the following measures:

- painting the roof with a light colour
- adding 4cm thick insulation on the concrete slab roof
- replacing the cement blocks by rammed earth blocks
- having roof overhangs of 2 m in all directions
- facilitating night time natural ventilation by providing the proper shutters
- generalizing the use of ceiling fans in non-cooled spaces

We looked at the comfort levels in several rooms which are not mechanically cooled.

For instance, in the rooms with 4 beds, which are naturally vented:

In the 2020 climate, the baseline room has **90% of its occupancy hours (occupancy hours are defined as the hours when at least one person occupies the room) outside of the comfort zone** (the one set for still air), with a maximum indoor operative temperature reaching 35.3°C.

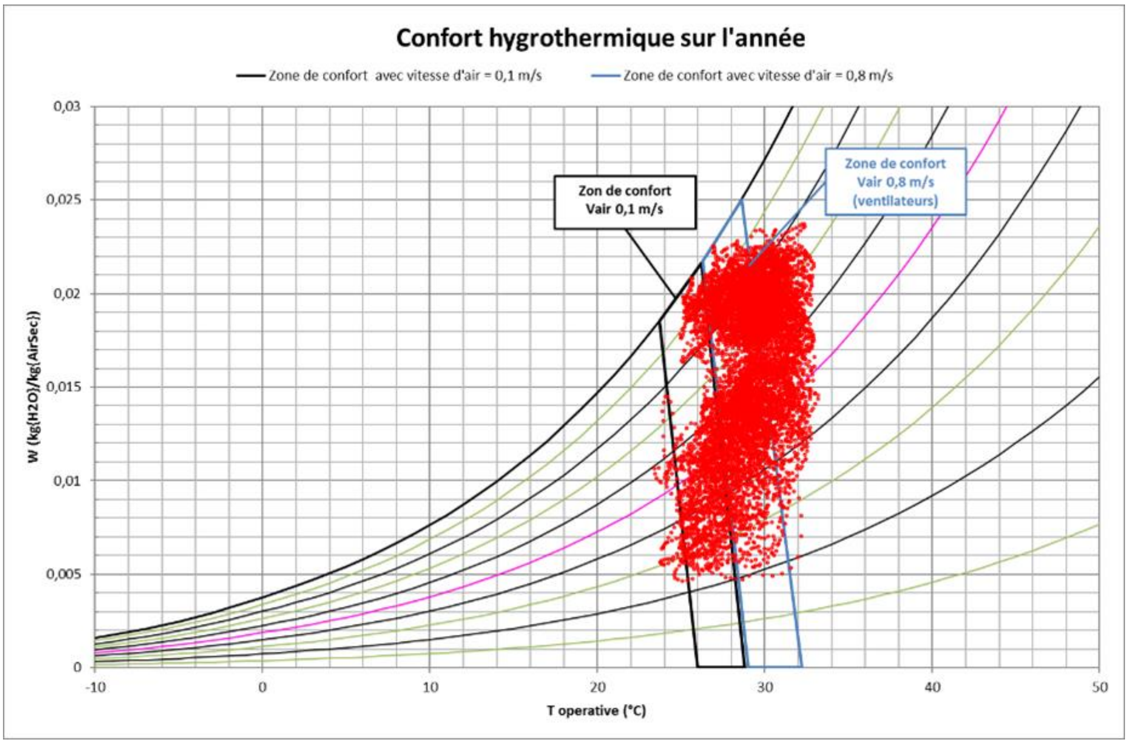



**Figure 43: Occupancy hours within and outside the comfort zones**

*Note: Each red dot represents an hourly indoor condition – Baseline room – 2020 Climate*

In the same climate, the improved case has **10% of its occupancy hours outside the comfort zone**, with the use of fans, with a maximum indoor operative temperature reaching 31.7°C, **a drop of 3.6°C** as compared to the baseline case. For this comparison we used comfort zones defined for a limit of 10% dissatisfied people (and not 20% as for houses, as in health centers we need to be more cautious).

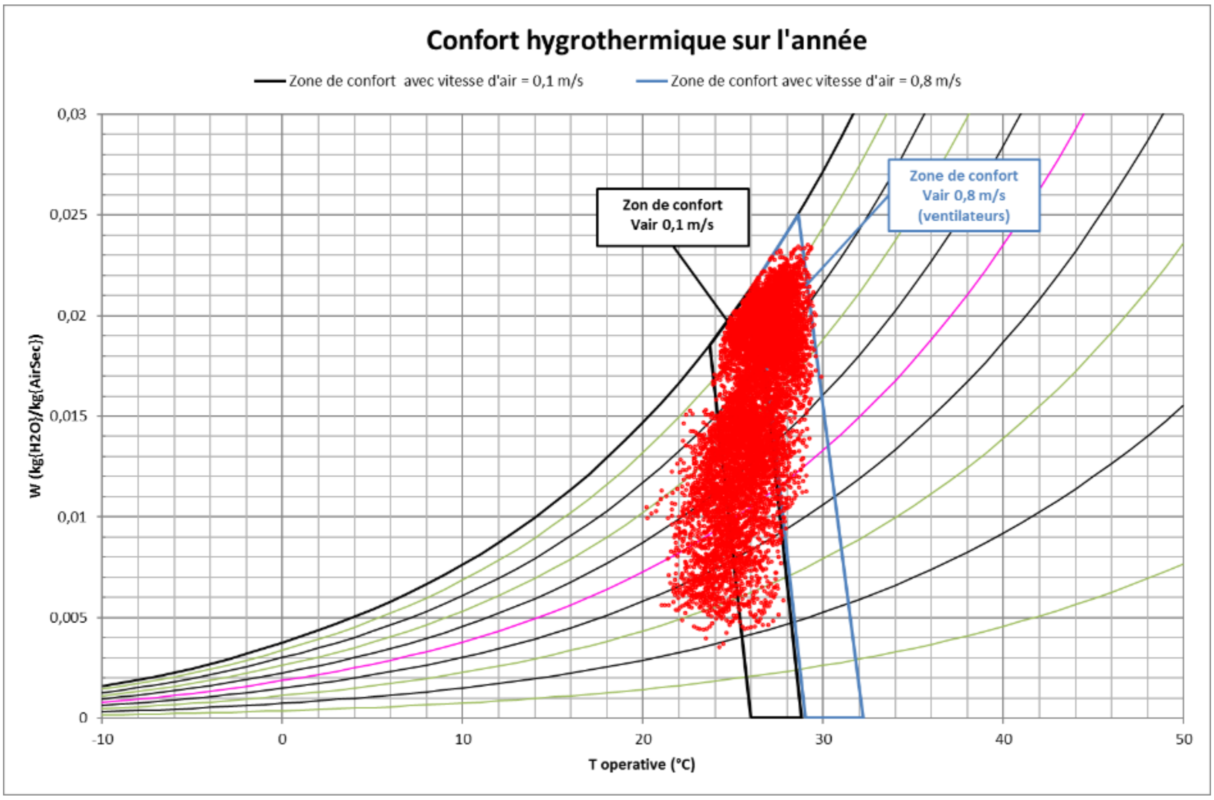



**Figure 44: Occupancy hours within and outside the comfort zones in a Health Center in a tropical climate**

*Note: Each red dot represents an hourly indoor condition) – Improved case – 2020 Climate*

Both the baseline case and the improved case have been simulated in a 2050 climate (RCP 2.6 scenario).

The baseline case has **92% of its occupancy hours outside of the comfort zone** (the one set for still air), with a maximum indoor operative temperature reaching 35.6°C.

In the same climate, the improved case has **17% of its occupancy hours outside the comfort zone**, with the use of fans, with a maximum indoor operative temperature reaching 32.2°C, **a drop of 3.4°C** as compared to the baseline case.

The maximum indoor operative temperature is just slightly over the 32°C limit showingthe resilience of the proposed modified project with global warming taken into account.

The construction cost of the baseline health center is 572 €/m$^2$. The construction cost of the improved project is 613 €/m$^2$, i.e. an extra cost of 7.1%.

### 5.5.3. Direct beneficiaries

Having pieced together the surface areas of each building type, we can estimate the number of direct beneficiaries.

Direct beneficiaries are defined as the users of buildings whose construction or renovation is financed by the PEEB Cool Programme. According to the Programme targets, in buildings without mechanical cooling PEEB Cool support will lead to an increase of at least 20% in thermal comfort of users of the building, and often this number will be much higher.

To assess the number of beneficiaries for PEEB Cool, the subproject portfolio that was analyzed was broken down by building type after having defined the direct beneficiaries for each building.

In the residential sector the beneficiaries were calculated based on the number of households to be built/retrofitted in each country multiplied by the members of household in each country taking into consideration the assumption that a household will reside in a house for 25 years.

Education direct beneficiaries were assessed based on an average occupancy density of 5m2/person. It is assumed that a child will remain in the same school for 5 years so for a period of 15 years the turnover ratio equals to 3.

Direct beneficiaries of the health sector were assessed based on the number of people served by health center/hospital per country. Beneficiaries correspond to the population covered and therefore are unique, even though they could use the healthcare services several times in the 15-year programme period.

Similarly to the case of education commercial use beneficiaries have been based on the default occupancy density form the EDGE app. It was further assumed that during the 25 years period 1 business will use the same space.

In particular, direct beneficiaries were estimated following the methods presented below:

**Housing Units:**

$B_D=A_c/A_h*H_c*T$

$B_D$: Direct Beneficiaries(residents)

$A_c$: Area to be built per country

$A_h$: Average area of a house based on the default area used by EDGE software

$H_c$: Size of the household per country

T: residents turnover factor. The factor is equal to one (1) assuming that in 15 years one households will be using the house.

**Schools:**

$B_D=A_c/A_s*S*T$

$B_D$: Direct Beneficiaries (students)

$A_c$: Area to be built per country

$A_s$: Average area of a school based on the default area used by EDGE software

S: School occupancy density based on the default density used by EDGE software

T: students' turnover factor. The factor is equal to three (3) assuming that each student will remain in school for 5 years

**Hospitals:**

$B_D = A_c / A_{Hc} * P_c * T$

$B_D$: Direct Beneficiaries (patients and staff)

$A_c$: Area to be built per country

$A_{Hc}$: Average area of a hospital based on the default area used by EDGE software

$P_c$: Population covered by a health centre per country. Data from WHO Global Health Observatory

T: Population turnover factor. The factor is equal to one (1) assuming that in a period of 15 years all the population covered with use the services provided at least once.

**Offices Retail:**

$B_D = A_c / A_O * O * T$

$B_D$: Direct Beneficiaries (business workers)

$A_c$: Area to be built per country

$A_o$: Average area of a business office - retail based on the default area used by EDGE software

O: Office occupancy density based on the default density used by EDGE software

T: Business' turnover factor. The factor is equal to one (1) assuming that each office or retail area will be used by one business in a period of 15 years.

**Small-scale offices:**

$B_D = A_c / A_O * O * T$

$B_D$: Direct Beneficiaries (workers)

$A_c$: Area to be built per country

$A_o$: Average area of an office based on the default area used by EDGE software

O: Office occupancy density based on the default density used by EDGE software

T: Business' turnover factor. The factor is equal to two (2) assuming that each office or retail area will be used by two businesses in a period of 15 years.

Distinguishing between building types, we can draw up the following table:

Table 37: Breakdown of direct beneficiaries according to types of buildings

| | Residential | Small scale healthcare | Hospital | Education | Small scale office | Hotel | Retail | Total |
|---|---|---|---|---|---|---|---|---|
| **Albania** | 0 | 0 | 735 294 | 0 | 0 | 0 | 0 | 735 294 |
| **Argentina** | 28 875 | 0 | 0 | 0 | 0 | 0 | 0 | 28 875 |
| **Costa Rica** | 0 | 0 | 0 | 43 680 | 0 | 0 | 0 | 43 680 |
| **Djibouti** | 0 | 0 | 0 | 0 | 4 286 | 0 | 0 | 4 286 |
| **Indonesia** | 13 852 | 0 | 0 | 0 | 0 | 0 | 0 | 13 852 |
| **N. Macedonia** | 0 | 0 | 0 | 0 | 0 | 0 | 14 061 | 14 061 |
| **Mexico** | 11 794 | 0 | 0 | 0 | 4 286 | 0 | 0 | 16 079 |
| **Morocco** | 85 225 | 0 | 0 | 6 750 | 0 | 0 | 0 | 91 975 |
| **Nigeria** | 6 125 | 0 | 0 | 0 | 0 | 0 | 500 | 6 625 |
| **Sri Lanka** | 0 | 0 | 0 | 0 | 1 071 | 0 | 0 | 1 071 |
| **Tunisia** | 22 100 | 0 | 155 363 | 0 | 0 | 0 | 0 | 177 463 |
| **Total** | **167 971** | **0** | **890 657** | **50 430** | **9 643** | **0** | **14 561** | **1 133 261** |

Even though housing represents the largest total surface area that will be built or renovated as part of the PEEB Cool program, hospitals, and health centres have many more direct beneficiaries due to the turnover of people (i.e. 5 people may benefit from a dwelling being improved while the a large portion of the population will likely use a hospital in a 15-year period). Housing has the second highest number of direct beneficiaries followed by schools.

The health sector is therefore an interesting sector to combine both energy efficiency actions on buildings and actions to raise public awareness of energy savings through noticeboards or information displayed on signs or boards for visitors or through digital means.

### Gender disaggregation and population percentage

Gender disaggregation of direct beneficiaries was based on the country sex ration based on UN DESA data for 2020.

Similarly, the population percentage for each country was estimated based on the percentage of direct beneficiaries for the country population according to UN DESA data for 2020 .

Table 38: Estimated number of direct female beneficiaries

| | Residential | Small scale healthcare | Hospital | Education | Small scale office | Hotel | Retail | Total |
|---|---|---|---|---|---|---|---|---|
| **Albania** | - | - | 360 969 | - | - | - | - | 360 969 |
| **Argentina** | 14 785 | - | - | - | - | - | - | 14 785 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Costa Rica** | - | - | - | 21 862 | - | - | - | 21 862 |
| **Djibouti** | - | - | - | - | 2 034 | - | - | 2 034 |
| **Indonesia** | 6 878 | - | - | - | - | - | - | 6 878 |
| **North Macedonia** | - | - | - | - | - | - | 7 027 | 7 027 |
| **Mexico** | 6 023 | - | - | - | 2 189 | - | - | 8 212 |
| **Morocco** | 42 935 | - | - | 3 401 | - | - | - | 46 335 |
| **Nigeria** | 3 020 | - | - | - | - | - | 247 | 3 267 |
| **Sri Lanka** | - | - | - | - | 558 | - | - | 558 |
| **Tunisia** | 11 139 | - | 78 308 | - | - | - | - | 89 447 |
| **Total** | **84 780** | **-** | **439 277** | **25 262** | **4 781** | **-** | **7 273** | **561 373** |

| **Direct Beneficiaries by gender and country (females)** | **Population (thousands)** | **Direct as % of the country population** |
|---|---|---|
| **Albania** | 2 878 | 25,55% |
| **Argentina** | 45 196 | 0,06% |
| **Costa Rica** | 5 094 | 0,86% |
| **Djibouti** | 988 | 0,43% |
| **Indonesia** | 273 524 | 0,01% |
| **North Macedonia** | 2 083 | 0,68% |
| **Mexico** | 128 933 | 0,01% |
| **Morocco** | 36 911 | 0,25% |
| **Nigeria** | 206 140 | 0,00% |
| **Sri Lanka** | 21 413 | 0,01% |
| **Tunisia** | 11 819 | 1,50% |
| **Total** | **729 885** | **0,15%** |

#### 5.5.4.Indirect beneficiaries

The number of indirect beneficiaries has been computed only for the education sector – as the impacts are only modeled for a 10 year period after the first 15 years of implementation. While additional indirect impacts could occur (especially in the residential sector), this was not estimated so as to use a conservative approach.

| Direct Beneficiaries by gender and country (females) | Total Indirect Beneficiaries |
|---|---|
| **Albania** | 0 |
| **Argentina** | 0 |
| **Costa Rica** | 29,120 |
| **Djibouti** | 0 |
| **Indonesia** | 0 |
| **North Macedonia** | 0 |
| **Mexico** | 0 |
| **Morocco** | 4,500 |
| **Nigeria** | 0 |
| **Sri Lanka** | 0 |
| **Tunisia** | 0 |
| **Total** | **33,620** |

The total number of indirect beneficiaries of the Programme is 33,620 people.

### 5.6. Calculation of the gross payback period

The investment costs relating to the avoided emissions in the construction and operational phases, which were previously calculated, are used as the basis for the financial model. They represent the investment flow.

We then calculated the financial savings related to the energy savings as well as the gross payback periods.

In order to do so, we researched the residential and non-residential rates charged for electricity consumption in the 11 countries:

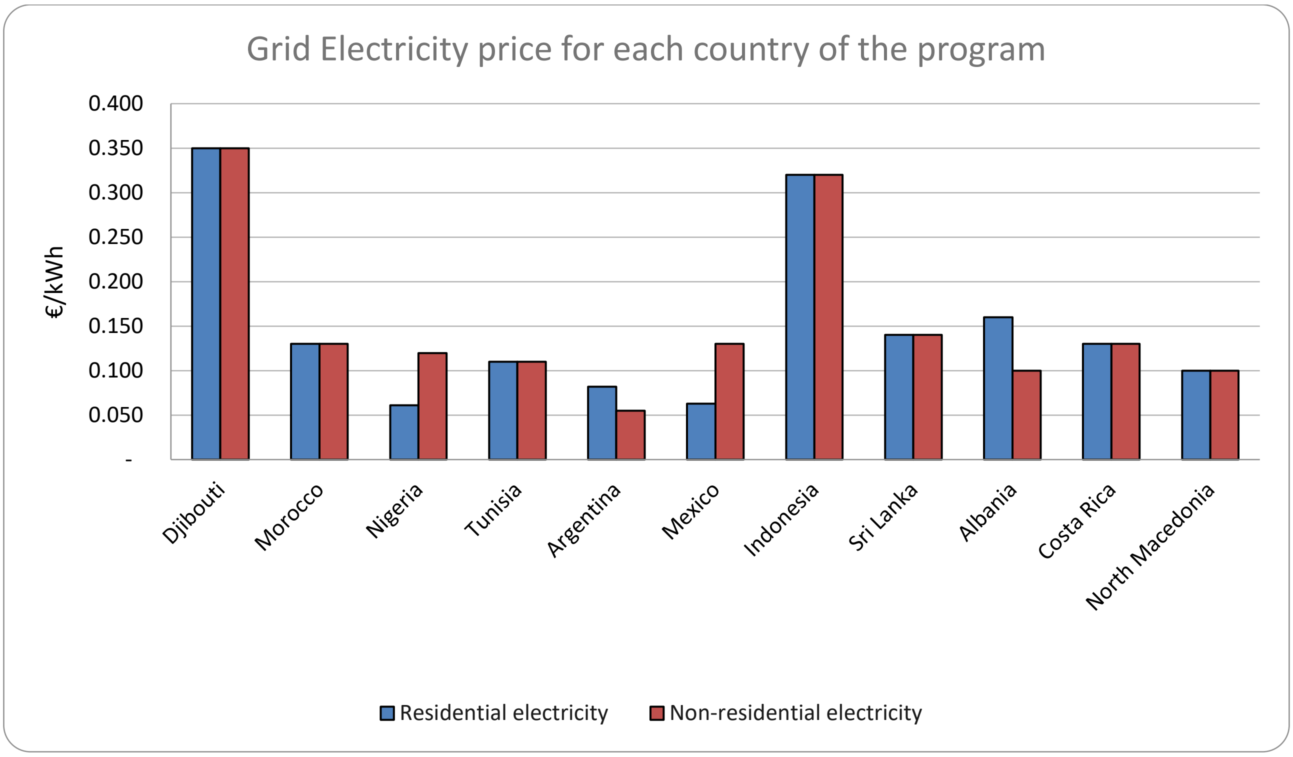



**Figure 45: Electricity prices in the 18 countries of the PEEB Cool program**

We found significant variation in the electricity prices among the 11 countries ranging from a price of about 6 Euro cts to 35 Euro cts for a kWh of electricity.

We also researched the price of natural gas but obtained less data. In the countries for which we obtained data, the price ranges from 3 Euro cts to 13 Euro cts per kWh of natural gas. This seems to reflect the general trend that in some countries gas prices are subsidized and in others it follows the international market price of oil. Therefore, we applied the average value of this range, which is 8 cts per kWh of natural gas, to all countries where data was not readily available.

The simple payback period of the « -40% » package is presented below for each building type included in the PEEB project portfolio:

**Table 39: Average simple payback period for the "40% package"**

| Gross payback period –40% package | Payback by building type in the 11 countries (years) |
|---|---|
| Small multi-family residential | 6.7 |
| Health centers | 6 |
| Hospitals | 6.7 |
| Schools | 29.2 |
| Small office buildings | 4.4 |
| Retail | 14.7 |

The average simple payback period of the investments for achieving the « -40% » package is **7.1 years**.

We present below the average payback period for the « -20% » package by building type on the basis of the PEEB project portfolio:

Table 40: Average simple payback period for the "20% package"

| Simple payback period – package 20% | Payback by building type in the 11 countries (years) |
|---|---|
| Small multi-family residential | 5.8 |
| Health centers | 7.7 |
| Hospitals | 6.7 |
| Schools | 18.3 |
| Small office buildings | 3.4 |
| Retail | 21 |

The average simple payback period of the investments for achieving the « -20% » package is **6.6 years**.

If we assume that the average energy savings over the entire PEEB program is « -30% », the simple payback period is **around 7 years.**

We also notice that the educational buildings, with little air conditioning, have rather long payback periods. This is mainly due to the fact that they are low energy intensity projects. However, investments for such projects can present other benefits. Firstly, investments in low carbon materials can significantly contribute to avoiding emissions in the construction phase. Secondly, investments aimed at improving the thermal comfort can lead to a reduction in the perceived indoor temperature, thereby leading to a reduction in the hours of discomfort felt by the occupants. In the cases of classrooms, this can for instance contribute to a potential increase in schooling hours as well as increased student concentration.

As for retail, the results given relate only to one single project which was included in the subproject pipeline. This project is in North Macedonia where the cost of energy is relatively cheap. With very little data on this project, we conservatively assumed a relatively higher cost of energy renovation compared to Africa. This is clearly a specific case which would need to be further investigated during the PEEB Cool's implementation phase.

# 6. Implementation arrangements

## 6.1. Beneficiaries and financial intermediaries

**Financial intermediaries**

AFD will work in priority with national accredited entites, wherever and whenever it is suitable. It includes, but not limited to, the following national accredited entities identified in PEEB Cool countries:

- Agency for Agricultural Development of Morocco (ADA_Morocco)
- Moroccan Agency for Sustainable Energy S.A. (MASEN)
- CDG Capital S.A. (CDG_Capital) - Morocco
- Fondo Mexicano para la Conservación de la Naturaleza A.C. (FMCN)
- Nacional Financiera, S.N.C., Banca de Desarrollo (Nafin) - Mexico
- Kemitraan bagi Pembaruan Tata Pemerintahan (Partnership for Governance Reform) - Indonesia
- PT Sarana Multi Infrastruktur (PTSMI) - Indonesia

- Unidad Para el Cambio Rural (UCAR) - Argentina

Technical assistance to these entities is eligible to PEEB Cool financing for the implementation of credit lines under Component 1.
Additional intermediaries will be added to the list during the course of progamme preparation and implementation.

**Beneficiaries**

Beneficiaries of the activities in component 1 include:

- Subproject owners (including ministries, other public entities and private developers), architects/designers and construction companies, who will receive financial support and technical assistance that will build their capacity to design, construct and operate buildings that include bioclimatic and energy efficiency measures
- Financial intermediaries, including banks specialised in housing construction or generalist banks working in the service sector, who will gain knowledge of and experience with the financing of energy efficient buildings
- Auditors, who will gain knowledge of and experience with verification and certification
- Appliance retailers, who will see an increased demand for energy efficient appliances to be used in the buildings constructed
- Other companies in the green building ecosystem such as suppliers of building materials and renewable energy technologies, who will see an increased demand for their services
- Workers newly employed in the green building ecosystem, including energy managers, maintenance workers, groundskeepers and others
- Households benefiting from improved building quality through better national regulations and implementation capacity of the sector

Beneficiaries of the activities in component 2 include:

- Sectoral actors such as national federations, alliances and their industry members or other public-private interest groups that will be supported in developing sectoral frameworks or other industry commitments
- Public sector representatives who receive support in designing and implementing regulations, standards, and programmes.

- Local experts and consultants on green buildings, who will see a rise in demand for their services
- Actors at all levels (buildings and construction sector professional, policymakers), who receive trainings and strategic support to develop further business activities on green buildings
- Sectoral stakeholders as well as the wider public, who will benefit from developed knowledge products
- Interested stakeholders in other countries, who will have access to the knowledge products developed
- Households and other building users benefiting from improved building quality through better national regulations and implementation capacity of the sector

## 6.2. Governance arrangement

A Programme Management Unit will coordinate the overall implementation of the programme, while a Steering Committee will ensure that PEEB Cool remains consistent across subprojects. The Programme Management Unit will be supported by a Programme Team which will bring technical expertise.

Governance arrangement and programme management

PEEB Cool will be monitored by a Programme Management Unit (PMU) established at AFD's headquarters in Paris. The Programme Management Unit will consist of three full time programme officers.
The PMU will be responsible for structuring, implementing and monitoring the programme and will ensure:

- Technical and administrative supervision of the programme
- Coordination of the programme's activities
- Support in implementation of eligible subprojects via expertise and technical assistance mobilization
- Communication activities

Programme Team the PMU will be supported by a team of AFD Group experts consisting of an environmental and social specialist, a climate specialist, an energy efficiency specialist, a private sector specialist, a legal expert, a procurement expert, and a finance specialist. They will not be part of the PMU and will not be fully dedicated to the programme but will act as part of a pool of experts, providing advice in their field of expertise when needed.

AFD and PROPARCO staff based in Paris or in local offices will follow up preparation and implementation of each eligible subproject identified under the Investment Facility. GIZ will mainly implement the Enabling Facility with staff based in Germany (for coordination) and locally in each country of intervention.

PEEB Cool's PMU will work under the supervision of the PEEB Cool Steering Committee (SC). It will be responsible for making the strategic decisions required for the execution of the programme. The steering committee meets at least once per year. Its members are representatives of the executing entities (PROPARCO, GIZ, and AFD). The SC shall notably review and approve programme annual budget and work plans, discuss implementation issues and identify solutions, and ensure coordination and communication between implementing entities.

Due to the large number of countries in the programme, a Steering Committee with representatives of all the countries would be unwieldy. However, to increase participation and ownership there will also be an annual meeting between the Steering Committee and representatives from the participating countries, to be nominated by the NDA of each country. At this meeting the results achieved by PEEB Cool will be presented and the feedback of the country representatives invited will be shared.

## 6.3. Program implementation

### 6.3.1.Implementation structure

PEEB Cool will be implemented jointly by the following three institutions:

- AFD, as accredited entity, executing entity and co-financier for the Investment Facility (financial incentives and technical assistance) targeting public sector subproject owners (Component 1);
- PROPARCO, as executing entity and co-financier for the Investment Facility (financial incentives) targeting private sector subproject owners (Component 1);
- GIZ, as executing entity for activities within the Enabling Facility (Component 2).

As accredited entity, AFD will manage the contractual relation with the GCF. The three entities will closely coordinate through the Steering Committee (see governance arrangement above). In addition, AFD will be in charge of the PEEB Cool investment facility implementation within the public sector. AFD project teams will be responsible for the identification, appraisal, implementation and evaluation of eligible investments. The subprojects' appraisal process will follow AFD's procedures.

In particular, task team leaders will carry out due diligence and appraisals on each subproject in accordance with AFD Group standards and procedures. Due diligence includes, KYC and anti-money laundering policies, and E&S standards.

PROPARCO will be in charge of PEEB Cool implementation within the private sector: building construction and renovation, financial sector and actors within the construction ecosystem. As per AFD projects, PROPARCO project teams will be responsible for the identification, appraisal, implementation and evaluation of eligible investments and appraisal process will follow PROPARCO's procedure.

GIZ will be responsible for the implementation of activities within the Enabling Facility (component 2). GIZ will ensure the implementation of activities using a combination of own staff based in headquarters and respective partner countries as well as independent consultants. All will report to the PEEB Cool Programme Management Unit.

### 6.3.2.Experience and track record of AE and EE

**AFD**

Agence Française de Développement (AFD) / French Development Agency is a financial institution and the main implementing agency for France's official development assistance to developing countries and overseas territories. In 2018, AFD engaged a record volume of EUR 14.1 billion of commitments, 6.1 billion of which are designed for positive impact on the climate. Regarding energy efficiency in construction sector, AFD has implemented two large-scale programmes (SUNREF and PEEB) that have shown encouraging results worldwide.

Energy efficiency constitutes one of the three focuses of AFD's energy transition strategy 2018-2020. In 2019, AFD has committed EUR 1,650 million in energy efficiency including EUR 546 million of direct financed projects, EUR 660 million public policy lending with energy efficiency component and EUR 444 million of intermediated financing.

AFD has local offices in 15 PEEB Cool countries and has construction and retrofitting experience (education, health, energy sectors) in most of them.

**PROPARCO**

PROPARCO (société de Promotion et de Participation à la Coopération économique) is an affiliate of AFD focused on private sector development. It has been promoting sustainable economic, social and environmental development practices for the past 40 years. As a development finance institution, PROPARCO provides funding and support to both businesses and financial intermediaries, and aims to boost the contribution of the private sector to achieving the sustainable development goals.

In 2018, PROPARCO approved EUR 2.5 billion, increasing its outstanding portfolio at EUR 4.6 billion with over 500 clients in 115 countries. With a growing interest to embed energy efficiency in projects, PROPARCO is able to tap into a vast pipeline of opportunities and mobilise its expertise in financing: constructions of buildings within health, education, tourism, infrastructure, and industrial sectors; Green credit lines and guarantees for financial institutions; and expansions of production capacities or greenfield projects with actors in the construction ecosystem.

PROPARCO is financing operations in all PEEB Cool countries and has physical presence in 5 of them (Morocco, Nigeria, Tunisia, Mexico, and Indonesia). The remaining countries are coordinated from the closest regional office ensuring on-the-ground presence.

**GIZ**

As a service provider in the field of international cooperation for sustainable development and international education work, GIZ has over 50 years of experience in a wide variety of areas, including economic development and employment promotion, energy and the environment, and peace and security. GIZ works with businesses, civil society actors and research institutions, fostering successful interaction between development policy and other policy fields and areas of activity. In 2017, GIZ generated a business volume of around 3 billion euros and employed 20,726 persons, almost 70 per cent of whom are national personnel in 120 countries.

GIZ is present through local GIZ offices with national and international staff in 17 PEEB Cool countries (the exception is Argentina). In 7 of the PEEB Cool countries (Costa Rica, Morocco, Tunisia, Vietnam, Nigeria, Mexico, Indonesia,), ongoing GIZ bilateral projects in the energy sector advise partners in the area of energy efficiency, renewable energies, or rural electrification. A further 6countries are involved in regional or global projects in or related to the energy sector, implemented by GIZ and its partners (Argentina, Albania, Djibouti, North Macedonia, Sri Lanka, Mali).

### 6.3.3.Implementation arrangements

Implementation arrangement for direct financed subprojects and Component 2 are illustrated below:

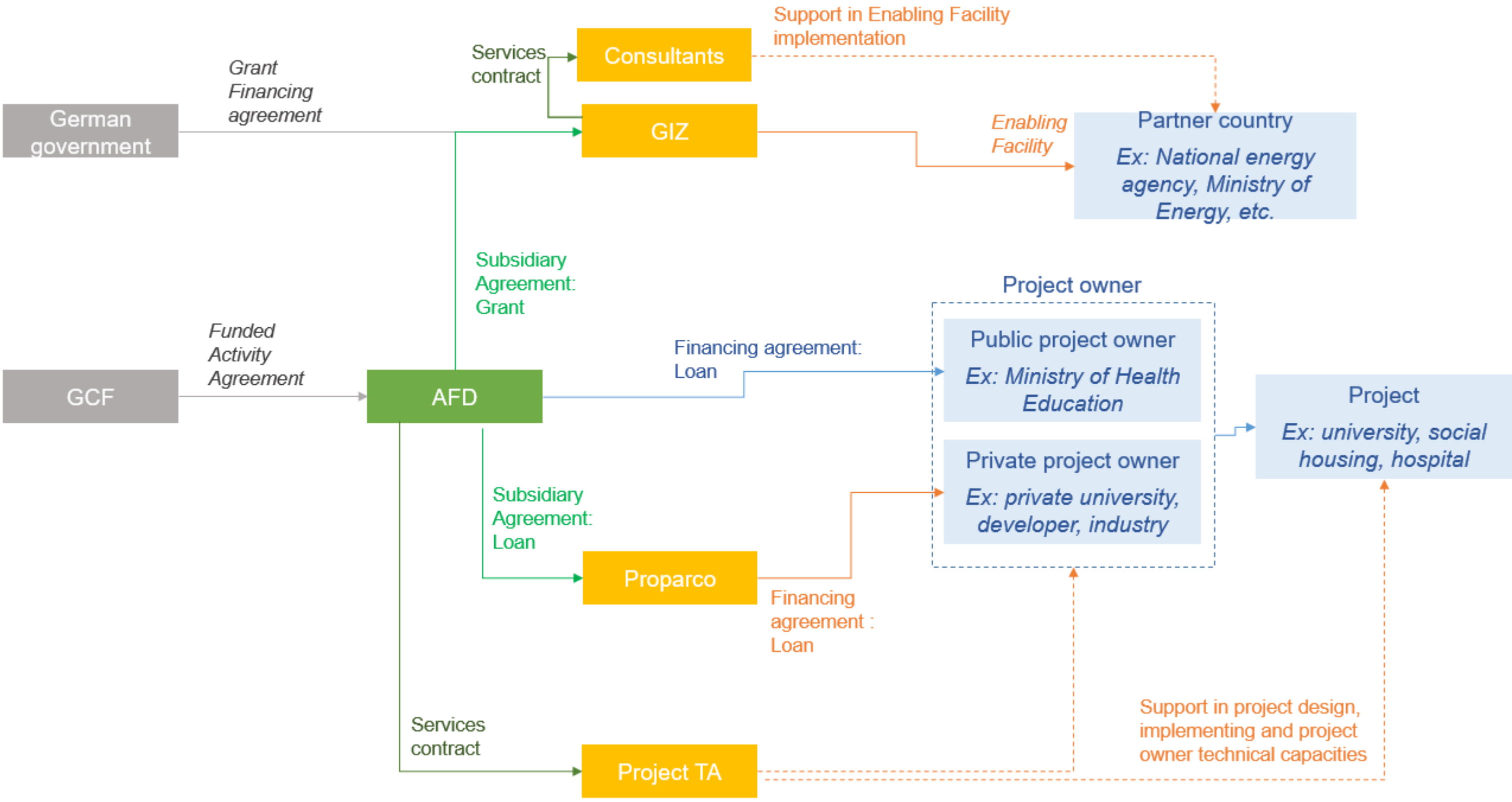



Figure 46: Implementation arrangement for direct financed subprojects

Implementation arrangement for intermediated subprojects (Component 1):

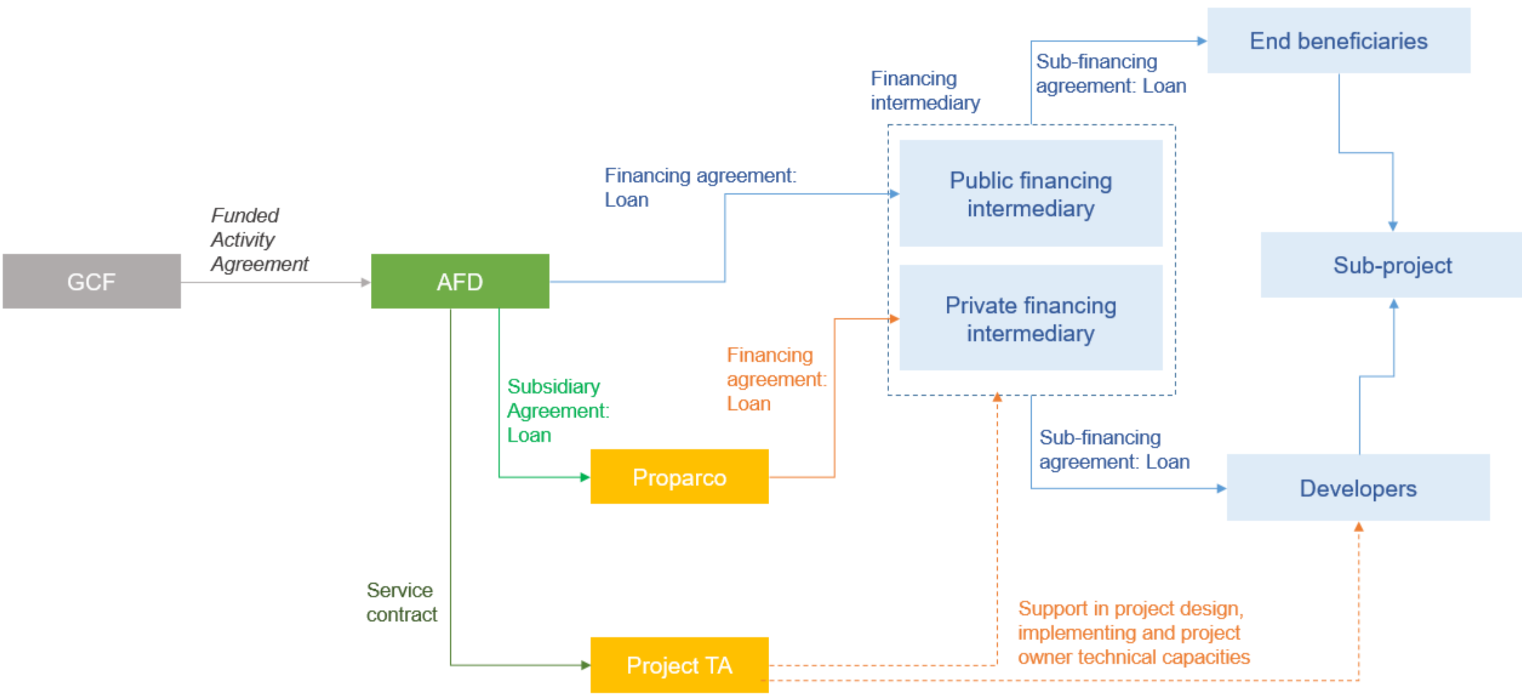



Figure 47: Implementation arrangement for intermediated financed subprojects

6.3.3.1. Contractual arrangements

The GCF and AFD will sign a Funded Activity Agreement (FAA) and all GCF funds, whether reimbursable or non-reimbursable funds, will be transferred from the GCF to AFD according to the provisions set in the FAA;

AFD will sign a subsidiary agreement with GIZ and will channel GCF funds to GIZ for the purpose of component 2 implementation;

AFD will sign a subsidiary agreement with PROPARCO, which will define the fiduciary and implementation arrangements between AFD and PROPARCO;

Under component 2, GIZ will assure the implementation of activities using a combination of own staff based in headquarters and respective partner countries as well as independent consultants. All will report to the GIZ representative located in Paris belonging to the PEEB Cool program management unit.

#### 6.3.3.2. Financing agreement between AFD or PROPARCO and the implementing bodies

**For direct financing**

Eligible subprojects within AFD's scope (public sector) and PROPARCO's scope (private sector) will benefit from financial support extended by AFD and PROPARCO through the Investment Facility (Component 1) on a subproject-by-subproject basis. For this purpose, PROPARCO and AFD will sign financing agreements with the respective implementing bodies (developers, ministries, etc.). Financing agreements will describe the provisions and modalities for disbursing and using the funds for the purpose of implementing the subprojects, and will be developed and negotiated according to AFD Group templates and procedures.

While no decision has been made yet on the subprojects to be financed, consultations have been held with potential subproject owners. These are listed in Annex 7.

**For intermediated financing**

Loan agreements will be signed between AFD and financial intermediaries. The loan agreement will specify the eligibility criteria, including the targeted final beneficiaries.

The eligibility criteria will be defined at conception stage by the technical assistant (Output 1.1) but will at least abide by the eligibility criteria of direct financing subprojects. Based on the targeted beneficiaries and local context, the technical assistant will prepare technical specification for eligible investments. The financial intermediary will assess the creditworthiness of potential eligible investments (construction for developers or acquisition for households) and structure a financial offer in line with the need to reduce the barriers to investment in the country.

For example, in Peru, AFD and Fondo Mivivienda have launched a new product called a "green mortgage" which allows households to benefit from a subsidy if their home is certified, making the price of green housing equal to the price of conventional housing for certified homes.

#### 6.3.3.3. Service contracts between AFD and consultants

AFD will hire consulting companies to implement the subproject technical assistance activities (Component 1). In order to implement Component 1 of PEEB Cool, a pool of consulting firms hired after a call for tender, shall be mobilised through the issuance of purchase orders by the PMU. This will allow flexibility in the TA activities and speed in the mobilisation of consultants for the subprojects. Consultants will work at subproject level for both AFD subprojects and PROPARCO subprojects. They will report to the PEEB Cool PMU.

#### 6.3.3.4. Service contracts between GIZ and consultants

In order to deliver the results of the Enabling Facility (Component 2), GIZ will partially rely on additional technical expertise for specific topics within the Enabling Facility output areas, as per country needs and priorities. Consultant pools will be recruited for this according to GIZ procurement standards. Substantial experience in contracting at both national and international level ensures the implementation of such arrangements is realistic and feasible.

#### 6.3.3.5. Co-financiers

Co-financiers to the programme include AFD Group and the German Government.

- AFD Group will co-finance the programme through a grant and loans.AFD Group intends to co-finance the programme with a grant reaching 5 MEUR and loans up to 1,111 MEUR.
- The co-financing by the German Government (2.5 MEUR) will be complementary to activities included in Component 2 of PEEB Cool and subject to a separate bilateral contractual arrangement between GIZ and the Federal Ministry for the Environment, Nature Protection and Nuclear Safety.

AFD Group is searching for further financing for the PEEB Cool programme. While none of these have been confirmed yet, potential additional funds could come from:

- Fonds Français pour l'Environnement Mondial (FFEM) - AFD has submitted an application for FFEM funds that would allow PEEB Cool to benefit from additional 3 MEUR grants to support project financing. If approved, the funds should be committed in Q1 2023. Should this request be successful, FFEM funds would be used to promote innovative cooling solutions within PEEB Cool.
- Some eligible subprojects financed under PEEB Cool, both in the public and in the private sector, might be financed together with other, as yet unidentified, financiers.

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