Annex Feasibility Study

1. Table of contents

2. Country forms

2.1. Albania

National Designed Authority	Ministry of Tourism and Environment of Albania

Project title	PEEB Cool Albania
Name and typology (public/private) of the institutions	Ministry of Infrastructures and Energy (MoIE). Agency for Energy Efficiency.
End beneficiaries (households, students…)	Hospital employees, patients, patients' relatives and citizens
Mitigation/adaptation focus	Mitigation

2.1.1.Climate profile

Albania is ranked 75th on the ND-GAIN index having been categorised as 90th most vulnerable and 84th most ready.

2.1.1.1. Historic climate data

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 (USAID, 2016). The number of days where temperature reaches above 35°C has also risen, with such events occurring annually now rather than every few years.[1]

2.1.1.2. Future climate projections

Models show temperature will rise intensely throughout the century. Some show warming of around 2°C by mid-century and reaching up to 3.1°C during summer months (USAID, 2016). By 2100, warming will likely reach around 4°C under a business-as-usual scenario. Moreover, hot days are expected to increase by 1-2 days per year by as soon as 2025.[2] Albania's capital city, Tirana, is expecting to suffer heat extremes. Table 1 shows data for the city.[3]

Table 1 Future temperature changes in Tirana, Albania

Time Period and Emission Scenario	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)
2011-2040 (RCP 4.5)	1.20	0.77	0.75	-130

[1] World Bank. 2019. Climate Change Knowledge Portal.

[2] World Bank. 2019. Climate Change Knowledge Portal: Albania.

[3] Data from Climate Information Site-specific report.

Time Period and Emission Scenario	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)
2041 – 2070 (RCP 4.5)	2.40	1.30	1.60	-260
2071-2100 (RCP 4.5)	2.70	1.70	1.80	-330
2011 – 2040 (RCP 8.5)	1.20	0.64	0.82	-150
2041 – 2070 (RCP 8.5)	2.90	2.30	2.00	-340
2071 – 2100 (RCP 8.5)	5.30	3.90	3.60	-610

Large changes can be seen towards the end of the century, with around double the warming in a high emissions scenario compared with medium emissions. Maximum temperature changes are especially high at 5.30°C although minimum temperatures also outpace mean temperature, suggesting a fall in cooler periods.

Similar trends can be seen nationally. Table 2 highlights future heat climate indicators.

Table 2 Future climate indicators for Albania

Time Period and Emission Scenario	Hot Days	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	4.68	0.04	273.97
2040-2059 (RCP 2.6)	5.84	0.05	351.34
2060-2079 (RCP 2.6)	6.62	0.05	355.18
2080-2099 (RCP 2.6)	5.83	0.04	327.63
2020-2039 (RCP 4.5)	5.15	0.05	284.45

2040-2059 (RCP 4.5)	8.52	0.07	420.16
2060-2079 (RCP 4.5)	11.64	0.09	523.00
2080-2099 (RCP 4.5)	13.81	0.11	621.43
2020-2039 (RCP 8.5)	4.77	0.05	334.49
2040-2059 (RCP 8.5)	10.38	0.10	609.32
2060-2079 (RCP 8.5)	25.10	0.16	993.29
2080-2099 (RCP 8.5)	42.52	0.21	1405.51

The number of hot days is predicted to increase tenfold by 2100 under a high emissions scenario compared to the current figure (42 to 4). The probability of suffering a heat wave also increases by a factor of five, from 4% currently to 21%.

Heat waves impact Albania strongly. A study of Shkodra and Tirana over thirty years found 61 heat wave episodes – an average of 2 per year and 569 days in total (Porja, 2013). In recent years, the intensity, duration and frequency of heat waves have increased across the eastern Mediterranean by 6-8 times (USAID, 2016). In 2017, a heat wave that swept through Europe reached over 40°C in Albania, resulting in the national government asking the European Union for assistance to tackle wildfires near Tirana.

The ILO report on the impact of warming on work included specific reference to working hours lost to heat stress in the Mediterranean and Southern Europe. Their analysis found a total loss of 6,300 full-time jobs in the region in 1995 due to heat. Projections using the conservative low emission (RCP 2.6) pathway show this figure to more than double by 2030, to 14,400 (ILO, 2019). The majority of these losses coming from construction and industry. While construction occurs outside, industrial facilities are one of the sectors targeted by PEEB Cool.

2.1.1.3. The impact of high temperature on health

Higher temperatures are likely to increase mortality and morbidity from heat-related stress, including exacerbating pre-existing conditions. Equally, longer and more intense heat waves could affect the dispersion of air pollution and increase the range of vector-borne diseases (USAID, 2016).

Population health under high temperatures throughout Europe is expected to be at risk. A multi-country European study combined historical heat and mortality data to model future mortality risk under different emissions scenarios. For Albania, the expected fraction of deaths attributable to mean temperature above the comfort threshold under an RCP 8.5 scenario by the end of the century would reach 5.15% compared to the historical value of 0.15% (Kendrovski, 2017). This is equivalent to 910 deaths per warm season or 3.6 deaths per 10,000 inhabitants.

To limit the damage from excessive heat, buildings need to adapt and provide efficient and effective cooling mechanisms. A simulation study of residential buildings and their materials in Tirana found that changes to building design, such as windows, wall and roof construction and an emphasis on natural ventilation, improves thermal performance and limits energy usage (Resuli, 2015). Moreover, a study of bioclimatic design in Tirana found that the use of passive cooling techniques, such as cool materials, green spaces, water and the use of shading, can limit ambient temperatures by 3°C during summer months. Where construction materials with high emissivity and reflectivity are used, thermal comfort improved significantly (Fintikakis, 2011).

Another study on traditional houses in the Kukes region of Albania focused on five different housing types. Those made from materials such as clay, stone and wood were found to be hotter in the summer periods (Belba, 2018.) Similar studies have been conducted in industrial buildings. 2020 research found that indoor air temperature could be reduced by 1.5°C in summer by using insulation fabrics, modifying roof design and incorporating a ventilation regime (Dervishi, 2020).

Data taken from a hospital in Tirana shows correlations between temperature and high blood pressure, as well as a spike in the total number of cases. Equally, the vast majority of hospital visits occurred when temperatures exceed 35°C (Republic of Albania Ministry of Health, 2012).

2.1.2. Market context and barriers

2.1.2.1. Strategic context and market potential

The Albanian government has increased the sensitivity on the importance of improving energy efficiency, as a very important element in increasing the security of supply of energy sources and reducing greenhouse gas emissions. For this reason, in cooperation with various actors, initiatives and programs will be promoted in the development of cost-effective services of energy efficiency and conservation, avoidance of negative impacts on the environment, on the basis of technological, cultural and economic changes, for a sustainable economic development.

Albania's contribution to the global greenhouse gas emissions is relatively low, estimated at an average of 9.4 million ton/year of CO2 eqv. This is because over 100 per cent of Albania's electricity is mostly produced from hydroelectric sources and high-energy intensity industries are no longer operating. Albania has set a target to reduce its CO2 emission by 11.5% in 2030 compared to base line scenario in 2016 in its intended NDC.

Energy demand from the residential construction sector hold an important place in the total energy consumption in the country. According to 2013 estimates, this sector accounts for about 30% of national final energy consumption and 60% of electricity consumption.

The Republic of Albania is at the end of the process of setting up energy efficiency legal framework and the national system for implementation of energy efficiency measures in buildings and the Agency for Energy Efficiency (AEE) is strengthening its overall capacity and effectiveness.

In 2015, the Energy Efficiency Reference Law (Law No. 124/2015) was adopted, transposing many of the requirements of the EU Directive 2012/27/EU ("Directive on Energy Efficiency"). The Law on energy efficiency and on energy performance of buildings provides the foundation for new EE strategies developments in Albania, including the creation of the Energy Efficiency Agency (EEA) and the Energy Efficiency Fund (EEF). This law furthermore makes energy audits mandatory for three target groups: 1) energy consumers with an annual energy consumption of more than 3 M kWh., who also have to nominate an Energy Manager in charge of the maintenance of the energy consuming equipment, improving and managing the energy use and the rational use of energy in the industry and buildings, 2) all applicants for a programme funded by the Energy Efficiency Fund to promote and improve energy efficiency, and 3) all buildings which are evaluated, put into operation and / or being constructed or subject to substantial renewal.

The law on Energy Efficiency 125/2015 transposed from EED, inter alia aims to improve the energy efficiency of public and private Large Energy Consumers through the implementation of specific measures with the assistance of Energy Services Companies (ESCO), in reference to article 18.

EU Directive 2010/31/EU (the "Energy Performance Building Directive") was transposed into the Albanian Law in Energy Performance of Buildings (Law No. 116/2016). This law requires that all buildings sold or leased have a mandatory Certification of the energy performance of the building. Since 2018 all public buildings with a usable area of over 2500 m2 are required to display the energy performance certification for the public to see. However, full-scale implementation is dependent on the adoption of bylaws on for minimal energy performance requirements and certification of buildings, which were still pending in 2020. Advances were recently made on the adoption of a methodology for cost optimal levels of energy performance of buildings in July 2020.

Without district heating or cooling systems in place, discussions to envisage obligations to assess the country's district heating and cooling potential.are still ongoing.

To improve energy efficiency in all sectors, Albania develops National Energy Efficiency Action plans; its most recent National Energy Efficiency Action Plan (2017 – 2020) defines a combination of energy efficiency obligation schemes and alternative measures as key actions. According to this, the Agency for Energy Efficiency is tasked to implement energy efficiency policies and measures.

Appropriate interventions to improve energy efficiency include:

1. The building envelope (outside walls, roofs, and basement insulation), which will not only improve the exterior wall design, but it will also reduce energy consumption and CO2 emissions in the long term, increase the comfort of living so the zone will be warmer, drier, and properly ventilated, which lowers the risk of illnesses and mold growth.
2. Replacement of electromechanical equipment, heat pumps with high efficiency in electricity consumption.
3. Replacement of indoor and outdoor lighting in order to improve energy performance and result in associated energy savings

Progress on EE in Albania has also been made with the support of international financial institutions and donors through the development of a number of pilot projects in renovating public buildings, training auditors and energy managers. For example, The KfW financed project "Promotion of Renewable Energies and Energy Efficiency" targeted energy performance of dormitories. The WB financed project "Development of a Financing Mechanism for Energy Efficient Public Buildings in Albania", aimed at informing and enabling decision-making for sustainable financing mechanisms for energy efficiency in the public buildings sector, serving as a possible draft for an expansion to the residential building sector.

Additionally, the Ministry of Infrastructure and Energy is financing the Project "On Energy Auditing of Public Buildings" under the state budget. In 2018, 60 public buildings were selected for this project, whose aim is to create a database of the necessary information to draft energy efficiency policies.

2.1.2.2. Analysis of relevance of barriers

Barriers type	Country specific
Technical barriers	
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	Although Albanian regulatory framework is well advanced and creates a helpful environment for investment, capacities to implement EE projects remain weak. Local stakeholders lack experience and capacities for such projects.
Financial barriers	
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	No financing framework (fund) for energy efficiency exists. Draft amendments to the Energy Efficiency Law envisage support for the development of the ESCO market. Several international technical assistance programmes support energy efficiency improvements, especially in the building sector.
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	Existing and past programs with donors mainly target the development of a banking offer to the privately owned residential dwellings or buildings.
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	Industrial actors need incentives and financial tools to implement EE actions
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	The National Energy Efficiency Action Plan (NEEAP) set the general 2020 target. It is completed by the revised Energy Efficiency Law which is in governmental procedure and awaits adoption?
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 2016 Law on Energy Performance of Buildings remains not implementable as two key drafted by-laws (on setting minimal energy performance requirements and certification of buildings) remain to be adopted.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	Energy efficiency is a key priority for Albanian authorities which are fully aware the challenges and employment opportunities of energy efficiency investments

2.1.2.3. AFD experience in financing buildings construction of refurbishment projects

In Albania, AFD is a new actor, present officially from august 2020.

2.1.2.4. Environmental public policies analysis

Environmental policies related to the building sector

Albania's Intended Nationally Determined Contribution to the Paris Agreement commits to reduce the CO_2 emissions compared to the baseline scenario in the period of 2016 and 2030 by 11.5 % through a number of mitigation actions including : promotion of renewable energy (the country's power is already 95% hydroelectric, solar water heaters in substitution to electric boilers in existing buildings), new Energy Efficiency Agency and new Energy Efficiency Fund, new laws on Energy Performance in Buildings, thermal insulation of existing residential buildings, the use of efficient appliances and lighting, etc.

Albania is a contracting party of the Energy Community Treaty which aims to extend the EU internal energy market to South East Europe and beyond on the basis of a legally binding framework. As such, it has adopted the 2010/30/EU and 2012/27/EU Directives on energy efficiency and the energy labeling of equipment, implementation within national regulations is however not complete.

The DCM 567 On the Housing Design Norms, approved in 1993, introduces winter comfort temperatures (20°C in the living room for instance) and minimal thermal resistance of the envelope elements (0.3 to 0.5 K/W for outer walls for instance).

Law 116/2016 on Energy Performance of Buildings introduces the framework for setting minimum energy performance for new and existing buildings and for technical systems, for "buildings consuming almost zero energy", energy audits, etc. However, it remains not implementable as two key drafted by-laws (on setting minimal energy performance requirements and certification of buildings) remain to be adopted.

A net metering scheme is in place since 2019 for small and medium sized enterprises and households with PV systems (less than 500kW).

Adaptation to climate change policies

The country did not include in its 2016 NDC adaptation priorities, adaptation indicators have however been included in sectoral plans under the National Strategy for Development and Integration (NSDI) 2014-2020, and in the Medium-Term Budget Process (2018-2020, with the support of GIZ, with topics integrated into the Urban Planning and Housing program). A National Adaptation Plan 2020-2030 is currently being finalized, specific strategies relative to the built environment could not be identified. According to Albania's UNFCCC, the most vulnerable sectors to climate change are hydrological systems, agricultural lands, the energy production sector (reliance on hydroelectricity), ecosystems (e.g. protected coastal areas) as well as tourism (via impacts on tourism infrastructure and natural attractions).

2.1.2.5. Summary of stakeholders' consultations

AFD has discussed with Ministry of Infrastructure and Energy as well as the Agency for Energy Efficiency. Both have shown interest in the program. AEE has shared with AFD a list of potential eligible investments that confirms the high demand for energy efficiency projects throughout the country.

The Ministry of Infrastructures and Energy is the policy maker and regulatory authority of the energy sector in Albania. The development of the sector is a strategic priority for the government.

The creation of the Albanian Agency for Energy Efficiency in 2016 and the legislative frame about energy efficiency shows the importance given by the government to improve the performance of the energy efficiency in buildings and in the construction sector.

The Agency for Energy Efficiency (AEE) is a public, budgetary legal entity, under the responsibility of the Ministry of Infrastructure and Energy. AEE is responsible for improving and promoting energy efficiency throughout the energy cycle, in all sectors and economic zones of the country, enabling consumers to reduce their energy supply costs and reduce the negative impact on environmental pollution and climate change.

2.1.3. Project description

2.1.3.1. Project's objectives and description

1. Investment Facility

Albania is a contracting member of the Energy Community Treaty, and thus, it is obliged to introduce EU energy efficiency legislation. Addressing the targets and requirements of this legislation need more ambitious policy efforts and larger investments into demand-side energy efficiency than it occurs at present.

Based on the information provided by Albania, it was estimated that in 2016 the floor area of the main types of public buildings was 6,6 million m2.

The highest energy demand belongs to hospitals and dormitories, because of the high DHW demand. The heating energy demand is also high in these buildings types, because of the more the double weekly heated hours than those for schools and universities. In general, it can be stated than in the present state the user's profiles have a higher influence on the energy demands than the buildings themselves.

The direct impact on the reconstruction of public buildings (hospitals, schools, institutional buildings) will be reflected in:

- Lower energy consumption and reduced CO2 emissions;
- New standards in the way of life and health of the people;
- New standards in terms of construction quality and energy efficiency;
- Lower maintenance costs as a result of using quality materials;
- Environmental sustainability and lifestyle improvements.

The demand, as sent by the Albanian Agency for the Energy Efficency (in annex 1) is very important, approximatively 300M€.

The Albanian Energy Efficiency Energy invites AFD to support:

1. The Regional building Hospital, Lezha
2. The hospital building, Tirana
3. The Ihsan Cabej's hospital,building Lushnje
4. The "Seladin Mborja" polyclinic building, Korça
5. The Hospital building Pogradec
6. The Hospital building Librazhd
7. The Hospital building Peqin
8. The Hospital building Ballsh

9. The medical center building, Fier
10. The medical center building, Orikum

The AEE aims to realize the design future actions to reduce CO2 emissions of these buildings and reduce the energy consumption.

The below tables outline the GHG baseline emissions and emissions reductions for an Albanian hospital. Full calculations can be found in Annex 22c.

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	424,307
Emissions - 20% reduction case	282,609
Emissions - 40% reduction case	266,907
GHG reductions - 20% reduction case	141,698
GHG reductions - 40% reduction case	157,399
GHG reductions - average of 20% and 40% reduction case	159,018

GHG emissions without EE measures:	Source of information	Unit	Value
Albania			
Type of building			Hospital
m2 impacted	A	m2	393,700
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	256
Natural gas	C1	kWh/m2/yr	137
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.043
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	11.0
Natural gas	G1 = C1 x E	kgCO2/m2	31.6
Building materials	H1	kgCO2/m2	438.0
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	4,330
Natural gas	J1 = G1 x A	tCO2/yr	12,459
Electricity	I1 = F1 x A x L	tCO2 over lifetime	64,956
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	186,891

Building materials	K1 = H1 x A	tCO2 over lifetime	172,459
Total		**tCO2 over lifetime**	**424,307**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	254
Natural gas	C2	kWh/m2/yr	39
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.043
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	11
Natural gas	G2 = C2 x E	kgCO2/m2	9.0
Building materials	H2	kgCO2/m2	419.0
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	4,297
Natural gas	J2 = G2 x A	tCO2/yr	3,547
Total GHG emissions per unit	I2 = F2 x A x L	tCO2 over lifetime	64,449
Electricity	J2 = G2 x A x L	tCO2 over lifetime	53,203
Building materials	K2 = H2 x A	tCO2 over lifetime	164,958
Total		**tCO2 over lifetime**	**282,609**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	219
Natural gas	C3	kWh/m2/yr	34
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.043
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	9
Natural gas	G3 = C3 x E	kgCO2/m2	7.9
Building materials	H3	kgCO2/m2	419.0
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	3,705
Natural gas	J3 = G3 x A	tCO2/yr	3,092
Total GHG emissions per unit	I3 = F3 x A x L	tCO2 over lifetime	55,568
Electricity	J3 = G3 x A x L	tCO2 over lifetime	46,382
Building materials	K3 = H3 x A	tCO2 over lifetime	164,958
Total		**tCO2 over lifetime**	**266,907**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	34
Natural gas	J1 - J2	tCO2/yr	8,913
Electricity	(I1 - I2) x L	tCO2 over lifetime	507
Natural gas	(J1 - J2) x L	tCO2 over lifetime	133,689
Building materials	K1 - K2	tCO2 over lifetime	7,502
Total	**Sum of 20% case**	**tCO2 over lifetime**	**141,698**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	626
Natural gas	J1 - J3	tCO2/yr	9,367
Electricity	(I1 - I3) x L	tCO2 over lifetime	9,388
Natural gas	(J1 - J3) x L	tCO2 over lifetime	140,510
Building materials	K1 - K3	tCO2 over lifetime	7,502
Total	**Sum of 40% case**	**tCO2 over lifetime**	**157,399**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	330
Natural gas	Average 20% and 40% case	tCO2/yr	9,140
Electricity	Average 20% and 40% case	tCO2 over lifetime	4,948
Natural gas	Average 20% and 40% case	tCO2 over lifetime	137,099
Building materials	Average 20% and 40% case	tCO2 over lifetime	7,502
Total	**Sum of above**	**tCO2 over lifetime**	**159,018**

2. Enabling Facility

The enabling facility is directly linked to the sectors of intervention of the investment facility, and is expected to extend the climate impact of PEEB Cool beyond the program duration. The following non-exhaustive examples of activities could potentially be supported but will have to be agreed upon depending on the financed projects with the project partner at program start.

2.1. Sectoral investment frameworks

This output aims at strengthening public and private investment towards energy efficiency and resilience in buildings through support in the development of key sectoral and private sector led roadmaps, investment plans, engagements and/or initiatives in sectors targeted by the project facility’s technical assistance. In Albania, this will likely target the hospital and hospital energy efficiency technology and services sector.

2.2. Support for public policies

The precise demands and opportunities for public policy support will be subject to the discussions at program start, and could relate to completing the regulatory framework regarding minimum energy performance in buildings, labeling or creating an incentive mechanisms to foster faster adoption of energy efficiency measures by the health sector.

2.3. Capacity building for sector actors

Within this activity, a number of capacity development measures linked to the other program activities (sectoral frameworks, public policies) could be foreseen. These would build upon trainings and information and awareness campaigns already implemented within the national energy efficiency improvement action plan for specific sectors (i.e. hotel buildings) and extend those to health establishments. As a consequence, actors in the buildings sectors will be better equipped to integrate energy efficiency aspects into their professional activities.

2.1.3.2. Paradigm shift potential

This project will establish a first step towards the realization of a larger project targeting all public buildings (schools, nurseries, dormitories etc).

The Energy Efficiency Law provides for the EEF to be capitalized through loans and to finance improvements in energy efficiency through issuing grants, loans, financial guaranties and/or other methods of financing that guarantee results.

This will then serve as a showcase for other EE initiatives in Albania. On the supply side, this will create real opportunities for construction, heating and air conditioning companies and they will work to increase their skills and knowledge in order to win contracts to implement EE measures in the building stock.

The project will achieve a paradigm shift in knowledge creation and sharing across all market players. This will be achieved through the provision of technical assistance aligned with EE building retrofits provided to the construction sector and government (national and local).

Energy and financial savings information will also be collected, mined, analysed and disseminated.

2.1.3.3. Sustainable development potential

According to a preliminary estimation, the potential investment on the 10 hospitals, is a priority for the AEE but studies must be carried out to find the solution to achieve the best results for the reduction in CO2eq/year.

2.1.3.4. Project indicative financing

	Total Amount (a+b)	Currency	GCF amount (a)	AFD amount (b)
1. Senior loan*	15	Million EUR	2.25	12.75
2. Grant (technical support)**	0.5	Million EUR	0.5	0
Total project financing (1+2)	15.5	Million EUR	2.75	12.75

This amounts are provisional at this stage and are still to be discussed

2.2. Argentina

National Designed Authority	**National Direction for Financing from International Credit Institutions, Under-Secretariat for International Financial Relations for Development, Secretariat for Strategic Matters (Presidency of the Republic of Argentina)**
Project title	Provincial Programme for Social Housing
Name and typology (public/private) of the institutions	Province of Cordoba (Argentina)
End beneficiaries (households, students…)	Vulnerable households
Mitigation/adaptation focus	Adaptation

2.2.1. Climate profile

Argentina is classified as having a humid subtropical climate, but with a variety of temperate zones in different regions. Argentina's dense population in urban regions make it vulnerable to a variety of hazards, including extreme heat.[4] The ND-Gain Index ranks Argentina 69th on vulnerability and 108th on readiness.[5]

2.2.1.1. Historic climate data

Argentina's mean annual temperature between 1901-2016 was 14.31°C, with significantly warmer periods in recent decades. The country's Nationally Determined Contribution (NDC) mentions warming of around 0.5°C since 1960, with areas in Patagonia experiencing double the change (Argentina Republic , 2015). Moreover,

[4] https://thinkhazard.org/en/report/429-argentina-buenos-aires

[5] ND-Index. https://gain.nd.edu/our-work/country-index/rankings/

the country has experienced a rise in the number of days with heat waves. Overall trends show clear warming over previous decades, with the average minimum temperatures having increased more than the average maximum temperatures.[6]

A study of the warm season between 2001-2012 found Buenos Aires experienced an average of 8 heat wave days per year based on a minimum temperature definition, 6.5 heat wave days per year on a maximum temperature definition and 2.5 heat wave days under an extreme heat wave definition (Rusticucci, 2013). Persistent warm temperatures occurred over the northern region. Under the short heat waves, the northern area experienced between 10 and 30 times as many heat events – a significant change.

2.2.1.2. Future climate projections

According to climate projections, the temperature increase in the next fifty years will be similar to the world average in regions of Northern Argentina while Southern Argentina will face slightly below average warming, although still significant.

Under the high emissions, business-as-usual, scenario, average temperature increase is expected to be over 1.5 °C by mid-century, with an increase in the number of warm days and nights, and longer warm spells.[7] These changes are anticipated to be more pronounced in high altitude regions.

With around 92% of the population residing in urban areas, it is useful to understand how climate change in densely populated regions will impact people. Buenos Aires is home to over 15 million people, accounting for around 33% of the total population. Table 3 summarises projected future changes in Buenos Aires.[8]

Table 3 Future climate indicators under different emission scenarios for Buenos Aires, Argentina.

Time Period and Emission Scenario	Tropical Nights (Days)	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)
2011-2040 (RCP 4.5)	15	0.53	0.31	0.47	-79
2041 – 2070 (RCP 4.5)	26	1.10	0.60	0.97	-150
2071-2100 (RCP 4.5)	35	1.60	0.71	1.40	-210
2011 – 2040	14	0.63	0.35	0.61	-88

[6] World Bank Climate Change Knowledge Portal. Argentina.

[7] Ibid

[8] Data from Climate Information Site-specific Report: Buenos Aires.

Time Period and Emission Scenario	Tropical Nights (Days)	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)
(RCP 8.5)					
2041 – 2070 (RCP 8.5)	39	1.70	0.83	1.60	-250
2071 – 2100 (RCP 8.5)	74	2.90	1.60	2.70	-390

The heating trend is also expected more broadly throughout the country, see Table 4 for more information.

Table 4 Estimated climate indicators under future emission scenarios at country level for Argentina. (World Bank data).

Time Period and Emission Scenario	Hot Days (over 35°C)	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	7.16	2.86	0.01	180.47
2040-2059 (RCP 2.6)	9.62	3.88	0.02	245.11
2060-2079 (RCP 2.6)	10.36	3.58	0.02	239.91
2080-2099 (RCP 2.6)	9.68	4.20	0.02	234.48
2020-2039 (RCP 4.5)	7.17	2.62	0.02	203.14
2040-2059 (RCP 4.5)	11.23	4.40	0.03	312.76
2060-2079 (RCP 4.5)	15.09	6.22	0.04	402.74

Time Period and Emission Scenario	Hot Days (over 35°C)	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2080-2099 (RCP 4.5)	17.35	7.05	0.05	445.81
2020-2039 (RCP 8.5)	7.69	3.32	0.02	213.00
2040-2059 (RCP 8.5)	14.21	7.30	0.04	396.12
2060-2079 (RCP 8.5)	23.04	12.09	0.08	653.85
2080-2099 (RCP 8.5)	34.08	17.91	0.13	947.87

This data highlights a worrying trend, especially with a significant increase in the probabilities of heat waves and cooling degree days. As the country warms throughout the century, the energy sector is expected to see a spike in demand for cooling any time temperature rises above 18.3°C.

The length of warm spells will also rise under a business-as-usual scenario (RCP 8.5) by 6.6 days in 2040-2059 to 25.6 days by 2100.[9] Analysis by The Climate Service Center Germany (GERICS) anticipates similar results, with a very likely projected change of up to 16 days by 2085.[10]

A study from 2015 focused on decadal variability in maximum temperatures to distinguish the likelihood of a future heat wave event being similar to a severe heat wave that occurred in 2008. They found the probability to be small in the current climate, but "it is likely to increase substantially in the near future even under a moderate warming trend." (Rusticucci, 2013). That likelihood is predicted to increase by a factor of 6-10 under 1°C of warming, 30-70 under 2°C and 500-1000 under 4°C.

[9] World Bank Climate Change Knowledge Portal. Argentina.

[10] GERICS. Argentina Fact Sheet.

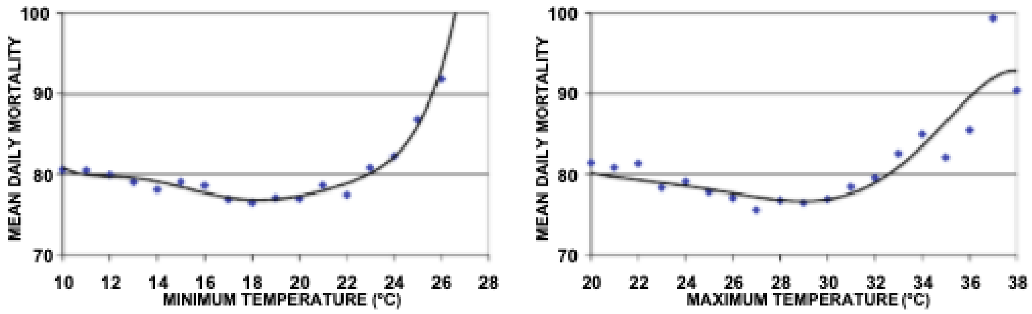

Figure 1 Past heat-related mortality in Buenos Aires

Source: Rusticucci et al.2013

2.2.1.3. The impact of high temperatures on health

Such heat data is concerning for Argentina because the country has a history of devastating heat waves and is increasingly vulnerable. Extreme heat has been associated with both increased morbidity and mortality rates. This relationship has been explored previously in Buenos Aires, with a strong correlation between higher minimum and maximum temperatures and higher daily mortality rates. Please see Figure 1**Error! Reference source not found.** for more details.

In 2008, Buenos Aires experienced a prolonged period of high temperatures that killed several, (Barros, 2015) while a 2013 heat wave saw seven people, mostly elderly, killed (BBC, 2013). Temperatures in excess of 45°C in the northern regions made the 2013 event the worst in the region in over a century since records began. Other areas experienced temperatures of more than 15°C higher compared to average temperatures for the same period in the decade before (see **Error! Reference source not found.** for temperature variations).

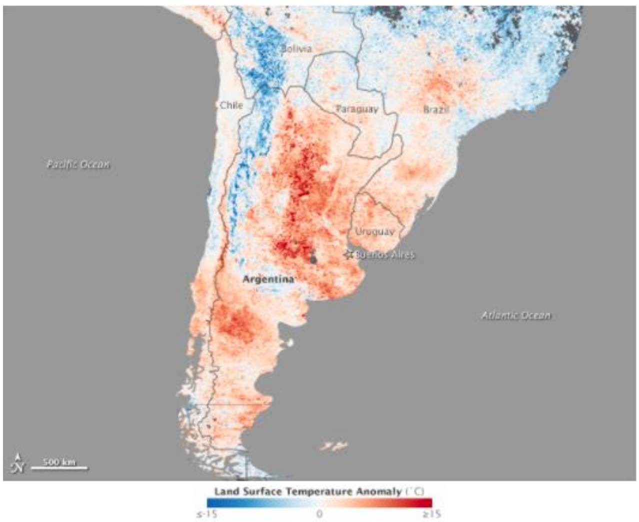

Figure 2 Map of heat changes during the Argentinian heat wave in 2013

Source: Rusticucci et al 2013

Hundreds of people required medical help and doctors warned citizens to stay inside during the hottest hours. However, in buildings with limited cooling availability, lacking A/C or highly energy inefficient, another heat wave of this nature could see severe risk. High outdoor temperatures are connected to high indoor temperatures, and without the ability to cool down in the heat of the day, staying inside may not limit heat exposure significantly enough to prevent illness or death.

The increasing hazard of heat waves is acknowledged by researchers, with one study noting, “no matter which definition is used to define them, heat waves have been increasing in Argentina” (WIREs, 2014) and another warning “the first and more urgent need is public adaptation to heat waves”(Barros, 2015). A particular vulnerability is an expected surge in power demand during hot days (as shown in the cooling days data above). The high demand for air-conditioning in the country combined with an ageing power grid makes power cuts under high energy demand more common. For example, the 2013 heat wave led to outages for weeks in some places. People took to the streets in protest of the lack of services.

2.2.1.4. Economic vulnerability

As one of the largest economies in the region, with a GDP totaling USD 600 billion, Argentina has both a greater ability to adapt and more assets vulnerable to weather extremes. Indeed, the 2021 Climate Risk Index ranks Argentina 28th in terms of total losses (USD millions) resulting from climate risks (GermanWatch, 2020).

While studies specific to the economic impacts of warmer temperatures in the country are limited, the National Climate Change Cabinet acknowledges that adverse socio-economic impacts will result from the intensification of extreme weather events (Argentinian National Climate Change Cabinet, 2019).

Moreover, a broader analysis of all climate change impacts on GDP was undertaken. Using different emission scenarios, researchers measured the long-run impacts of climate change on world GDP (% change per year) (Kompas, 2018). For Argentina, expected losses are:

- -0.36% under 1°C of warming
- -0.872% under 2°C of warming
- -1.583% under 3°C of warming
- -2.610% under 4°C of warming.

2.2.2. Market context and barriers

2.2.2.1. Strategic context and market potential

Argentina is a federal republic with 24 federated Provinces and it recognises three levels of government (national/federal, provincial and local/municipal). Power resides in the Provinces, which delegate a part of it to the Federal Government according to the National Constitution, dating from 1853. Each of the 24 federated units are autonomous, having their own executive, legislative and judicial powers, issuing their own constitutions and choosing their institutions and authorities, without any intervention from the Federal Government. All representatives are directly elected by people.

The Province of Córdoba is the fifth Argentinian Province by its size (4% of the national territory) and second by its population (8% of the national population). It has 3.6 million inhabitants and 427 local governments (municipalities).

Energy Policy

At a Federal level, the Secretariat for Energy ('Secretaría de Energia'), under the Ministry of Productive Development ('Ministerio de Desarrollo Productivo'), is in charge of developing the energy national policy. The deregulation and privatisation of the oil, gas and electricity sectors took place in the 90s in order to separate the production, transport and distribution activities. At a federal level, National Law (N.L.) N° 15.336 and N.L. N° 24.065 characterise the national market and its application authorities. N.L. N° 27.424 stands to the renewable energies regulatory framework, promoting the disseminated generation and its integration to the public power grid.

ENRE, the National Electric Regulatory Entity, represents the federal authority for generation, transportation and distribution along the country and in interjurisdictional zones, such as the Metropolitan Area of Buenos Aires, shared between two provinces. It is responsible for regulating the electricity sector and controlling that all sector firms (producers, transmitters, distributors) comply with their obligation as established in the regulatory framework and concession contracts. ENRE is in charge of regulation and overall supervision of the sector under federal control, while provincial regulators control the rest of the utilities. ENRE and the provincial regulators set tariffs and supervise compliance of regulated transmission and distribution entities with safety, quality, technical and environmental standards.

ENARSA, the energy public company, is involved in the entire energy sector (State 53%, provinces 12% and private shareholders 35%) and it was created as a response to the energy crisis of 2004. The crisis was due to the freezing of energy prices, which led to a rapid increase in demand and a reduction in companies' investments, especially in the gas sector. In 2018, Argentina launched the energy transition to 2050 initiative as part of its presidency to G20. The main objective is to support the definition of energy and climate policies and strategic planning.

The National Administrator of the wholesale electricity market (CAMMESA) coordinates the operation and dispatch of electricity, price calculation in the spot market and commercial transactions carried out throughout the national power grid (SIN), which covered the 23 continental provinces and it is interconnected with neighbouring countries power networks. CAMMESA's goal is to guarantee sufficient and quality supply to cover the demand of electricity at the minimum possible cost.

Argentina ranks first in South America in term of gas per capita production, and third and fourth in terms of gas and oil reserves, respectively. The country's electricity sector is mainly powered by gas, with almost 60 % share in the power mix. Argentina represents the third largest power market in Latin America (after Brazil and Mexico), and per capita energy consumption is the second highest, just after Chile.

The current energy efficiency plan targets a decrease of 5.9% of the final energy consumption compared to a BAU scenario in order to achieve the revised NDC objective. Energy savings will be distributed as follow: 55% in residential, 24% in transport, 14% in industry and 7% in public buildings and lighting. The previous plan of 2007, National Programme for the Rational and Efficient Use of Energy (PRONUREE), included the following energy savings objectives: 10% in the residential sector for 2016, 12% in the services sector and 10% in public buildings (savings for 2016). PRONUREE aimed to decrease electricity consumption by 6% compared with a reference projection and to save 1 500 MW by 2016. It also supported educational programmes on energy efficiency, regulations to expand cogeneration activities, labelling of appliances, energy efficiency regulations, and broader use of CDM to support the development of energy efficiency projects. In 2015, the Inter-American Development Bank and the Global Environmental Facility (GEF) approved a non-refundable financing grant of US$14.4m, to be invested in energy efficiency and renewable projects. Amongst the projects to be financed are the construction of low-cost, energy efficient housing, and the establishment of new technical standards.

What concerns to energy efficiency, between 2009 and 2013, different national laws have obliged the labelling of all electronic devices, spotlights and households appliances, including gas water heaters and gas stoves. All energy consumer appliance disposed within the national market. In 2016, ENRE has also published the “Guidelines and Good Practices for a Responsible Use of Energy”, produced by the National Secretary for Energy Efficiency and Saving.

According to the results of Argentina’s Third National Communication on Climate Change, GHG emissions are estimated in 429 M ton CO_2e for the latest national inventory, 43% of those emissions come from the energy sector, and among which about 40% corresponds to building sector (including construction and operation). These figures show an 80% increase from the 238.7 million Ton CO_2e reported in the Second National Communication in 2000. Argentina’s goal, set forth in their 2016 first revision of the 2015 NDC, is to reduce GHG emissions by 18% by 2030 with respect to projected BAU emissions for that year. The main axes relies on diesel replacement by natural gas and nuclear power biofuels, energy efficiency promotion at all levels, disseminated renewable energy production and sustainable forest and agricultural land management.

In the case of Cordoba, the Provincial Law (P.L.) N° 8.599 provides the electricity regulatory framework as a public service within its jurisdiction, including generation, transport, transformation, distribution and commercialisation. It also determines the provincial regulation authority and consumers protection mechanisms. P.L N° 8.810 concerns energy efficiency and renewable sources, and P.L N° 10.604 subscribes to the N.L. N° 27.424.

Housing Policy

The National Ministry for Territorial Development and Habitat is the federal authority who oversees and defines the Argentinian state's policies on housing sector. The current Law of Ministries states that housing is a right and a basic need for people’s wellbeing. In this vein, the Ministry is in charge of intervening in the elaboration of public policy oriented towards the development of habitat, housing and socio-urban integration, whilst attending to the diversities, demands and ways of inhabiting that manifest across the Argentinian territory. This Ministry implements subsidised credit programmes, such as ProCreAr or ‘Argentina Construye’, that allow new segments of the population to become homeowners and, therefore, partially contribute to solve the housing deficit whilst boost the construction industry and local economies. However, certain population categories with informal or low incomes cannot benefit from these programmes.

In a constructing larger sense, and as a post-pandemic measure, ‘Argentina Hace’ is a Federal initiative, which consists in a fast-track infrastructure programme and an estimated investment of USD 400 M. It promotes a social and gender-sensitive development encouraging young job, community participation and all-sector local infrastructure improvement reaching the 2.300 Argentinian municipalities.

In spite of National Ministry existence, N.L. N° 24.130 delegates all powers in housing policy matters to the Provinces. Within Province of Cordoba, General Department for Housing (DGV) is in charge of the design, proposal and implementation of provincial housing programmes and its coordination with the National Government and Municipalities.

Despite the right to decent housing enshrined in article 58 of the Provincial Constitution, unhealthy conditions and housing lack still affect Cordoba and its population. According to projections made by the Statistics and Census Provincial Division in 2017, there are 13.482 precarious dwellings to replaced, 40.554 new ones to build to solve families’ cohabitation, and 188.347 overcrowded houses to enlarge. In total, the Province's housing deficit was estimated at 242.383 housing units in 2017, which represents an investment requirement of $ 3.7 billion (not including land and basic infrastructure development).

The Cordoba social housing policy is part of a broader social policy, which promotes human dignity, equal opportunities, and family protection as a social well-being vector. An important part of this policy is devoted to women's rights promotion and gender-based violence prevention.

Since the early 2000s, the Province of Cordoba has led a series of projects targeted on i) vulnerable population relocation ('Mi Casa, Mi Vida' financed by the IADB), and ii) informal neighbourhoods requalification (PROMEBA program, financed by the IADB). 'Mi Casa, Mi Vida' (2003-2010) made possible the relocation of nearly 10.000 Cordoban families living in high-risk flood areas.

Residents from 70 informal settlements have been relocated to new neighbourhoods with public amenities and all essential infrastructure. Through PROMEBA, more than 4,500 families were benefited by the reclassification of 9 informal neighbourhoods between 2000 and 2011, 6 located within the provincial capital city metropolitan area and 3 in the rest of the Province.

Since 2016, the Cordoba Housing Policy, financed by provincial, federal and international funds, has been based on:

I. Social programmes, such as 'Vida Digna', to improve housing while promoting urban densification by enlarging and renovating existing houses. This programme provides economic assistance through loans or grants, intended to improve housing conditions for families living in overcrowded housing or without private toilet. It has already helped more than 70,000 families and it still offers a fast and effective solution to solve unhealthy living conditions. The province's goal is to reach 100,000 credits.by 2020
II. Subsides to support new or self-built housing for low/medium-income families, as '25 Mil Viviendas', approved in 2019. It will take place over 4 years and it promotes the construction of new houses through various financial instruments depending on the family's incomes.
III. Increase land availability to act as a lever effect on construction of affordable housing. In this way, 'Lo Tengo' aims to create more than 17,000 social lots with all basic services, infrastructure and integrated into the urban fabric.

As a local technical support, and attached to the National Council for Scientific and Technical Research (CONICET), the Research Institute for Housing and Habitat (INVIHAB) works inside the School of Architecture and Urbanism of the National University of Cordoba (UNC).

2.2.2.2. Analysis of relevance of barriers

Barriers type	Country specific
Technical barriers	
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	Several international programs (GCF, EU) and local initiatives in some cities of Argentina promote sustainable practices in energy efficiency, (often in building) including new voluntary building code and city's materials purchases regulation, green certification and labeling (LEED). National Programme for the Rational and Efficient Use of Energy (PRONUREE) supported educational programmes on energy efficiency and labelling regulations. Still capacities to implement EE building projects

	remain weak. Local stakeholders lack experience and capacities for such projects, especially in Cordoba (rather high barriers).
Financial barriers	
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	Argentina is the second South American country most affected by the Covid-19 pandemic after Brazil and among the countries in the world which growth is the most affected. International programs support energy efficiency improvements in the building sector (e.g. the 2015 Inter-American Development Bank and the GEF grant of US$14.4m, to be invested in energy efficiency among which the construction of low-cost energy efficient housing), and housing projects promote green certification and labeling with subsidies (LEED: eSe in Cordoba). This will need to be completed to raise building owners' barriers increased by the economic crisis.
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	International past and existing programs and local initiatives provided technical assistance, trainings on certification, developed e-learning platform, could be further used and extended to accompany at a national scale the potential financing programs in the housing sector. Yet especially in Cordoba, bankers lack of knowledge on renewable/energy efficiency market and profitability; credit officers' lack of knowledge about these projects evaluation and regulations.
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	Industrial actors need incentives and financial tools on top of projects developed with subsidies related to certification, as to implement EE actions and expand EE device and regulations.
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	Several regulations and laws on EE practices and labelling in building were issued in Argentina within the framework of the PRONUREE (Rational and Efficient Energy Use in Public Buildings), National Program on Household Labelling. Different national laws have obliged the labelling of all electronic devices, spotlights and households appliances, including gas water heaters and gas stoves. This will need to be extended to accompany at a national scale the decarbonation of the sector
Building codes lack specific requirements for energy efficiency in buildings and enforcement is often weak, mandatory for	The city of Buenos Aires presented a new building code that incorporates sustainability regulations (on voluntary basis), that

certain types of buildings only, or still under discussion	will need to be extended at national scale and other cities like Corduba.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	Energy efficiency is a key priority for the authorities. They provided for regulations and labelling laws in public sector and residential sector within the framework of mentioned programmes that widely diffused educational programmes, e-learning platform and guidelines (Guidelines and Good Practices for a Responsible Use of Energy, etc.). These will need to be further developed especially.

2.2.2.3. AFD experience in financing buildings construction of refurbishment projects

AFD has started its operation in Argentina in 2017 and it has not yet experienced in the building construction or refurbishment sector.

2.2.2.4. Environmental public policies analysis

Environmental policies related to the building sector

Argentina's Nationally Determined Contribution aims at -18% of emissions in 2030 compared to 2010 and -37% conditioned on the availability of financing. In 2019, the State announced a carbon neutrality target for 2050.

The EU-funded "Eficiencia Energética en Argentina" project on EE (2018-2021) supports the development of a national EE plan, including at the municipal level (pilot projects for the energy certification of residential buildings, audits of public buildings). The regional project "EUROCLIMA+ de Eficiencia Energética" is also financed by the EU for the coordinated development of EE policy, especially in public buildings (2016-2020).

The Global Environment Facility project "Eficiencia Energética y Energías Renovables en la Vivienda Social Argentina" aims to develop new standards integrating bioclimatic design, EE and RE for the construction of social housing.

Starting in 2020, all state-funded housing must submit the evaluation of the energy performance index according to IRAM 11.900/2017 (voluntary approach for other buildings), and must meet minimum performance requirements for equipment and construction materials.

There is a National Home Labeling program that aims to introduce the Energy Efficiency Label as an instrument that provides information to users about the energy performance of a home, for existing, new and renovation projects. Since 2017, 6 tests have been carried out in different cities, in which more than 1,400 homes have been labeled, 14 certification courses have been given and 675 professionals have been trained.

Energy labeling for AC appliances is in place only for Split and Compact technologies, with minimum energy performance standard.

A framework for the valorization of excess PV production is in place (feed-in tariff + net metering in 6 provinces).

Below are some plans, policies and measures related to climate change mitigation:

- National Promotion Regime for the Use of Renewable Sources of Energy for the Production of Electric Power (Laws N ° 26,190, 26,093 and 27,191): It seeks to reach 8% of the national electricity consumption from renewable sources by 2017 and 20% in 2025.
- National Program for the Rational and Efficient Use of Energy - PRONUREE (Decree No. 140/07 - Resolutions SEN 7/2008 - 8/2008 - 682/2013 - 684/2013 - 814/2013 - 228/2014) - Prohibition of Incandescent Lamps (Law No. 26,473): The main objective is to promote the rational and efficient use of energy. The following lines of work are carried out within the framework of the program:
    - Standardization, labeling and energy efficiency standards,
    - Argentina Fund for Energy Efficiency (FAEE) as a financial instrument,
    - Energy efficiency industrial, residential,
    - Etc...

Adaptation to climate change policies

The 3rd National Communication on Climate Change (2015) suggests that the main focus in terms of adaptation strategies has been until then on flooding hazards and precipitation variations impacts. Adaptation to heat waves is identified as a neglected issue that should be addressed on the short term (public health data improvement, population information, adaptation of the electric grid to demand peaks). On the medium term (2015/2039), the identified priorities include investing in the energy distribution system to adapt to the increased demand for cooling.

In December 2019, Law No. 27520 on Minimum Budgets for Adaptation and Mitigation to Global Climate Change was published to guarantee adequate actions, instruments and strategies for mitigation and adaptation to climate change throughout the national territory. Some of the considered adaptation measures are:

- Prevention measures for the protection of human health from climate change effects
- Global management of the water resource to ensure resource availability, quality and sustainable use
- Assessing the impact on the energy grid and energy demand of climate change
- Mapping of the areas most vulnerable to desertification.

2.2.2.5. Summary of stakeholders' consultation

AFD financing would be a non-sovereign loan to the Province of Cordoba, which will ensure the programme implementation through the Cordoba Financing and Investment Agency (ACIF), acting as the delegated contracting authority. ACIF is a mixed-ownership provincial society, with shares held by the Provincial State and private local stakeholders. It acts at the same time as a cooperation and investment agency for provincial development and infrastructure.

Starting from bilateral relations with the Provincial Government, the project was first conceived as a traditional housing programme. It has included the energy efficiency perspective later during negotiations between AFD and Cordoban authorities, previewing a next PEEB Programme phase and in the same line with the National Project for "Energy Efficiency and Renewable Energies in Social Housing in Argentina", financed by the GEF and implemented by the IADB.

2.2.3. Project description

2.2.3.1. Project's objectives and description

1. ***Investment Facility***

The funding objective is to support the Provincial Social Housing Programme in order to improve citizens' living conditions by:

i. Increase land availability with basic services and infrastructure for low/middle-income families;
ii. Allow people with no access to the property financial market to get a decent dwelling place; and
iii. Contribute to gender equality in housing sector by reserving a significant part of the programme for women heads of household and victims of domestic violence.

The Cordoban social housing policy is based on 3 complementary programmes, which offer a global response to the housing deficit that affects the low/middle classes within the Province.

a) 'Vida Digna' provides economic assistance through loans or grants, intended to improve living conditions for families in overcrowded housing or without a private bathroom.

b) 'Lo Tengo' intends to strengthen land availability for construction purposes and to allocate them to families by raffle.

c) '25 Mil Viviendas' promotes, through different types of subsidies, the production of decent and affordable housing for low/middle-income families. This programme has 4 sub-components ('Vivienda Semilla', 'Vivenda Semilla Plus', 'Tengo Casa – Bancor' & 'Casa Bancor') which aim to achieve different population segments according to their financial capacity.

Provincial funds, the National Housing Funds (FONAVI) and AFD would finance these programmes. AFD funding would particularly support 'Lo Tengo' and 'Vivienda Semilla' and 'Vivienda Semilla Plus' from '25 Mil Viviendas' Programme. The households targeted by 'Vivienda Semilla' should earn a maximum of 2 SMVM (Minimum living wage) while 'Vivienda Semilla Plus' will target households earning between 2 and 4 SMVM.

AFD funding will target three components: 'Lo Tengo', which aims to finance the development of serviced land for low-income families, and 'Vivienda Semilla', which allows low-income families to receive construction materials kits to be able to build up their own houses whilst they benefit from a subsided consulting architect support. 'Vivienda Semilla Plus' is a programme variant, which will allows middle-low-income families to benefit from an extra loan to hire construction workers, apart from the construction materials loan.

The potential 100 million-dollar funding would cover 100 % of 'Vivienda Semilla' and 'Vivienda Semilla Plus' needs, and 17% of 'Lo Tengo' investments. A 50 million-dollar second loan phase was already taken into account to complete the financing support to the Programme.

The project should allow the achieve nearly 3.000 plots of land with basic services and the supply of 15,000 construction kits for low and middle-income families, from which 3,200 will be dedicated to female-headed households and 400 for women victims of domestic violence.

The below tables outline the GHG baseline emissions and emissions reductions for Argentina residential buildings. Full calculations can be found in Annex 22c.

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	514,227
Emissions - 20% reduction case	391,223

Emissions - 40% reduction case	346,625
GHG reductions - 20% reduction case	123,004
GHG reductions - 40% reduction case	167,602
GHG reductions - average of 20% and 40% reduction case	145,303

GHG emissions without EE measures:	Source of information	Unit	Value
Argentina			
Type of building			Residential
m2 impacted	A	m2	525,000
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	69
Natural gas	C1	kWh/m2/yr	65
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.350
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	24.2
Natural gas	G1 = C1 x E	kgCO2/m2	15.0
Building materials	H1	kgCO2/m2	391.8
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	12,686
Natural gas	J1 = G1 x A	tCO2/yr	7,883
Electricity	I1 = F1 x A x L	tCO2 over lifetime	190,286
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	118,243
Building materials	K1 = H1 x A	tCO2 over lifetime	205,698
Total		**tCO2 over lifetime**	**514,227**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	48
Natural gas	C2	kWh/m2/yr	54
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.350
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	17
Natural gas	G2 = C2 x E	kgCO2/m2	12.5
Building materials	H2	kgCO2/m2	305.9

Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	8,825
Natural gas	J2 = G2 x A	tCO2/yr	6,549
Electricity	I2 = F2 x A x L	tCO2 over lifetime	132,373
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	98,233
Building materials	K2 = H2 x A	tCO2 over lifetime	160,617
Total		**tCO2 over lifetime**	**391,223**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	47
Natural gas	C3	kWh/m2/yr	31
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.350
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	16
Natural gas	G3 = C3 x E	kgCO2/m2	7.2
Building materials	H3	kgCO2/m2	305.9
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	8,641
Natural gas	J3 = G3 x A	tCO2/yr	3,760
Electricity	I3 = F3 x A x L	tCO2 over lifetime	129,615
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	56,393
Building materials	K3 = H3 x A	tCO2 over lifetime	160,617
Total		**tCO2 over lifetime**	**346,625**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	3,861
Natural gas	J1 - J2	tCO2/yr	1,334
Electricity	(I1 - I2) x L	tCO2 over lifetime	57,913
Natural gas	(J1 - J2) x L	tCO2 over lifetime	20,010
Building materials	K1 - K2	tCO2 over lifetime	45,081
Total	**Sum of 20% case**	**tCO2 over lifetime**	**123,004**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	4,045
Natural gas	J1 - J3	tCO2/yr	4,123
Electricity	(I1 - I3) x L	tCO2 over lifetime	60,671

Natural gas	(J1 - J3) x L	tCO2 over lifetime	61,850
Building materials	K1 - K3	tCO2 over lifetime	45,081
Total	**Sum of 40% case**	**tCO2 over lifetime**	**167,602**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	3,953
Natural gas	Average 20% and 40% case	tCO2/yr	2,729
Electricity	Average 20% and 40% case	tCO2 over lifetime	59,292
Natural gas	Average 20% and 40% case	tCO2 over lifetime	40,930
Building materials	Average 20% and 40% case	tCO2 over lifetime	45,081
Total	**Sum of above**	**tCO2 over lifetime**	**145,303**

2. *Enabling Facility*

Three areas of work may potentially be supported through the PEEB Cool Enabling Facility, with actions being confirmed at program start together with national partner authorities. The investment and policy framework facility is directly linked to the sectors of intervention of the project facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration.

Output 2.1 Sectoral investment frameworks demonstrate investment potential for green recovery

Within this output area, support for strengthening public and private investment towards energy efficiency and resilience in buildings is offered, through advise in development of key sectoral and private sector led roadmaps, investment plans, industry decarbonization engagements and/or initiatives in sectors targeted by the project facility. In Argentina ,the national energy efficiency action plan under development as well as the recently conducted sectoral energy efficiency studies, among others for parts of the construction industry (i.e. cement), may provide an entry point for such a sectoral decarbonization and investment roadmap. Roadmaps may also be extended to public buildings and/or residential buildings in line with projects financed within component 1.

Output 2.2 Policy proposals prepare the ground for buildings sector transformation

Depending on national priorities and the relevance of the suggested areas for decarbonizing the buildings and construction sector, national and international expertise may be mobilized to advice on public policies in areas such as COVID recovery policies in the building sector, building codes, sector-specific energy efficiency guidelines, fiscal policies encouraging investments in energy efficiency, building performance labels, etc. In

Argentina, PEEB Cool could build on the ongoing EU-funded project promoting energy efficiency. While this project does not focus on buildings per se, some activities included pilots for energy certification of residential buildings, and energy audits for public building that could be further developed. This links to the tentative projects proposed within the project facility (housing, public buildings).

Output 2.3 Private and public sector actors are enabled to work towards buildings sector transformation

Training and awareness raising modules on topics ranging from bioclimatic building design to policy options and financing for energy efficiency in buildings will be offered within this work area, in particular for the sector actors benefiting from public policy support or financing projects. For example, the ongoing EU-funded "Energy Efficiency in Argentina" project supported trainings for energy efficiency certification of residential housing units and developed an e-learning platform, which could be further used and extended to accompany at a national scale the potential financing programs in the housing sector.

2.2.3.2. Paradigm shift potential

Working with ACIF and DGV could enable the improvement of their energy efficiency policies, and through them, to be reflected in the implementation of future provincial housing programmes. At the same time, the Cordoba DGV has a regular dialog and cooperation with other provincial housing divisions and the National Ministry for Territorial Development and Habitat (and its institutions, such as FONAVI). Promoting this cooperation and intensifying the work along, energy efficiency aspects included in this project could be transferred into others within the country. For this purpose, it is highly important to be able to show through concrete indicators the real impacts that energy efficiency standards could achieve in economic savings and GHG emissions reduction.

Together with both of precedents entities, the Bank of Cordoba, a public financial institution, appears as an important provincial actor and a possible shift potential institution. It has their own financial products orientated to house programs and traditional loans. Energy efficiency standards could be reflected in its policies and eventually incorporated in its financial products. It could also contributes to orientate public social investments towards subsided interest rates to future housing credit programmes ruled by the Bank or the Provincial State.

2.2.3.3. Sustainable development potential

The program will generate spin-offs in the construction sector and will positively impact the economic development of the province. Generally accepted ratios indicate that the construction of one dwelling creates two jobs in one year. The Semilla Plus component alone could generate the equivalent of 15,000 jobs over one year.

The project aims to improve the living conditions of the most modest populations who live in precarious housing conditions or do not have their own housing (cohabitation situation in particular). By promoting access to building land or self-construction housing under sustainable financial conditions for these families, the project contributes to improving the well-being of the most fragile populations and to reducing social and economic inequalities since the program will reach households belonging to the working class and the lower middle class.

In Argentina, and particularly in the Province of Córdoba, where the risk of flooding is high, the project, by providing the poorest populations with access to land located in non-exposed areas, reduces their vulnerability to risk and improves their resilience to climate change.

Construction plans and kits are planned to integrate thermal insulation measures (wall and roof), natural ventilation, aimed at improving summer comfort and limiting the use of air conditioning. The support from PEEB Cool from the design phase of the house will make it possible to include certain principles of bioclimatic construction, and in particular the choice of an optimal layout of each dwelling to maximize the contributions of the environment (air circulation allowing natural ventilation in particular).

2.2.3.4. Project indicative financing

	Total Amount (a+b)	Currency	GCF amount (a)	AFD amount (b)
Senior loan	92	Million EUR	13.8	78.2
Grant (technical support)	4.5	Million EUR	4.5	0
Total project financing (1+2)	96.5	Million EUR	18.3	78.2

This amounts are provisional at this stage and are still to be discussed

2.3. Costa Rica

National Designed Authority	**Ministry of Environment and Energy (MINAE)**
Project title	PEEB Cool Costa Rica
Name and typology (public/private) of the institutions	Ministry of Housing and Human Settlements (MIVAH), Ministry of Public Education (MEP) Public Banks (Banco Nacional de Costa Rica, Banco de Costa Rica, Banco Popular, etc.), Public Companies/Institutions (Costa Rican Social Security Fund - CCSS, Costa Rican Institute of Electricity - ICE, etc.) Private Companies and Institutions
End beneficiaries (households, students…)	End beneficiaries will include public and private financial institutions, municipalities and smaller entities (individuals, entrepreneurs).
Mitigation/adaptation focus	Cross cutting

2.3.1. Climate profile

Both the ND-GAIN index and the Environmental Performance Index place Costa Rica as the 52nd least vulnerable country (with the ND-GAIN Index also ranking the country as 68th most ready). That is, while climate and environmental vulnerabilities certainly exist, the country is reasonably well-positioned to adapt.[11][12]

Nonetheless, with over three quarters of the population residing in urban regions, and an urbanisation rate of 1.5% annually, the economic and health risks of climate change and natural hazards are high.

2.3.1.1. Historic climate data

Costa Rica has various climatic zones but mostly falls within the tropical savanna (including the capital San Jose) and tropical monsoon climates. 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.[13] The number of warm days has increased by 2.5% and warm nights rose by 1.7%

[11] ND-GAIN Index. 2021.

[12] Environmental Performance Index. 2021.

[13] World Bank Climate Change Knowledge Portal.

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.

Temperature and precipitation patterns in Costa Rica are significantly impacted by regional extreme weather events, such as El Niño and La Niña cycles that see large changes in ocean temperature. The El Niño cycle warms the country and typically sees much of the land experience very dry, drought-like conditions while La Niña often leads to excessive precipitation events and floods.

2.3.1.2. Future Climate Projections

Costa Rica's Third National Communication submitted to the UNFCCC expects a 1-2°C increase in temperature by 2050 and up to 4°C by 2080, with temperature variance under future trends likely to be more significant at higher elevations than in the lowlands (Government of Costa Rica, 2014).

City specific data allows us to see clear climate trends under different scenarios. Please see Table 5 for more information on San Jose.

Table 5 Future temperature changes in Costa Rica

Time Period and Emission Scenario	Tropical Nights (Days)	Max. Temperature (°C)	Min. Temperature (°C)	Temperature (°C)
2011-2040 (RCP 4.5)	0.2	0.93	0.79	0.87
2041 – 2070 (RCP 4.5)	0.27	2.00	1.40	1.60
2071-2100 (RCP 4.5)	0.23	2.40	1.70	1.90
2011 – 2040 (RCP 8.5)	0.17	1.10	0.94	1.10
2041 – 2070 (RCP 8.5)	0.23	2.80	2.10	2.60
2071 – 2100 (RCP 8.5)	0.23	4.90	3.60	4.30

There is a clear trend in temperature increases, especially under higher emission scenarios, towards the end of the century against the 1960 – 1990 baseline. Higher temperatures, higher minimum and maximum temperatures and a rise in the number of warm nights increases vulnerability to heat stress.

Country level data is also valuable to understand the probabilities of extreme temperature events and expected magnitude cooling requirements. See Table 6.[14]

Table 6 Climate indicators under different emission scenarios at a national level (World Bank Data)

Time Period and Emission Scenario	Hot Days	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	4.79	0.22	0.08	451.4C
2040-2059 (RCP 2.6)	6.26	0.33	0.11	563.82
2060-2079 (RCP 2.6)	6.68	0.62	0.12	555.28
2080-2099 (RCP 2.6)	6.95	0.22	0.11	565.29
2020-2039 (RCP 4.5)	4.90	0.20	0.09	485.29
2040-2059 (RCP 4.5)	10.48	2.31	0.18	785.80
2060-2079 (RCP 4.5)	14.11	6.46	0.32	1011.06
2080-2099 (RCP 4.5)	16.64	13.28	0.37	1101.99
2020-2039 (RCP 8.5)	6.85	0.15	0.11	567.70
2040-2059 (RCP 8.5)	15.80	6.95	0.30	1059.47
2060-2079 (RCP 8.5)	37.09	73.84	0.63	1707.46

[14] World Bank. Climate Change Knowledge Portal. Costa Rica Climate Data Projections.

2080-2099 (RCP 8.5)	72.17	209.36	0.89	2365.75

Climate models studying future warming in the Central American region (Costa Rica, Nicaragua and Panama) find a correlation between a positive heat index change in both RCP 4.5 and RCP 8.5 and an increase in the number and intensity of heat waves. Researchers find that by the end of the century, the number of annual heat wave events in the region will range between 60-100 (Angeles-Malaspina and Ramirez-Beltran, 2018).

Models published by the Global Facility for Disaster Reduction and Recovery (GDFRR) classify Costa Rica's vulnerability to extreme heat as medium based on future projections (please see Figure 3 for more information). That is, there is a more than 25% probability that at least one period of prolonged heat exposure, resulting in heat stress, will occur within the next five years.[15]

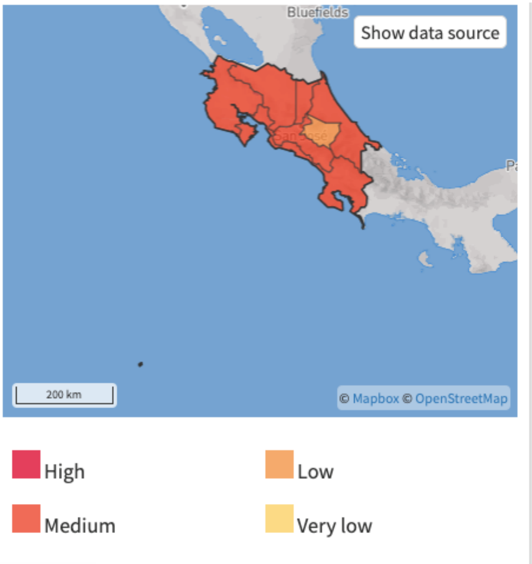

Figure 3 Extreme heat risk in Costa Rica (GFDRR data)

2.3.1.3. The impact of high temperature on health

Temperature extremes will create socio-economic and health challenges for Costa Rica. For example, a study of classroom temperature and performance in the country focused on the impacts of cooling on student performance in primary schools. The results showed that older children performed the language and logical thinking tasks better in lower temperatures while less able students performed better on every task at lower temperatures (Porras-Salazar, 2018). These results suggest that performance and attainment could suffer in schools where no such cooling options exist.

Costa Rica has implemented, and committed to, several mitigation plans to lower overall GHG emissions, including a focus on buildings. However, adaptation measures are less well defined. As temperatures continue to rise in the country, especially in densely populated cities, risks to health and the economy are expected to

[15] Think Hazard. 2021. Costa Rica. Available at https://thinkhazard.org/en/report/61-costa-rica/EH

become more pronounced. Therefore, the inclusion of Costa Rica and eventual upscaling of the proposed project within the country can greatly enhance Costa Rica's adaptive capacity to heat within buildings - limiting such risks dramatically.

A 2011 study on temperatures and economic output in the Caribbean and Central America observed a fall in services output by over 6% for every 1 degree Celsius above summer averages (Hsiang, 2010). Such effects at a smaller, micro level run the risk of a much broader cumulative effect at the macro level, therefore hindering a country or region's economy.

2.3.2. Market context and barriers

2.3.2.1. Strategic context and market potential

Economy

The most prosperous of the Central American Common Market's five countries, Costa Rica has a long history of democratic stability and one of Latin America's highest levels of foreign direct investment per capita. Traditional agricultural exports of bananas, coffee, sugar, and beef are still the backbone of its commodity-driven export economy, but Costa Rica is also one of Central America's most popular ecotourism destinations and an exporter of medical devices and other high-value-added goods and services.

Prior to the pandemic, Costa Rica was determined to reduce the high budget deficit and apply a fiscal rule that restrains public spending growth. Poverty has remained around 20-25% for nearly 20 years, and the government's strong social safety net has eroded due to increased constraints on its expenditures. Costa Rica's credit rating was downgraded several times from 2015, upping pressure on lending rates. Unlike the rest of Central America, Costa Rica is not highly dependent on remittances - which represented just 1 % of GDP in 2016, but instead relies on Foreign DI - which accounted for 5.1% of GDP.

According to the OCDE, with the COVID-19 crisis the economic activity is projected to contract by around 5% in 2020, before rebounding by 1.5 % in 2021, if there is a second virus outbreak in the autumn of 2020. The protracted recovery will hinge on the delayed normalisation of tourism, with the affected sectors likely to be subject to near complete shutdowns until the last quarter of 2020. If the pandemic subsides soon, GDP will shrink by about 4% in 2020 and expand by around 2.75% in 2021, due to a stronger recovery in domestic demand and exports. In early October 2020, Costa Rica withdrew its request for support (US$1 750 million) to the IMF in response to protests over the announcement of new taxes.

Energy

Costa Rica has recently adopted an ambitious plan to be a zero net emissions economy by 2050 (National Decarbonisation Plan, "PND"), in line with the objectives of the Paris Climate Change Agreement. With the goal of reducing greenhouse gas emissions, the plan includes significant measures in public and private transport, energy, industry, agriculture, waste management and rural, urban and forest management. Costa Rica is well positioned to achieve this target, as its economy is less energy intensive than the average OECD economy and half of its primary energy supply is renewable, mostly hydro, geothermal and wind power.

Over the last six years, Costa Rica has generated more than 98% of its domestic electricity from renewable energy. This makes Costa Rica the country with the highest share of renewables in the region. The country has 99.4% electrical coverage, and a robust, reliable and flexible electrical system. One of the major challenges for the country will be to further lower the cost of energy, which was for several years one of the most expensive in the region.[16]

Yet despite this high share of renewable production the country continues to import more and more electricity from other parts of Central America to counter the drop in hydro production during drought periods (NB: when the demand for cooling is the highest). It represents about 8% of the country's total electricity supply in 2018, of which nearly 60% from thermal sources.

Buildings and construction

More than 62% of energy in the residential sector comes from electricity, 12% from hydrocarbons and 26% from biomass. With respect to COP21's 2015 (0.18 MtCO2eq.), emissions in a BAU scenario will increase by 198%, while in the WAM (With Additional Measures) scenario they will only increase by 162%. This sector is highly influenced by the use of LPG for cooking, due to a subsidized cost. In addition, by 2050, biomass consumption is almost zero.

In 2017, the construction sector represented 5.3% of the GDP. It reached 10.2 Mio m² of built area. 35% of these constructions were due to housing projects. Despite the fact that most of the projects are new (57%), the renovations present a very dynamic annual growth rate in the same period. Costa Rica is the leader in terms number of LEED certified projects in the region. However, the initial high extra costs remain the greatest obstacle to implementing this type of construction, followed by the lack of incentives. Moreover, one still observes little awareness of energy efficiency benefits in some consumer groups, mainly due to only voluntary standards and therefore limited use of comparative energy labels. Generally, there is a large potential to increase consumer awareness, building on success stories in other sectors (e.g. ecotourism).

The non-energy industrial processes and product uses that generate the most GHG emissions are cement, lime and glass production, along with refrigeration and air conditioning[17]. Compared to 2015, GHG emissions in these sectors, in the BAU scenario, increase by 39% in 2050. Thus, encourage the application of bioclimatic design, promote the reuse of materials, low carbon footprint materials such as cement and green concrete, as well as local inputs (wood from national plantations and/or bamboo) is a crucial strategy of mitigation of building sectoring in the NDC 2018-2030.

Cooling and appliances challenge

The market size for AC is relatively small but is growing rapidly. In view of the rapid growth of the AC market, it is therefore particularly relevant and efficient to act quickly on building envelopes and air-conditioning equipment before the market becomes too large with significant associated emissions.

The continuously growing demand for cooling in Costa will result in significantly increased emissions from this sector in the coming decades. This applies both to emissions caused by energy consumption and the emissions of released coolants.

Costa Rica is obliged to import more and more carbonized electricity from its neighbours, and as air conditioning is and will be one of the major factors of increasing energy demand in the country, one can

[16] In 2020 the price of electricity is 0.169 U.S. Dollar per kWh for households and 0.192 U.S. Dollar for businesses which includes all components of the electricity bill such as the cost of power, distribution and taxes. In comparison the world average is 0.14 U.S. Dollar per kWh for households and 0.12 U.S. Dollar

[17] IBA 2019 https://unfccc.int/sites/default/files/resource/IBA-2019.pdf

consider the marginal emissions of on kWh of air conditioning equal to the one of this imported electricity (c 366 g CO2/kWh, 2019).

Given Costa Rica's current low emission factor of its electricity mix (0.14 tCO2/MWh,[18] 2018), and hence low energy-related CO2 emissions throughout the economy, HFC-related emissions represents now a particularly important target for GHG abatement. The RAC sector currently contributes approximately 13.5% of total GHG emissions in 2015, and this share might increase to 31% by 2030, assuming a BAU scenario in the RAC sector which follows the HFC phase-down of the Kigali Amendment schedule and declining total emissions as formulated in the NDC. Split unit AC accounts for approximately 7% of RAC emissions.

Appliances are for now relatively inefficient and the potential for both economic and emissions savings is very significant if efforts are made to improve the awareness on the benefits of energy-efficient cooling.

Public policy and legal framework

The VII National Energy Plan (2015-2030): The main objective of this plan is to guide future development of the power sector in Costa Rica. Divided into 6 strategic pillars, a strong emphasis is made on energy efficiency, notably in the buildings sector.

National Decarbonisation Plan 2018-2050:[19] The National Decarbonisation Plan (2018-2050) was presented on February 24th, 2019. In line with the objectives of the Paris Climate Change Agreement, its objective is to turn Costa Rica into a modern green, emissions-free, resilient and inclusive economy by 2050 where human rights and gender equality are respected. The Plan seeks to transform the country into an economy that responds to the changes of global context and to enable the transition to a green economy that promotes the sustainable use of natural resources. The NDC reaffirms the government's aspiration of achieving partial carbon neutrality by 2021 and becoming a net carbon-neutral economy by 2085. The NDC also includes an unconditional 44% GHG reduction target against business-as-usual by 2030. HFCs specifically included in the NDC.

Costa Rica has already succeeded in establishing an electric grid that is more than 98% emissions-free and ensuring a very low deforestation rate, with a wooded surface area that covers 52% of the territory. The National Decarbonisation Plan represents the base for the construction of the National Development and Public Investment Plan (2019-2022) and the Long-Term Strategy Plan of Costa Rica 2050. The implementation of the National Decarbonisation Plan is coordinated the Climate Change Department (DCC) from the Ministry of Environment and Energy (MINAE), with support from the Ministry of Planning (MIDEPLAN), the Presidency and the Ministry of Treasury (HACIENDA).

Under the activities that are planned for implementation, Axis 5 (development of buildings for commercial, residential and institutional use under standards of high efficiency and low emissions) specifically mentions the use of energy efficient ACs to be included in the standards that promote low-emission sustainable construction practices. Additionally, it emphasises the use of efficient refrigeration equipment and natural or low Global Warming Potential (GWP) air conditioning systems (in accordance with the Kigali Amendment) in existing buildings (GoCR, 2019).

[18] https://www.iges.or.jp/en/pub/list-grid-emission-factor/en

[19] https://cambioclimatico.go.cr/wp-content/uploads/2019/02/PLAN.pdf

In 2019, Costa Rica reformed its Executive Decree No. 41578. With this reform, it extended the national moratorium on oil exploration and exploitation from September 2021 until the end of 2050 (MINAE, 2017).

Energy efficiency - Window type air conditioners, divided type and package type – MEPS and Labelling (INTE E14-1 and 2:2019): The purpose of this standard is to establish the requirements that must be met by the energy efficiency label of air conditioners. This Standard covers all air conditioners, window type, split, package with nominal cooling capacities up to 17 589 W (60,000 Btu/ h).

Technical Guide for Sustainable Construction (2017): Published by MIVAH[20] and CFIA, this Technical Guide is of voluntary use, and the aim is for both professionals and the general public to start to introduce the concepts of sustainable construction in their projects, provides guidelines on water and energy efficiency in new buildings being built in Costa Rica

The National Sustainable Buildings Standard (INTE C170: 2020) covers optimized building design, the use of sustainable materials as part of the sustainable construction principles, but also the usage of energy efficient appliances. Providing a guideline for construction in the public sector, the Standard refers to international building energy efficiency concepts and certifications such as LEED and applies them to tropical climate conditions (concept RESET: Requisites for Sustainable buildings in the Tropics). The RESET certification is awarded for compliance with a set of construction evaluation criteria. The Standard limits overall energy use by the largest energy consumers (not area-specific) but does not require a specific minimum energy performance.

The Green Construction Standard (Directriz Nº 050 MINAE) has the objective to promote the application of sustainable construction practices in buildings throughout the public administration, both in those to be constructed and in existing buildings that are to be extended, adapted, rehabilitated, renewed, improved, maintained or remodelled. It is mandatory for the public sector and energy efficiency of buildings is addressed.

2.3.2.2. Analysis of relevance of barriers

Barriers type	Country specific relevance
Technical barriers	
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	Architects and engineers lack knowledge on bioclimatic and energy efficient building design. EE/RE technologies are new and mainly imported.
Financial barriers	
Building owners are reluctant to invest in the higher upfront cost of energy efficient, low carbon and resilient	Developers and building owners lack of access to financing and are reluctant due to higher up-front costs

[20] Ministry of Housing and Human Settlements of the Republic of Costa Rica

buildings, especially with the economic crisis caused by the COVID-19 pandemic	for energy efficient measures and technologies. Also, energy subsidies reduce potential cost savings of EE measures. There is a lack of financial incentives for EE construction. The COVID-19 pandemic let to a strong GDP downturn in 2020. Green construction stimulus programmes can be essential for the economic recovery.
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	The awareness on financing for EE buildings is low. Banks are hesitant to invest due to lacking technical parameters to evaluate the performance and sustainability. Loan officers and risk managers of banks lack knowledge on EE technologies or on energy performance contracting. However, initiatives exist and Commercial Bank of Ceylon has special terms for businesses and consumers on investments made in green projects.
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	There is a very fragmented market structure along the construction value chain. Split incentives between landlords and tenants represent an economic barrier. There is a strong dependency of imported products which makes technology prices very high.
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	Strategies and regulations are fragmented. There is a lack of mandatory standards for EE in buildings and no adequate follow-up on the implementation of regulations by corresponding authorities. The National Sustainable Buildings Standard only addresses the largest energy consumers. The Green Construction Standard is only mandatory for public sector buildings.
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	There is a lack of detailed guidelines, tools and experts and enforcement of standards. The process of drafting legislation is slow due to lack of capacity by authorities. There is also a lack of green building certification and testing and certification of new EE building products and technologies.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	Among developers, building managers, construction companies and consumers there is lack of awareness of design measures and benefits of green buildings.

2.3.2.3. AFD experience in financing buildings construction of refurbishment projects

AFD has been authorized to operate directly in Costa Rica since 2019 with a mandate focused on climate change issues.

In this framework, a first operation was approved in December 2019 consisting of a support program for the implementation of the National Decarbonisation Plan through a public policy loan and an associated technical assistance program. However, AFD does not have for the time being a specific experience in terms of financing Energy Efficient buildings construction or refurbishment projects in Costa Rica. Meanwhile these types of projects fit perfectly with AFD's mandate in Costa Rica and AFD is willing to develop and finance them.

2.3.2.4. GIZ experience in financing buildings construction or refurbishment projects in Costa Rica:

GIZ has about 60 years (since the early 1960s) of experience working in the field of technical and policy advice with the Costa Rican government and implemented various projects in different areas with various ministries. Currently GIZ has many projects and programs with MINAE, MOPT; MEP and other ministries.

GIZ has been implementing MOPT/BID financed projects in the road construction sector. GIZ has around 10 years (2010-2020) of experience working on climate change and energy efficiency in Costa Rica.

- Costa Rica as a low emission country - supporting the national strategy of climate neutrality in Costa Rica as a model for low carbon development, Phase II (and project before from 2011)
- Renewable energy and energy efficiency in Central America (4E III) (since 2010)

GIZ has 4 years (2016-2020) of extensive experience working with MINAE in the field of ozone, climate and energy efficiency in Costa Rica.

- Cool Contributions fighting Climate Change (C4) (to be extended to 2023, phase II)
- Renewable Energies and Energy Efficiency in Central America (4E III)
- A Sustainable and climate-friendly Phase out of Ozone Depleting Substances (SPODS)
- Green Cooling (GCF funding proposal to be submitted in 2020)

Moreover, under the C4 project GIZ has implemented demonstration projects with (ICE, MOPT, MEP; MINAE, Hotel Ambassador) on the introduction of ozone and climate friendly and highly energy efficient ACs.

The above projects were successful, and the counterpart contributions have occurred. However, GIZ does not have specific experience in terms of financing buildings construction or refurbishment projects in Costa Rica.

2.3.2.5. Environmental public policies analysis

Environmental policies related to the building sector

The Costa Rican Chamber of Construction with the support of the German Agency for Technical Cooperation - GIZ and the Technological Institute of Costa Rica (ITCR) have published the " Guía de Construcción Sostenible " and the " Guía de Manejo Eficiente de Materiales de la Construcción ". These two documents provide specific measures, as a manual of good practices, to promote construction with sustainability criteria and mitigate the adverse effect that construction practice has on the environment.

No national building energy code is in place.

With regard to certifications, coexist in the country: RESET “Requisitos para las edificaciones sostenibles en el Trópico”, it is an INTECO “Instituto de Normas Técnicas de Costa Rica” technical standard, protected by the National System for Quality and promoted by the Institute of Tropical Architecture; EDGE (Excellence in Design for Greater Efficiencies, 2017) and LEED (Leadership in Energy and Environmental Design).

The MINAE “Ministerio de Ambiente y energía”, together with the National Quality System, are working on efforts aimed at positioning the environmental labeling of products at the national level, based on the ISO 14024 and ISO 14025 standards. In the meanwhile, the current energy rating system is aligned on the Mexican system, with the exception of some air conditioning appliance types (window, split, package, divided) which have a national regulation and minimum performance standards (INTE E14:2015).

Micro and small renewable energy producers can claim benefit for surplus production by monthly or yearly net metering since 2014.

Adaptation to climate change policies

The country is in the process of establishing and implementing its National Adaptation Plan, with a first version compiled in 2018 for the 2018-2030 period. It identifies extreme hydrometeorological conditions and water scarcity as the major climate change related vulnerability issues. Within the global strategy, a Human Rights approach refers amongst other issues to human health, access to potable water and decent housing, considering also anticipated population migrations; the integrated adaptation strategy considers also seeks the adaptation of the land planning to the extreme climatic events exposure. Among the identified actions axis:

- Axis 2: Fostering the conditions for the resilience of human and natural systems through territorial, marine and coastal planning
- Axis 4: Adapted public services and resilient infrastructure (continuity of energy, water, health and education services; norms and guidelines for investment in resilient infrastructures, etc.)

In Annex 2 "Sustainability Criteria for Application in New Constructions" of DIRECTIVE N ° 050-MINAE that applies to public works, sustainable construction strategies are promoted, such as reducing the heat island effect, selection of materials reducing the environmental impact of construction, implementation of passive measures, etc.

2.3.2.6. Summary of stakeholders’ consultation

Ministry of Environment and Energy (MINAE)

In charge of regulation and implementation of policies applicable to energy, electricity, climate change and ozone-depleting substances, as well as water and wastewater services. The minister is the focal point to the GCF (NDA). MINAE has the following directorates/secretariat:

- Energy Directorate (DE) could be the implementing entity for EE in buildings.

The DE is the implementing entity of the technical regulation. It is responsible for the definition, updating and periodic adoption of INTECO’s standards e.g. for MEPS and labelling and for their monitoring in the market.

- Climate Change Directorate (DCC)

The DCC is supporting IMN on the compilation of the NC4 (Fourth National Communication to the UNFCCC). Responsible for the eNDC, Costa Rica's strategic program on climate change and the low-carbon economy plan, as well as overall consultancy and planning programs on climate change, are provided by these institutions.

- Energy Subsector Secretariat Planning (SEPSE) Under the supervision of the Ministry of Environment and Energy (MINAE); implementation of the National Energy Plan, energy efficiency-related policies, laws and regulations. Undertaking research and implementing projects for reducing energy consumption and promoting energy-efficient electrical appliances, including air conditioners. Responsible for technical regulations such as MEPS and labelling.
- Directorate of Environmental Quality Management (DIGECA)

Responsible for implementing Montreal Protocol obligations such as the HCFC Phase-out Management Plan (HPMP) and ozone layer protection projects, as well as future national HFC phase-down policies in accordance with the Kigali Amendment.

AFD and GiZ maintain close contact to the MINAE. The PEEB COOL initiative was presented to the MINAE and received its support for application to the GCF (letter of Non Objection of the NDA).

Ministry of Housing and Human Settlements (MIVAH)

The MIVAH is the technical governing body in matters of land management and human settlements. It is responsible for issuing and managing guidelines, directives and policies on land use planning, urban planning, human settlements and adequate housing. The objective is to improve the quality of life of the inhabitants of our country, according to the needs and demands of the different socioeconomic strata, with the purpose of facilitating access to housing, subject to the coordination of a comprehensive planning of our country.

AFD and GiZ maintain close contact to the MIVAH. The PEEB COOL initiative was presented to the MINAH and received its support.

Technical Standards Institute of Costa Rica *(*INTECO*)*

INTECO is the sole organization in the country that can lawfully develop and designate official standards for products. INTECO is also responsible for the certification of appliance labelling (currently voluntary) as well as drafting or updating MEPS and building codes. GiZ is in contact with them on the topics of efficient cooling and Energy Efficiency.

Costa Rican Social Security Fund (CCSS)

The CCSS is in charge of most of the nation's public health sector. Its role in public health (as the administrator of health institutions) is key in Costa Rica, playing an important part in the state's national health policy making. The CCSS is in charge of most public hospital and clinics in Costa Rica and therefore owns many buildings all over the country. They are interested in energy efficiency and sustainable buildings. GiZ is in contact with them on the topic of efficient cooling and Energy Efficiency.

Ministry of Public Education (MEP)

The MEP is in charge of executing the development and consolidation of an educational system that allows the entire population access to quality education. The MEP manages most public schools and vocational training centers and therefore owns many buildings all over the country. They are interested in improving energy efficiency and sustainabilmity of the buildings they manage and buid . GiZ is in contact with them on the topic of efficient cooling and Energy Efficiency training.

Central American Bank for Economic Integration (CABEI) **(CABEI):** The CABEI (BCIE in Spanish) is an international multilateral development financial institution. Its resources are invested in projects that foster development to reduce poverty and inequality; strengthen regional integration and the competitive insertion of its member countries in the global economy; providing special attention to environmental sustainability. AFD is already working with BCIE and GiZ is in relation with them regarding Energy Efficiency topic.

2.3.3. Project description

2.3.3.1. Project's objectives and description

The main objective of the PEEB Cool project is to support the adoption of sustainable and renewable energy practices in the construction of new low-carbon and cool buildings through a multi sector approach that will benefit both public and private institutions in Costa Rica. The project will contribute to Costa Rica´s Nationally Determined Contribution (NDC) targets and provide sectorial technical assistance to support the transformation of the building sector towards a low-carbon development path.

PEEB Cool will focus on new construction projects with high energy demand and cooling needs in the following building segments, offering support to public and private sector entities alike:

Public sector project that could be financed by AFD:

- Public hospitals of Costa Rican Social security Fund (CCSS)
- Administrative buildings of various institutions
- Public schools of Ministry of Public Education (MEP) and universities
- Residential sector through program lead by public entities

Private sector financing by PROPARCO:

- Commercial buildings
- Private hospitals
- Private schools and universities

The components of the described program are:

Component 1: Investment Facility

The Project Facility provides technical and financial assistance to project owners (private and public entities) to identify, prepare and support energy efficient and cool building projects in its partner countries.

Tentative Activity 1: Identification of projects

- Support to public or private project owners on the selection of suitable low-carbon construction projects for financing by the PEEB Cool Investment Facility.
- Elaboration on pre-feasibility studies and initial project concepts for promising potential low-carbon cool building construction projects.

Tentative Activity 2 – Preparation of financing

- Elaboration of technical and financial feasibility studies for specific public or private sector low-carbon and cool building construction projects.
- Support to public or private project owners on design improvements and technical criteria for low-carbon building projects subject to finance preparation under PEEB Cool.

- Preparation of public sector low-carbon construction projects and financial mechanisms and conditions which are subject for potential financing by French AFD under PEEB Cool (e.g. public hospitals, schools, administrative buildings).
- Preparation of private sector low-carbon construction projects subject for potential financing by French PROPARCO under PEEB Cool (e.g. private hospitals, commercial buildings).

Tentative Activity 3 – Implementation of projects

- Training measures to national financiers like development banks and their intermediary banks on low-carbon construction financing and eligibility criteria, evaluation and verification criteria and procedures.
- Technical and financial accompaniment of construction projects.
- Support on monitoring, reporting and verification of implemented projects.

The below tables outline the GHG baseline emissions and emissions reductions for a Costa Rica education case. Full calculations can be found in Annex 22c.

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	30,751
Emissions - 20% reduction case	26,663
Emissions - 40% reduction case	26,346
GHG reductions - 20% reduction case	4,088
GHG reductions - 40% reduction case	4,405
GHG reductions - average of 20% and 40% reduction case	4,246

GHG emissions without EE measures:	Source of information	Unit	Value
Costa Rica			
Type of building			Education
m2 impacted	A	m2	72,800
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	34
Natural gas	C1	kWh/m2/yr	3
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.145
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	4.9
Natural gas	G1 = C1 x E	kgCO2/m2	0.7
Building materials	H1	kgCO2/m2	338.0
Total GHG emissions			

Electricity	I1 = F1 x A	tCO2/yr	359
Natural gas	J1 = G1 x A	tCO2/yr	50
Electricity	I1 = F1 x A x L	tCO2 over lifetime	5,389
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	757
Building materials	K1 = H1 x A	tCO2 over lifetime	24,605
Total		**tCO2 over lifetime**	**30,751**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	21
Natural gas	C2	kWh/m2/yr	3
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.145
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	3
Natural gas	G2 = C2 x E	kgCO2/m2	0.7
Building materials	H2	kgCO2/m2	310.1
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	222
Natural gas	J2 = G2 x A	tCO2/yr	50
Electricity	I2 = F2 x A x L	tCO2 over lifetime	3,329
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	757
Building materials	K2 = H2 x A	tCO2 over lifetime	22,577
Total		**tCO2 over lifetime**	**26,663**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	19
Natural gas	C3	kWh/m2/yr	3
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.145
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	3
Natural gas	G3 = C3 x E	kgCO2/m2	0.7
Building materials	H3	kgCO2/m2	310.1
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	201
Natural gas	J3 = G3 x A	tCO2/yr	50
Electricity	I3 = F3 x A x L	tCO2 over lifetime	3,012

Natural gas	J3 = G3 x A x L	tCO2 over lifetime	757
Building materials	K3 = H3 x A	tCO2 over lifetime	22,577
Total		**tCO2 over lifetime**	**26,346**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	137
Natural gas	J1 - J2	tCO2/yr	-
Electricity	(I1 - I2) x L	tCO2 over lifetime	2,061
Natural gas	(J1 - J2) x L	tCO2 over lifetime	-
Building materials	K1 - K2	tCO2 over lifetime	2,027
Total	Sum of 20% case	tCO2 over lifetime	4,088

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	159
Natural gas	J1 - J3	tCO2/yr	-
Electricity	(I1 - I3) x L	tCO2 over lifetime	2,378
Natural gas	(J1 - J3) x L	tCO2 over lifetime	-
Building materials	K1 - K3	tCO2 over lifetime	2,027
Total	Sum of 40% case	tCO2 over lifetime	4,405

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	148
Natural gas	Average 20% and 40% case	tCO2/yr	-
Electricity	Average 20% and 40% case	tCO2 over lifetime	2,219
Natural gas	Average 20% and 40% case	tCO2 over lifetime	-
Building materials	Average 20% and 40% case	tCO2 over lifetime	2,027
Total	Sum of above	tCO2 over lifetime	4,246

Component 2: Enabling Facility

The Enabling facility provides technical assistance for policy support on energy efficient and cool buildings at different levels to its partner countries. This component will be implemented by GIZ. The enabling facility is directly linked to the sectors of intervention of the project facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration.

Output 2.1 - Sectoral investment frameworks

- Support on the development of specific sectoral roadmaps, frameworks, engagements or action plans for building segments which are targeted under the Project Facility (e.g. energy efficient and cool hospitals, hotels, schools).

Output 2.2 – Public Policies

- Advisory on the improvement and enforcement of energy efficiency policies, such as energy efficiency building codes and regulations (e.g. actualization of INTE C170: 2020)
- Support on the development of energy performance systems for specific building segments, including baseline definitions, design standards, monitoring, reporting and verification formats.
- Support on public or private energy efficient building initiatives for low carbon construction.
- Specific policy advice on building segment targeted for financing under the Project Facility.

Output 2.3 – Capacity building for sector actors

- Development of tailor-made training formats to public and private key stakeholders of the low-carbon building sector and the air conditioning sector.
- Training to investors and developers on the design and construction of energy efficient, climate-adapted and low-carbon cool buildings.
- Training to financiers on eligibility criteria and verification procedures for the financing of low-carbon building based on energy performance system.
- Awareness to end users on the economic, social and health benefits of energy efficient and cool buildings.

Tentative Activity 4 – Dissemination and knowledge sharing

- Support on knowledge-sharing of policies, roadmaps and action plans as well as technical and financial solutions for the construction of low-carbon and cool buildings at federal, state and municipal levels (vertical integration).
- Support on regional and global peer-to-peer networking and learning on good practices on policies, technical and financial solutions.

2.3.3.2. Paradigm shift potential

Under the Investment Facility, PEEB Cool will provide financing to public and/ or private sector entities for new low-carbon construction projects with high energy demand and cooling needs. Thus, PEEB Cool will contribute to the development of financial incentive products (credits, loans, subsidies) for EE/RE measures and technologies in buildings contributing to the low carbon transformation of the building and construction sector in Costa Rica. By providing adequate financing, innovative low carbon construction in different building sector segments will be encouraged and a change towards climate-adapted building design, more energy efficient equipment and appliances and low carbon building materials will be promoted at national and local level.

Under the Enabling Facility, PEEB Cool will support the improvement of the legal framework and support mechanisms for low carbon and cool buildings. Through the support with the development of sectoral investment frameworks national public and private actors mobilize additional investments with mitigation and adaptation impacts.

2.3.3.3. Sustainable development potentials

To be defined with the Ministry of Environment and Energy (MINAE) after definition of components and beneficiaries.

2.4. Djibouti

National Designed Authority	**Republic of Djibouti**
Project title	Programme for Energy Efficiency in Administrative Buildings
Name and typology (public/private) of the institutions	Public institutions concerned: Ministry of Economy and Finance charged with Industry (MEFI) Djiboutian Energy Control Agency (ADME) Territory Organization, Urbanism and Accommodation Direction (DATUH) Ministry of Energy and Renewable Resources (MERN)
End beneficiaries (households, students…)	Buildings in the Ministerial district ADME head office Electricité de Djibouti (EDD) head office Other public buildings: intellectual proprety office ('Office Djiboutien de la Propriété Intellectuelle', ODPIC) head office, mosques, high schools, primary schools, community development centers ('Centres de Développements Communautaires', CDC), hospital, and clinics, among others.
Mitigation/adaptation focus	Mitigation

2.4.1. Climate profile

The ND-Gain index rates Djibouti 117th overall, suggesting high vulnerability and limited adaptive capacity and a need for significant urgency in climate action.[21]

2.4.1.1. Historic climate data

Djibouti has a largely hot and semi-arid climate with an average annual temperature of around 28°C.[22] During the summer months, temperature can reach as high as 45°C and rarely fall below 18°C any time in the year. Moreover, humidity can top 90% making temperatures feel even higher. Temperature is also part influenced by ENSO cycles which can cause periods of extreme heat and dryness.

[21] ND-GAIN Index. 2020.

[22] World Bank. 2019. Climate Change Knowledge Portal.

Temperatures have been increasing quickly in recent years, at a rate of around 0.22°C per decade in the last 30 years.[23] 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.[24]

2.4.1.2. Future climate projections

Models agree that Djibouti will see significant warming throughout the century. In the shorter term, the World Bank expects Djibouti to see warming of 2.4°C by 2050. Whereas analysis by the Climate Service Center Germany shows likely annual mean temperature warming of up to 5.3°C by 2085 and both minimum and maximum temperatures slightly lower.[25]

These projections are consistent with subnational data. Table 7 shows data for the capital, Djibouti City.[26]

Table 7 Future temperature changes in Djibouti City

Time Period and Emission Scenario	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)
2011-2040 (RCP 4.5)	1.10	0.72	0.92
2041 – 2070 (RCP 4.5)	2.00	1.40	1.70
2071-2100 (RCP 4.5)	2.60	2.00	2.10
2011 – 2040 (RCP 8.5)	1.30	0.98	1.00
2041 – 2070 (RCP 8.5)	2.90	2.30	2.40
2071 – 2100 (RCP 8.5)	4.90	3.90	4.20

[23] Climate Service Center Germany. 2016. Climate fact sheet.

[24] Climate Service Center Germany. 2016. Climate fact sheet.

[25] Climate Service Center Germany. 2016. Climate fact sheet.

[26] Data from Climate Information Site-specific report.

This data shows significant temperature increases across all indicators with a particularly high maximum temperature change of 4.90°C under the high emissions scenario. Due to the city's coastal location, warming is expected to be slightly less than inland although still very high.

Data for the whole country paints a similar picture. Table 8 shows future climate indicators, specifically focused on heat.

Table 8 Future heating indicators for Djibouti (World Bank data)

Time Period and Emission Scenario	Hot Days	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	21.12	26.04	0.06	507.37
2040-2059 (RCP 2.6)	29.77	40.93	0.08	694.50
2060-2079 (RCP 2.6)	29.17	37.37	0.07	691.94
2080-2099 (RCP 2.6)	27.30	37.01	0.06	625.92
2020-2039 (RCP 4.5)	22.01	23.09	0.07	572.39
2040-2059 (RCP 4.5)	35.73	44.32	0.12	934.33
2060-2079 (RCP 4.5)	46.78	60.14	0.15	1231.62
2080-2099 (RCP 4.5)	51.14	65.07	0.17	1308.09
2020-2039 (RCP 8.5)	26.31	40.12	0.08	681.20
2040-2059 (RCP 8.5)	46.82	72.33	0.16	1246.93
2060-2079 (RCP 8.5)	73.80	120.29	0.24	1971.01

Time Period and Emission Scenario	Hot Days	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2080-2099 (RCP 8.5)	96.37	159.89	0.30	2645.72

The trend is clear: significant warming and chance of heat across all time frames and emissions scenarios. Under a medium emissions scenario, an additional 51 hot days per year will occur with an even higher heat index. However, under a business-as-usual scenario, 96 additional hot days will occur, and the probability of a heat wave will rise to 30%. In every scenario the energy burden rises with temperature as demand for cooling increases.

The duration of heat waves in Djibouti, and in the Horn of Africa region as a whole, is expected to increase significantly. One estimate expects the change in duration to increase by 21 days by 2030, 36 days by 2050 and 84 days by 2085.[27] Even under a low emission scenario, the same analysis projects an increase of 9 days by 2085. Therefore, it is clear that adaptation measures are necessary to limit the burden and heat stress risk on the population.

The GFDRR classifies Djibouti's extreme heat risk as high throughout the whole country, with no regions less vulnerable. Figure 4 shows the visualization.

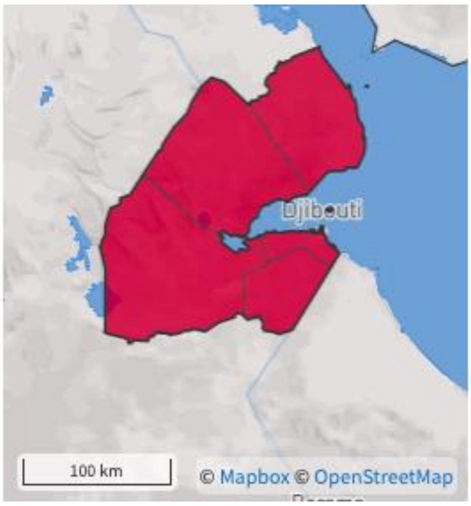

Figure 4 Extreme heat risk in Djibouti (GFDRR data)

Between 1980 and 2010, 4% of the population were affected by extreme heat periods.[28] However, it is worth noting that this figure is expected to rise significantly in the future. For example, one study showed that heat wave characteristics have become 15 times more frequent than in the past (Ozer, 2014). The researchers define a heat wave in this study as daily maximum temperatures above 45°C. This is a much higher threshold compared to other definitions.

2.4.1.3. The impact of high temperature on health

[27] Climate Service Center Germany. 2016. Climate fact sheet.

[28] EM-DAT Disaster Database

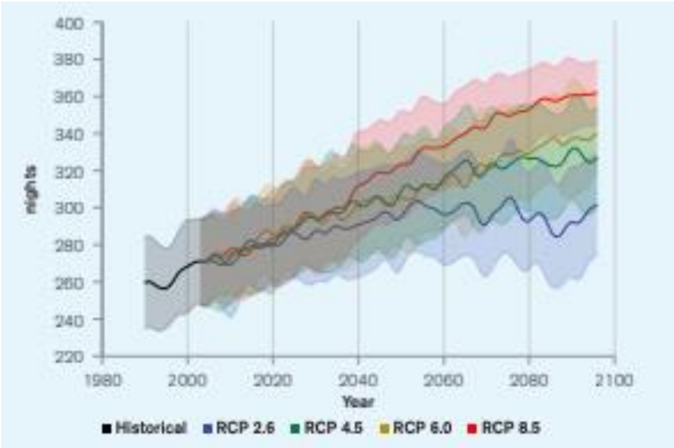

Figure 5 Number of tropical nights under different emissions scenarios in Djibouti (World Bank)

Health impacts of higher temperatures are especially concerning for Djibouti, especially among low-income groups and the rural population. The World Bank notes the likely resurgence of communicable diseases under higher temperatures as well as exacerbating respiratory illnesses (World Bank, 2020). Moreover, the rise in expected number of tropical nights (those when the minimum temperature is above 20°C) is likely to lead to discomfort and disruption to sleep. Figure 5 shows that at least 290 nights a year will fall under this classification under every emissions scenario. However, the highest emissions scenario suggests around 360 nights can be classified as tropical. That is, only a handful of nights every year would not be considered in this category.

Enhancing ventilation and optimising building design to reduce heat and improve thermal comfort have been studied in Djibouti. One study in Djibouti City found that natural ventilation creates a comfortable indoor temperature and would allow buildings to benefit from cooling with the need for energy inefficient cooling (Omar et al, 2016). A similar study into building materials in Djibouti found that using double-skin material for roofs on residential buildings reduced the cooling load of the hot climate, improved ventilation and thermal comfort, and enhanced energy saving (Omar A. V., 2017).

Similar research into bioclimatic design emphasised the need to integrate natural ventilation and wind flow as passive cooling strategies. The researchers note that Djiboutians spend 80-90% of the time in their homes, therefore bioclimatic designs allow to regulate thermal comfort, improve air quality and ventilation, and eliminate excess humidity and energy consumption (Idris, 2016).

2.4.1.4. Economic vulnerability

While data on the impacts of high temperatures on the economy are limited for Djibouti, some estimates about the loss of working hours due to heat have been made. By 2030, the ILO expects 3% of total working hours to be lost from industry, 6.48% in construction and 0.4% in services (ILO, 2019). As temperature rises quickly, these figures are expected to rise significantly especially in rapidly urbanising areas like Djibouti City.

To limit the health and economic risks associated with such heat, buildings should implement adaptive measures such as those within the proposed PEEB programme to bring indoor temperatures to a reasonable comfort level.

2.4.2. Market context and barriers

2.4.2.1. Strategic context and market potential

Mitigation and adaptation to climate change is a major stake for Djibouti, which is one of the countries the most affected and strongly hit by this phenomenon and its harmful effects. The political strategy, through the governmental programme "Djibouti Vision 2035", aims to make Djibouti the first African country to use 100% of green energy and to stimulate the use of least energy intensive equipment, thus contributing to reducing its greenhouse gas emissions.

This "Djibouti Vision 2035" programme also has the ambition to reach by 2035 a renewable energy production level of 300MW. This would cover 100% of Djibouti energy needs through renewable energy, focusing on solar technologies development and deployment, enabling a more inclusive access to electricity, and the introduction of renewable energy policies in order to structure private and entrepreneurial investments, as well as the creation of the related value chains and sources of employment.

At a legislative level, the energy field is ruled by three fundamental laws:

- Law N° 42/AN/14/7èmeL (2014) covering the reorganization of the Ministry of Energy and Renewable Resources (MENR);
- Law N° 88/AN (1984) regulating independent producers' activities;
- Law N° 90/AN/15/7emeL de 2015 related to the energy efficiency legislative framework.

The application of these laws on energy regulation is very recent. The main decrees and orders were approved in 2019, and include the following texts:

- Decree N°2019-013/PR/MERN clarifying the assignments, organization, regulation, control, and conditions of application for the provision of electricity as a public service;
- Decree N°2019-094/PR/MERN specifying the conditions for periodic energy audits, which are mandatory in Djibouti;
- Order N° 2019-072/PR/MERN relating to the design of street lighting.

Several other energy efficiency regulatory texts are being developed, and some are waiting to be approved by Djiboutian authorities. These concern the following issues:

- Energy performance for buildings;
- Energy performance for domestic and electrical appliances;
- Equipment and material used in energy mastering and renewable energy;
- Terms and conditions for energy audits, including to broaden the scope of accredited energy auditors.

One significant factor which is motivating greater promotion of energy efficiency in Djibouti relates to the cost of electricity in Djibouti. Indeed, prices implemented by Electricity of Djibouti (EDD) are among the highest in Africa (an average of US$ 39 cents/KWh). However, since the new electrical interconnection with Ethiopia in 2011, Djibouti has now an access to a cheap electricity (between 6 and 7 US$ cent/kWh), mainly hydroelectrically. In 2017, the total imported energy reached 508 GWh.

In sum, various factors are creating a highly favorable context for a step-change in energy efficiency efforts in Djibouti, including:

- High electricity prices and the absence of price subsidies on electricity, which lead to significant budget burden on consumers and the government;
- Djibouti's current reliance on foreign imports of all kind, especially energy, exposing the country to international price fluctuations;
- Recent policy and regulatory developments (see above, "Djibouti Vision 2035") that show a strong commitment by the government and central agencies, such as the Ministry of Finances for instance, to tackle public debt and ensure sustainable development through renewable energy and energy efficiency;
- Large presence of state owned enterprises (SOEs) in the national economy, which can act as driving forces for new energy efficiency markets and flagship/demonstration projects;
- Long-term temperature trends and extremes on the rise, exacerbating communities' climate vulnerabilities and making cooling even more essential to development, wellbeing, as well as environmental, economic and societal resilience.

Hence, the proposal presented hereafter combining both an energy efficiency investment program and technical assistance, would help tackle these major challenges and deliver sizeable benefits, including economic (more jobs, business and skilled labour), environmental (less GHG emissions), and social (enhanced living conditions) ones.

2.4.2.2. Analysis of relevance of barriers

Barriers type	Country specific relevance
Technical barriers	
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	Project stakeholders lack technical knowledge and the project that could be supported by PEEB Cool would be a pilot project that would demonstrate the benefit of EE in buildings and support capacity building of the project stakeholders. The national agency for energy management is relatively recent (2013) and its staff lack experience. However, AFD has been discussing with Djibouti on a potential support in EE and has financed energy audits that show the high potential of Djibouti public buildings. This has contributed to raise awareness of the public institutions on the matter.
Financial barriers	
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	In Djibouti, there is a lack of international support for energy efficiency in buildings and the implementation of dedicated projects to stimulate both the offer and the demand for energy efficiency investments.

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	Djibouti banking system comprises 12 active commercial banks but not all MSMEs have a bank account and when they need financing, the primarily source of financing remains the tontine. If they plan borrowing, only 4% of them will use the financing to renovate or maintain their equipment.
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	Djibouti's economy is mainly concentrated in the service sector. However, 20% of registered companies as of 2018 belong to the public work and construction sector. Main constraints of SMEs is the high cost of electricity. This argues in favor of EE investments.
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	Since the issuance of the energy efficiency law on 2015, little has been done because all decrees that are needed to precise the implementation framework of the law have not been adopted. Existing or coming texts are often unclear and not very applicable.
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	A building code is planned. However, no pilot project has been carried out to measure the relevance and efficiency of measures to be implemented. In addition and relating to energy performant appliances, the country wants to define its own assessment criteria instead of building on the existing international rating systems. This is a barrier to rapid development of performant appliances in the local market.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	Stakeholders lack knowledge on EE. For instance, there is a law that makes energy audits mandatory but it is not implemented because the country does not have the technical knowledge to perform energy audits. Indeed, energy audits must be performed by experts recognized by the national energy management agency (ADME), but as of 2020, no expert had been accepted by ADME.

2.4.2.3. AFD experience in financing buildings construction of refurbishment projects

In Djibouti, AFD is currently involved in buildings' construction and renovation through the financing of projects in the fields of urban development, and education and professional training.

Some examples of past and current projects covering such areas and districts are presented below:

- Renovation of the district PK12 (2002-2010);

- Integrated Urban Development Project (IUDP) to equip the district of Wahle Daba with the necessary infrastructure, and open it up (2018-2014);
- Project of Solid Waste Management including renovation of the Djiboutian Public Road Office ‘s technical base (2012-2019);
- Integrated Urban Development Project 2 to equip with infrastructures and open-up the districts of Layableh and Moustiquaire (2016-2025).

These projects covered for some energy efficiency and climate aspects, and offer many relevant insights in terms of building renovations and urbanization challenges.

Regarding the education and professional training sectors, several projects have made possible the development of new infrastructure, including:

- the construction and reconditioning of primary school in Tadjourah and Obock (2002-2007);
- the construction and equipping of the general education high school PK12 in Balbala (2007-2013); as well as
- the construction of a professional training center to promote the transport, logistic and port industry.

2.4.2.4. Environmental public policies analysis

Environmental policies related to the building sector

Institutional entities are in charge of EE (ADME, ODDEG), a regulatory framework is in place for energy audits, labeling of household appliances, EE in public buildings, etc. but most of them are awaiting implementation decrees.

Electricity production by independents is regulated with power thresholds for self-generation with and without surplus injection and total export. Feed-in tariffs for injected electricity are negotiated on a case-by-case basis.

The 2015 SCPD aims at reducing emissions by 40% compared to a baseline scenario by 2030, and among the proposed actions is the improvement of EE in public buildings. An additional 20% is conditioned by international financing (thermal rehabilitation of buildings, distribution of low-energy lamps, generalization of audits for administrative buildings, renewal of the fleet of air conditioners and refrigerators).

Adaptation to climate change policies

Djibouti is exposed to several climate change risks: increases in temperatures and both intensity and frequency of extreme weather events (droughts and floods), sea level rise (88% of the population living in the coast), availability and quality of water resources, desertification. The country integrated the adaptation approach in several of its strategies (National Adaptation Program of Action - 2006, 2035 Vision, Strategy of Accelerated Growth and Promotion of Employment, Nationally Determined Contribution – 2016, National Strategy on Climate Change – 2017). Six priority areas for adaptation are defined, including:

- Ensuring access to water for all
- Reducing vulnerability to the effects of climate change and increasing the resilience of the most exposed social-economic or geographical sectors
- Ensuring the development of sustainable and resilient cities in the context of climate change
- Ensuring the resilience and sustainability of the country’s key strategic infrastructure

2.4.2.5. Summary of stakeholders consultation

The programme was presented to and discussed with Ministry of Environment and Ministry of Finance. Stakeholders showed a strong interest in the programme.

The MERN is the regulatory authority of the energy sector in Djibouti. The energy management is a strategic priority for the government. The creation of the Djiboutian Energy Control Agency (ADME) in 2012 and the legislative framework for energy efficiency shows the importance given by the government to measures in favor to the improvement of energy performance in buildings and construction. The ADME is a public administrative institution with an administrative and financial autonomy and depends on the MERN. It aims to implement the national policies and strategies regarding energy management and energy efficiency, as well as to promote energy efficiency and savings in all business sectors over the national territory. In order to advance its environmental strategy, the ADME provides expertise and advice to firms, local collectivities, public authorities and the general public.

The MERN signed the 15th July 2018 the Programme for Energy Efficiency in Buildings' charter and the ADME is member of the Global Alliance for Buildings and Construction (GABC).

As Djibouti has committed to reach 100% of renewable energy in its Vision 2035, the ADME has set a drastic target to limit energy consumption in public sector: the agency aims to reduce national energy expenditures by 50% by 2030 compared to the spending level of 2016.

2.4.3. Project description

2.4.3.1. Project's objectives and description

A preliminary study financed by the PEEB and set up in collaboration with the ADME was carried out in 2019 by the design offices TERAO and GINGER BURGEAP to analyse the energy situation of 10 public pilot sites. The buildings listed hereafter were selected as being representative of the diversity of public buildings in the country:

- The ministerial Estate;
- The ADME's head office;
- The EDD's head office;
- The Djiboutian Intellectual and Commercial Property Office's head office;
- The Osman Ben Affan mosque;
- The Balbala high school;
- The Balbala 2 primary school;
- The Communitarian Development Centre in the district 5;
- The Peltier hospital;
- The Farah Had polyclinic.

The study provided a number of energy diagnoses, recommendations, as well as suggestions for an investment programme (approx. EUR 7 million) to halve the energy consumption of the buildings covered by the study.

It also enabled the design of important, long-term mitigation actions for the future, including:

1. Potential energy efficiency retrofits and investments in high energy-consuming public buildings;
2. The need for institutional and regulatory reinforcement and capacity building ;
3. Communication and awareness-raising activities on the potential for energy efficiency at a national level.

Building on the conclusions of this first study, the current proposal is based around two important components that could take forward the identified opportunities and unlock significant, long-term energy efficiency gains in Djibouti. These include:

Investment Facility

In order to inform the development of the suggested energy efficiency investment programme, a scoping study has been commissioned in order to determine some of its key aspects, including the type of works, organisational arrangements, capacity building, communication, and sustainability activities. Additional elements will also be studied, such as:

- The operating process for the project, especially describing the building contractor;
- The conditions for on-site energy generation and consumption, or electricity injection into the network, as well as EDD's buying prices; as well as
- The potential for financial savings and budget redistribution possible through energy efficiency gains.

This study will allow a better definition of the potential project that could be supported under the investment facility.

It will also help inform the formulation and implementation of the following proposed technical assistance activities. The below tables outline the GHG baseline emissions and emissions reductions for a Djibouti small scale office case. Full calculations can be found in Annex 22c.

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	138,431
Emissions - 20% reduction case	94,141
Emissions - 40% reduction case	79,767
GHG reductions - 20% reduction case	44,290
GHG reductions - 40% reduction case	58,664
GHG reductions - average of 20% and 40% reduction case	51,477

Emissions without EE measures (baseline):	Source of information	Unit	Value
Djibouti			
Type of building			Small scale office
m2 impacted	A	m2	60,000
Lifetime of investment	L	Years	15

Baseline characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	197
Natural gas	N/A	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.639
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	125.9
Natural gas	G1 = C1 x E	kgCO2/m2	0.0
Building materials	H1	kgCO2/m2	419.4
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	7,551
Natural gas	J1 = G1 x A	tCO2/yr	-
Electricity	I1 = F1 x A x L	tCO2 over lifetime	113,269
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	-
Building materials	K1 = H1 x A	tCO2 over lifetime	25,162
Total		**tCO2 over lifetime**	**138,431**

Emissions - 20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	125
Natural gas	N/A	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.639
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	80
Natural gas	G2 = C2 x E	kgCO2/m2	0.0
Building materials	H2	kgCO2/m2	371.2
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	4,791
Natural gas	J2 = G2 x A	tCO2/yr	-
Electricity	I2 = F2 x A x L	tCO2 over lifetime	71,871
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	-
Building materials	K2 = H2 x A	tCO2 over lifetime	22,270
Total		**tCO2 over lifetime**	**94,141**

Emissions - 40% reduction case			
Characteristics of building			
Energy consumption		kWh/m2/yr	
Electricity	B3	kWh/m2/yr	100
Natural gas	N/A	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	tCO2/MWh	0.639
Natural gas	E	tCO2/MWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kWh/m2/yr	64
Natural gas	G3 = C3 x E	kWh/m2/yr	0.0
Building materials	H3	kgCO2/m2 (lifetime)	371.2

Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	3,833
Natural gas	J3 = G3 x A	tCO2/yr	-
Electricity	I3 = F3 x A x L	tCO2 over lifetime	57,497
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	-
Building materials	K3 = H3 x A	tCO2 over lifetime	22,270
Total		**tCO2 over lifetime**	**79,767**

Emissions reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	2,760
Natural gas	J1 - J2	tCO2/yr	-
Electricity	(I1 - I2) x L	tCO2 over lifetime	41,398
Natural gas	(J1 - J2) x L	tCO2 over lifetime	-
Building materials	K1 - K2	tCO2 over lifetime	2,892
Total	**Sum of 20% case**	**tCO2 over lifetime**	**44,290**

Emissions reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	3,718
Natural gas	J1 - J3	tCO2 over lifetime	-
Electricity	(I1 - I3) x L	tCO2 over lifetime	55,772
Natural gas	(J1 - J3) x L	tCO2 over lifetime	-
Building materials	K1 - K3	tCO2 over lifetime	2,892
Total	**Sum of 40% case**	**tCO2 over lifetime**	**58,664**

Emissions reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	3,239
Natural gas	Average 20% and 40% case	tCO2 over lifetime	-
Electricity	Average 20% and 40% case	tCO2 over lifetime	48,585
Natural gas	Average 20% and 40% case	tCO2 over lifetime	-
Building materials	Average 20% and 40% case	tCO2 over lifetime	2,892
Total	**Sum of above**	**tCO2 over lifetime**	**51,477**

Enabling Facility

To complement the above activities, the project would also aim to engage national authorities in capacity building activities, including:

1. <u>Support for developing sectoral investment roadmaps:</u>

This activity would facilitate the development of sectoral sector led roadmaps and investment plans, in order to identify and overcome main investment barriers to more energy efficiency. Targeted sectors would include those covered by other technical assistance, with a potential focus on the public sector actors, given the large presence of state owned enterprises (SOEs) in Djibouti. These could include: finance, real estate, construction, refrigeration and air conditioning/HVAC and other electrical equipment and building materials manufacturing.

The objective would be to work with building owners, public/private financial institutions, equipment manufacturers, energy management service providers, etc. on the range of tools that support greater energy efficiency. Through for example: stimulating the introduction of energy-labels, deploying high performance cooling and other appliances; increasing awareness, setting-up incentive programs, de-risking investments, and building a pipeline of bankable projects for investors; developing new and viable business models, jobs and investments.

Outputs would include sectoral roadmaps, pathways, investment plans, and other initiatives, with links to the “Djibouti Vision 2035” as relevant, and other aspects of the program, including financing of infrastructure projects and other capacity building activities.

2. Capacity building for public authorities covering the formulation, development and deployment of public policy and regulations:

These capacity building activities would be aimed first and foremost at public entities to enhance their knowledge, skills, tools, and first-hand experience in the development, implementation, enforcement and compliance of existing national building policies and roadmaps, an opportunities for efficient cooling. As the effective implementation of building codes, through robust enforcement and compliance policies, is a major issue, this could potentially represent an important aspect of these activities in order to achieve and measure real-world energy efficiency gains. Policies for efficient cooling appliances with low GWP (In compliance with Kigali Amendment) would also be worth considering.

3. Outreach and professional training targeting building professionals

This training would aim to bolster the awareness, skills and knowledge of professionals in the private, public and civil society sectors, in relation to the financing, technical solutions, building codes, users’ best practices, as well as joint efficiency and cooling efforts. It would also aim to bring together key actors to enhance coordination, and ensure harmonization of norms and of their applications across buildings and locations. Given the large percentage of SOEs in Djibouti, this activity could potentially have a major leverage effect in terms of boosting business and employment, up-skilling local workforce, and creating new markets and help lock-in durable, long-term efficiency gains. For instance, providing training to people on the most effective ways to use the building and its appliances (air-conditioning, lighting, etc.) would be instrumental in ensuring durable energy gains and limit perverse rebound effects.

This technical assistance would be fully aligned with the broader PEEB Cool approach. It could be rolled out by a team of long-term experts, holding expertise in energy efficiency, climate and energy policy-making, as well as stakeholder engagement/training and development. Short-term experts could also provide support on highly technical topics (for example on how to treat the “Measurement, Reporting and Verification” of GHG building emissions). Such teams would work closely with the MEFI, ADME, EDD and other relevant agencies through activities geared towards reinforcing their capacity (e.g. workshops, technical trainings, working-level one-on-one collaborations, webinars, secondments to select policy teams, etc.).

2.4.3.2. Paradigm shift potential

Achieving the project’s objectives, including through concrete examples of energy-intensive public buildings, would help establish a stronger case for the Djiboutian state to continue its generalised strategy for improving energy management and performance of its building assets.

The project would also support the emergence of a broader ecosystem in the energy efficiency sector, including customers, building companies, suppliers, installers, energy auditors, architects, public sector, and end-use consumers, among others.

The institutional support delivered through the programme would also help better structure the legislation linked to energy efficiency, acting for the purpose of approving of decrees and orders (cf. A.2.i).

Other major environment and social benefits would be realized in terms of reduced GHJG emissions, reduced financial burden, improved access to cooling, enhanced living conditions for better education, health and productivity outcomes, among others.

2.4.3.3. Sustainable development potential

According to the preliminary study led by TERAO and GINGER BURGEAP, this project, through energy efficiency investments in the identified public buildings, would generate 3,975 MWh electricity saving, and would create savings estimated at 24 tons of CO2eq/year. This value has to be put in connection with the low carbon content of Ethiopian hydraulic electricity imported by Djibouti.

In addition to this, GCF grant funding for technical assistance activities would act as an essential tool for catalyzing change in the way energy efficiency is dealt with by the Djiboutian government. Given current restrictions on international lending, the AFD is not in a position to issue loans for Djibouti, despite the tangible need for greater efficiency gains in Djibouti. Moreover, the energy efficiency challenge rests not with technology, as appliances' performances are far ahead their market uptake (the average efficiency of air conditioner for example is less than half of what is available in the market, according to IEA analysis). It is much more about overcoming the cultural resistance that impedes the uptake of more efficient technologies. Policies and regulations are the most effective tool to tackle this gap, while capacity building, technical assistance, public/private sector collaborative efforts, and state-industry-users dialogues are the most effective means to shift mindsets and introducing key elements of policy bedrocks (minimum efficiency floors, standards and labels, buildings disclosure programmes, etc.). Grant funding is a more appropriate tool for funding such soft activities, as opposed to hard infrastructure investments through loans. Given the GCF's links to major energy efficiency and cooling transition initiatives, such as on the Kigali Agreement, this proposal would add coherence to the body of other GCF work underway. Finally, it would offer an opportunity to structure a transformational project for the region, working closely with the NDA and GCF focal points, and act as a precursor for further projects.

2.4.3.4. Project indicative financing

	Total Amount (a+b)	Currency	GCF amount (a)	AFD amount (b)
3. Senior loan		Million EUR		0
4. Grant (technical support)	8.5-9 M€	Million EUR	3 M€	5.5-6 M€

Total project financing (1+2)	8.5-9 M€	Million EUR	3 M€	5.5-6 M€

This amounts are provisional at this stage and are still to be discussed

2.5. Indonesia

National Designed Authority	**Center for Climate Finance and Multilateral Policy** **Fiscal Policy Agency, Ministry of Finance**
Project title	PEEB Cool Indonesia
Name and typology (public/private) of the institutions	Public (Ministry) • Ministry of Energy and Mineral Resources • Ministry of Public Works and Housing, Public (State Owned Enterprise) • BTN (Bank Tabungan Negara) • PERUMNAS (Perumahan Nasional)
End beneficiaries (households, students…)	Households, Building Owners
Mitigation/adaptation focus	Mitigation

2.5.1. Climate profile

Indonesia is ranked 97th on the ND-Gain index, including being 76th most vulnerable and 90th least ready.[29]

2.5.1.1. Historic climate data

Indonesia has a tropical climate that's hot and humid with a mean annual temperature of 25.83°C over the last century. Its capital city, Jakarta, is home to more than 10 million people and has a very high humidity, reaching over 90%. 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.

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 duration of 4 days, although both are expected to increase.[30]

2.5.1.2. Future climate projections

[29] ND-Gain Index. 2020.

[30] Climate Service Center Germany. 2016. Climate Fact Sheet Indonesia.

Estimates of future indicators vary but the overall trend is agreed: temperatures and dry spells will increase. GERICS analysis shows a mean temperature increase of 3.2°C by 2085, with maximum temperatures likely to rise by up to 3.4°C and minimum temperatures by 3°C in the same period.[31]

These figures are well aligned with city level projections. Table 9 shows data for Indonesia's capital city, Jakarta.

Table 9 Future temperature changes in Jakarta, Indonesia

Time Period and Emission Scenario	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)
2011-2040 (RCP 4.5)	0.75	0.59	0.64
2041 – 2070 (RCP 4.5)	1.90	1.20	1.40
2071-2100 (RCP 4.5)	2.20	1.60	1.70
2011 – 2040 (RCP 8.5)	0.94	0.62	0.71
2041 – 2070 (RCP 8.5)	2.30	1.50	1.60
2071 – 2100 (RCP 8.5)	3.90	2.70	3.00

Similarly, in this data, maximum temperatures also rise the most (3.90°C) with minimum temperature increasing by over one degree less.

Other climate indicators at the national level help emphasise the significant warming that is expected. For example, Table 10 shows data for hot days, heat index, heat wave probability and cooling degrees for Indonesia as a whole.

Table 10 Future climate indicators in Indonesia (World Bank data)

Time Period and Emission Scenario	Hot Days	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039	3.21	1.29	0.11	395.02

[31] Climate Service Center Germany. 2016. Climate Fact Sheet Indonesia.

(RCP 2.6)				
2040-2059 (RCP 2.6)	4.60	2.50	0.17	496.10
2060-2079 (RCP 2.6)	4.80	2.70	0.16	504.70
2080-2099 (RCP 2.6)	4.48	2.91	0.15	482.86
2020-2039 (RCP 4.5)	3.05	1.74	0.14	442.45
2040-2059 (RCP 4.5)	7.23	7.25	0.32	666.44
2060-2079 (RCP 4.5)	12.26	20.34	0.48	855.97
2080-2099 (RCP 4.5)	15.65	30.89	0.55	935.91
2020-2039 (RCP 8.5)	5.18	3.18	0.17	510.58
2040-2059 (RCP 8.5)	16.66	24.58	0.49	926.59
2060-2079 (RCP 8.5)	51.36	124.77	0.82	1477.52
2080-2099 (RCP 8.5)	108.90	267.00	0.95	2052.96

National data within the RCP 4.5 and 8.5 pathways show trends of warming, with an added 108 days of hot days annually by 2100. Furthermore, it predicts a 55% likelihood of a heat wave by the end of the century under a medium emissions pathway and a 95% chance under a business-as-usual scenario. That is, it will be nearly certain that daily temperature on three or more days will exceed the 95th percentile.

Perhaps unsurprisingly, heat wave duration is expected to increase enormously. GERICS predicts a likely projected change of long-lasting heat waves up to 30 days by 2030, 118 days by 2050 and 1340 days by

2085.[32] This suggests that, unless an aggressive emissions reduction pathway is taken, heat waves could last nearly four years in Indonesia by 2085.

2.5.1.3. The impact of high temperature on health

Indonesia's warm and humid climate year-round means that extreme heat is common, as many days already fall within the 'heat wave' definition. Therefore, GFDRR categorises Indonesia's risk to extreme heat as medium, meaning that there is a 25% chance that at least one period of prolonged heat will result in heat stress in the next five years.[33] Sudden, unexpected heat waves are less likely but the higher temperatures and longer heat wave durations expected, as outlined in the data above, will drive more people to spend the majority of their time inside to keep safe. Therefore, regulating thermal comfort inside will be key to effective adaptation.

A study of thermal comfort in office buildings in Bandung, Indonesia found that comfort ranges varied depending upon ventilation modes with those in free running offices feeling comfortable at 24.7°C while those with air conditioning able to withstand higher temperatures (26.3°C and 27.5°C) (Damiati, 2015). Those in the free running offices noted adaptation behaviours such as opening windows and doors to limit indoor temperature. Moreover, another study in Bandung found that naturally ventilated buildings allowed workers to be comfortable at lower temperatures, and that there was a big opportunity to design free running offices efficiently to avoid unnecessary energy use (Karyono, 2007). If buildings are designed with cross ventilation and with the prevailing climate in mind, indoor temperatures can be regulated with adaptation measures rather than costly and inefficient technological cooling (Karyono, 1995).

Conditions in classrooms have also been of research focus. Students in primary school in Makassar, Indonesia recorded their thermal comfort levels throughout the day. As temperature increased from 28°C in the morning to 34°C in the afternoon, more than 50% more students responded that they felt warm compared to those that felt neutral. Moreover, 72% said they would prefer the indoor temperature to decrease (Hamzah, 2017).

In naturally ventilated homes, Indonesians feel a preference for cooler environments and a study found them to prefer higher wind speed in the home to limit temperatures where mechanical cooling was not easily available (Feriadi, 2004).

The combination of high temperatures, extreme humidity and long-lasting hot periods make for a significantly high risk of heat-related illness and death. Those in large and rapidly growing cities like Jakarta are expected to be the most at risk. For example, one study of the elderly in Jakarta used past daily maximum temperatures between 2006 and 2015 and simulated future temperatures between 2046 and 2055. They found the likely heat-related deaths in elderly to be around 12-15 times as many as the baseline period in August (Varquez, 2020).

Similar, but even more dramatic, increases in heat-related mortality in the elderly has been modelled by the World Health Organization. They expect around 53 deaths per 100,000 annually by 2080 compared to 1 per 100,000 in the baseline period 1960-1990 (WHO, 2015). Figure 6 shows the full projections under different

[32] Climate Service Center Germany. 2016. Climate Fact Sheet Indonesia.

[33] Think Hazard. 2019. Indonesia. Available at https://thinkhazard.org/en/report/116-indonesia/EH

emissions scenarios, highlighting a gradual decrease in deaths after 2030 if emissions can be kept to the RCP 2.5 scenario.

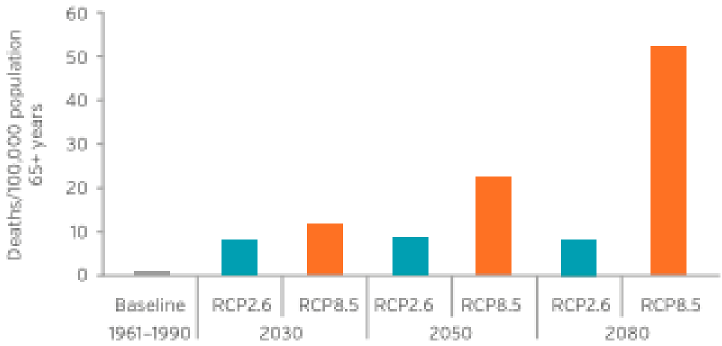

Figure 6 Future heat-related mortality in Indonesia (World Bank data)

Therefore, elderly groups are vulnerable but so too are those with underlying medical conditions, especially heart diseases or respiratory illnesses. Considering Indonesia's high household use of solid fuels for cooking, including 65% of rural homes, indoor air pollution is also very high – 29% of total deaths are attributable to this (WHO, 2015). If indoor environments cannot provide relief from high temperatures and pollution, both can cause severe illness or death. Therefore, appropriate ventilation measures in buildings should be a priority.

2.5.1.4. Economic vulnerability

Heat stress will also impact Indonesia's economy, likely through a lack of productivity. WHO estimates that warming of around 4 degrees, in line with the upper estimates for Indonesia, would see productivity losses in heavy labour (construction, industry etc) of around 23% by the end of the century (WHO, 2015). Furthermore, moderate labour would fall by around 12% and light labour by 2.5-3%. Naturally, this would create significant economic losses.

In the shorter term, and under a conservative low emissions scenario, working hours losses from industry are expected to top 2.80%, 7.68% in construction and 0.17% in services by 2030 (ILO, 2019).

2.5.2. Market context and barriers

2.5.2.1. Strategic context and market potential

Economy

Indonesia is the world's fourth most populous nation, the world's 10th largest economy in terms of purchasing power parity, and a member of the G-20. Indonesia's population in 2016 was 261 million, with

54% living in urban areas, up from 46% a decade ago (World Bank, 2017). By 2025, nearly 68% of the Indonesians are expected to be living in cities[34].

Indonesia has made enormous gains in poverty reduction, cutting the poverty rate by more than half since 1999, to 9.78% in 2020. Prior to the COVID-19 crisis, Indonesia was able to maintain a consistent economic growth, recently qualifying the country to reach the upper middle-income status. Indonesia's economic planning follows a 20-year development plan, spanning from 2005 to 2025. It is segmented into 5-year medium-term plans, called the RPJMN (*Rencana Pembangunan Jangka Menengah Nasional*) each with different development priorities. The current medium-term development plan – the last phase of the long-term plan – runs from 2020 to 2024. It aims to further strengthen Indonesia's economy by improving the country's human capital and competitiveness in the global market[35].

Energy

Indonesia is the largest energy consumer in Southeast Asia, making up over 36% of the region's energy demand and consuming nearly as much energy as Thailand, Malaysia and Singapore combined. Rapid economic growth has brought a sharp rise in electricity demand. Between 2000 and 2015, Indonesia's GDP doubled and its demand for electricity increased by 150% (IEA, 2016).

Per-capita electricity consumption in 2014 (814 kWh) was only about one quarter of the global average (3,030 kWh) (IEA, 2016). Around 23 million people, or 8.9% of the population, still do not have access to electricity, mostly on small islands and in remote areas (Anditya, 2017), and 38% do not have access to clean cooking technology (IEA, 2016). Indonesia's strong economic growth is expected to continue, increasing electricity consumption to 491 TWh by 2030. As GDP increases, demand for greater levels of comfort and personal mobility will continue to drive up demand for energy.

Building sector

In commercial and public buildings, the energy savings potential ranges from 18% to 56%. In residential buildings, it is estimated that the introduction of the best available technologies for lighting, refrigerators, air conditioning, fans, televisions, and standby power needs could result in a combined peak demand reduction of 15.2GW or 25% in 2025 compared to the BAU scenario. Some of the reasons why this potential so far is not being realized include insufficient coverage and enforcement of regulations, an underdeveloped ESCO industry, and a lack of incentives.

Residential buildings: The residential sector's share of total energy use (total final consumption) fell from 44% in 2000 to 38% in 2015. Since 2000, residential energy demand has risen by 35%, because of increases in population, in the number of dwellings and their floor area, and in appliance ownership. Domestic cooking and lighting represent high energy saving potentials. Efficiency improvements from switching cooking fuels and using more efficient lighting fixtures contributed to a 2.4% decrease in overall residential energy use per capita between 2000 and 2015[36].

There is a huge demand for affordable housing both contributed by new annual demand and the backlog. Based on 2015 National Household Survey data by the Central Agency of Statistics, MPWH estimates a

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[34] IBRD. Project Appraisal Document for National Affordable Housing Program project.2018

[35] The World Bank, (2020). Mexico Overview. October 2020.

[36] International Energy Agency (IEA. Energy efficiency 2017. 2017

housing backlog of 11.4 million units[37]. There are approximately 64.1 million housing units in Indonesia, around 20% of which are in abysmal conditions and an estimated 820,000 to 1 million new units are needed each year to respond to annual housing demand from population growth, new household formation and migration to urban areas. However, against this demand, the private sector only produces around 400,000 units per year and public sector programs, including incremental home improvement assistance, rental housing, and social housing programs may enable additional 150,000 to 200,000 units.

Though the potential energy saving per household is considered lower in the affordable housing segment, there is a huge overall energy saving and GHG mitigation potential due to the projected massive housing construction in the next decade.

Commercial buildings: The projected economic growth and, thus, increase of new construction will result in a high increase of energy consumption.

Space cooling challenge

The demand for space cooling is likely to double between 2016 and 2020. Increased efforts could save Indonesian consumers nearly $690 million per year by 2030 (IEA 2017). According to the *Chilling Prospects: Providing Sustainable Cooling for All* report, Indonesia is among the top nine countries worldwide at risk of a lack of access to sustainable cooling. *Chilling Prospects* also shows Indonesia as having the second largest “Carbon Captive” population, describing a growing lower-middle class with limited purchasing power who are likely to turn to inefficient cooling devices that can cause a dramatic increase in energy consumption. This increase could undermine the country’s ability to shift away from its reliance on fossil fuels. New government regulations on energy conservation (issued in September 2019) can initiate progress. These regulations cover all main sectors of the economy (Industry, Buildings, Transportation and Household), and encompass incentives and disincentives, clearer standards, target setting guidelines, and reporting requirements[38].

2.5.2.2. Analysis of relevance of barriers

Barriers type	Country specific relevance
Technical barriers	
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	Project developers often lack the skills and knowledge to convince the CEOs of property companies that EE investments are an important business area. EE/RE technologies are new and mainly imported, so knowledge and information are limited and often outdated.
Financial barriers	

[37] MPWH 2016. http://ppdpp.id/konsep-backlog/. This data may be overstated as it is based on the home ownership information and does not consider people staying in rented houses and those not willing to take up house ownership.

[38] Sustainable Energy for All (SE4ALL). Building markets for sustainable cooling technology in Indonesia. 2019

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	The risk for RE building projects is considered high because, in addition to the lack of knowledge about bioclimatic design and EE technologies, a different approach is required as incremental financing monetarizes later during the operation of the building. The COVID-19 pandemic sent Indonesia into recession. Green construction stimulus programmes can be essential for the economic recovery.
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	Generally, awareness on financing options for EE is low. Banks are hesitant to invest due to missing sustainable finance guidance form central banks or other government institutions. Lending credit policies of banks are often strict and make it difficult for new customers, like ESCOs, due to lack of collateral required by banks. Financiers often lack access to reliable knowledge on the performance of EE technologies and access to energy consumption data of buildings to enable benchmarking and measurement of impacts of EE projects. Loan officers and risk managers within financial institutions lack knowledge on EE technologies or on energy performance contracting. However, programs with PT Ciputra exist to promote green housing.
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	Project developers and ESCOs lack capacity to develop financial attractive project proposals. There is a lack of readily available EE technologies in the country. Industrial actors need incentives and technical support to implement and scale EE actions.
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	The Government Regulation No. 36/2005 on Buildings mandates new buildings to implement energy conservation measures, but it addresses only large residential and commercial buildings and enforcement is weak. The regulatory framework is insufficient and there is a general lack of efficiency targets and standards. Cross-ministerial coordination for improving and enforcing EE standards and targets remains a challenge. Government provides tax allowance for business areas that can contribute to environmental preservation.
Building codes lack specific requirements for energy efficiency in buildings and enforcement is often weak,	There are only very few mandatory energy efficiency policies for energy use such as MEPS or labelling. At local

mandatory for certain types of buildings only, or still under discussion	level, the cities of Jakarta and Bandung have developed and implemented local green building codes with energy efficiency requirements and mandatory requirements for large buildings.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	A variety of actors are involved in EE building projects; as the markets are new, trust between the different actors still needs to mature. Green building council of Indonesia has developed GREENSHIP, a rating tool to benchmark green buildings in Indonesia.

2.5.2.3. AFD experience in financing buildings construction of refurbishment projects

AFD has been operating in Indonesia since the post-tsunami development. On the energy sector, AFD has been supporting the development of efficient electricity transmission in the country, including the construction of new substation. Besides that, AFD also supports on the energy efficiency study with BAPPENAS (National Planning Agency) for industrial sector.

AFD's subsidiary focusing on the private sector, PROPARCO, has been active countrywide to finance projects in debt or equity. A green bond project is currently under discussion with a corporate partner. The green bond proceeds will fund new retail stores construction which will be independently certified 'green' according to EDGE. New prospects are regularly under identification and instruction, and often include as a project's component a building construction/renovation (health, education, commercial, housing, industrial facilities).

2.5.2.4. Environment public policies analysis

Policies and legal framework

The energy sector is of high importance in Indonesia to ensure the sustainability and as essential support to the country's economic and social activity. Knowing that the energy sector is strategic and crucial for the country, the government has been actively managing the sector as its key priority. The Government of Indonesia has been developing regulations and planning documents for the energy sector, by enacting the Law No.30/2007 on the Energy Sector, then the Government Regulation No.79/2014 on the National Energy Policy, the Presidential Regulation No.22/2017 on the General National Energy Plan (RUEN), and the Ministerial Decree of Energy and Mineral Resources No. 143/2019 on the General National Electricity Plan (RUKN). By having those policies in place, the Government aims to ensure a sustainable, accessible, reliable, and efficient energy provision.

Energy sector targets on the National Energy Policy include:

1. Primary energy supply to be more than 400MTOE by 2025 and more than 1000MTOE by 2050
2. Energy mix share in 2025 comprises of 23% renewable energy, 55% fossil fuel, and 22% gas. The share swifts by 2050 to comprise of 31% renewable energy, 45% fossil fuel, and 24% gas.
3. Power generation reaches 115 GW by 2025 and 430GW by 2050.
4. 100% electrification ratio by 2020
5. Primary energy per capita 1.4 TOE by 2025 and 3.2 TOE by 2050

6. Electricity per capita 2500KWh by 2025 and 7000 KWh by 2050
7. Energy elasticity reaches less than 1 by 2025
8. Annual 1% reduction of final energy intensity
9. Household gas ratio 85% in 2015

The Government Regulation No. 36/2005 on Buildings mandates new buildings to implement energy conservation measures. The law requires residential buildings of more than 500 m^2 and commercial buildings of more than 5,000 m^2 to meet minimum energy performance (MEP) requirements. However, compliance with the Government Regulation No. 36/2005 has not been strictly enforced.

In 2015, the Ministry of Public Works and Housing (MPWH) introduced the Ministerial Regulation No. 02/ PRT/M/2015 on Green Buildings to assist in green building certification and implementation in the country. The regulation classifies green building requirements as mandatory, recommended, and voluntary based on specific building size, criteria, as well as energy and water consumption.

Alongside national energy efficiency standards, the cities of Jakarta and Bandung have developed and implemented local whole-building green building codes that include energy efficiency requirements. Both cities have mandatory requirements for large buildings, while Bandung also has building code requirements that incorporate energy performance and incentives for small buildings[39].

Only 16% of Indonesian energy use is covered by mandatory energy efficiency policies such as MEPS or labelling (IEA, 2017). Innovative financing methods by energy service providers (ESCO) are still underrepresented in Indonesia. On the one hand, this is due to the fact that the number of existing ESCOs is very small in relation to the size of the market.

The country is implementing a program on EE in air conditioning with actions to promote efficient equipment. The minimum performance of residential air conditioners is regulated since 2017 with a 4-star label system whose threshold will be gradually raised (EER>9.96 from 01/08/20).

NDC targets

Indonesia is committed to fight climate change. Under its National Determined Contribution (NDC), Indonesia is committed to reduce emissions under the Paris climate agreement and converted the target to several sectors, including energy, as mentioned below:

- National target: (i) Unconditional: reduce total greenhouse gas (GHG) emissions by 29% by 2030 from Business-As-Usual (BAU) level; (ii) Conditional: reduce total GHG emissions by 38% by 2030 from BAU level.
- Energy sector: (i) Unconditional: reduce energy sector GHG emissions by 314 million tons of carbon dioxide equivalent ($MtCO_2e$) by 2030 from a BAU projection of 1699 $MtCO_2e$. This correspondents to a reduction in energy sector emissions relative to BAU level of 19%; (ii) conditional: reduce energy sector GHG emissions by 398 MtCOe by 2030, corresponding to a reduction of 24% relative to BAU level. The RE share objectives are 23% in 2025 and 31% in 2050.

[39] ASEAN Centre for Energy (ACE). Mapping of Green Building Codes and Building Energy Efficiency in ASEAN. 2017

The energy sector targets shall mainly be achieved through the penetration of renewable energy in the energy mix and energy efficiency measures. However, both subjects remain largely untapped in the country due to insufficient regulatory framework. Indonesia's energy efficiency performance is relatively poor while the market potential is huge.

Section II: Current State of EEF in Indonesia

This section builds on the previous sections by reviewing the current state of energy efficiency finance in Indonesia, including:

- Existing private EEF models;
- Existing public support mechanisms.

2.1. Key findings

Deployment of EE finance in the commercial building sector in Indonesia is still limited. Currently the available options to fund energy efficiency projects in Indonesia are:

- Internal capital from the building owner
- Bank loan through an existing credit line from the building owner
- Bank loan via a project developer
- Limited ESCO finance (provided by a private investor and arranged by an ESCO company)

Reviewing the existing public/ private EEF mechanisms and financial incentives it was found that despite numerous public sector efforts to support EEF (mostly driven by international donor agencies), most of the mechanisms have faced significant challenges and delivered limited impact to date.

2.2. Existing private EEF models

Overall available private finance models are limited and mostly restricted to building owner finance or bank loans. Interviewees confirmed that EE projects in new commercial buildings are usually funded by the building owner themselves, either through their own funds or existing credit lines from banks[11]. For EE retrofits, some projects are funded by loans from project developers or ESCOs, and some examples of ESCO/Project developer finance are provided in Table 3. For bank loans project developers are required to provide 30-50% of the needed equity.[16] No examples of other private mechanisms such as the usage of green bonds or EE leasing could be identified.

11. (1_PD; 19_PD).
16. (4_PD)(Carbon & Programme 2015)

Table 3: Experiences of private sector models that could be found in Indonesia [17]

Type of finance EEF model	Description	Actors and customers	Project size	Comments
Loan by the Project developer (ESCO finance)[18]	Was used to retrofit floors with new cooling devices in an office building	Office buildings	700 Mio RP (70.000 US$)	Only did one floor and achieved 10% savings which was the companies target...no other floors retrofitted.
Loan by the Project developer	Retrofitting of lighting and cooling in a grocery store	Project developer and Medium sized grocery store	3.5 Billion Rp. 300.000 US$	Rolling capital of the ESCO was used. New funding every six months (up to 15 buildings).
ESCO Finance	Retrofit the building envelope	ESCO firm/ Mall	Less than 1 Mio. USD	Not financed yet
ESCO finance	Retrofit an apartment building with EE lights	Apartment	7.7 bio. RP (750.000 US$)	The ESCO received funds from a private investor. The project runs over 3 years (simplified EPC contract). The interest rate is 16%
ESCO finance	Commercial buildings (telecommunications) are retrofitted	State owned enterprise subsidiaries	16.5 Billion RP (1.2 million US$)	Project is funded via private investors over 8 years with a 16% interest rate. Every year 5 more buildings are added until they reach 20 buildings.

2.3. Public/private EEF mechanisms in Indonesia

Many public/private EEF mechanisms have been developed in Indonesia (see Table 4). As

Error: Reference source not found below indicates, most efforts focus on the development of public/private EEF mechanisms, with a focus on the barriers Availability of Funds and Capacity Building (mainly for project developers and financial institutions). However, at the moment only one public/ private EEF mechanism (the Joint Crediting Mechanism – see Figure 2) is currently providing finance to EE projects in the commercial building sector – others have been discontinued or are not supporting EE projects in this sector. One interesting financial incentive was provided by the city of Bandung, which offered tax advantages to building owners whose developments complied with green buildings standards.

16. (4_PD)(Carbon & Programme 2015)
17. Based on interviews conducted in Indonesia (4_C;1_PD; 8_PD). Thus, this is not a comprehensive survey of the situation but rather a snap shot of the current situation.
18. (1_PD)

Table 4: Private/public blended support mechanism and financial incentives in Indonesia

Initiatives	Type of Support	Period	Implementer	Result/Status	Barrier
Private/public EEF mechanisms					
1. Joint Crediting Mechanism (JCM)	Technology subsidy: 50% subsidy for GHG mitigation projects	2013 – present (ongoing)	Japan; building owner, project developer	Two energy savings projects in commercial buildings (up to 2016)	Availability of funds
2. Policy loan programme/ EE accelerator programme	Concessional credit lines Technical assistance	Ongoing	ADB; Ministry of Energy and mineral resources	Contributed to the ESCO law; Contributes to IGA trainings	Project development and transaction costs
3. ESCO programme	ESCO support/ Super ESCO: Technical assistance	Ongoing	AfD; ESCO firms; PT.SMI	Support ESCO companies to develop projects; supports PT.SMI for project development	Project development and transaction costs
4. Clean energy information and communication centre (LINTAS)	General EE finance Collection of information on	Ongoing	Danish embassy; MEMR	The Danish Embassy is providing one more year of finance.	Information, awareness and communication
5. Green building programme	General EE finance Technical assistance	Ongoing	IFC; DKI Jakarta; MEMR	EDGE software implementation (cost estimation for retrofits in buildings. in DKI Jakarta, Bandung and Surabaya)	Limited capacity
6. Concessional loan to EXIM bank	Concessional credit lines: Financial incentive	Stopped in 2016	ADB; banks; EXIM bank	Limited impact: two projects were financed and the scheme has been closed down.	Availability of funds
7. EE Concessional loan	Concessional Credit line:	Stopped in 2016	AFD; MEMR; project dev.	Bank Mandiri concessional lending. The credit line was closed in 2016 without any projects being financed.	Availability of funds
8. EE revolving fund	EE revolving fund: Technical assistance	2011-2013	Carbon trust, UNDP, MEMR, MoF	Develop a concept and programme for a revolving fund. Via PIP mechanism Due to government changes it was not approved.	Availability of funds
9. IEPC I and IEPCII	Concessional credit line: Financial incentive	Finished in 2012	KfW, MEMR	Loans were provided for EE technology.	Availability of funds
10. EEF capacity building programme	Super ESCOs: Free IGAS	ongoing	MEMR, AFD	IGA training of 10 industries. They IGAs were for free	Limited capacity

Table 4: Private/public blended support mechanism and financial incentives in Indonesia

Initiatives	Type of Support	Period	Implementer	Result/Status	Barrier
			Framework conditions		
11. Indonesian financial support (INFIS)	Technical assistance	Ongoing	GIZ, OJK	Provide technical assistance to OJK for example to conduct a project finance analysis.	Risk perception
12. First movers programme	Technical assistance	2016 – July 2017	OJK; Environmental NGO	Drafted the sustainable investment guide-lines. Follow up programme has started.	Limited capacity
			Financial Incentives		
13. Green Chiller	Financial incentive	2014-present	MEMR GIZ	Conducted a study on financial incentives for EE cooling systems	Conducted a study on financial incentives for EE cooling systems
14. Green Building Code implementation	Tax incentive	2012-present	Ministry of Public Works, city of Bandung; city of Surabaya	Green commercial buildings can get some tax benefits. However, the operationalisation is still being developed.	Green commercial buildings can get some tax benefits. However, the operationalisation is still being developed.

Table 5: Overview of public initiatives and which barriers they address

	Barriers targeted				
Public initiatives	Barrier 1: Availability of Funds	Barriers 2: Information, Awareness and communication	Barrier 3: Project development and transaction costs	Barrier 4: Risk perception	Barrier 5: Limited capacity
Total #	7	1	2	1	3

Adaptation to climate change policies

The country will be confronted to sea level rise, changes in precipitation patterns, increase of average temperatures, decrease in agriculture production and increase in some vector borne disease incidents. The national adaptation strategy focuses on the most vulnerable to climate change sectors : agricultural, water and fishing industries. The 3rd National Communication (2018) identifies the following adaptation options by sector (examples):

- Water resources: sea water desalination, water use efficiency, rainwater harvesting.

2.5.2.5. Summary of stakeholders consultation

AFD presented the PEEB Cool concept to the Ministry of Finance, Ministry of Energy and Mineral Resources, and to the Ministry of Public Works and Housing through several consultations from June to August 2020. Based on the undertaken consultations, the ministries are supporting the PEEB Cool proposal and recommend the program to focus on energy efficiency in residential buildings (public/mixed commercial-housing use). The following institutions have been consulted:

- Ministry of Public Works and Housing (MPWH), DG of Human Settlements: MPHW is responsible for project preparation and implementation and policies for green buildings including the regulation on the Green Building guideline and shows particular interest in green building projects/ models and mitigation policies and implementing activities especially in educational buildings.

- **Ministry of Energy and Mineral Resources (MEMR), DG of New, Renewable Energy and Energy Conservation (EBTKE):** EBTKE is responsible and interested in cooperating in the field of policies and solutions for green buildings in general which are large energy consumers and can contribute to climate mitigation at large scale.
- **Bank Tabungan Negara (BTN):** The commercial bank BTN, a State-Owned Enterprise (SOE) is regulated by the central bank of Indonesia and is the main financier in Indonesia´s housing mortgage and housing market. BTN shows interest in introducing green financing instruments (credit lines) and new green business models for energy efficiency in the housing construction market.
- **PERUMNAS** is one of the largest and state-owned construction developers and active in the housing construction market.

2.5.3. Project description

2.5.3.1. Project's objectives and description

Component 1: Investment Facility

The project facility provides the project financing and the project preparation study such as environmental and social safeguard documents. Several investment opportunities have been discussed in the consultations and are described below.

Indicative project 1:

The project aims to materialize the implementation of energy efficient, low-carbon and cool buildings (including the GCF "cooling" focus) for residential housing (public, mixed-used) and public building, in Indonesia. This objective will unlock the challenge on financing such initiative as the sector is remained untapped for the development despite of the potential of reducing GHG through energy efficiency measures. The project will consist of:

- Credit line to finance public housing with energy efficiency component
- Project preparation study, including E&S document
- Incentive schemes for financing energy efficiency program for housing

Indicative project 2:

The project consists of preparation, financing and support the implementation of green building projects such as educational and commercial buildings

- Identification of financing models for green building that are suitable for Indonesia's NDC target for energy sector, e.g. educational purpose
- Project preparation study

The below tables outline the GHG baseline emissions and emissions reductions for an Indonesia residential case. Full calculations can be found in Annex 22c.

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	253,965
Emissions - 20% reduction case	190,092
Emissions - 40% reduction case	181,452
GHG reductions - 20% reduction case	63,873
GHG reductions - 40% reduction case	72,513

GHG reductions - average of 20% and 40% reduction case	68,193

GHG emissions without EE measures:	Source of information	Unit	Value
Indonesia			
Type of building			Residential
m2 impacted	A	m2	207,778
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	76
Natural gas	C1	kWh/m2/yr	30
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.637
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	48.4
Natural gas	G1 = C1 x E	kgCO2/m2	6.9
Building materials	H1	kgCO2/m2	391.8
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	10,064
Natural gas	J1 = G1 x A	tCO2/yr	1,440
Electricity	I1 = F1 x A x L	tCO2 over lifetime	150,958
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	21,599
Building materials	K1 = H1 x A	tCO2 over lifetime	81,409
Total		**tCO2 over lifetime**	**253,965**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	55
Natural gas	C2	kWh/m2/yr	24
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.637
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			

Electricity	F2 = B2 x D	kgCO2/m 2	35
Natural gas	G2 = C2 x E	kgCO2/m 2	5.5
Building materials	H2	kgCO2/m 2	305.9
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	7,283
Natural gas	J2 = G2 x A	tCO2/yr	1,152
Electricity	I2 = F2 x A x L	tCO2 over lifetime	109,246
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	17,279
Building materials	K2 = H2 x A	tCO2 over lifetime	63,567
Total		**tCO2 over lifetime**	**190,092**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/ yr	55
Natural gas	C3	kWh/m2/ yr	12
GHG emissions factors			
Electricity	D	kgCO2/k Wh	0.637
Natural gas	E	kgCO2/k Wh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m 2	35
Natural gas	G3 = C3 x E	kgCO2/m 2	2.8
Building materials	H3	kgCO2/m 2	305.9
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	7,283
Natural gas	J3 = G3 x A	tCO2/yr	576
Electricity	I3 = F3 x A x L	tCO2 over lifetime	109,246
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	8,639
Building materials	K3 = H3 x A	tCO2 over lifetime	63,567
Total		**tCO2 over lifetime**	**181,452**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	2,781
Natural gas	J1 - J2	tCO2/yr	288

Electricity	(I1 - I2) x L	tCO2 over lifetime	41,712
Natural gas	(J1 - J2) x L	tCO2 over lifetime	4,320
Building materials	K1 - K2	tCO2 over lifetime	17,842
Total	Sum of 20% case	tCO2 over lifetime	63,873

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	2,781
Natural gas	J1 - J3	tCO2/yr	864
Electricity	(I1 - I3) x L	tCO2 over lifetime	41,712
Natural gas	(J1 - J3) x L	tCO2 over lifetime	12,959
Building materials	K1 - K3	tCO2 over lifetime	17,842
Total	Sum of 40% case	tCO2 over lifetime	72,513

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	2,781
Natural gas	Average 20% and 40% case	tCO2/yr	576
Electricity	Average 20% and 40% case	tCO2 over lifetime	41,712
Natural gas	Average 20% and 40% case	tCO2 over lifetime	8,639
Building materials	Average 20% and 40% case	tCO2 over lifetime	17,842
Total	Sum of above	tCO2 over lifetime	68,193

Component 2: Enabling Facility

The Enabling Facility provides technical assistance for policy support on energy efficient and cool buildings at different levels. The enabling facility is directly linked to the sectors of intervention of the project facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration. Tentative activities in the different output areas are described below.

Output 2.1: Sectoral investment frameworks demonstrate investment potential for green recovery

- Advisory to MPHW/ EBTKE-MEMR on national green building strategies related to affordable low carbon housing and educational buildings which are financially supported by the Project Facility.

- Advisory for sectoral engagement and development of decarbonization roadmaps, in relation to sectors involved in the implementation of financing projects.

Output 2.2: Policy proposals prepare the ground for buildings sector transformation

- Advisory to MPHW/ DG of Human Settlements on the improvement and enforcement of energy efficiency building codes and regulations with a priority on residential buildings (public, mixed-use with commercial) and educational buildings, both of which are tentative sectors of the intervention of the project facility.
- Support on the development of energy performance systems for specific building segments such as housing and education, including baseline definitions, design standards, monitoring, reporting and verification formats.
- Support for specific energy efficient and low-carbon policies for large energy consuming buildings with high mitigation potential.
- Harmonisation on MEMR and MPWH's green building policies

Output 2.3: Private and public sector actors are enabled to work towards buildings sector transformation

- Training to financiers (e.g. BTN) on 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.
- Training to investors and developers (e.g. PERUMNAS) on design and construction of energy efficient, climate-adapted and low-carbon cool buildings, to ensure homogenous quality of constructed housing units.
- Training to project owners and developers of commercial buildings on energy efficient design, construction and operation of buildings (i.e. to complement PROPARCO's potential financing activities in the retail sector).

Output 2.4: Dissemination and knowledge sharing

- Support on dissemination and knowledge sharing of policies, roadmaps, and action plans as well as technical and financial solutions for the construction of low carbon and green buildings at national, provincial, and municipal levels (vertical integration)
- Support on regional and global peer-to-peer networking and learning on good practices on policies, technical, and financial solutions

2.5.3.2. Paradigm shift potential

PEEB Cool expects two major shifts in Indonesia:

- First, the financing for green housing under the Investment Facility will catalyze the implementation of energy efficiency in the housing sector by acting on both the supply and demand sides. The design recommendations for affordable, yet low carbon housing will be replicable, low cost and low tech and will be adapted to similar projects. Thus, it is expected that other commercial banks will start preparing similar facilities for financing energy efficiency in residential buildings and other sector buildings e.g. educational and commercial. Through financially viable low carbon solutions for affordable housing the government expects to meet its huge housing deficit, contributing to achieve its NDC mitigation goals.

- Second, the support to the Ministry of Public Works and Housing and the Ministry of Energy and Mineral Resources on project preparation and policy advice on public green buildings will stimulate the formulation on developing national policies for large energy consuming buildings in Indonesia. By providing support on policy advice, the project will contribute to set Indonesia's building and construction sector on a low-carbon development path towards zero carbon buildings by 2050.

2.5.3.3. Sustainable development potential

PEEB Cool envisages the following co-benefits in Indonesia:

1. Climate co-benefit:
   The program will contribute to mitigation action by reducing energy consumption at the demand side. The end-user household energy consumption could contribute 25% of GHG reduction relative to the BAU case. The program will also provide advice on climate adapted building design and green building materials and technologies, taking into account climate-adapted and resilient planning principles for buildings, contributing to the buildings adaptation to climate change.
2. Social co-benefit:
   The program will ensure social inclusion and gender aspects, engaging the community in active participation, including the participation of women in decision making, for example, regarding affordable low carbon housing planning processes. Furthermore, the program will contribute to providing access to sustainable cooling for low income households.
3. Economic co-benefit:
   Through the policy advice to the government and private sector on green housing and construction, it is expected that the energy efficient construction ratio increases significantly. In the public sector, the energy saving can reduce the operational expenditure in the range from 18% to 56% compared to BAU.

2.5.3.4. Project indicative financing

	Total Amount (a+b)	Currency	GCF amount (a)	AFD amount (b)
5. Senior loan	100	Million EUR	15	85
6. Grant (technical support)	10	Million EUR	10	0
Total project financing (1+2)	110	Million EUR	25	85

This amounts are provisional at this stage and are still to be discussed

2.6. Mexico

National Designed Authority	**Ministry of Finance**
Project title	PEEB Cool Mexico
Name and typology (public/private) of the institutions	Ministry of Finance, NAFIN, BANCOMEXT, SHF, SEMARNAT
End beneficiaries (households, students…)	End beneficiaries will include public and private financial institutions, municipalities and smaller entities (individuals, entrepreneurs).
Mitigation/adaptation focus	Cross cutting

2.6.1. Climate profile

2.6.1.1. Historic climate data

Mexico's National Meteorological Service notes the country has four main climate zones: arid, tropical, temperate and humid. 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 (Government of Mexico, 2016).

2.6.1.2. Future projections

Warming throughout the country is expected, especially in hotter urban regions. Table 11 shows future changes in Mexico City.[40]

Table 11 Future climate changes in Mexico City, Mexico

Time Period and Emission Scenario	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)
2011-2040 (RCP 4.5)	1.10	0.22	0.89	-250
2041 – 2070	2.20	0.73	1.80	-460

[40] Data from Climate Information. Site specific report: Mexico City.

(RCP 4.5)				
2071-2100 (RCP 4.5)	3.00	0.78	2.40	-550
2011 – 2040 (RCP 8.5)	1.60	0.36	1.10	-300
2041 – 2070 (RCP 8.5)	3.60	1.10	2.80	-570
2071 – 2100 (RCP 8.5)	6.00	2.00	4.90	-800

This data shows a clear warming trend throughout the century, with a significant acceleration in the last period. Moreover, mean changes to maximum temperatures are up to three times higher than changes to minimum temperature in the high emission scenario. Heating of up to 6 degrees Celsius in Mexico City will pose enormous risks to the nearly 22 million residents within the wider metropolitan area.

Expected heating changes at the national level are similar. Table 12 shows this in more detail.

Table 12 Future climate changes in Mexico (World Bank data)

Time Period and Emission Scenario	Hot Days	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	16.63	1.64	0.05	458.00
2040-2059 (RCP 2.6)	24.69	2.84	0.06	566.20
2060-2079 (RCP 2.6)	26.26	2.90	0.07	564.03
2080-2099 (RCP 2.6)	24.33	3.06	0.06	538.65
2020-2039 (RCP 4.5)	21.31	1.19	0.06	487.26
2040-2059 (RCP 4.5)	32.65	3.92	0.10	730.71

2060-2079 (RCP 4.5)	40.52	7.23	0.13	900.96
2080-2099 (RCP 4.5)	45.90	9.28	0.16	1010.02
2020-2039 (RCP 8.5)	22.59	1.50	0.06	537.76
2040-2059 (RCP 8.5)	42.93	7.16	0.15	1004.67
2060-2079 (RCP 8.5)	69.11	19.30	0.26	1581.34
2080-2099 (RCP 8.5)	97.44	41.78	0.36	2221.51

Under a medium emissions scenario there is expected to be 45 more hot day annually and a 16% chance of a heat wave. However, the high emissions scenario illustrates the rapid escalation in heating with both figures more than doubling – an additional 97 hot days and a 36% likelihood of a heat wave.

WHO estimates around 240 days of warm spells under a high emission scenario by 2100 compared to around 10 in 1990. This can be limited to 65 with aggressive emission reductions (WHO, 2015).

2.6.1.3. The impact of high temperature on health

Mexico’s NDC notes that poverty is a determining factor of social vulnerability with up to 60% of the population having been affected by natural disasters – a similar proportion to those in either poverty or extreme poverty (Government of Mexico, 2015). These risks are exacerbated for those living in “precarious housing facilities” (Government of Mexico, 2015).

The rapid rate of growth in private housing has led to detached dwellings accounting for 84% of total housing in cities with over 100,000 inhabitants. Increased urbanisations and low-income housing caused infrastructure deficiencies and enhanced energy demands, especially during hot periods. A study of indoor temperature and housing type found a temperature increase 5 degrees Celsius higher than in the urban centre nearby.

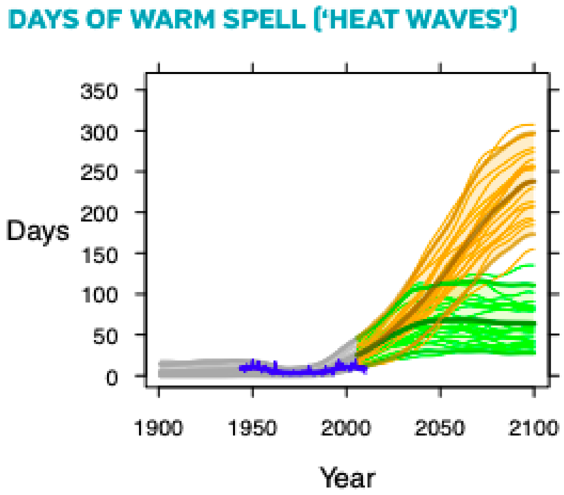

Figure 8 Future annual heat wave days under different emission scenarios (WHO data)

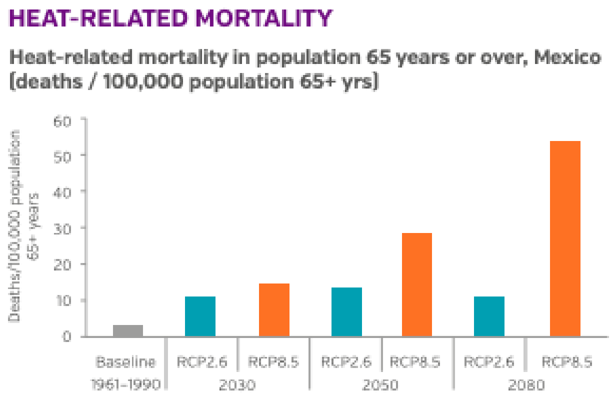

Figure 7 Future heat-related mortality in Mexico (WHO data)

The same researchers suggest the need to focus on the "dehumidification of the spaces as well as on the reduction and conservation of indoor temperatures, so that it remains within thermal comfort limits" (Barrientos-González, et al., 2019).

A 2018 study on thermal comfort and air quality in university buildings found that mean hourly values of CO2 and temperature exceeded maximum values recommended by WHO guidelines. Moreover, humidity levels were significantly higher than regulations (Magaña Villegas, 2018). Such characteristics can inhibit productivity and output, especially in a learning environment.

A multi-city study of heat-related mortality between 1998 and 2002 found a significant link between same and previous day temperature and mortality risk. In Mexico City, the increase in risk was 3.22% with higher risk for women, the elderly and those with a lower level of education (Bell ML, 2008).

Analysis of three national surveys and temperature data, research conducted by the Inter-American Development Bank found the impacts of heat waves to be longer lasting rather than causing a sudden uptick in mortality rates. In particular, high temperatures during childhood and adolescence were found to have detrimental effects on developmental characteristics, especially height, with the strongest effect in low-income districts. The research concluded that hotter periods would therefore "amplify health differences by socio-economic status" (Aguero, 2014).

The US state of Arizona neighbours the Mexican state of Sonora. In Phoenix, Arizona, a region with an arid climate that frequently experiences high temperatures, research into local adaptive capacity have been completed. A 2009 study focused on 359 households classified at heat vulnerable during a hot period. 36.2% reported symptoms associated with heat stress such as high temperature, dizziness, fatigue and elevated heart rate. 35.8% worked indoor service jobs and 17.1% worked indoor office jobs (Hayden, 2011.)

2.6.1.4. Economic vulnerability

Temperature increases can also create potential labour market impacts. Using employment and temperature data over a 28-year period, one study of rural Mexico found a reduction in local employment. This figure could reach 1.4% even under a medium emission scenario (Jessoe, Manning, & Taylor, 2016).

In the Southwestern United States, bordering on Mexico, an analysis of classroom ventilation rate and temperature on academic achievement was completed. Researchers found strong association between ventilation rates and mathematics scores, with an additional increase of 12-13 points per 1°C decrease within an optimal temperature range of 20-25°C (Haverinen-Shaughnessy, 2015). Such damaging impacts and trends do not lead to an easily quantifiable economic loss, especially in the short term, but threaten to derail individual attainment which can ultimately lead to loss of economic potential when entering the job market in the future.

Mexico's climate change adaptation strategy (PECC 2014-2018) explicitly mentioned the need to strengthen strategic infrastructure, including incorporating climate criteria into design, construction and maintenance. Moreover, protecting the productive sector was labelled as a key adaptation measure to better limit the risks of economic and social losses (Government of Mexico, 2016).

2.6.2. Market context and barriers

2.6.2.1. Strategic context and market potential

Economy

With a population of almost 130 million, Mexico has the second-largest economy in Latin America, the 11th largest economy in the world and is a major oil exporter. Its economic growth averaged around 2 percent a year between 1980 and 2018 despite the uncertain environment, fiscal consolidation and tighter monetary conditions. According with the OECD[41], the economy will rebalance, with a higher contribution of exports and investment to growth while private consumption will decelerate as high inflation dents purchasing power and credit expansion slows, owing to monetary policy tightening. Construction activity will pick up from its historically low levels, reflecting reconstruction after the September 2017 earthquakes. Recent structural reforms and successful tenders in the energy sector are expected to boost private investment. The COVID-19 pandemic has triggered a deep economic crisis; with respect to the fourth quarter of 2019, OECD-wide GDP is projected to have fallen by almost 15% by the second quarter of 2020[42].

Energy

Mexico´s energy mix is dominated by fossil fuels, particularly oil, which accounted for more than half of total demand in 2016. Energy data for the building sector is aggregated in residential sector and non-residential sector (sometimes referred to as commercial sector). Final energy use in the residential sector is dominated by gas, electricity and firewood and for the non-residential sector electricity. Projections for the building sector do not show a significant reduction on energy consumption for 2020 and 2030. There is a complex system of federal subsidies for electricity tariffs for residential sector. There is not a defined electricity tariff for other building subsectors. Primary energy demand in Mexico has increased by 25% since 2000 with the

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[41] OECD, (2018). "Mexico - Economic forecast summary". May 2018.

[42] The World Bank, (2020). Mexico Overview. April 2020.

largest growth in electricity consumption in the building sector. The biggest share comes from residential consumers where cooling demand is expected to grow with increased incomes and temperatures.

Buildings and construction

By 2050, Mexico's population is expected to grow to more than 150 million with more than 80% living in cities and urban areas. It is estimated that until 2050 the number of cities with populations of more than one million people will double, increasing from 11 to twenty cities with more than one million inhabitants. The real estate market is strongly linked to the growth of the population and cities, so it is necessary to decouple urban and economic growth from the increasing energy consumption, especially in the building and construction sector.

The residential sector is the fastest growing subsector. There are 33 million inhabited housing units (2017)[43], with the majority having a construction area between 45 and 60m^2 (46%) or larger than 60m^2 (41%). The government expects that about 15 million new housing units will be built by 2030, adding more than 600 million m^2 of floor area. Non-residential buildings such as commercial buildings or schools, are also experiencing rapid growth. These buildings comprised an area of around 155 million m^2 (2005)[44].

Cooling challenge

More than 60% of the national territory has hot climates (humid, semi-dry and dry), with high cooling demands.

The *Iniciativa Climática de México* estimates the sale of air conditioners in Mexico will grow from 16 million units today to 126 million units in 2050[45]. This is a significant contribution to electricity demand from buildings, placing pressure on the national grid, and emphasizing the need to increase energy efficiency in buildings. Space cooling already represents 37 TWh of power consumption or 10% of the total final energy use in buildings[46]. The power needed for residential space cooling alone is estimated to quadruple from 5 TWh to 20 TWh by 2030. This is estimated to rise to almost 20 TWh/year by 2030[47].

Public policy and legal framework

In 2012 Mexico adopted the General Climate Change Law, one of the world's first climate laws—and the first in an emerging country. Under this law, Mexico aims to reduce its emissions by 50% by 2050, based on 2000 levels.

Mexico has been implementing the Montreal Protocol since 1991, developing projects in the refrigeration sector that have been attributed of reducing in 99% the ozone depleting substances as registered in 1989. Mexico also put in place a National Plan to Eliminate the Chlorofluorocarbons (CFC's) and since 2018, there are actions to eliminate the Hydrofluorocarbons (HFC) and Hydrochlorofluorocarbons (HCFC) from refrigerants in commercial and residential buildings.

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[43] INEGI, (2018). "Encuesta Nacional sobre Consumo de Energéticos en Viviendas Particulares (ENCEVI)". Presentación de resultados. Instituto Nacional de Estadística y Geografía. México.

[44] de Buen, O., et al., (2008). "Edificación Sustentable en América del Norte". Documento uno: Escenarios energéticos de la edificación sustentable para 2030. Comisión para la Cooperación Ambiental (CCA).

[45] Cool Coalition (2020). Mexico

[46] IEA (2018). The Future of Cooling.

[47] IRENA (2016). REmap 2030 – Renwable Energy Propsects: Mexico

In 2016, Mexico submitted its first Nationally Determined Contribution (NDC) which is consistent with the climate change law. The NDC aims at unconditionally reducing GHG emissions in 2030 by 22% below its BAU baseline and by 36% with international support. To achieve its mitigation targets, so far there are only few specific mitigation actions for meeting the unconditional targets in the building sector: the use of water saving fittings, the substitution of water heaters for more efficient ones and/or solar water heaters in residential buildings. In general, emission reductions are targeted in residential and commercial buildings.

The Energy Conservation Code for Buildings in Mexico (IECC-Mexico) is a voluntary model code that regulates the minimum requirements for energy conservation in new residential and non-residential buildings. It includes every building-related energy efficiency standard issued by the government (envelope, Heating, Ventilation and Air Conditioning (HVAC), artificial lighting, water heating and other building services).

The voluntary standards for schools (NMX-R-021-SCFI-2013) and green buildings (NMX-AA-164-SCFI-2013) contemplate aspects of energy efficiency. Their effectiveness depends on their incorporation into municipal or state building regulations. The standard NMX-AA-164-SCFI-2013 specifies the criteria and minimum environmental requirements of a green building to contribute to the mitigation of environmental impacts and the sustainable use of natural resources. Its field of application is for both residential and non-residential buildings. The standard NMX-AA-164 considers all the product and system standards applicable to buildings and also recommends the collection of information on energy and water consumption.

2.6.2.2. Analysis of relevance of barriers

Barriers type	Country specific relevance
Technical barriers	
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	Mexican authorities and building developers have gained experience in the field of energy efficient housing (e.g. Housing NAMA implementation), commercial and office buildings. Nevertheless, the capacities on bioclimatic building design and its high CO_2 mitigation potential need to be improved. Capacities of installers and building craftsmen need to be strengthened and built for some technologies.
Financial barriers	
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	Building developers and investors, especially in the residential sector, gained experience with green building designs and financing programmes with international climate finance. However, due to the complexity the sector and its stakeholders with diverse financing needs, a huge demand for financial incentive programmes remains. After experiencing a severe economic downturn in the 2nd quarter of 2020, Mexico is slowly rebounding

	from the initial shock of the coronavirus pandemic. Green construction stimulus programmes can be essential for the economic recovery and social agenda.
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	Mexican banks have gained experience with financing instruments for energy efficient buildings (e.g. ECOCASA Programme, Green Mortgage, Housing NAMA subsidy). Existing and past programmes mainly target financial products for private apartments or residential buildings. There is further need for financial products for commercial, office and educational as well as health care buildings, new and existing.
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	In Mexico there are several EE/RE technologies and systems on the market. ESCO models are developed and initially applied. However, industrial actors need incentives and technical support to implement and scale EE actions.
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	Mexico´s updated NDC from December 2020 emphasizes on synergies between mitigation and adaptation measures and highlights the NDC as basis for the Green Recovery. While the adaptation component has increased ambitions, there is no quantitative increase of the mitigation component foreseen. Mexico also delayed the previously adapted energy transition. Support and efforts are needed for aligning strategies, policies and increasing ambition for the building sector.
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	In general, the regulatory framework for sustainable housing is more robust than for other building types. There is a lack of a national law or regulation for buildings. Mexican official standards are not very demanding, and compliance is low. The regulatory framework is not prepared for the transition to buildings with NET Zero or very low energy consumption.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	Although there are practical implementation experiences with energy efficient buildings, there are generally still significant gaps in knowledge and awareness among authorities, developers and end users about which measures have which potential impacts and co-benefits.

2.6.2.3. AFD experience in financing buildings construction of refurbishment projects

Hospital sector*:*

AFD is currently financing a technical cooperation between AP-HP International and IMSS (Mexican Social Security) in order to develop a Sustainable Hospital Management System, which will allow taking sustainable development actions in IMSS hospitals. The technical cooperation will focus on the following five points: Waste Management, Water Management, Responsible and Sustainable Procurement and:

- *Energy management:*
  - *I*dentify, through an evaluation of each hospital, the interventions that represent the most cost-effective impact in terms of energy efficiency. The actions that could be carried out are the following:
  - Conduct energy audits to find waste points and efficient alternatives for savings;
  - Evaluation of energy substitution by renewable sources such as solar or wind energy;
  - Establish training programs to reduce energy consumption in the activities carried out.
- *Building design:*
  - Sharing good practices on how to take into account sustainable development issues in the design of new buildings, preparation of technical specifications, in the use, maintenance and improvement of the existing fleet, presentation of the French HQE (high environmental quality) standard.
  - Disseminate the concept of resilient health infrastructures, i.e. infrastructures that are planned, designed, built and operated in a way that anticipates, prepares and adapts to climate change and therefore meets projected needs until the end of their lifecycle and not just at the beginning.

Residential sector*:*

AFD is contemplating financing to the CFE (Mexican National Utility) the project "*Hogares Solares*" that aims at implementing Solar PV generators on the roof of 14 000 houses belonging to the low income population living in the warmer part of the country. This project will allow to use social public subsidies on electricity bills (OPEX) to finance sustainable energy production (CAPEX) and to capitalize on it. There will be triple benefits:

- Decrease of the electricity bill of poor people,
- Replacement of high carbonized generation by clean energy,
- Decrease of the cost for the government budget of the cost of subsidizing electricity bill.

In 2015, AFD has set the basis for a program with SHF to finance Energy Efficient housings with the following objectives

1. Promote electrical energy savings in buildings and housing.
2. Strengthen energy efficiency actions in the residential sector
3. Promote the construction of housing that ensures an efficient use of energy.
4. Promote the use of technologies that allow the use of biomass (ecological cookers).

The financing was postponed due of a lack of investment grant available at the time, but AFD has kept the contact with SHF, which is still active in this field, and who could be an interesting partner for a PEEB COOL project.

Through its private financing subsidiary, PROPARCO, and through credit lines and equity investment, AFD has the possibility to finance energy efficient residential buildings and housings in Mexico. A first operation of PROPARCO took place in 2019 consisting in a 20 M$ Equity investment in VINTE. VINTE, a real estate developer, has developed a unique concept in Mexico of integrated communities. The company's activity covers the entire urban construction value chain (land acquisition, permitting, urban planning, design, construction and marketing of lots) offering its clients a final product that is not limited, like its competitors' offerings, to housing alone, but includes all the basic infrastructure of a medium-sized city (water, electricity, roads, health, education, parks, sports fields, playgrounds, etc.). Its approach aims to promote a living environment based on community values and environmental protection through a more efficient use of natural resources. The design of the housing, with thermal insulation and solar protection of the windows, allows for energy savings and responsible management of resources, with the homes having energy efficiency certificates. VINTE focuses on the development of sustainable housing and has in the past carried out several "green and social" bond issues.

Commercial buildings*:*

Through its private financing subsidiary, PROPARCO, and through credit lines and equity investment, AFD has the possibility to finance Energy Efficient commercial buildings in Mexico.

Educational sector:

AFD has appraised in 2018, a financing for a project whose main objective was to reduce the energy consumption of schools and public hospitals through the financing of energy efficiency works and the strengthening of the capacities of institutions in these sectors in terms of preparation, implementation and monitoring of such investments.

The project, though very promising, was postponed mainly due to a lack of investment grant available and might be reactivated through PEEB Cool.

2.6.2.4. Baseline and public policies analysis

Environmental policies related to the building sector

The Mexico City objectives for the Paris Agreements are: -25% to -40% emissions in 2030 compared to a reference scenario. The RE share objectives are 35% in 2024 and 50% in 2050. An EE Road Map has been set for 2017.

The country is engaged in a program on EE of air conditioning with actions for the replacement of underperforming refrigeration equipment, energy labeling and the elimination of HFCs among other activities.

A framework for allowing excess PV production is in place since 2013 (feed-in tariff + net metering for small powers).

Adaptation to climate change policies

The government started working on a National Adaption Plan was established in 2018, with the support of the GCF. The vulnerabilities to climate change arise mainly from the increased frequency and intensity of cyclones (swells and winds in coastal areas, floods and mudslides from rain even inside the country) and, depending on the season and climate zone, droughts and heat and cold waves. The 6th National Communication (2019) provides a detailed mapping of the identified vulnerabilities and adaptation strategies by area and by sector (National Atlas of Vulnerability to Climate Change). Several initiatives are in place with international funding, covering for instance in our sectors of interest:

- Water resources: National Program against Droughts, water treatment programs, water reserves programs, rainwater harvesting systems for domestic use in poor areas
- Urban planning: resilient cities network, Urban Resilience Guide (2016)
- Housing : Ecocasa program for funding passive or high-efficiency housing (supported by the Latin America Investment Facility)

2.6.2.5. Summary of stakeholders' consultation

Ministry of Finance *(Secretaría de Hacienda y Crédito Público - SHCP):* SHCP is the National Designated Authority (NDA) and in charge of implementing policies, actions and efforts that promote the reduction of GHG and increase resilience and decrease vulnerability to the adverse effects of climate change in the sectors prioritized in the National Strategy for Climate Change. AFD has cooperation experience with SHCP in the field of Green Finance. The Green Finance Public Policy Loan (250 M€) aims to support the development and strengthening of legislative, regulatory and institutional measures to encourage the alignment of public and private financial flows in Mexico with the mitigation and adaptation objectives of the Paris Agreement.

Ministry of Environment and Natural Resources (*Secretaría de Medio Ambiente y Recursos Naturales - SEMARNAT)*: SEMARNAT is the main governmental agency in charge of enacting and enforcing environmental regulation at the federal level and implementing national climate change policies. PEEB cooperates with SEMARNAT since 2018 in the field of energy efficient building regulations, particularly in the hotel and lodgment building segment.

National Financial (*Nacional Financiera - NAFIN*): NAFIN is a national development bank charged with promoting savings and investment through project management, the establishment of financing programs, investment coordination of capital and increased productivity. It operates as a second tier, i.e. it does not finance directly from individuals or companies, but that it provides financing to the intermediaries of the sector. AFD has appraised the possibility in 2018 of a loan for Energy Efficiency in public schools and hospital with NAFIN, and has kept the contact since.

National Exterior Commerce Bank *(Banco Nacional de Comercio Exterior - Bancomext):* Bancomext is a Mexican state-owned bank and export credit agency to promote and finance small and medium exporting Mexican companies in international markets as well as providing Consulting services for small and medium companies wishing to export their goods and/or services. Since 2019, Bancomext and NAFIN share the same board. AFD is maintaining a regular contact with Bancomext.

Sociedad Hipotecaria Federal (SHF) is a development bank, created in 2001 to "promote access to quality housing for low-income Mexicans". It operates as a second tier, i.e. it does not finance directly from individuals or companies, but that it provides financing to the intermediaries of the sector. SHF is active in financing Energy Efficient dwellings through the program ECOCASA. SHF provides concessional loans to private banks, which finance private real estate developers with competitive loan rates, which depends on the level of energy performance of the dwellings. The difference between the rate obtained by the developers and the market condition rate allows compensating the extra costs of Energy Efficiency. AFD is keeping a regular contact with SHF and has maintained its interest to contribute to the financing of an extension or a new program dedicated to Energy Efficiency in Building. In October 2020, AFD has presented PEEB Cool initiative to SHF during a meeting. SHF was interested by the initiative and will write to AFD and GCF a letter of support and interest to be part of.

2.6.3.Project description

2.6.3.1. Project's objectives and description

The main objective of the PEEB Cool project is to support the adoption of sustainable and renewable energy practices in the construction of new low-carbon and cool buildings through a multi sector approach that will benefit both public and private institutions in Mexico. The project will contribute to Mexico´s Nationally Determined Contribution (NDC) targets and provide sectorial technical assistance to support the transformation of the building sector towards a low-carbon development path.

PEEB Cool will focus on new construction projects with high energy demand and cooling needs in the following building segments, offering support to public and private sector entities alike.

Public sector financing by AFD:

- Public hospitals in cooperation with the Mexican Institute of Social Security (*Instituto Mexicano del Seguro Social,* IMSS)
- Administrative buildings (*Edificios de la Administración Pública Federal* - APF)
- Public schools under the Federal Ministry of Education or state/municipal educational entities
- Residential sector through program lead by public entities

Private sector financing by PROPARCO:

- Commercial buildings
- Private hospitals,
- Private schools,
- Residential sector through credit line to private bank.

The components of the described program are:

Component 1: Investment Facility

The Investment Facility provides technical and financial assistance to project owners (private and public entities) to identify, prepare and support energy efficient and cool building projects in its partner countries.

Tentative Activity 1: Identification of projects

- Support to public or private project owners on the selection of suitable low-carbon construction projects for financing by the PEEB Cool Investment Facility, such as energy efficient public hospitals, schools or public administrative buildings.
- Elaboration on pre-feasibility studies and initial project concepts for promising potential low-carbon cool building construction projects.

Tentative Activity 2 – Preparation of financing

- Elaboration of technical and financial feasibility studies for specific public or private sector low-carbon and cool building construction projects.
- Support to public or private project owners on design improvements and technical criteria for low-carbon building projects subject to finance preparation under PEEB Cool.
- Preparation of public sector low-carbon construction projects and financial mechanisms and conditions which are subject for potential financing by French AFD under PEEB Cool (e.g. public hospitals, schools, administrative buildings).
- Preparation of private sector low-carbon construction projects subject for potential financing by French PROPARCO under PEEB Cool (e.g. private hospitals, commercial buildings).

Tentative Activity 3 – Implementation of projects

- Training measures to national financiers like development banks and their intermediary banks on low-carbon construction financing and eligibility criteria, evaluation and verification criteria and procedures.
- Technical and financial accompaniment of construction projects.
- Support on monitoring, reporting and verification of implemented projects.

The below tables outline the GHG baseline emissions and emissions reductions for a Mexico residential case followed by a small scale office case. Full calculations can be found in Annex 22c.

Residential case:

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	462,056
Emissions - 20% reduction case	345,362
Emissions - 40% reduction case	321,714
GHG reductions - 20% reduction case	116,694
GHG reductions - 40% reduction case	140,342
GHG reductions - average of 20% and 40% reduction case	128,518

GHG emissions without EE measures:	Source of information	Unit	Value
Mexico			
Type of building			Residential
m2 impacted	A	m2	525,000
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	78
Natural gas	C1	kWh/m2/yr	33
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.320
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	24.9
Natural gas	G1 = C1 x E	kgCO2/m2	7.6
Building materials	H1	kgCO2/m2	391.8
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	13,088
Natural gas	J1 = G1 x A	tCO2/yr	4,002
Electricity	I1 = F1 x A x L	tCO2 over lifetime	196,327
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	60,031
Building materials	K1 = H1 x A	tCO2 over lifetime	205,698
Total		**tCO2 over lifetime**	**462,056**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	55
Natural gas	C2	kWh/m2/yr	26
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.320
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	18
Natural gas	G2 = C2 x E	kgCO2/m2	6.0
Building materials	H2	kgCO2/m2	304.1
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	9,229
Natural gas	J2 = G2 x A	tCO2/yr	3,153
Electricity	I2 = F2 x A x L	tCO2 over lifetime	138,436
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	47,297
Building materials	K2 = H2 x A	tCO2 over lifetime	159,630
Total		**tCO2 over lifetime**	**345,362**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	55
Natural gas	C3	kWh/m2/yr	13
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.320

Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	18
Natural gas	G3 = C3 x E	kgCO2/m2	3.0
Building materials	H3	kgCO2/m2	304.1
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	9,229
Natural gas	J3 = G3 x A	tCO2/yr	1,577
Electricity	I3 = F3 x A x L	tCO2 over lifetime	138,436
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	23,649
Building materials	K3 = H3 x A	tCO2 over lifetime	159,630
Total		**tCO2 over lifetime**	**321,714**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	3,859
Natural gas	J1 - J2	tCO2/yr	849
Electricity	(I1 - I2) x L	tCO2 over lifetime	57,891
Natural gas	(J1 - J2) x L	tCO2 over lifetime	12,734
Building materials	K1 - K2	tCO2 over lifetime	46,069
Total	Sum of 20% case	**tCO2 over lifetime**	**116,694**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	3,859
Natural gas	J1 - J3	tCO2/yr	2,426
Electricity	(I1 - I3) x L	tCO2 over lifetime	57,891
Natural gas	(J1 - J3) x L	tCO2 over lifetime	36,383
Building materials	K1 - K3	tCO2 over lifetime	46,069
Total	Sum of 40% case	**tCO2 over lifetime**	**140,342**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	3,859
Natural gas	Average 20% and 40% case	tCO2/yr	1,637
Electricity	Average 20% and 40% case	tCO2 over lifetime	57,891
Natural gas	Average 20% and 40% case	tCO2 over lifetime	24,558
Building materials	Average 20% and 40% case	tCO2 over lifetime	46,069
Total	Sum of above	**tCO2 over lifetime**	**128,518**

Small-scale office:

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	82,694
Emissions - 20% reduction case	58,227
Emissions - 40% reduction case	50,748
GHG reductions - 20% reduction case	24,467

GHG reductions - 40% reduction case	31,946
GHG reductions - average of 20% and 40% reduction case	28,206

GHG emissions without EE measures:	Source of information	Unit	Value
Mexico			
Type of building			Small scale office
m2 impacted	A	m2	60,000
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	200
Natural gas	C1	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.320
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	63.9
Natural gas	G1 = C1 x E	kgCO2/m2	0.0
Building materials	H1	kgCO2/m2	419.4
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	3,835
Natural gas	J1 = G1 x A	tCO2/yr	-
Electricity	I1 = F1 x A x L	tCO2 over lifetime	57,532
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	-
Building materials	K1 = H1 x A	tCO2 over lifetime	25,162
Total		**tCO2 over lifetime**	**82,694**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	125
Natural gas	C2	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.320
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	40
Natural gas	G2 = C2 x E	kgCO2/m2	0.0
Building materials	H2	kgCO2/m2	371.2
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	2,397
Natural gas	J2 = G2 x A	tCO2/yr	-
Electricity	I2 = F2 x A x L	tCO2 over lifetime	35,957
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	-
Building materials	K2 = H2 x A	tCO2 over lifetime	22,270
Total		**tCO2 over lifetime**	**58,227**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	99
Natural gas	C3	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.320
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	32
Natural gas	G3 = C3 x E	kgCO2/m2	0.0
Building materials	H3	kgCO2/m2	371.2
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	1,899
Natural gas	J3 = G3 x A	tCO2/yr	-
Electricity	I3 = F3 x A x L	tCO2 over lifetime	28,478
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	-
Building materials	K3 = H3 x A	tCO2 over lifetime	22,270
Total		**tCO2 over lifetime**	**50,748**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	1,438
Natural gas	J1 - J2	tCO2/yr	-
Electricity	(I1 - I2) x L	tCO2 over lifetime	21,574
Natural gas	(J1 - J2) x L	tCO2 over lifetime	-
Building materials	K1 - K2	tCO2 over lifetime	2,892
Total	**Sum of 20% case**	**tCO2 over lifetime**	**24,467**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	1,937
Natural gas	J1 - J3	tCO2/yr	-
Electricity	(I1 - I3) x L	tCO2 over lifetime	29,054
Natural gas	(J1 - J3) x L	tCO2 over lifetime	-
Building materials	K1 - K3	tCO2 over lifetime	2,892
Total	**Sum of 40% case**	**tCO2 over lifetime**	**31,946**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	1,688
Natural gas	Average 20% and 40% case	tCO2/yr	-
Electricity	Average 20% and 40% case	tCO2 over lifetime	25,314
Natural gas	Average 20% and 40% case	tCO2 over lifetime	-
Building materials	Average 20% and 40% case	tCO2 over lifetime	2,892
Total	**Sum of above**	**tCO2 over lifetime**	**28,206**

Component 2: Enabling Facility

The Enabling Facility provides technical assistance for policy support on energy efficient and cool buildings at different levels to its partner countries. The Enabling facility is directly linked to the sectors of intervention of the Investment facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration.

Output 2.1: Sectoral investment frameworks demonstrate investment potential for green recovery

Indicative activities:

- Support on the development of specific investment roadmaps or action plans for building segments which are targeted under the Investment Facility (e.g. energy efficient and cool hospitals, schools, administrative buildings).

Output 2.2: Policy proposals prepare the ground for buildings sector transformation

Indicative activities:

- Specific policy advice on building segment targeted for financing under the Investment Facility.
- Support on the development of energy performance systems for specific building segments targeted by the Enabling facility (i.e. hospitals, schools, administrative buildings), including baseline definitions, design standards, monitoring, reporting and verification formats.
- Advisory on the improvement and enforcement of energy efficiency policies, such as energy efficiency building codes and regulations.
- Support on public or private energy efficient building initiatives for low carbon construction.

Output 2.3: Private and public sector actors are enabled to work towards buildings sector transformation

Indicative activities:

- Training to investors and developers on the design and construction of energy efficient, climate-adapted and low-carbon cool buildings, in sectors targeted by the Investment facility
- Training to financiers on eligibility criteria and verification procedures for the financing of low-carbon building based on energy performance systems, for sectors targeted by the Investment facility

2.6.3.2. Paradigm shift potential

Under the Investment Facility, PEEB Cool will provide financing to public and/ or private sector entities for new low-carbon construction projects with high energy demand and cooling needs. Thus, PEEB Cool will contribute to the development of financial incentive products (credits, loans, subsidies) for EE/RE measures and technologies in buildings contributing to the low carbon transformation of the building and construction sector in Mexico. By providing adequate financing, innovative low carbon construction in different building sector segments will be encouraged and a change towards climate-adapted building design, more energy efficient equipment and appliances and low carbon building materials will be promoted at national and local level.

Under the Enabling Facility, PEEB Cool will support the improvement of the legal framework and support mechanisms for low carbon and cool buildings that generalize climate impact beyond the individual financing projects. Through capacity building and the support of the Mexican Alliance for Buildings and Construction, national governments and the private sector are empowered and strengthened to implement mitigation and adaptation measures in the building sector.

2.6.3.3. Sustainable development potential

- Economic: the creation of energy efficiency and low carbon capacities and financial and technical solutions for hospitals, schools and administrative buildings at the public and private levels will contribute to a sustainable economic growth of the construction market and its employment perspectives in a context of high demographic growth. Lower public spending on energy subsidies for the operation of public buildings will provide funding for further sustainable and low carbon development measures in the buildings and construction sector.
- Social and health: The program will ensure social inclusion and gender aspects, engaging the public and responsible institutions in the planning and implementation processes, including the participation of women in decision making. Furthermore, the program will contribute to improve health and living conditions for end users, for example, better health, hygiene and comfort conditions in public hospitals.
- Mitigation: The program will contribute to a lower energy consumption in buildings compared to baseline. For example, according to a 2015 study of the Mexican Ministry of Energy for 45 public hospitals, energy efficiency and renewable solutions in these 45 hospitals represent a high energy saving potential of up to 12,500 GWh/a (12,500,000 MWh/a) and a GHG emission reduction potential of up to 26 $MtCO_2$/a (2,600,000 tCO_2/a)[48].

Specific co-benefits and sustainable development potentials are to be defined with the Ministry of Environment after definition of components and beneficiaries.

[48] SENER. Estudio de Eficiencia Energética en Hospitales. 2015, p. 55

2.7. Morocco

National Designed Authority	**Environmental Department (Ministry of Energy, Mining and Environment)**
Project title	PEEB Cool Morocco
Name and typology (public/private) of the institutions	Public administrations in particular Finance, Housing, Interior, Education (schools), Industry Public enterprises like AMEE (EE Agency) and SIE (public ESCO)
End beneficiaries (households, students…)	State Budget / workers / citizens, Households
Mitigation/adaptation focus	Cross cutting

2.7.1. Climate profile

2.7.1.1. Historic climate data

Most of Morocco falls within the Mediterranean climate classification, with mild winters and hot, dry summers. 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 (USAID, 2015).

2.7.1.2. Future projections

Morocco is expected to see warming of between 1.5 and 3.5°C by 2050, with this rising to up to 5°C by 2100.[49] Warming will increase at a faster rate in the interior, where regions are drier, rather than the coastline.

Table 13 illustrates changes in Morocco's capital city, Marrakech, throughout the rest of the century.[50]

Table 13 Future climate indicators under different emission scenarios in Marrakech, Morocco

Time period and emission scenario	Tropical Nights (days)	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)

[49] World Bank. 2021. Climate change risk profile. Morocco.

[50] Data from Climate Information. Site-specific Report: Marrakech.

2011-2040 (RCP 4.5)	15	1.30	0.47	0.85	-98
2041-2070 (RCP 4.5)	31	2.10	0.91	1.50	-170
2071-2100 (RCP 4.5)	34	2.70	1.30	2.00	-200
2011-2040 (RCP 8.5)	19	1.30	0.71	1.00	-110
2041-2070 (RCP 8.5)	42	3.20	1.20	2.30	-230
2071-2100 (RCP 8.5)	68	5.50	2.60	3.90	-350

This data shows a troubling warming trend, especially accelerating in the later periods under the high emission scenario (RCP 8.5). Moreover, changes in maximum temperature are more significant than minimum temperature, suggesting more frequent and longer periods of hotter weather. Equally, the projected number of tropical nights under the high emission scenario is double that of the medium emission scenario by 2100. Such impacts could cause challenges to health, such as trouble sleeping. These projections align with the National Meteorological Directorate, who estimate average temperatures to rise between 2 and 5°C, depending on the scenario.

Data at the national level shows a similar trend. Table 14 shows the future heating indicators for the country.

Table 14 Future heating indicators for Morocco (World Bank data)

Time Period and Emission Scenario	Hot Days	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	14.41	0.03	378.50
2040-2059 (RCP 2.6)	17.34	0.04	445.41
2060-2079 (RCP 2.6)	15.61	0.04	422.11
2080-2099	16.70	0.04	418.39

(RCP 2.6)			
2020-2039 (RCP 4.5)	13.66	0.04	344.65
2040-2059 (RCP 4.5)	22.25	0.06	558.66
2060-2079 (RCP 4.5)	27.31	0.08	705.55
2080-2099 (RCP 4.5)	30.99	0.09	825.05
2020-2039 (RCP 8.5)	16.28	0.04	448.95
2040-2059 (RCP 8.5)	29.86	0.09	802.41
2060-2079 (RCP 8.5)	47.79	0.14	1363.34
2080-2099 (RCP 8.5)	63.78	0.19	1903.24

The World Bank's projections show similar extreme changes in heat. Figure 10 shows the bank's warm spell duration index under different emission scenarios from 1986 to 2099 (World Bank, 2020). It clearly shows significant divergence occurring from the middle of the century onwards, with the high emission scenario yielding more than double the number of warm days than the next highest emission scenario.

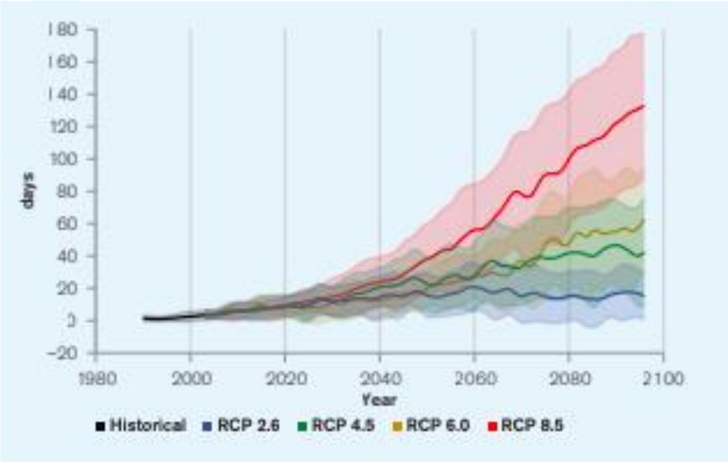

Figure 9 Future hot days under different emissions scenarios (World Bank data)

Extreme outdoor heat creates challenges to regulating heat indoors, especially in cities or where building material and/or design is suboptimal. GFDRR models show that Morocco falls within the high-risk level for extreme heat, with the southern and eastern regions especially susceptible to heat events. This suggests that exposure to heat stress will likely occur within the next five years.[51]

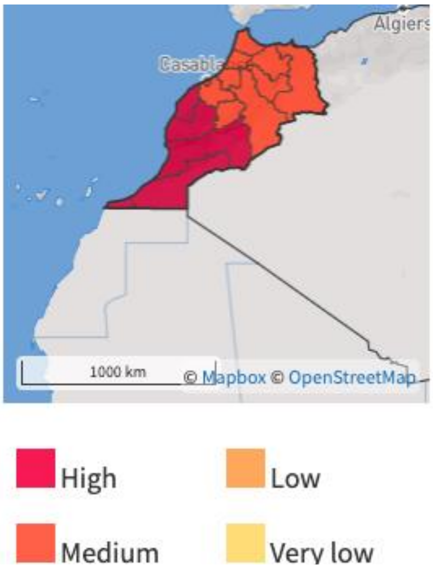

Figure 10 Extreme heat risk in Morocco (GFDRR data)

2.7.1.3. The impact of high temperature on health

Vulnerability to heat is widely recognised in Morocco. For example, under a high emissions scenario, the World Health Organization (WHO) project an increase in the number of warm spell days from 10 in 1990 to

[51] GFDRR. Think Hazard: Morocco. Available at https://thinkhazard.org/en/report/169-morocco/EH

around 210 annually by 2100. While this figure is expected to increase even under a lower emission scenario, it could be limited to around 50 days. (Figure 11 provides further detail and graphical representation).

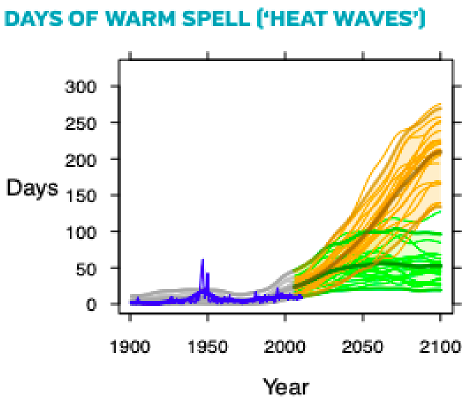

Figure 11 Future warm spell days in Morocco under different emissions scenarios (WHO data)

This projection is aligned with other broader studies. For example, a 2020 study of 53 cities in the Middle East and North Africa region found that 80% of the most populated cities, including those in Morocco, will spend at least 50% of their year under heat wave conditions under both medium and high emission scenarios (Varela, 2020).

Naturally, greater exposure to higher temperatures raises the risks of heat-related mortality. WHO estimates a rapid rise in heat-related mortality by the end of the century under a BAU scenario. They project, as shown in Figure 13, an expected mortality rate of nearly 50 per 100,000 in 2080 compared to 5 per 100,000 in 1990 (WHO, 2015).

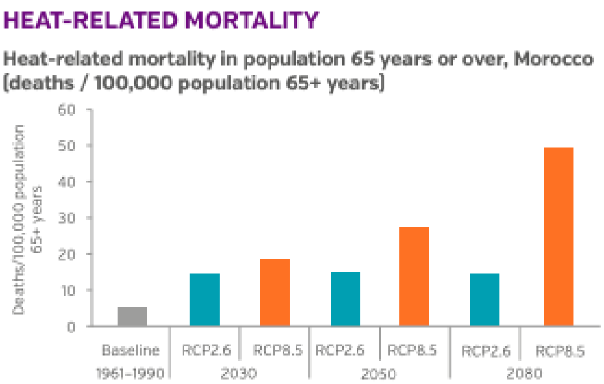

Figure 12 Future heat-related mortality (WHO data)

WHO also notes that heat can work in unison with indoor air pollution to increase vulnerability. In poorly constructed homes with limited ventilation and air flow, where damaging fuels are used for cooking, heating, cooling etc., the development of respiratory illnesses and heart diseases can occur. Then, when prolonged hot periods happen, those with underlying illnesses (typically women, children and the elderly) are placed at greater risk.

2.7.1.4. Economic vulnerability

Higher risk of heat stress and detrimental health impacts will impact the economy. The International Labour Organization expects the proportion of working hours lost to heat stress in the country to fall by 0.14% in industry, 0.39% in construction and 0.02% in services by 2030 (ILO, 2019). Moreover, they expect the economy as a whole to lose 19,000 jobs by the end of the decade due to heat, even under a low emission scenario. Without methods for adaptation to higher temperatures, especially those that enhance heat comfort, these figures will likely rise even higher.

Indeed, PEEB's own fact sheet notes that 249 million m^2 of new construction within Morocco's residential sector will occur by 2030, with hotels and commercial subsectors presenting the largest growth in non-residential buildings (PEEB, 2018). The focus in the country, so far, has been on energy conservation and wider mitigation strategies to limit the energy demand for cooking, heating and cooling. However, adaptation measures to enhance cooling are required to better regulate thermal comfort. Equally, with a likely increase in cooling load in line with higher temperatures, coping capacity may be limited or the additional costs of production could be passed on consumers (IEA, 2014).

Therefore, to limit unnecessary energy loads, adaptation measures to be taken to allow for efficient cooling within Moroccan buildings.

2.7.2. Market context and barriers

2.7.2.1. Strategic context and market potential

National Energy Strategy

Morocco has adopted a national energy strategy that aims at increasing the share of renewable energies in the total installed capacity to 52% by 2030 and increasing the energy efficiency level to 15% by 2030. The breakdown of expected energy savings per sector is 48 % for industry, 23 % for transport, 19 % for residential and 10 % for services.

Legislative and institutional framework related to energy efficiency

Several laws were enacted by Morocco to allow the achievement of the energy efficiency objectives of the National Energy Strategy, mainly:

- **The energy efficiency law 47-09** to promote energy efficiency in building, industrial, and transportation sectors, among others, by encouraging the development of minimum energy performance standards in different sectors and the generalization of energy audits.
- **Law 39-16 modifying and supplementing law 16-09 related to the creation of the Moroccan Agency for Energy Efficiency (AMEE):** AMEE's main attributes are to elaborate sectoral and regional energy efficiency development plans, to conceive and implement energy efficiency programs, to promote the adoption of energy efficiency standards and labels, and to raise awareness on the technical, economic, and social benefits of energy efficiency.

NDC

Morocco's current NDC commits to reducing the country's GHG emissions by a total of 42% below Business As Usual (BAU), of which 17% is unconditional and 25% is conditioned by international financial support.
4 unconditional actions to which Morocco commits can be associated to energy efficiency in the building (residential and tertiary) sector, namely:

- Energy certification labelling of refrigerators
- Implementation of the Code for the Thermal Regulation for Housing in Morocco (RTCM) in residential and tertiary housing
- Development of an energy efficiency program in the tourism sector that includes low-energy light bulbs, solar water heaters, and implementation of the RTCM.
- And the creation of a model low-carbon city

While 3 conditional actions can be associated to energy efficiency in the building sector:

- The National Development Plan for solar water heaters
- Low-energy lighting in residential housing and
- The implementation of a program to promote photovoltaic panels connected to the low-voltage grid with a target of 1,000 MW by 2030.

In terms of adaptation, climate change accentuates extreme phenomena, especially floods and affects the availability of resources (water, agricultural resources, biodiversity) and all sectoral activities (health, agriculture, tourism, etc.)

- The average temperature in Morocco increased by 1.2 ° C between 2000 and 2008. The simulations for 2040 predict an average increase of 1 ° C and a decrease in rainfall of 16% by 2050.
- Morocco is ranked 51st least vulnerable country, and 102nd country least prepared for climate change (ND-Gain, 2016).
- The water sector is strongly impacted by CC with significant extreme phenomena: Flooding, water scarcity (surface and underground), water pollution.
- Vulnerability of Moroccan agriculture, which represents 13% of national GDP, thus affecting the country's food security.
- The vulnerability of the health sector is significant given the risk of reactivation of certain endemic diseases (malaria, cholera, etc.) and the deficiencies of the health coverage and social protection system.

National Plan for the Exemplarity of the Administration (PNEA)

In 2019, a National Plan for the Exemplarity of the Administration (PNEA) was developed in accordance with the sustainable development strategy to promote development governance sustainable in Morocco focusing on the need to make the exemplarity of the administration a lever for implementation of sustainable development.

Building codes

Morocco promulgated a Building Energy Efficiency Code (known as RTCM) that specifies the thermal prescriptions to be respected by constructors in new buildings in 6 different climatic zones. The Code specifies the minimal building thermal performance in KWh/m^2/year and sets the requirements for the performance of the buildings envelope: level of thermal insulation, optimization of the rate of glazing by orientation, solar protection of windows, etc. The code entered into force in 2015. The resulting over-cost is estimated by the RTCM to be around 3.2% <u>on average</u>, ranging approximately between 4 to 30€ per m^2 depending on the climatic zone.

The resulting over-cost, associated with the absence of a conformity controlling mechanism, make the Code so far inapplicable by building constructors/real estate developers in Morocco.

Minimum Energy Performance Standards (MEPS) of Appliances

The Ministry of Energy, Mines, and Environment (MEME) in cooperation with the Ministry of Industry in Morocco are currently developing MEPS for appliances, with fridges and air conditioners considered as priority appliances to target given their high share in the electricity bill of a typical Moroccan Household. For those two, MEPS and energy labels have been developed but are not yet compulsory. They are in broad technical agreement with the Commission Delegated Regulations (EU) No 1060/2010 and 626/2011 related to labeling of the energy consumption of household refrigeration appliances and air conditioners, and are expected to become soon mandatory after the publication of a ministerial decree currently in the legislative approval process.

Any household appliances producer or importer must therefore ensure that all the appliances they put on sale on the national market are in compliance with MEPS and energy labelling requirements.

Technical and financial cooperation projects in Morocco in the energy efficiency in the buildings sector

AFD and GIZ currently have 2 major energy efficiency projects in the pipeline of cooperation projects with Morocco:

- The German Cooperation energy efficiency project in Morocco which will be commissioned by the German Federal Ministry for Cooperation and Development (BMZ) with a budget of 20 M€. This project is expected to be implemented by GIZ from 2021 onwards and aims to support Morocco's energy efficiency efforts in the most energy-consuming sectors, including (but not limited to) the building sector, with a focus on public and tertiary buildings.
- The NAMA Support Project (NSP) “Improving Energy Performance of Moroccan Households” expected to be funded by the NAMA Facility and currently in the Detailed Preparation Phase. The project aims at improving the energy performance of Moroccan households and is expected to be implemented by the AFD and GIZ from mid-2021 onwards - if approved. It specifically targets energy efficiency in residential buildings and aims to incentivize real-estate developers to invest in energy efficiency in low- and mid-income housing, and consumers to purchase the highest energy efficient household appliances (mainly fridges).

These cooperation projects as well as the previous experiences of AFD and GIZ in building construction and energy efficiency would lay the ground for implementing a comprehensive support approach that would position the construction and buildings sector in Morocco on a low emission pathway.

2.7.2.2. Analysis of relevance of barriers

Barriers type	Country specific relevance
Technical barriers	
Project stakeholders lack technical knowledge and experience in planning and implementing energy efficient and resilient building projects based on	Little experience and knowledge on bioclimatic design exist in the market. While several university and technical vocational schools increasingly offer

bioclimatic design principles and efficient cooling technologies	specialization on energy efficiency, general technical knowledge and experiences is still lacking among project stakeholders. This concerns particularly strongly specific sub-sectors of actors, such as small and medium sized construction companies as well as self-assisted contractors.
Financial barriers	
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	This barrier was highly relevant even before the COVID-19 pandemic, as visible also in the particularly slow compliance with the mandatory thermal energy efficiency regulation (which induces extra costs for the project owners). The pandemic, however, reinforced barriers on institutional and administrative level as no incentives for energy efficiency in building or climate change mitigation and adaptation were included in government stimulus packages.
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 are clearly reluctant to expand their portfolio to green building finance, mainly because of low demand and supply. While financing experiences have been made in related sectors (i.e. for energy efficiency in industry), in cooperation with development finance institution, there is no commercially available product for green construction or mortgage finance available.
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	While the industry actors harbor an important unexploited potential in their workforce and business models, also reinforced by international business contacts and linkages, there is inertia to invest significant resources in the development of low carbon and resilient building products. The economic crisis has reinforced this standstill in the construction industry.
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	The Moroccan government has established clear and ambitious targets (i.e. in NDCs) and translated them into strategies and sectoral action plans that are publicly available and integral part of public policy. The exemplarity of the public sector is particularly emphasized.
Building codes lack specific requirements for energy efficiency in buildings and enforcement is often weak,	The thermal energy efficiency regulation is well-developed, covers the vast majority of new construction

mandatory for certain types of buildings only, or still under discussion	and was adopted at the end of 2015. It nevertheless still struggles with enforcement, and no regulation or strategy exists for renovation of existing buildings.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	Many well-developed sectoral structures exist (i.e. national federations, Moroccan Alliance for Buildings and the Climate, Green Building Council, Ecomaterial Cluster, …), however the information flow is not consistently ensured, and different levels of awareness and knowledge persist across sectoral stakeholders. The political will to raise the commitment of public sector is there, however, the mobilization of stakeholders remains an obstacle to overcome.

2.7.2.3. AFD experience in financing buildings construction of refurbishment projects

AFD has a long experience and several projects in financing buildings construction or refurbishment projects in Morocco.

Since 1999, to support social housing policy in Morocco, AFD has focused its funding on **Al Omrane**, a public enterprise under the supervision of the Ministry of Housing and City Policy. Al Omrane is in charge of the implementation of government policy in the area of housing. AFD has already granted Al Omrane five successive loans for a total amount of 215 MEUR and is initiating a loan for a PEEB project with the mobilization of the NAMA Facility.

AFD also partially financed, (i) with a loan of € 150 million, the program for the development of integrated industrial platforms (P2I) entrusted to the operator **MEDZ** within the framework of the national strategy for the development of the industrial sector and (ii) with a loan 20 million euros for **SAPST** for the Taghazout Bay tourist resort to make it a model resort by its contribution to the socio-economic development of the Agadir region, while seeking environmental performance.

For 20 years, AFD has granted the **Moroccan state** successively four loans totaling € 62 million in the training sector for the construction and rehabilitation of 25 training centers in several sectors of activity.

AFD's subsidiary focusing on private sector, PROPARCO, is also active countrywide in the identification of projects prospects for lending or capital participation, with a strong focus on building construction (health, education, tourism, commercial, housing) or industries, and aims to promote the adoption of energy efficiency measures in the design of such projects.

PROPARCO did already invest in local actors such as TGCC, one of Morocco's leaders in industrial, public and building works. TGCC has built several reference facilities in Morocco: the extension of the Mohamed V Airport, the Casablanca Train Station, and a number of hotels and shopping centers in Tangiers and Casablanca. PROPARCO also invested in smaller actors of the Healthcare industry with strong needs when it comes to facilities quality/energy efficiency.

PROPARCO is regularly studying projects in Morocco which could benefit from PEEB Cool technical expertise and financing solutions so to bring additional value to the existing projects.

2.7.2.4. Environmental public policies analysis

Environmental policies related to the building sector

The country is very proactive in deploying RE and strengthening EE. A 2011 law encourages the systematic integration of EE measures in all sectoral development programs.

The Moroccan Agency for Energy Efficiency (AMEE) was set up in 2010 to achieve the following objectives: +20% of EE compared to a baseline scenario in 2030, 42% of RE in 2020 and 52% in 2030 (hydro, solar, wind).

The National EE Strategy has identified 11 priority measures for the building sector, including the adoption of energy regulations and the implementation of a label for efficient buildings.

Law 47-09 (2011) introduces a framework for EE in buildings (studies, audits) and equipment (labeling). The Building energy code came into force in 2014. An "eco-Binayate" energy performance label was planned for the first quarter of 2020. A decree is currently being finalized for the labeling of equipment.

A framework for the production of renewable electricity was set up in 2010 and amended in 2015. It allows the sale of 20% of excess production to the national operator but only for installations connected to the national HV and EHV grid.

A Country Partnership Program was signed with UNIDO in 2019 with among its objectives the support of RE and EE projects (and circular economy). The MorSEFF fund finances corporate investments in EE and RE.

The air conditioning market represents between 130,000 and 240,000 units sold per year, 30% of which are inverter systems, with an average EER of 3.5.

A strategy for low carbon building materials has not been identified, but building industry players are interested in alternative materials.

Adaptation to climate change policies

The country is exposed to the following climate change risks: rising temperatures, decreasing precipitations, droughts, rising sea levels (60% of the population is located in coastal zones), erosion and flooding of the coastline (42% of the coastline is at high risk by 2030). An adaptation strategy has been developed in several environmental and climate change policies around 8 Strategic Sectoral Pillars for Adaptation (Water; Agriculture; Fishing; Forestry and fight against desertification; Biodiversity; Health; Tourism; Housing, town planning and territories). The country expects to dedicate 15% of its investment budgets between 2020 and 2030 to adaptation to climate change, mainly for the water, forestry and agriculture sectors.

In relation with water resources, below are some of the measures presented in the 3rd National Communication (2016):

- rainwater harvesting (ongoing pilot projects),
- efficiency of the distribution networks,
- water saving policies (demand side, including population information)

2.7.2.5. Summary of stakeholders consultation

Main public actors:

- Ministry of Finances
- Ministry of Habitat (MATNUHPV)
- Ministry of Energy, Mines, and Environment (MEME)
- Others Ministries
- Energy Efficiency Agency (AMEE)
- Public Super ESCO(SIE)
- Public entreprises

AFD Rabat discusses energy efficiency in buildings with all main public actor in particular with Ministry of Habitat and SIE which has been recently repositioned as a Super Esco.

The Ministry of Habitat confirmed the needs of technical assistance in the sector and is interested about a technical assistance for the segment "self-assisted construction for the Moroccan Modern House" which represents 40% of the demand of the new buildings.

SIE has conducted a study to estimate a first potential pipe of energy efficiency projects in existent public buildings. The estimated volume of investment of this pipe is 85 MEUR for only energy efficiency measures and 250 MEUR if is included installation of solar PV station on the roof for electricity production. SIE is interested to implement 10% of this potential for a first stage with public administrations or enterprises

AFD is also discussing directly with some public enterprises that could implement energy efficiency projects in their existent buildings.

2.7.3. Project description

2.7.3.1. Project's objectives and description

(1) Component 1: Investment Facility

Below are presented indicative projects that could be eligible to PEEB Cool.

Indicative project 1: National Plan for the Exemplarity of the Administration (PNEA) or public enterprises

Implementing energy efficiency measures and PV-roof installation in existent public buildings. The partners and buildings concerned are not yet fully determined, but a list of initial stakeholders that will be explored is included below. The impact is the reduction of electrical consummation that can reach 30% of the initial electrical consummation for a building.

Investment of the 1st phase : 25-30 MEUR

Subsidies : to be determined

Project organization (main beneficiary, involved stakeholders, roles & responsibilities): Al Omrane, Ministry of Habitat (MATNUHPV), Public Super ESCO(SIE), Public enterprises, municipalities, "syndics" (Common property management entities in residential buildings), local ESCOs.

Indicative project 2: Support to the PEEB cool and climate adaptation for the self-building

Strengthening of the institutional, regulatory and technical mechanism governing the production of self-constructed housing, in particular for Al Omrane's "Cities without Slums" operations, involving one or two local authorities. The objective is to construct several new Moroccan Modern House adapted to climate change (raising of temperature). This segment of Moroccan Modern House represent 40% of the demand of the new buildings.

Project organization (main beneficiary, involved stakeholders, roles & responsibilities): Al Omrane, Ministry of Habitat (MATNUHPV), Public Super ESCO(SIE), Public enterprises, municipalities, "syndics" (common property management entities in residential buildings), local ESCOs

The below tables outline the GHG baseline emissions and emissions reductions for a Morocco residential case followed by an education case. Full calculations can be found in Annex 22c.

Residential case:

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	1,423,934
Emissions - 20% reduction case	1,066,049
Emissions - 40% reduction case	977,457
GHG reductions - 20% reduction case	357,885
GHG reductions - 40% reduction case	446,476
GHG reductions - average of 20% and 40% reduction case	402,181

Emissions without EE measures (baseline):	Source of information	Unit	Value
Morocco			
Type of building			Residential
m2 impacted	A	m2	1,217,500
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	69
Natural gas	C1	kWh/m2/yr	60
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.551
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	38.0
Natural gas	G1 = C1 x E	kgCO2/m2	13.9
Building materials	H1	kgCO2/m2	391.8
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	46,253
Natural gas	J1 = G1 x A	tCO2/yr	16,875
Electricity	I1 = F1 x A x L	tCO2 over lifetime	693,792
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	253,118
Building materials	K1 = H1 x A	tCO2 over lifetime	477,024
Total		**tCO2 over lifetime**	**1,423,934**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	48
Natural gas	C2	kWh/m2/yr	50
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.551
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	26
Natural gas	G2 = C2 x E	kgCO2/m2	11.6
Building materials	H2	kgCO2/m2	305.9
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	32,176
Natural gas	J2 = G2 x A	tCO2/yr	14,062
Electricity	I2 = F2 x A x L	tCO2 over lifetime	482,638
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	210,932
Building materials	K2 = H2 x A	tCO2 over lifetime	372,479
Total		**tCO2 over lifetime**	**1,066,049**

40% reduction case			
Characteristics of building			
Energy consumption		kWh/m2/yr	
Electricity	B3	kWh/m2/yr	48
Natural gas	C3	kWh/m2/yr	29
GHG emissions factors			
Electricity	D	tCO2/MWh	0.551
Natural gas	E	tCO2/MWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kWh/m2/yr	26
Natural gas	G3 = C3 x E	kWh/m2/yr	6.7
Building materials	H3	kgCO2/m2 (lifetime)	305.9
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	32,176
Natural gas	J3 = G3 x A	tCO2/yr	8,156
Electricity	I3 = F3 x A x L	tCO2 over lifetime	482,638
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	122,340
Building materials	K3 = H3 x A	tCO2 over lifetime	372,479
Total		**tCO2 over lifetime**	**977,457**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	14,077
Natural gas	J1 - J2	tCO2/yr	2,812
Electricity	(I1 - I2) x L	tCO2 over lifetime	211,154
Natural gas	(J1 - J2) x L	tCO2 over lifetime	42,186
Building materials	K1 - K2	tCO2 over lifetime	104,545
Total	Sum of 20% case	**tCO2 over lifetime**	**357,885**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	14,077
Natural gas	J1 - J3	tCO2 over lifetime	8,719

Electricity	(I1 - I3) x L	tCO2 over lifetime	211,154
Natural gas	(J1 - J3) x L	tCO2 over lifetime	130,778
Building materials	K1 - K3	tCO2 over lifetime	104,545
Total	**Sum of 40% case**	**tCO2 over lifetime**	**446,476**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	14,077
Natural gas	Average 20% and 40% case	tCO2 over lifetime	5,765
Electricity	Average 20% and 40% case	tCO2 over lifetime	211,154
Natural gas	Average 20% and 40% case	tCO2 over lifetime	86,482
Building materials	Average 20% and 40% case	tCO2 over lifetime	104,545
Total	**Sum of above**	**tCO2 over lifetime**	**402,181**

Education case:

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	6,569
Emissions - 20% reduction case	5,633
Emissions - 40% reduction case	5,198
GHG reductions - 20% reduction case	936
GHG reductions - 40% reduction case	1,371
GHG reductions - average of 20% and 40% reduction case	1,153

Emissions without EE measures (baseline):	Source of information	Unit	Value
Morocco			
Type of building			Education
m2 impacted	A	m2	11,250
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	26
Natural gas	C1	kWh/m2/yr	9
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.551
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	14.3
Natural gas	G1 = C1 x E	kgCO2/m2	2.1
Building materials	H1	kgCO2/m2	338.0
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	161

Natural gas	J1 = G1 x A	tCO2/yr	23
Electricity	I1 = F1 x A x L	tCO2 over lifetime	2,416
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	351
Building materials	K1 = H1 x A	tCO2 over lifetime	3,802
Total		**tCO2 over lifetime**	**6,569**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	17
Natural gas	C2	kWh/m2/yr	10
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.551
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	9
Natural gas	G2 = C2 x E	kgCO2/m2	2.3
Building materials	H2	kgCO2/m2	325.6
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	105
Natural gas	J2 = G2 x A	tCO2/yr	26
Electricity	I2 = F2 x A x L	tCO2 over lifetime	1,579
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	390
Building materials	K2 = H2 x A	tCO2 over lifetime	3,663
Total		**tCO2 over lifetime**	**5,633**

40% reduction case			
Characteristics of building			
Energy consumption		kWh/m2/yr	
Electricity	B3	kWh/m2/yr	14
Natural gas	C3	kWh/m2/yr	6
GHG emissions factors			
Electricity	D	tCO2/MWh	0.551
Natural gas	E	tCO2/MWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kWh/m2/yr	8
Natural gas	G3 = C3 x E	kWh/m2/yr	1.4
Building materials	H3	kgCO2/m2 (lifetime)	325.6
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	87
Natural gas	J3 = G3 x A	tCO2/yr	16
Electricity	I3 = F3 x A x L	tCO2 over lifetime	1,301
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	234
Building materials	K3 = H3 x A	tCO2 over lifetime	3,663

Total		tCO2 over lifetime	5,198

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	56
Natural gas	J1 - J2	tCO2/yr	- 3
Electricity	(I1 - I2) x L	tCO2 over lifetime	836
Natural gas	(J1 - J2) x L	tCO2 over lifetime	- 39
Building materials	K1 - K2	tCO2 over lifetime	139
Total	Sum of 20% case	tCO2 over lifetime	936

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	74
Natural gas	J1 - J3	tCO2 over lifetime	8
Electricity	(I1 - I3) x L	tCO2 over lifetime	1,115
Natural gas	(J1 - J3) x L	tCO2 over lifetime	117
Building materials	K1 - K3	tCO2 over lifetime	139
Total	Sum of 40% case	tCO2 over lifetime	1,371

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	65
Natural gas	Average 20% and 40% case	tCO2 over lifetime	3
Electricity	Average 20% and 40% case	tCO2 over lifetime	976
Natural gas	Average 20% and 40% case	tCO2 over lifetime	39
Building materials	Average 20% and 40% case	tCO2 over lifetime	139
Total	Sum of above	tCO2 over lifetime	1,153

(2) Component 2: Enabling Facility

The enabling facility is directly linked to the sectors of intervention of the investment facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration.

In Morocco, the enabling Facility will build on the current PEEB and other cooperation projects with the Moroccan Ministry of National Territory Planning, Urban Planning, Housing and City Policy (MATNUHPV) and the Ministry of Energy, Mines and Environment (MEME). The national context urges to pursue efforts for effective enforcement of energy efficiency regulations in buildings, for a better engagement of the private sector in the climate action, and for enhanced framework conditions for the implementation of NDC actions in the building sector. The advisory support provided by the enabling Facility in Morocco may focus on those areas, while taking into consideration activities of other energy efficiency cooperation projects currently in the pipelines of AFD and GIZ in Morocco (described earlier in section A.2.i)

The support of the enabling Facility within the framework of PEEB Cool in Morocco could therefore tackle the following areas:

2.1. Sectoral investment frameworks

In this support area, the enabling Facility could support sectoral stakeholders in developing national investment frameworks and/or industry engagements that favor the decarbonization of the sector, and de-risk national investment into energy efficiency in buildings. This could for example entail strengthening existing industry labels. Activities in this support area may be conducted within the framework of the *Moroccan Alliance of Buildings for the Climate* (AMBC). Initiated by the Ministry of Housing in line with the recommendations of the *Global Alliance for Buildings and Construction* (GlobalABC), this national alliance acts as a platform to promote the public-private cooperation for climate action in the buildings and construction sector and catalyze exchange between stakeholders on a national level to disseminate instruments, best practices and/or experiences. The enabling Facility could build on the current capacity building technical support provided by PEEB to the Alliance, as well as on the numerous capacity development measures and instruments developed by GIZ and AFD projects to disseminate knowledge through the Alliance.

Project organization (main beneficiary, involved stakeholders, roles & responsibilities): GoM, AMBC members (federations and companies).

2.2. Support for public policies

Morocco has developed a regulatory framework to promote energy efficiency in buildings mainly through the adoption of a mandatory building energy efficiency code (known as RTCM in Morocco) as described in section A.2.i above, in addition to ongoing development of Minimum Energy Performance Standards (MEPS) and labelling of household appliances. Many barriers are however still impeding an effective application of these regulations: financial barriers due to the extra costs of including energy-efficiency measures in buildings envelopes or for acquiring energy-performant appliances, absence of RTCM conformity checks prior, during, and after the construction phase of buildings, in addition to a need for extensive capacity building amongst the building and construction professionals and for consumer awareness raising. While the NAMA Facility's Support Project (NSP) "Promoting Energy Efficiency of Moroccan Households'" is expected to provide financial and technical support to trigger an incentive-based policy for large-scale deployment of energy efficiency in residential buildings, and the BMZ project is expected to provide support for further development of the regulatory and normative energy efficiency framework, the offered support by the enabling Facility in this area could help developing necessary requirements for efficient and effective building energy-performance conformity control, especially in the self-assisted construction sector that holds the largest share of new constructions in the residential sector. Moreover, the PEEB policy component could further complement and complete the support areas covered by the above mentioned AFD and GIZ-implemented cooperation projects, by supporting the development of MEPS and energy efficiency labels for appliances other than the ones covered by the NSP, for instance.

Project organization (main beneficiary, involved stakeholders, roles & responsibilities): MATNUHPV (RTCM enforcement); MEMDE/AMEE (MEPS and labels), Al Omrane, and public super ESCO(SIE).

2.3. Capacity building for building sector actors

For public buildings, the enabling Facility could provide trainings to staff responsible for overseeing construction projects, using specific training modules developed by GIZ in Morocco for managing energy efficiency construction projects. For “self-assisted” constructions, the enabling Facility could also build on training modules to be developed by AFD within the NSP to build the capacities of traditional small construction companies to implement energy efficiency in residential buildings. For capacity building to public and private sector professionals, this could be done within the framework of the *Moroccan Alliance of Buildings for the Climate* (AMBC).

Project organization (main beneficiary, involved stakeholders, roles & responsibilities): the main beneficiaries of capacity building activities would be the sector professionals such real-estate developers, architects, and construction workers in small to medium construction companies. The AMBC provides a good platform to mobilize such stakeholders. For public buildings, the main beneficiaries would be public entities staff responsible for managing public building construction projects.

2.7.3.2. Paradigm shift potential

These projects proposed are innovative and concentrated on only a small part of the potential market. These projects, if well executed, could become a reference to conduct others similar project.

For the National Plan for the Exemplarity of the Administration, only a pipe of 10% of the identified projects by SIE is targeted to show the possibility to conduct this type of projects and to remove the obstacles to this type of project. The real potential of public buildings is more than 250 MEUR investments and a huge potential for existing buildings in the tertiary sector.

For the project “climate adaptation for the self-building”, it target one or two local authorities to determine, among 1503 local authorities in Morocco.

The other support on PEEB cool will also contribute to enhance the regulatory framework and the well application of policies by the stake holders

2.7.3.3. Sustainable development potential

Indicative sustainable development potential are as follows and will be defined at appraisal stage of the project.

- Environment: avoided GHG to be assessed.
- Social: increased thermal comfort in buildings will allow final beneficiaries to work under improved condition .
- Economical: lowering the pressure on electrical network, energy demand management to prevent the boom in energy demand due to cooling needs.

2.7.3.4. Project indicative financing

	Total Amount (a+b)	Currency	GCF amount (a)	AFD amount (b)
7. Senior loan*	30	Million EUR	5	25
8. Grant (technical support)	1.5	Million EUR	1.5	
Total project financing (1+2)	31.5	Million EUR	6.5	25

This amounts are provisional at this stage and are still to be discussed

2.8. Nigeria

National Designed Authority	**Federal Ministry of Environment (Dr. Yerima Tarfa)**
Project title	PEEB Cool Nigeria
Name and typology (public/private) of the institutions	Family Homes Fund (FHF)
End beneficiaries (households, students…)	Students, general population
Mitigation/adaptation focus	Adaptation

2.8.1. Climate profile

2.8.1.1. Historic climate data

Nigeria has a largely tropical climate with drier, arid regions in the far north. The annual mean temperature is around 27°C. However, recently, Nigeria has seen a greater 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.[52] 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.

Dry spells and hot periods are significant, with a 17-day average duration of dry spells and 7-day average duration of heat waves.[53] Yet, there is significant variability throughout the country. Some studies found a maximum heat wave frequency of twice a year for a duration of nine days in the north between 1986-2015 (Adefisan, 2018). Moreover, the research observed an increasing trend in the most recent decade as the three years with the highest heat wave intensity and number of days all occurred during this period (Adefisan, 2018). As climate change worsens and temperature rises, such weather events are expected to become more challenging.

2.8.1.2. Future climate projections

The warming trend seen in recent years is expected to continue at a faster rate. The whole country will likely see significant warming, under a business-as-usual scenario, with those in rapidly growing urban populations at risk. Table 15 shows future climate indicators under varying emission scenarios in Lagos, where more than 14 million people live.

Table 15 Future temperature projections under different emission scenarios in Lagos, Nigeria

[52] Climate Service Center Germany. 2016. Climate fact sheet Nigeria.

[53] Climate Service Center Germany. 2016. Climate fact sheet Nigeria

Time Period and Emission Scenario	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)
2011-2040 (RCP 4.5)	0.95	0.68	0.73
2041 – 2070 (RCP 4.5)	1.60	1.40	1.30
2071-2100 (RCP 4.5)	2.00	1.70	1.70
2011 – 2040 (RCP 8.5)	1.00	0.77	0.78
2041 – 2070 (RCP 8.5)	2.30	2.00	1.80
2071 – 2100 (RCP 8.5)	4.10	3.20	3.30

The data shows a clear warming trend throughout the century for both emission scenarios with an especially significant increase towards 2100. The potential for an increase of over 4 degrees Celsius in a densely populated city is likely to create risks to health and the economy.

Data at the national level shows even more significant changes, as arid northern regions may exceed 5°C of warming. Table 16 shows a variety of climate indicators at the national level.[54]

Table 16 Climate indicators under future emission scenarios at national level (World Bank data)

Time Period and Emission Scenario	Hot Days	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	24.44	11.00	0.05	563.87
2040-2059 (RCP 2.6)	34.13	17.13	0.06	739.75
2060-2079	35.48	19.05	0.06	744.81

[54] World Bank. 2019. Climate Change Knowledge Portal. Nigeria.

(RCP 2.6)				
2080-2099 (RCP 2.6)	34.23	18.86	0.06	722.24
2020-2039 (RCP 4.5)	31.25	12.66	0.05	605.42
2040-2059 (RCP 4.5)	45.81	26.28	0.09	917.52
2060-2079 (RCP 4.5)	60.52	43.85	0.13	1172.55
2080-2099 (RCP 4.5)	67.10	53.02	0.16	1314.54
2020-2039 (RCP 8.5)	34.43	15.00	0.06	686.46
2040-2059 (RCP 8.5)	63.72	46.58	0.14	1289.42
2060-2079 (RCP 8.5)	99.68	102.72	0.28	2002.86
2080-2099 (RCP 8.5)	139.05	186.55	0.46	2708.51

These projections illustrate a clear rise in the number of hot days and the heat index under all emission pathways, but especially prominent under the medium and high emission scenarios. Moreover, energy usage estimates show enormous cooling degree day figures, suggesting a large increase in the need for cooling which will place greater burden on the grid. Lastly, the probability of a heat wave will rise by more than eight times, from around 5-6% currently to 46% in the high emission scenario. Regular exposure to heat like this without sufficient adaptation and cooling capacity will create detrimental impacts to the population.

The GDFRR shows the hazard risk of extreme heat to be high in Nigeria throughout the country, with only a handful of coastal states being slightly less vulnerable (see Figure 14 for map).

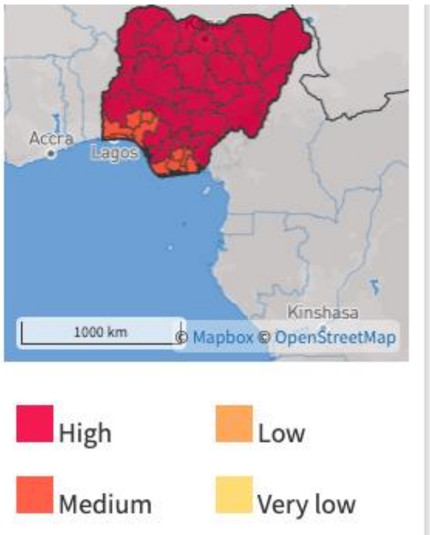

Figure 13 Extreme heat risk in Nigeria (GFDRR data)

Future heat wave projections match historic data by distribution. For example, regions in the north are expected to see more frequent, intense and longer lasting periods of extreme heat. The World Health Organization predicted, under a high emission scenario, the number of warm spell days to increase from about 10 in 1990 to 260 by 2100 (WHO, 2015).

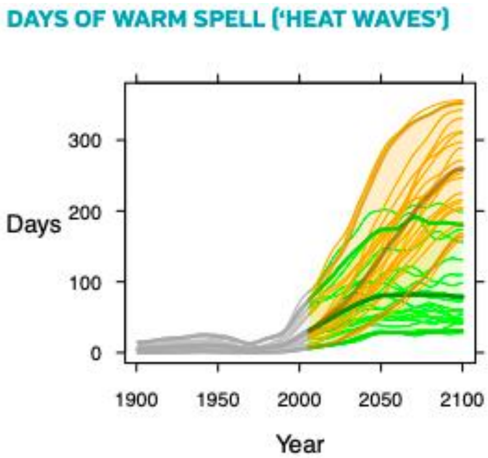

Figure 14 Days of warm spell under different emission scenarios (WHO data)

2.8.1.3. The impact of high temperature on health

Heat-related deaths in the elderly generation will rise dramatically from climate change unless adaptation measures are in place. WHO estimates, as shown in Figure 16, 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 (WHO, 2015). Given that the elderly spend the vast majority of their time indoors, it is likely that a significant portion of heat-related mortality will come from those living in inadequate buildings or low-income settlements.

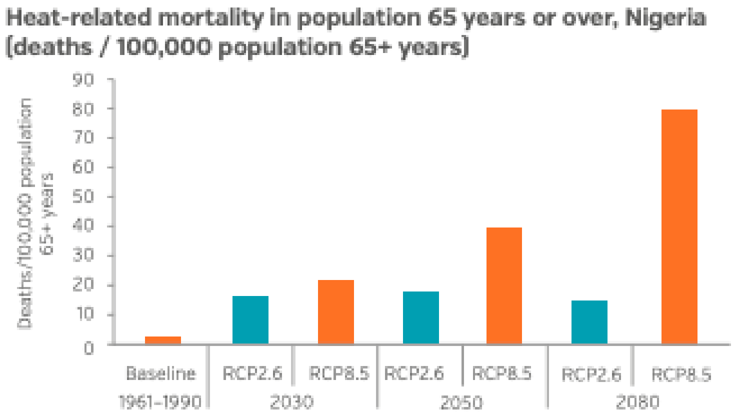

Figure 15 Future heat-related mortality in Nigeria (WHO data)

Indoor temperatures in Nigeria are especially important considering the country faces an enormous threat from indoor air pollution too. According to WHO data, around 50% of total deaths are attributable to household air pollution from the use of solid fuels indoors (WHO, 2015). Where temperatures are also extremely high, the chance of respiratory illnesses, strokes, heart diseases and other underlying ailments rises dramatically. Studies in Nigeria have shown that poor household ventilation influences both temperature and indoor air quality (Okafor, 2008).

Research from Ghana, which has a climate similar to that of the tropical part of Nigeria, focused on the link between pregnancy and temperature. Researchers found an increase in adverse outcomes, such as miscarriages, with every additional degree Celsius (Asamoah B, 2018.)

2.8.1.4. Economic vulnerability

Heat stress is expected to damage Nigeria's economy throughout the century. A study of working hours lost showed a 2.27% loss in industry, 5.40% loss in construction and 0.33% loss in services in 1995. Under an ambitious low emission scenario, these figures rise to 4.84%, 9.79% and 0.96% respectively by 2030 (ILO, 2019). It is worth noting that the largest increase, by proportion, is in the services sector, which nearly triples. If emissions continue to rise in line with higher scenarios, these figures will rise even more dramatically throughout the century. Those working in offices or other buildings where ventilation is lacking will lose valuable working hours due to heat stress.

Moreover, there are associations with high outdoor temperatures (especially in the summer months) and high indoor temperatures in buildings without sufficient cooling. A study of building characteristics in Yenagoa, Nigeria found a strong correlation between the two during the hot season. The researchers concluded by recommending the need to design buildings based on specific climate needs, such as more windows to enhance ventilation and improve physiological comfort (Wodu, 2020).

Equally, the benefits of ventilation have also been explored. A 2020 study on thermal environments in schools in a warm and humid region of Nigeria found that natural ventilation in either open-space or enclosed-plan led to a temperature range where students felt comfortable. The researchers note that where natural ventilation keeps temperatures at a comfortable level and within acceptable thermal rules, there is no need for high energy usage in air conditioning (Munonye, 2020). Therefore, upscaling the PEEB cooling programme to enhance adaptation and build cooling capacity will regulate temperature effectively while avoiding unnecessary emissions and energy usage.

2.8.2. Market context and barriers

2.8.2.1. Strategic context and market potential

Nigeria is the sub-Saharan African country with the second highest greenhouse gas (GHG) emissions after South Africa, mainly because of gas flaring and deforestation. GHG emissions are growing at a stable rate since 1990 and are now exceeding 2tCO2eq per inhabitant, slightly beyond the emissions per capita that would meet the Paris Agreement's average need (2 tCO2/inh/yr). The rise in CO2 emissions from fuel combustion is mostly due to the economic and demographic growth; the improvements in energy efficiency, which used to compensate this surge, have now slowed down[55]

In terms of resilience to climate change, the country is facing many climate related risks, most of them affecting the entire country, urban and rural zones. Temperature is expected to increase significantly, which will challenge many economic and biologic activities. Annual mean temperature is 27°C. Over the last 30 years, average increase is of + 0.19 °C per decade. Future mean temperature are expected to reach + 1.5 °C by 2030 and + 2.4 °C by 2050, temperature increase will be stronger in the North. In addition, longer heatwaves are expected (+ 13 days by 2030 and + 23 days by 2050)[56]. Nigeria is among the 25% more climate vulnerable countries in the world[57] and the trend is worsening.

The national determined contribution of Nigeria aims at 45% reduction of GHG emissions compared to baseline scenario (conditional), 2% of annual improvement of energy efficiency (30% in 2030) and 13 GW of off-grid solar plant.

The strategy of SE4ALL aims at the replacement of 80% of traditional cooking stove by efficient cooking equipment, efficient lighting for 100% of the households, 4% of nuclear energy, 30% of renewable energy and 19% of solar energy by 2030.

According to the National Energy Efficiency Action Plan, adopted in 2016, Nigeria targets a 100% use of efficient lighting by households by 2030, a 50% increase in energy efficiency in energy-intensive sectors (transport, power and industry) compared to baseline, the curbing of firewood demand below supply capacity, and a reduction in transport & distribution losses to less than 10%.

An energy efficiency building code was launched in 2017 and concerns tertiary and residential buildings. It aims at reducing energy consumption (excl. specific uses) by 40% compared to baseline scenario. This is to be reached through a prescriptive method (requirement for means, including air conditioning with energy

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[55] AFD internal analysis

[56] GERICS, 2015

[57] ND-Gain

efficiency ratio > 2.8 and inverter system) or a performance method (requirement for results). After having been piloted at federal level, state adoption is ongoing as construction legislation is the responsibility of the states. After two years of implementation on a voluntary basis (label), the Code is expected to become mandatory.

Nigeria is committed to the Kigali program related to energy efficiency of air conditioners, which includes capacity reinforcement of local actors, promotion of efficient appliances on local market and integration of Ozone and GHG strategies. The air conditioning market represented between 500 000 and 600 000 units per year in 2016 (biggest AC market in Africa), 3% of which are inverter systems. An energy-labelling program for equipment was introduced in 2017 (effective in 2019) with a ban on energy efficiency ratio < 2.8.

The government aims at reaching access to electricity for 90% of the population by 2030 and installation of 2 GW of renewable energy by 2020. No strategy for low-carbon construction materials has been identified.

Nigerian population accounts for 195.9 million people, 50% of which live in urban areas.

The mean size of households is 4.9 people. Due to urbanization, housing market growth is expected to rise by 3.8% per year until 2050. [58]

According to the World Bank, 700 000 housing units are needed each year while the formal sector can only provide between 100 000 and 200 000 of them. In 2017-2018, the government set up the Family Homes Fund that aims at providing 500 000 housing units in 4 years. To date, only 5 000 units have been provided. Increasing temperature will decrease comfort performance of building and call for efficient heat management in urban areas and buildings to limit energy consumption during hot periods.

The residential-tertiary sector is the main final energy consumer, accounting for 78% of consumption. Transport and industry absorb 15% and 6% respectively, of final consumption.[59]

According to IFC[60], lack of adoption of green building practices is explained by the perception of green buildings as expensive.

2.8.2.2. Analysis of relevance of barriers

Barriers type	Country specific relevance
Technical barriers	
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	Applied knowledge of energy efficient and resilient buildings based on bioclimatic principles is missing. Though a new topic, there is growing awareness and capacity building on EE in building topics for building professionals (architects, engineers, builders) but no university/vocational trainings yet though conceptualising trainings for universities.

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[58] IFC, Green buildings market intelligence, Nigeria country profile

[59] Enerdata, Country energy report, Nigeria, September 2019

[60] Green buildings market intelligence, Nigeria country profile

Financial barriers	
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	The high cost of, and limited access to, capital hinders construction of energy efficiency, low carbon and resilient buildings. Additionally, high exchange rates and import duties make importing of innovative materials and products expensive. Overall, transaction costs are very high, making such investments unattractive. Regulatory distortion for building owners exist in terms of inadequate government regulations, policies, intervention, implementation in place for RE and EE financing.
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	Financial institutions have limited awareness and experiences, skills, and knowledge of energy efficiency and resilience in buildings. They in particular lack trust in unfamiliar technologies and systems and perceive them as high risk, complicating access to finance for project owners.
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	Industry actors lack manufacturing capabilities and efficient processes for importing and locally manufacturing the required goods/inputs. They are also concerned by weak supply chain relationships and confidence, as well as the perceived low trust in ability to enforce contracts.
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	The pace of decarbonization strategies and policy development as well as for implementation is slow. Dedicated government support is inadequate. Inefficient implementation of the national trade policy erodes confidence and long-term thinking, necessary for decarbonization of the sector.
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	A Building Energy Efficiency Code (BEEC) covers new construction as well as retrofits and is in place; however, there is low level awareness leading to lack of implementation, compliance and enforcement.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	There is inadequate awareness and information regarding energy efficient and resilient buildings, on the side of consumers, entrepreneurs as well as financial sector institutions.

2.8.2.3. AFD experience in financing buildings construction of refurbishment projects

AFD operates in the energy, transport, drinking water and rural development sectors in Nigeria, alongside the European Union and World Bank, for example. AFD has been a partner of the country since 2008 and has committed over EUR 2bn in over 30 development projects.

In Nigeria, AFD has not developed a specific experience in financing building construction or refurbishment projects (hospitals, schools, housing). However, one of the main AFD's objectives in Nigeria is to promote a harmonious development of cities and territories. To this end, AFD is financing projects in several sectors, while assisting Nigeria with the achievement of its climate commitments:

- Water: AFD is supporting projects in the capitals of seven states, from Lagos to Kano, to improve access to services, empower water authorities and improve governance.
- Urban mobility: in Lagos, AFD is supporting the renovation of roads to improve the quality of bus services and the construction of two multimodal transit hubs. In Kaduna, AFD is preparing its first urban transport project.
- Energy: AFD supports the ongoing sectoral reform. It is targeting the efficiency of the power system, improving the energy mix and developing renewable resources. For example, AFD has contributed to upgrading power transmission infrastructure in the federal capital of Abuja and to reinforcing the grid to increase the power transmission capacity for hydro and photovoltaic energy in the Northwest.
- Waste collection and treatment: AFD is financing technical assistance at the federal level to produce a solid waste management master plan.
- Digital technologies: Lagos has been selected for the African Smart Towns Network (ASToN) to rethink urban mobility using digital technologies.

2.8.2.4. Environmental public policies analysis

Environmental policies related to the building sector

The national contribution to climate action targets: -45% GHG emissions compared to a reference scenario (conditional), 2% annual improvement of EE (30% in 2030), 13 GW of PV off-grid.

The SE4ALL strategy aims for 2030: the replacement of 80% of traditional households by efficient cooking equipment, efficient lighting for 100% of households, 4% nuclear electricity, 30% renewable electricity, 19% solar energy (PV and thermal).

An EE Building Code was launched in 2017 (service + residential) with a target of -40% of consumption (excluding DHW and specific uses) compared to a reference building to be achieved by a prescriptive method (requirement of means, including air conditioning with EER>2.8 and an inverter system) or a performance method (requirement of results). After 2 years of voluntary implementation (label), it became mandatory.

Nigeria is involved in the KIGALI program on EE in air conditioning with actions to train local industry players in EE, promote high-performance equipment on the local market and integrate the Ozone and GHG strategies. The air conditioning market represents between 500 and 600,000 units per year in 2016 (1st market in Africa), inverter systems represent only 3% of the market. An energy labeling program for equipment has been implemented in 2017 (effective in 2019) with the banning of air conditioners with EER<2.8.

The government aims to provide access to electricity for 90% of the population in 2030 and the installation of 2GW of renewable electricity in 2020. The valorization of PV production is possible by net-metering (less than

1MW), feed-in tariff (less than 5MW PV, 10MW wind or biomass, 30MW small hydro), or by tender for higher power.

A strategy for low carbon building materials has not been identified.

Adaptation to climate change policies

The main climate change risks faced by the country are floods, droughts and heat waves. An exhaustive National Adaptation Plan has not yet been finalized (a National Adaptation Plan Framework was set in 2020), but the 2020 3rd national communication provides some adaptation policies and strategies in vulnerable sectors:

- Water resources: solar power systems to support water supply and irrigation facilities, water efficient systems, population information and community advocacy, water harvesting
- Infrastructures and buildings: construction of climate resilient buildings, on-site renewable energy development

2.8.2.5. Summary of stakeholders consultation

The Ministry of Works and Housing (Housing sector) is responsible for polices and regulations in the housing sector (including energy efficiency) though the Ministry of Power is responsible for driving polices on Renewable energy and energy efficiency in Nigeria. The Ministry of Power is therefore informed on all programmes been implemented by the Ministry of Works and housing on energy efficiency.

As GIZ Nigerian energy support programme (NESP) is supporting energy efficiency in buildings since 2013, the stakeholder consultation has been coordinated by NESP to get the buy-in and approval of both key ministries. Furthermore, the Ministry of Environment as the designated agency for GCF has been informed by both the Ministry of Housing and the Ministry of Power of their approval of the PEEB Cool. The Ministry of Housing is very eager to implement PEEB Cool together with relevant stakeholders.

2.8.3. Project description

2.8.3.1. Project's objectives and description

Component 1: Investment Facility

Against the backdrop of an explosion of student numbers in Nigeria, where projections identify average growth rates close to 12% per annum, affordable student housing capacity falls far short of needs. 1.3 million students do not have access to quality housing on university campuses. Dedicated public funding however, falls far short of the investment needed to significantly reduce this gap, which has many social and educational consequences.

AFD is already working on the development of sustainable student housing with FHF. The present project (phase 2) aims at working further on the provision of sustainable student housing. The objective of phase 2 will be to leverage the results of phase 1 in terms of energy efficiency performance of the buildings and to further promote sustainable design and construction modes, including through the use of local, bio-sourced, materials in order to decrease the carbon footprint of construction.

Indeed, Nigeria benefits from major building materials available locally: adobe, bamboo, thatch, stones, timber, coconut tree and grasses. Traditional African building materials are available locally, affordable, energy efficient, low-carbon, reusable and biodegradable[61]. The project aims at lowering one of the main barriers of adoption local construction materials, which is acceptability as buildings made out of traditional materials are still perceived at substandard.

The project will foster the re-engineering of traditional building materials to suit present needs and increase their acceptability by the local population. Indeed, compressed earth block (CEB), is an alternative to adobe blocks and wattle and daub constructions and can be used for three floors constructions up to five floors constructions. CEB construction is more durable than wattle and daub and more accepted[62]. To further reduce the acceptability obstacle, student-housing construction will combine re-engineered traditional building materials with modern building materials to further increase the strength of building and suit to the needs of households.

The project will promote as much as possible local housing design, seeking to combine modern and traditional building techniques, allowing for a better thermal comfort and energy efficiency through passive systems for cooling, heating and lighting. The project will look into the feasibility of passive solar energy use (i.e. solar water heating).

The project owner in this project will be Family Homes Fund.

- AFD loan will allow FHF to refinance student-housing projects led by private companies that will meet bioclimatic criteria to be defined and in line with the Nigerian building energy efficiency code and which would include the utilization of traditional building materials, potentially at a pilot project. The pilot project would ensure that the building complies with structural safety standards and fire protection standards. The loan from FHF could target Niches of RE and EE technologies on housing which is currently been developed by GIZ NESP for the FHF within the context of a pilot financing scheme on energy efficiency in buildings.
- The project will also perform awareness raising activities to developers towards local materials as well as developing a national network of local actors in traditional construction materials.

The below tables outline the GHG baseline emissions and emissions reductions for a Nigeria residential case. Full calculations can be found in Annex 22c.

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	72,650
Emissions - 20% reduction case	54,021
Emissions - 40% reduction case	22,804

[61] Ikechukwu Onyegiri and Iwuagwu Ben Ugochukwu, Traditional buildings materials as a sustainable resource and materials for low cost housing in Nigeria : advantages, challenges and the way forward, 2016

[62] Ikechukwu Onyegiri and Iwuagwu Ben Ugochukwu, Traditional buildings materials as a sustainable resource and materials for low cost housing in Nigeria : advantages, challenges and the way forward, 2016

GHG reductions - 20% reduction case	18,629
GHG reductions - 40% reduction case	22,007
GHG reductions - average of 20% and 40% reduction case	20,318

Emissions without EE measures (baseline):	Source of information	Unit	Value
Nigeria			
Type of building			Residential
m2 impacted	A	m2	75,000
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	78
Natural gas	C1	kWh/m2/yr	33
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.395
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	30.8
Natural gas	G1 = C1 x E	kgCO2/m2	7.6
Building materials	H1	kgCO2/m2	391.8
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	2,313
Natural gas	J1 = G1 x A	tCO2/yr	572
Electricity	I1 = F1 x A x L	tCO2 over lifetime	34,689
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	8,576
Building materials	K1 = H1 x A	tCO2 over lifetime	29,385
Total		**tCO2 over lifetime**	**72,650**

Emissions - 20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	55
Natural gas	C2	kWh/m2/yr	26
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.395
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	22
Natural gas	G2 = C2 x E	kgCO2/m2	6.0
Building materials	H2	kgCO2/m2	304.1
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	1,631
Natural gas	J2 = G2 x A	tCO2/yr	450
Electricity	I2 = F2 x A x L	tCO2 over lifetime	24,460
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	6,757
Building materials	K2 = H2 x A	tCO2 over lifetime	22,804

Total		**tCO2 over lifetime**	**54,021**

Emissions - 40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	55
Natural gas	C3	kWh/m2/yr	13
GHG emissions factors			
Electricity	D	tCO2/MWh	0.395
Natural gas	E	tCO2/MWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kWh/m2/yr	22
Natural gas	G3 = C3 x E	kWh/m2/yr	3.0
Building materials	H3	kgCO2/m2 (lifetime)	304.1
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	1,631
Natural gas	J3 = G3 x A	tCO2/yr	225
Electricity	I3 = F3 x A x L	tCO2 over lifetime	24,460
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	3,378
Building materials	K3 = H3 x A	tCO2 over lifetime	22,804
Total		**tCO2 over lifetime**	**50,643**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	682
Natural gas	J1 - J2	tCO2/yr	121
Electricity	(I1 - I2) x L	tCO2 over lifetime	10,229
Natural gas	(J1 - J2) x L	tCO2 over lifetime	1,819
Building materials	K1 - K2	tCO2 over lifetime	6,581
Total	**Sum of 20% case**	**tCO2 over lifetime**	**18,629**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	682
Natural gas	J1 - J3	tCO2 over lifetime	347
Electricity	(I1 - I3) x L	tCO2 over lifetime	10,229
Natural gas	(J1 - J3) x L	tCO2 over lifetime	5,198
Building materials	K1 - K3	tCO2 over lifetime	6,581
Total	**Sum of 40% case**	**tCO2 over lifetime**	**22,007**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	682
Natural gas	Average 20% and 40% case	tCO2 over lifetime	234
Electricity	Average 20% and 40% case	tCO2 over lifetime	10,229
Natural gas	Average 20% and 40% case	tCO2 over lifetime	3,508
Building materials	Average 20% and 40% case	tCO2 over lifetime	6,581
Total	**Sum of above**	**tCO2 over lifetime**	**20,318**

Component 2: Enabling Facility

Three areas of work may potentially be supported through the PEEB Cool Enabling Facility, with actions being defined at program start together with national partner authorities. The enabling facility is directly linked to the sectors of intervention of the investment facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration.

Output 2.1: Sectoral investment frameworks demonstrate investment potential for green recovery

Within this output area, public and private investment towards energy efficiency and resilience in buildings is strengthened through support in the development of key sectoral and private sector led roadmap and/or initiatives in sectors targeted by their investment facility's activities The national energy efficiency action plan as well as the recently conducted sectoral energy efficiency studies, among others for parts of the construction industry (i.e. with Dangote cement), may provide an entry point for such a sectoral investment roadmap for the construction industry. An investment plan could also be supported for student housing projects, together with FHF.

Output 2.2: Policy proposals prepare the ground for buildings sector transformation

Depending on the priorities of the national governments and the relevance of the suggested areas for decarbonizing the buildings and construction sector, national and international expertise may be mobilized to advice on public policies in areas such as COVID recovery policies in the building sector, building codes adoption and revisions, sector-specific energy efficiency guidelines, fiscal policies encouraging investments in energy efficiency, building performance labels, etc. A priority shall be given to policies supporting the implementation and generalization of experiences with the student housing financing project. In Nigeria, PEEB Cool could build on the ongoing EU and BMZ (German Federal Ministry for Economic Cooperation and Development) funded Nigerian energy support programme promoting energy efficiency. This project will build on what has been done by NESP which includes activities on building energy codes, capacity building on energy efficient building design and energy audits, energy certification of residential and commercial buildings as well as product development of local building materials.

Output 2.3 Private and public sector actors are enabled to work towards buildings sector transformation

Training and awareness raising modules linked to existing or future financing projects within the investment facility, on topics ranging from urban zoning and master plan development, bioclimatic building design to policy options and financing for energy efficiency in buildings could be offered within this work area. For example, the ongoing EU-BMZ funded "Nigeria energy support Programme" supported trainings for energy efficiency building design, building energy code compliance, energy audits and building energy simulations which could be further used and extended for the specific case of student housing, but also in a larger contexts.

2.8.3.2. Paradigm shift potential

The project will review FHF's standard student-housing plans. This will affect not only the buildings that will be financed under the project but also the future student-housing units that will be financed by FHF.

In addition, the project will support local construction material value chain at both offer side (support to local actors) and demand side (awareness raising activities to developer). This will foster the development of a local market for low-carbon materials. The constructions to be built under the project will further contribute to address the acceptability barrier of local materials.

2.8.3.3. Sustainable development potential

- Economic: the development housing capacities of universities will contribute to a sustainable economic growth of universities in a context of high demographic growth.
- Social: the project contributes to the SDG 4 that promotes access to education at affordable cost. By targeting access to housing and improving the learning environment, the project will increase students' wellness.
- Gender: a gender mainstreaming approach will be foreseen in access to housing as well as at conception phase.
- Mitigation: the project will include bioclimatic design, which will induce a lower energy consumption compared to baseline. In addition, studies[63] show that a typical traditional building of earth emits fewer GHG, consumes less energy and maintains a high level of thermal comfort. The proximity of materials also saves cost and reduce pollution linked to transportation[64].
- Adaptation: bioclimatic design will improve indoor temperature of the buildings. At concept stage, dynamic thermal simulations will take into account projected temperature (IPCC scenario) so that vulnerable population (students) can leave in better conditions. Moreover, a correlation has been fund[65] between heat exposure and educational performance. By ensuring better living conditions, the project will also affect the students' performance in both the short and the long run.

2.9. North Macedonia

This Country Form and the information contained herein is initial expression of interest and needs and it is subject of further development and changes. Therefore, it does not commit the Government of North Macedonia and the NDA/ FP to any further financial arraignments with the AFD Group, GIZ, or GCF.

National Designed Authority	**Cabinet of Deputy President of the Government in charge of Economic Affairs**
Project title	PEEB Cool North Macedonia
Name and typology (public/private) of the institutions	Ministry of Economy Ministry of Environment and Physical Planning
End beneficiaries (households, students…)	Central level governmental institutions, local self-governments, private sector (companies), citizens.
Mitigation/adaptation focus	Mitigation

63 Iwuagwu and Azubuine, 2015

64 Ikechukwu Onyegiri and Iwuagwu Ben Ugochukwu, Traditional buildings materials as a sustainable resource and materials for low cost housing in Nigeria : advantages, challenges and the way forward, 2016

65 Jisung Park, Temperature, Test Scores and Human Capital Production, Harvard University, 2017

2.9.1.Climate profile

2.9.1.1. Historic climate data

North Macedonia has a variable climate, including Mediterranean, mountainous and humid subtropical zones. Average annual temperature is typically around 10°C, doubling in the warmer months (USAID, 2019). Average temperatures have been increasing in recent decades as estimates show up to 0.5°C of warming between 1981 and 2010.

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 were recorded between 1961-2012, including 25 in Skopje and 38 in Demir Kapija (USAID, 2019). Moreover, the number has been rising in recent periods with 8 heat wave events observed in Skopje in 2012 alone.

2.9.1.2. Future climate projections

Compared to the baseline period 1960-1990, models of future temperature expect an increase in annual temperature. The World Bank predicts a rise of 1°C by 2025, 1.9°C by 2050, 2.9°C by 2075 and 3.8°C by 2100.[66] Increases are expected throughout all months but especially pronounced during the summer, including more hot days, hot nights and heat waves. Moreover, warming in urban regions is predicted to be significantly higher. This can be illustrated in Table 17, which shows predicted climate data for North Macedonia's capital city, Skopje.

Table 17 Future climate changes in Skopje, North Macedonia

Time Period and Emission Scenario	Tropical Nights (Days)	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)
2011-2040 (RCP 4.5)	3.2	1.70	1.10	0.97	-250
2041 – 2070 (RCP 4.5)	9.1	2.90	2.70	2.00	-500
2071-2100	15	3.70	3.70	2.40	-630

[66] World Bank. 2019. Climate change knowledge portal.

Time Period and Emission Scenario	Tropical Nights (Days)	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)
(RCP 4.5)					
2011 – 2040 (RCP 8.5)	3.5	1.40	1.10	1.10	-300
2041 – 2070 (RCP 8.5)	16	3.70	3.70	2.50	-680
2071 – 2100 (RCP 8.5)	45	6.60	6.50	4.80	-1100

The warming trend is clear to see, with large increases in every indicator. Under a medium emissions scenario, average temperature increase will see a 2.40°C increase by the end of the century but both maximum and minimum temperatures will be more than a degree higher. Equally, under the RCP 8.5 scenario, temperature change in double the value of the RCP 4.5 scenario. The data suggests that there will be fewer cool periods as minimum temperatures could reach 6.5°C above the baseline and summer periods will become even hotter. In a city home to around 25% of the total population, and rapidly growing, such heat can cause challenges without the adaptation measures in place.

Heat risk also grows throughout the country. Table 18 shows national level data for various heat indicators.

Table 18 Future climate indicators in North Macedonia (World Bank data)

Time Period and Emission Scenario	Hot Days	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	4.83	0.04	233.82
2040-2059 (RCP 2.6)	6.52	0.06	302.71
2060-2079 (RCP 2.6)	6.96	0.05	330.34
2080-2099 (RCP 2.6)	6.91	0.05	300.07
2020-2039 (RCP 4.5)	5.77	0.04	238.51

Time Period and Emission Scenario	Hot Days	Probability of Heat Wave	Cooling Degree Days (°C)
2040-2059 (RCP 4.5)	8.21	0.07	379.16
2060-2079 (RCP 4.5)	12.61	0.09	490.17
2080-2099 (RCP 4.5)	15.81	0.11	565.4
2020-2039 (RCP 8.5)	6.45	0.05	328.30
2040-2059 (RCP 8.5)	14.61	0.10	603.98
2060-2079 (RCP 8.5)	27.53	0.15	984.56
2080-2099 (RCP 8.5)	45.58	0.20	1363.05

The probability of a heat wave nearly triples under a medium emissions scenario, from 4% currently to 11% by the end of the century. However, the risk quadruples from 5% to 20% under a high emissions scenario. Moreover, an additional 45 hot days each year are expected by 2100 meaning a greater risk of exposure to higher temperatures.

2.9.1.3. The impact of high temperature on health

In 2007, the country declared a national emergency due to a prolonged European heat wave that reached daily temperatures above 43°C. In Skopje, temperatures reached 3.4°C above the monthly average and there were 16.5% more deaths (Kendrovski V. S., 2014). Moreover, the World Health Organization noted that for every degree above 30.1°C (threshold temperature), mortality in Skopje increased by 3.2% (WHO, 2011). In 2017, Macedonia also felt the force of a European heat wave where temperature breached 40°C.

Yet, the GFDRR rates Macedonia's risk to extreme heat as medium, with higher risk in areas home to bigger cities like Skopje. Figure 17 shows the country map by regional vulnerability.

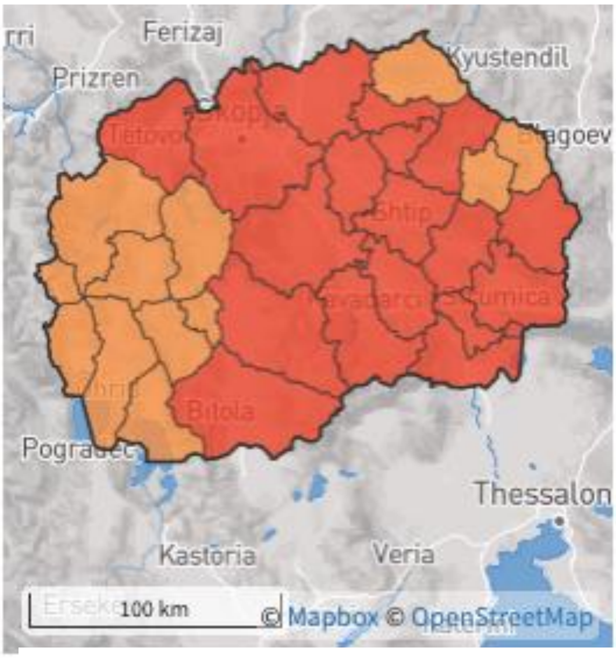

Figure 16 Extreme heat risk in North Macedonia (GFDRR data)

Nonetheless, excessive summer heat in Macedonian cities is increasingly becoming a problem. One study of Skopje used the period 1986-2005 as a baseline to model future heat-related mortality. Under an RCP 8.5 scenario, they found heat-related mortality will more than double in the period 2026-2045 and more than quadruple by 2081-2100 compared to the baseline (Martinez, 2016).

The national Climate Change Health Adaptation Strategy notes the growing impacts of heat waves. Mortality trends in Skopje after 2035 show that a 1-degree increase compared to the baseline period (1996-2000) will "significantly influence the distribution of total mortality" (WHO, 2012). The monthly mortality rates in April, May and June are expected to be 4-11% higher.

The link between indoor temperatures and air quality is also important to note. Macedonia has a high level of indoor air quality, with Skopje having some of the most polluted levels in Europe. One study of residential buildings found that human exposure to total volatile organic compounds was higher than the recommended levels in a third of the homes studied (Vilceková, 2017). Another found that indoor pollution in the summer was especially high, over half observed levels of dangerous particulate matter above the safe level (Apostoloski, 2018). When you combine this with high temperatures and humidity you increase the risk of respiratory illness and underlying health conditions. Creating indoor environments where temperature can be controlled to a level of thermal comfort and air can flow freely allows for a much safer and healthier situation.

2.9.1.4. Economic vulnerability

The economic consequences of high temperatures have also been studied. National research found that the cost of adaptation measures for high temperatures was a fraction of the health damage costs of heat – 12 million MKD (roughly £167,000) compared to 170 million MKD (around £2 million) (Hutton, Sanchez, & Menne, 2013).

To avoid such consequences, WHO note that measures such as increasing air circulation in buildings, integrating sun shades on windows of health, educational and social institutions, thermal insulation, the creation of ‘green zones’, and ventilated roofs can all be introduced (WHO, 2011).

2.9.2. Market context and barriers

2.9.2.1. Strategic context and market potential

The Government of North Macedonia (GONM) has made important progress during the last several years developing the strategic and legal framework for energy efficiency (EE), which provides opportunities for progressing further with specific EE targets and programs.

The Law for Energy Efficiency, in which the EU Energy Efficiency Directive, the EU Energy Performance of Buildings Directive and the Regulation for establishing a framework for labeling of Energy Community, has been transposed and was adopted in February 2020. National Strategy for Energy Development until 2040 was adopted this year by the GONM. This Strategy includes a separate dimension for energy efficiency. In parallel with the Strategy, the process of development of the National Energy and Climate Plan is ongoing, where the manner of achieving the targets, set out in the Strategy for Energy Development until 2040, according the chosen scenario, are going to be determined. The Fourth Energy Efficiency Action Plan is under preparation as well, and it is expected to be adopted until the end of 2020. Also, the Third Biannual Updated Report for Climate Change is under preparation emphasising the needs of the country in the energy efficiency area. In the past several years the Government, on the proposal of the Ministry of Economy, has adopted the annual Programs for Promotion of Renewable Energy Sources and Promotion of Energy Efficiency in Households, which envisages EE measures for reimbursement part of the costs for purchase of pellet stoves, PVC windows and solar collectors in the households. In the same time very similar program for reimbursement part of the costs for purchase of pellet stoves and electric scooters has adopted the City of Skopje as well.

Due to the big pollution in our county, the most polluted cities Skopje, Tetovo, Kichevo and Bitola announced public call for reimbursement approximately 100% of the costs for purchase invertors’ air conditioners. The main condition to be eligible applicant is not to be able to connect to the district heating system and to return the old heating stove.

According the draft NECP the indicative targets for EE in relation to the primary energy consumption are 34.5% and 51.8%, while for the final energy consumption are 20.8% and 27.5%, in 2030 and 2040, respectively, relative to the BAU scenario. In absolute terms, the target for EE in relation to the primary energy consumption is 2.3 Mtoe and for the final is 2 Mtoe in 2030. The economy wide GHG emission reduction target for the country is 82% in 2030 compared to 1990 or 78% compared to BAU scenario (defined in the Energy Strategy). The indicative trajectory shows that by 2020, North Macedonia will reach a reference point of 56% of the total GHG reduction target (which means that more than half of the emission reductions will be achieved by 2020), and 93% in 2025. After 2030, there is increase of the GHG emissions that are mainly result of the transport sector (increase in the transport of goods).

Until adoption of the new by-laws arising from the Law on Energy Efficiency Rulebook on energy consumption labeling and other resources for energy-using products and the existing Regulation on eco-design remain in force, where the European Union regulations in the area of energy labeling and eco-designation are partially transposed.

Until adoption of the package by-laws for buildings the existing Rulebook on energy controls and Rulebook on energy performance of buildings remain in force.

Part of the thermal regulation in the country is regulated with the Rules for heat supply.

There is credit line in three of our commercial banks from EBRD through the Green Energy Support Program that endorses green technology that contributes to a better environment. The loans are intended for citizens and housing associations who plan investments in improving the energy efficiency of residential buildings such as: investments in new heat or geothermal pumps, purchase of efficient stoves, windows, and installation of solar panels, insulation on walls, roof or floors, investments in hot water collectors and the like. With loans supported through the GEF program, citizens obtain the right to apply for a grant of up to 20% of the total amount of the investment.

The implementation of the project "Creating conditions for the implementation of ESCO projects", funded by the REEP Program, is aimed at supporting energy efficiency projects for street lighting and small distribution systems for heating in the municipalities. The ESCO Model or so called The Energy Performance Agreement as well as the tender documentation have been prepared with technical assistance under this Program. This project has so far covered eight municipalities with energy efficiency projects for public street lighting, The second phase of the project will continue, covering municipalities with energy efficiency projects in small distribution heating systems for public buildings. The public call is expected to be announced till the end of 2020.

The World Bank and UNDP within the next 4-5 months approximately will develop two individual analysis for the potential of climate friendly and energy efficient cooling/heating solutions.

The part for rooftop PV and prosumers is regulated in the Rulebook for Renewable Energy Sources deriving from the Law on Energy.

2.9.2.2. Analysis of relevance of barriers

Barriers type	Country specific
Technical barriers	
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	Although North Macedonian regulatory framework is well advanced and creates a helpful environment for investment, capacities to implement EE projects remain weak. The Energy Community[67] stresses that no energy efficiency expert is part of the Ministry of Economy's staff. Many donors and cooperation agencies are

[67] Energy Community Homepage (energy-community.org)

	providing active support in energy efficiency (EBRD, World Bank, EIB, USAID, Swiss Government, GIZ, UNDP)
Financial barriers	
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	The Government of North Macedonia (GoNM) is to set-up an independent Energy Efficiency Fund to support the achievement of national EE targets, with help from the World Bank and the EU. The EE Law includes EE obligations for large consumers, buildings owners, and equipment manufacturers. In the public sector, central government buildings have very limited budgetary provisions for capital improvements and municipalities have strong debt limitations, which limit access to financing for the private sector.
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 and other financiers often lack performance data and risk profiles on energy efficiency improvements. In 2017, EBRD launched the Green Economy Financing Facility (GEFF) that will provide loans to households through local commercial banks for EE investments in residential buildings.
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	Few ESCOs exit and the ESCO market remains underdeveloped. GoNM is implementing the project "Creating conditions for the implementation of ESCO projects" to support EE projects in the municipalities. It is worth noting that the industrial sector was the main contributor (52%) to North Macedonia energy reduction between 2012-2012 (before transport 19% and residential 17M sectors).
Regulatory and institutional barriers	
National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	GoNM has set ambitious EE goals: 12% reduction in energy use in its 2020 EE Strategy, more than the 9% required under the Energy Community Treaty' NEEAPs for the other aspiring Western Balkan EU candidate countries. The National Strategy for Energy Development until 2040 adopted in 2020 include a separate dimension for energy efficiency. The Fourth National Energy Efficiency Action Plan (NEEAP) is under preparation.
Building codes lack specific requirements for energy efficiency in buildings and enforcement is often weak,	The Low for Energy Efficiency (adopted in February 2020) transposes EU Energy Efficiency Directive, the EU Energy Performance of Buildings Directive and the Regulation

mandatory for certain types of buildings only, or still under discussion	for establishing a framework for labeling of Energy Community.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	Project owners often lack capacity to develop and finance energy efficiency projects. However, The GoNM has made important progress over the last years in developing a strategic and legal framework for EE, which shows the Government's awareness on this matter.

2.9.2.3. AFD experience in financing buildings construction of refurbishment projects

AFD has been allowed to carry out activities in North Macedonia since June 2018. In December 2019, AFD has carried out a mission and has identified several opportunities for future investments in the country. Because of its recent authorization of intervention, AFD does not have experience in construction or refurbishment in North Macedonia yet.

2.9.2.4. Environmental public policies analysis

Environmental policies related to the building sector

The country is member of the Energy Community, and is committed to the national transposition of a certain number of European regulations.

A comprehensive Law on Energy Efficiency transposed in 2020 the 2012/27/EU (Energy Efficiency), 2010/31/EU (Energy Performance of Buildings) and 2010/30/EU (Labelling of Energy-related Products) Directives. Secondary regulations still await approval to ensure complete full implementation:

- Updates of the 2013 Rulebooks on energy performance of buildings, energy audit of buildings and an energy performance certificates verification system in final stages (English versions of the texts could not be found)
- Incomplete labeling of 5 equipment families including space heaters and solid fuel boilers (AC equipment labelling fully implemented)

With only 18.12% at the end of 2018, the country is behind its renewable energy share target (23%). The Energy Law adopted in 2018 provides for administratively set feed-in tariffs (sale to the national operator) for PV production, or feed-in premiums granted on a competitive base allowing to sell the electricity on the market. Self-consumption is enabled through a rulebook adopted in 2019, but is not fully implemented.

Adaptation to climate change policies

The country is in the process of establishing its National Adaptation Plan with the support of the UNDP-UNEP.

Its 2013 Third National Communication on Climate Change includes an assessment of the vulnerability and adaptation to climate change in key sectors. It specifically identifies the southeast region of the country as the most vulnerable part of the country (scale of the climate changes, population and economic activities concentration, etc.). As far as land planning and built environment are concerned, we can mention the following adaptation strategies:

- Water-saving measures: water-saving technologies; domestic and municipal re-use of water; rainwater collection for non-potable uses; low-flow appliances;

- Urban planning measures: restriction of urban development in flood risk zones; migration of people away from high-risk areas
- Heat waves health impact: heat-health warnings, training of health professionals…no specific actions on the built environment

2.9.2.5. Summary of stakeholders consultation

The main entity dealing with the energy efficiency theme in the country is **the Ministry of Economy**, **the Sector for Energy**. The Ministry of Economy is the key stakeholder on national level in charge of creation and implementation of the main regulatory and strategic framework related with energy efficiency. Moreover, the Ministry of Economy is in charge of undertaking the systematic and structural reforms aiming at adequate response to energy sector, including energy efficiency challenges, in cooperation with the Energy Regulatory Commission and Energy Agency.

Beside the Ministry of Economy, **the Ministry of Environment and Physical Planning** is the main national institution responsible for the Climate Change policy and strategy on national level. These two Ministries in cooperation with **the Cabinet of Deputy President of the Government in charge of Economic Affairs which is National Designated Authority to the GCF** have given the biggest input in providing information regarding the current energy efficiency development, institutional set-up and legislation in the country. Additionally to that, **the Ministry of Finance** was consulted regarding the financial construction and mechanism of the proposals.

The detected needs regarding the policy/ strategy dimension and the needs regarding investments in this document are compiled based on the existing national strategic/ regulatory documents such as: the Law for Energy Efficiency, the Law on Energy, the Strategy for Energy, the draft- long term National Strategy for Climate Action, the draft Action Plan on Energy and Climate and the Outputs from the Technical Assistance provided by the GCF in 2019-2020.

A detailed **Plan for stakeholder engagement and awareness rising** will be developed in cooperation with the AE and implementing partners once the Programme Proposal is finalized and approved. The process of stakeholder engagement will reflect to the main national and sub-national actors responsible for sustainable implementation of the prioritized project activity for Energy Efficiency. The prioritization process will be based on the established Prioritization Mechanism that was developed under the first GCF Readiness and Preparatory Support Project for North Macedonia. Moreover, within the second GCF Readiness and Preparatory Support Project for North Macedonia which is under implementation, more concert pipeline of project ideas eligible for GCF support will be developed.

Beside the Ministry of Economy, the Ministry of Environment and Physical Planning and the Ministry of Finance, the Plan for stakeholder engagement will involve **other Ministries such as the Ministry of Transport and Communications, Ministry of Health, Ministry of Education and Sciences**.

Regarding the private sector components, the Plan for stakeholder engagement and awareness rising will dedicate special attention to **the Chambers and Association involvement**, as well as **the civil sector organizations**. Moreover, involvement of **the Municipalities and local self government authorities** will provide support of the activities on a sub-national level. Finally, the Plan for stakeholder engagement will include **the Academy and the Universities**, as well as **the Media** for dissemination of information, knowledge and best practices

2.9.3.Project description

2.9.3.1. Project's objectives and description

With the detected needs regarding the Energy Efficiency area, the following sectors/ activities were identified for a further support: the Buildings and Construction; Industry; Transport, Renewable Energy Sources and Private Sector.

1. **Investment Facility**

<u>Buildings and Construction</u>

- Development of financial incentive products (credits, loans, subsidies) for implementation of energy efficiency measures in the commercial sector. According the draft NECP there is measure for retrofitting of existing commercial buildings where is expected annual renovation rate of 1.5% of the existing commercial buildings and budget of 530M Euros for the period 2020-2040. The main objective is retrofitting of existing commercial buildings with aim to meet the objectives of the EE Directive and the Energy Efficiency Law. There is lack of data for the commercial building stock, but according to third National Energy Efficiency Action Plan the commercial building area is estimated to nearly 8 million m^2. This measure considers reconstructions of existing commercial buildings including windows replacement initiated by the owners and/or supported by commercial banks and funds. The measure will provide issuing of certificates for energy performance of buildings, as a prerequisite for putting the reconstructions into operation.

<u>Industry</u>

- Development of financial incentive products (credits, loans, subsidies) for implementation of ISO 50001 standard with public commercial banks or private banks. According the Law on Energy Efficiency one of the cases when the Large enterprises are not obliged to carry out an energy audit in accordance with the requirements from the law for the large enterprises is when they have implemented an energy or environmental management system certified by a conformity assessment body accredited in accordance with the Law on Accreditation, which is compliant with the relevant European or International Standards (ISO), provided that the management system includes an energy audit that meets the detailed conditions prescribed in the Rulebook on Energy Audits of the Large Enterprises. According the draft NECP there is measure for Energy management in manufacturing industries where the main objective is efficient management of manufacturing processes in industry aiming to increase production using the same energy consumption. This measure considers implementation of obligatory energy audits of large companies and implementation of ISO 50001 standard, as well as advanced measurement and introduction of new IT technologies. This will enable prevention of defects, better process control and quicker response times in manufacturing using advanced data analysis and predictive technologies. It is expected improvement of the systems efficiency in manufacturing industries at annual rate of 0.15%.

The below tables outline the GHG baseline emissions and emissions reductions for a North Macedonia residential case. Full calculations can be found in Annex 22c.

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	983,887

Emissions - 20% reduction case	796,345
Emissions - 40% reduction case	648,054
GHG reductions - 20% reduction case	187,542
GHG reductions - 40% reduction case	335,833
GHG reductions - average of 20% and 40% reduction case	261,687

	Source of information	Unit	Value
North Macedonia			
Type of building			Retail
m2 impacted	A	m2	393,700
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	189
Natural gas	C1	kWh/m2/yr	39
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.691
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	130.6
Natural gas	G1 = C1 x E	kgCO2/m2	9.0
Building materials	H1	kgCO2/m2	405.5
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	51,401
Natural gas	J1 = G1 x A	tCO2/yr	3,547
Electricity	I1 = F1 x A x L	tCO2 over lifetime	771,022
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	53,203
Building materials	K1 = H1 x A	tCO2 over lifetime	159,662
Total		**tCO2 over lifetime**	**983,887**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	145
Natural gas	C2	kWh/m2/yr	41
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.691
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	100
Natural gas	G2 = C2 x E	kgCO2/m2	9.5

Building materials	H2	kgCO2/m2	378.2
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	39,435
Natural gas	J2 = G2 x A	tCO2/yr	3,729
Electricity	I2 = F2 x A x L	tCO2 over lifetime	591,525
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	55,931
Building materials	K2 = H2 x A	tCO2 over lifetime	148,889
Total		**tCO2 over lifetime**	**796,345**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	114
Natural gas	C3	kWh/m2/yr	25
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.691
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	79
Natural gas	G3 = C3 x E	kgCO2/m2	5.8
Building materials	H3	kgCO2/m2	378.2
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	31,004
Natural gas	J3 = G3 x A	tCO2/yr	2,274
Electricity	I3 = F3 x A x L	tCO2 over lifetime	465,061
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	34,104
Building materials	K3 = H3 x A	tCO2 over lifetime	148,889
Total		**tCO2 over lifetime**	**648,054**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	11,966
Natural gas	J1 - J2	tCO2/yr	- 182
Electricity	(I1 - I2) x L	tCO2 over lifetime	179,497
Natural gas	(J1 - J2) x L	tCO2 over lifetime	- 2,728
Building materials	K1 - K2	tCO2 over lifetime	10,773
Total	**Sum of 20% case**	**tCO2 over lifetime**	**187,542**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	20,397
Natural gas	J1 - J3	tCO2/yr	1,273
Electricity	(I1 - I3) x L	tCO2 over lifetime	305,961
Natural gas	(J1 - J3) x L	tCO2 over lifetime	19,098

Building materials	K1 - K3	tCO2 over lifetime	10,773
Total	**Sum of 40% case**	**tCO2 over lifetime**	**335,833**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	16,182
Natural gas	Average 20% and 40% case	tCO2/yr	546
Electricity	Average 20% and 40% case	tCO2 over lifetime	242,729
Natural gas	Average 20% and 40% case	tCO2 over lifetime	8,185
Building materials	Average 20% and 40% case	tCO2 over lifetime	10,773
Total	**Sum of above**	**tCO2 over lifetime**	**261,687**

2. Enabling Facility

The enabling facility is directly linked to the sectors of intervention of the investment facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration. The following non-exhaustive examples of activities could potentially be supported but will have to be agreed upon program start.

2.1. Sectoral investment frameworks

This output aims at strengthening public and private investment towards energy efficiency and resilience in buildings through support in the development of key sectoral and/or private sector led roadmaps, investment plans, engagements and/or initiatives in sectors targeted by the investment facility's technical assistance activities, such as public buildings. The following activity could be foreseen in North Macedonia:

- TA for preparation of inventory (general energy audit) for all public buildings. The beneficiary will be the public sector entities. This inventory will be base for all future investments in reimbursement of public buildings and its prioritization

2.2. Support for public policies

The following non-exhaustive list of options for public policy support will be subject to the discussions at program start:

<u>Buildings and Construction</u>

-TA for development of Strategy for renovation of residential, public and non-residential buildings for a period of at least ten years. According the Law on energy efficiency, based on a proposal by the Ministry, the Government adopts Strategy for renovation of residential, public and non-residential buildings for a period of at least ten years. A technical assistance by HABITAT was provided for development of the Typology for buildings in accordance with the TABULA methodology, which will be base during the development of this strategy. The Strategy for renovation of residential, public and non-residential buildings will be ‘’guideline’’ for all future policies in the building sector.

- TA for development of a Plan for renovation of buildings used by the public sector entities on state level, which on annual level includes renovation of at least 1% of the total useful floor area from the inventory of buildings (which is already prepared) with a total useful floor area over 250 m^2 which do not meet the minimal requirements for energy performance and which are owned and used by public sector entities on state level. According the Law on energy efficiency, the Ministry, in cooperation with the Office for General and Common Affairs of the Government, prepares a proposal-plan for renovation of buildings used by the public sector entities on state level, which on annual level includes renovation of at least 1% of the total useful floor area from the inventory of buildings with a total useful floor area over 250 m^2 which do not meet the minimal requirements for energy performance and which are owned and used by public sector entities on state level. For this purpose in advance it is necessary to be performed detail energy audits to the buildings with a total useful floor area over 250 m2 which do not meet the minimal requirements for energy performance and which are owned and used by public sector entities on state level. This is obligation for North Macedonia arising from Article 5 from the EED. End beneficiaries are the public sector entities on state level.

<u>Renewable Energy Sources within buildings</u>

- TA for development of a study for possibility of forming and implementation of renewable energy cooperation on state level, as well as the potential barriers in the existing laws for uninterrupted establishment of this concept. The beneficiary will be the private and residential sector especially the residents in the collective buildings.

2.3. Capacity building for sector actors

Within this activity, a number of capacity development measure could be foreseen, such as:

- Capacity building and training measures to national financiers like development banks and their intermediary banks on low-carbon construction financing and eligibility criteria, evaluation and verification criteria and procedures covering the part for energy efficiency in buildings, industry and transport.

2.9.3.2. Paradigm shift potential

We expect the PEEB Cool Programme to the low carbon transformation in the country. Mainly in the energy efficiency in the private and public building sector, but also in industry, transport and renewable energy sources. By providing support, innovative approach and involvement of private sector low carbon paradigm shift will be promoted and low carbon development will be encourage towards climate-adapted building design, more energy efficient equipment and appliances and low carbon building materials will be promoted at national and sub-national level. Moreover, we hope that the PEEB Cool Programme will support the improvement of the legal framework and support mechanisms for low carbon transition.

Through the support on the specific low carbon initiative detected in the national strategic documents for energy efficiency, we plan the national public and private stakeholder to be capable to implement effective mitigation actions in the building sector and other related sectors with energy efficiency.

Furthermore, the improvement of the strategic and legal framework for energy efficiency in the country will provide better enabling environment for implementation of energy efficiency measures on national and local level on long perspective.

Through capacity building the national government entities, local municipalities and private sectors are empowered and strengthened to implement active energy efficiency measures.

2.9.3.3. Sustainable development potential

The needs identified during the policy/ strategy screening process will show sustainable development potential by providing structural and legislative improvements. Moreover, the institutional capacity building and development, the transfer and dissemination of knowledge, experiences, best practices and know-how among the participants and the stakeholders in the process will ensure environmental, social and economic co-benefits, including gender-sensitive development impact.

Moreover, the efforts to provide support through this initiative will be follow up on already existing national efforts and GCF support in the country. Namely, in 2019 the GCF provided Technical Assistance for North Macedonia. Within the Technical Assistance the country received a prioritized list of project ideas/ packages for the Energy Sector. The proposed activities in this document were identified the area of Energy Efficiency of the draft Strategy on Climate Action including details for the CO_2 emission reduction by 2030. These measures are also reflected in the draft Energy and Climate Action Plan.

Finally, in 2021 the process of establishment of the National Fund for Energy Efficiency is expected to start with support from the GCF, for what the North Macedonia NDA has issued a No-objection letter in May 2020.

However, once the PEEB Programme is approved, and prioritization of the needs is undertaken, a detailed plan for sustainability for North Macedonia (including progress indicators and impact indicators) will be defined within the scope of the work of the key beneficiary institutions – the Ministry of Economy and the Ministry of Environment and Physical Planning in cooperation with the NDA and the AE and Delivery Partners. Furthermore, this obligation will be requested from the private/ civil sector stakeholders that will be direct beneficiaries of the PEEB Programme, as well.

2.9.3.4. Project indicative financing

Financial elements of the projects are to be defined and will depend on the investments that will be identified under PEEB Cool.

2.10. Sri Lanka

National Designed Authority	**Ministry of Environment**
Project title	PEEB Cool Sri Lanka
Name and typology (public/private) of the institutions	Public Institutions : Ministry of Environment, Ministry of Power, Ministry of Finance, Ministry of Urban Development & Housing, Sri Lanka Sustainable Energy Authority, Urban Development Authority
End beneficiaries (households, students…)	To be defined depending on the project that will be financed
Mitigation/adaptation focus	Cross cutting

2.10.1. Climate profile

Sri Lanka ranks 103rd on the ND-Gain index, as 60th most vulnerable and 92nd least ready.

2.10.1.1. Historic climate data

Sri Lanka is a tropical climate, with a hot and humid summer and a monsoon season. Mean annual temperature over the last century was 26.68.[68] Over the last 50 years, temperature has increased at a rate of around 0.16°C per decade, with greater increases in minimum temperature.

2.10.1.2. Future climate projections

Warming trends are set to continue in Sri Lanka, with WHO finding a mean annual temperature increase of 3.7°C by 2100 under a high emissions scenario (WHO, 2015). This will likely be higher in the drier northern regions. Minimum temperatures are expected to rise the most, suggesting the likelihood for fewer cool periods and more consistent hot spells throughout the year. This is reflected in Table 19, which shows projected changes in Sri Lanka's capital city, Colombo.[69]

Table 19 Future temperature changes in Colombo, Sri Lanka

Time Period and Emission Scenario	Max. Temperature (Change in °C)	Min. Temperature (Change in °C)	Temperature (Change in °C)

[68] World Bank. 2019. Climate Change Knowledge Portal.

[69] Data from Climate Information. Site-specific report

2011-2040 (RCP 4.5)	0.65	0.66	0.61
2041 – 2070 (RCP 4.5)	1.20	1.40	1.10
2071-2100 (RCP 4.5)	1.40	1.80	1.30
2011 – 2040 (RCP 8.5)	0.79	0.79	0.69
2041 – 2070 (RCP 8.5)	1.70	2.00	1.60
2071 – 2100 (RCP 8.5)	3.10	3.40	2.80

The data shows a greater increase in minimum temperature compared to both temperature and maximum temperature in nearly every time period for both medium and high emissions scenarios. Therefore, not only will the country face hotter temperatures, but this will also be even more prevalent during months that are currently cooler. Warming like this is also reflected in national data. Table 20 shows this.

Table 20 Future climate indicators in Sri Lanka (World Bank data)

Time Period and Emission Scenario	Hot Days	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	9.60	22.02	0.06	405.65
2040-2059 (RCP 2.6)	14.25	43.66	0.09	513.68
2060-2079 (RCP 2.6)	15.58	42.63	0.09	527.17
2080-2099 (RCP 2.6)	15.13	43.48	0.09	490.33
2020-2039 (RCP 4.5)	9.52	26.29	0.08	453.90

2040-2059 (RCP 4.5)	19.07	47.73	0.14	677.79
2060-2079 (RCP 4.5)	27.20	77.61	0.20	882.47
2080-2099 (RCP 4.5)	32.13	98.62	0.22	995.59
2020-2039 (RCP 8.5)	14.87	16.41	0.09	505.02
2040-2059 (RCP 8.5)	32.77	76.74	0.21	974.42
2060-2079 (RCP 8.5)	62.91	198.08	0.43	1496.69
2080-2099 (RCP 8.5)	107.63	295.04	0.69	2165.36

Here, it clearly shows a distressing rise in the number of hot days, with 107 additional days under a high emissions scenario. Moreover, the probability of a heat wave rises significantly. Even under a medium emissions scenario, there is around a 20% chance of a heat wave while this more than triples to 69% by the end of the century under a business-as-usual pathway. Naturally, this will have highly damaging consequences to thermal comfort unless adaptation measures are implemented.

2.10.1.3. The impact of high temperature on health

Past studies of heat and thermal comfort have been conducted in Sri Lanka. For example, the study of temperature, humidity and relative strain in Colombo found a strong rise in thermal discomfort as the city became more urbanised. Researchers found especially high discomfort at nights within suburban regions where buildings and roads were being built (Emmanuel, 2005).

Given Sri Lanka's warm climate all year round anyway, changes to temperature and heat index will mean that there are very few days that do not fall within the 'heat wave' definition. World Health Organization estimates illustrate this. Figure 18 shows the projections of heat wave days under different emissions scenarios. Under high emissions, around 350 days on average will reach this temperature threshold compared with 25 in 1990 (WHO, 2015). That is, unless emissions fall significantly, all but around two weeks each year will be considered heat wave level.

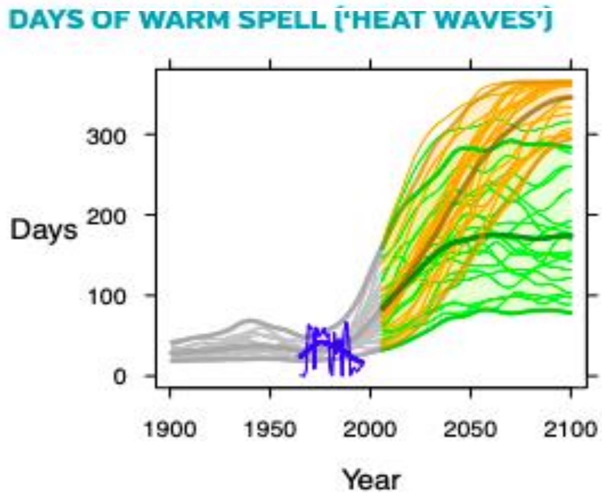

Figure 17 Future heat wave days in Sri Lanka (WHO data)

Vulnerability to these heat extremes will be considerable unless buildings can adapt. Studies of environmental heat stress in indoor environments found that temperatures could reach 38-42°C when air conditioning was not on. This is considered a critical heat stress situation. The researchers note that changes to bioclimatic and microclimatic design can reduce indoor temperature, increase ventilation and enhance energy efficiency of cooling devices (Rajapaksha, 2020). Moreover, changing the plan form, sectional form and orientation in a building can create shading that shields against the sun, therefore reducing temperature.

Equally, studies of the performance of different façades in buildings in Sri Lanka found that glass structure increased cooling load requirement inside. Moreover, the provision of ventilation at night was found to reduce indoor air temperature in buildings the next day, making for greater thermal comfort (Rajapaksha, Rupasinghe, & Rajapaksha., 2015). Nonetheless, indoor heat stress in office buildings, even those with air conditioning, has been found to be significant and building design should integrate climate-specific risks.

Studies on thermal comfort in Sri Lanka's residential buildings have also been conducted. Research that focused on case study housing found that implementing adaptation changes such as using mud concrete blocks as external wall material and clay tiles as roofing could achieve a desirable level of thermal comfort without using energy inefficient, and potentially expensive, air conditioning (Karunathilake, 2018). Similarly, research on thermal comfort in post-disaster housing in Sri Lanka found that material selection, especially for the roof, was critical in maintaining a comfortable temperature (Coorey, 2017).

Moreover, one study into thermal adaptation in Sri Lankan hotels found that naturally ventilated and more open environments yielded more positive perceptions of thermal comfort in tourists (Rajapaksa, 2017). Each of these studies implies the need to account for the climate in building design. As heat waves coincide was the heat island effect in cities, vulnerability will rise, especially as people will spend more time indoors but in households and buildings without air conditioning. As urbanisation continues, there is a threat that traditional climate-sensitive Sri Lankan buildings will be replaced with brick-concrete structures that provide less protection to heat extremes (UKRI, 2017).

Exposure to longer periods of hot temperatures raises the risk of respiratory illness. In Sri Lanka, 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 (WHO, 2015). Figure 19 has more details.

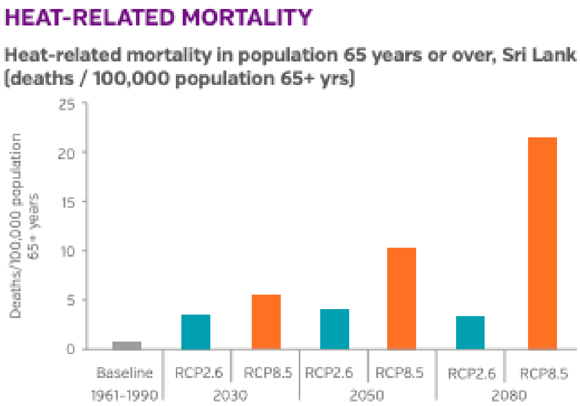

Figure 18 Future heat-related mortality in Sri Lanka (WHO data)

As outlined previously, considering that people will spend most of their time indoors and may lack air conditioning, it can be expected that many deaths from heat waves will be a result of having inadequate cooling and ventilation. This is especially true for those living in low-income buildings without climate resilient design or those living in rapidly urbanising cities, like Colombo. Moreover, with 74% of the population primarily using solid fuels for cooking, around 35% of total deaths in the country are attributable to household air pollution (WHO, 2015). Therefore, the combination of indoor air pollution, high temperatures and humidity can create enormous stress on the body.

2.10.1.4. Economic vulnerability

Equally, there will be economic consequences. A study of environmental factors (temperature, noise, light etc) on productivity of factory workers found that higher temperature was the only factor that significantly reduced productivity. Moreover, heat also contributed to illnesses or symptoms such as headaches (Meegahapola, 2018).

At a national level, 2.49% of working hours are expected to be lost to heat stress in the manufacturing industry by 2030, 6.98% in construction and 0.16% in services (ILO, 2019). If indoor temperatures are not regulated to a level of thermal comfort, these figures will rise even more throughout the century.

A study of the Indian manufacturing industry in Bangalore (with a tropical savanna climate) found a negative relationship between heat and productivity. However, when changing lighting in the factories to LEDs, which emit less heat, the inside temperature fell, and productivity rose (Adhvaryu, Kala, & Nyshadham, 2018).

2.10.2. Market context and barriers

2.10.2.1. Strategic context and market potential

Sri Lanka is a low-GHG emissions country (0,1% of global GHG emissions, 1,5tCO_2eq per inhabitant in 2012, which is 5 times less than the global average), but it is one of the world most vulnerable countries to climate change. Sri Lanka is ranked 122[e]/181 as per its vulnerability according to ND-Gain Index and the island is highly exposed to climate change effects. A strong increase of its GHG emissions is expected, reflecting the economic growth of Sri Lanka and the carbonization of its energy mix with the introduction of coal in the traditional hydropower-based power production. Sri Lanka's greenhouse gas (GHG) emissions grew by 43 percent from 1990 - 2011, with gross domestic product (GDP) growing by 198 percent in the same time period.

As a small island in the Indian Ocean, Sri Lanka has taken several steps to strengthen the country's capabilities to face the challenges of climate change, especially by formulating overarching policies, national level plans and strategies, amongst which the "Vision 2025" (2015) policy document sets out the long-term development trajectory of the country. Sri Lanka has also a National Climate Change Policy of Sri Lanka (2012), a National Climate Change Adaptation Strategy for Sri Lanka (2010) and a National Adaptation Plan (NAP) for Climate Change Impacts in Sri Lanka (2015). In addition to the aforementioned, the Long Term Electricity Generation Expansion Plan 2018-2032 and the National Solid Waste Management Strategy 2000, the Corporate Plan 2014-2018 by the Central Environmental Authority and various legal amendments made by government entities related to environment are being implemented.

In order to address climate change issues, a separate dedicated institution titled the Climate Change Secretariat (CCS) was created in 2008. A Ministry of Mahaweli Development and Environment was established in 2015 as the primary ministry responsible for sustainable development, and was chaired by the former President Sirisena. In November 2019, a new President was elected, and a new Government was appointed in August 2020 after general elections. The Ministry of Environment is now an independent Cabinet Ministry. The new Sri Lankan government will update its various strategies and action plans for the post-2020 period.

Sri Lanka signed the Paris Agreement in April 2016 and ratified it in September 2016. Sri Lanka submitted to the UNFCCC in September 2016 its NDC setting the unconditional GHG reduction target at 4% for energy sector and 3% for other sectors compared to the baseline scenario, which could be increased to 20% for energy sector and 10% for other sectors through international support (conditional targets). Sri Lanka is currently revising its targets set in its NDC, for submission of its NDC1 in 2020 to the UNFCCC.

<u>Building sector and Real Estate in Sri Lanka</u>

Globally, the building sector is the most emissive sector, with 40% of the energy-related CO_2 emissions and 36% of the consumption of final energy. This consumption is expected to increase by 50% by 2050, and 80% of this increase will take place in developing countries.

In Sri Lanka, buildings (commercial or industrial) already make up 60% of the electricity consumption. More than 50% of monthly operational costs in high-rise buildings in Sri Lanka are often for electricity bill. In a tropical country, the HVAC (Heating, Ventilating & Air Conditioning) equipment drives this increase of the energy demand. In 2014, the construction industry grew by 20% over 2013 and a similar growth is projected for the coming years, with important building projects in Colombo and islandwide.

The Government of Sri Lanka has recognized the importance of improving energy performance of buildings as an integral component of the national sustainable energy development strategy. The first comprehensive effort for promoting energy efficiency in buildings in Sri Lanka was the publication of the *Energy Efficiency Building Code* (EEBC) developed by the Demand Side Management (DSM) branch of the Ceylon Electricity Board in 2000. This code exempted residential and industrial buildings and applied only to commercial buildings on a voluntary basis. In 2008, the newly created *Sri Lankan Sustainable Energy Authority* developed a new version, the *Code of Practice for Energy Efficient Buildings*, to incorporate modern technologies and requirements. This code is applicable to commercial buildings, industrial facilities and large scale housing schemes. However, its implementation suffers from weak enforcement from the Urban Development Authority and lacks in its scope.

In parallel, the Green Building Council of Sri Lanka (established in 2009) created Sri Lanka's indigenous rating system, which is better suited to the country's tropical climate. This Green Labelling System established to certify products and promote the use of green products in construction. All the government buildings have been subject to green building standards since 2017. The objective is to extend compulsory Green Building Certification to the private sector in the next 5 years.

2.10.2.2. Analysis of relevance of barriers

Barriers type	Country specific relevance
Technical barriers	
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	Varying levels of awareness among building and construction practitioners (architects, engineers, consultants, developers) and lacking knowledge sharing opportunities among project stakeholders maintains overall low interest for bioclimatic design principles and efficient cooling technologies.
Financial barriers	
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	Building owners lack awareness on the benefits of low-carbon and resilient building, as the information is poorly shared among project teams. Their interest to carry higher upfront costs remains low.
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' awareness of the investment opportunity in green buildings is slowly growing. Certain banks with international support have started taking initiatives: Commercial Bank of Ceylon (CBC) has special terms for businesses and consumers on investments made in green projects, while Colombo Stock Exchange is part of the Sustainable Stock Exchanges Intiative.
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	Due to a lack of awareness on the clients' side, demand for sustainable technologies and services is not sufficient to push industry actors to shift.
Regulatory and institutional barriers	

National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	Sri Lanka has not clearly translated its NDC objectives into concrete targets for the building and construction sector. The country's National Adaptation Plan for Climate Change does not consider concrete measures addressing resilient buildings beside the need for awareness raising.
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	Sri Lanka passed in 2008 an energy efficient building code for the construction and retrofit of commercial buildings and industrial facilities. Enforcement, however, remains weak. Broader sustainable building regulations addressing the residential sector are missing. A building code for resilience is under discussion.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	There is a lack of commitment and leadership from key stakeholders, especially the government and most responsible authorities (beside the Sustainable Energy Authority). A Green Building Council Sri Lanka was established in 2008 which led to the creation of an indigenous green building rating system adapted to the Sri Lankan context.

2.10.2.3. AFD experience in financing buildings construction of refurbishment projects

After the 2004 tsunami, AFD financed a credit line to the Central Bank to refinance concessional loans for firms in the building and construction sector, and to finance trainings for professionals in this sector. AFD is also financing several projects in urban development, energy, water and sewerage sectors, which include the construction of different types of buildings (resettlement houses, grid substations and water treatment plant technical buildings, bus stations, visitor center).

2.10.2.4. Baseline and public policies analysis

Environmental policies related to the building sector

Sri Lanka has set a target to reduce its emissions by 23% by 2030.

The Building Energy Code currently in force in Sri Lanka is called "the Code of Practice for Energy Efficient Buildings" (CPEEB) and dates from 2008. This Building energy code applies to both new construction and renovations.

It sets minimum levels of performance to be achieved for:

- The envelope,

- Ventilation and air conditioning,

- Lighting,

- Electricity distribution,

- Hot water.

It applies to large commercial, industrial and residential buildings achieving one of the following four characteristics:

- 4 or more stories,

- Floor area of 500m2 or more,

- Electrical power of 100 kVA or more,

- Air conditioning system power of 350 kW or more.

A revision of the building energy code is planned in order to integrate a mix of prescriptive and performance requirements and to reflect international best practices (Institution of Engineers Sri Lanka, 2020).

Risks brought on by adaptation

Globally, Sri Lanka is one of the three countries in the world most affected by climate change risks according to the climate risk index produced by German Watch (2019). Indeed, coastal areas account for 32% of the total population and that is where most of the main infrastructure of the country is found (roads, railways, ports ...). The rise in sea level and the increasing frequency of tropical cyclones should lead to a profound transformation of the coast (cf. erosion/ accretion). Consequently, without major investments in adaptation, the World Health Organization predicts that about 65,600 people per year will be affected by flooding due to sea level rise between 2070 and 2100.

In addition, the risk of flooding and landslides with consequences on human settlements is accentuated by the decrease in forest cover due to the intensification of heavy rainfall. The World Health Organization predicts that about 25,700 people per year will be exposed to the risk of inland flooding by 2030 as a result of climate change.

As a result, Sri Lanka has set a target in its National Plan for Adaptation to Climate Change Impacts 2016-2025 to make cities and homes more resilient to climate change (Ministry of Mahaweli Development and Environment, 2016).

Adaptation to climate change policies

The country has formalized a National Adaptation Plan 2016-2025 to address the observed and projected changes on climate: increase in temperatures, changes in distribution pattern of rainfall (dry zones tend to become drier and wet zones wetter), increase in frequency and severity of extreme weather events. Below are some of the identified key vulnerability sectors with their priority areas and summary priority actions (relevant examples):

Vulnerability sectors - Priority areas	Priority actions
Water resources: water for agriculture, human consumption or industry and energy, degradation of watersheds;	- Develop and implement watershed management plans for critical watershed areas - Increase the efficiency of use and reduce losses of irrigation water - Assess the current practices of water management for climate resilience and identify ways to improve them

	- Identify and map areas vulnerable to droughts and flood hazards and prepare disaster risk management plans
Coastal and marine sector: Coastal zone management, Beach stability, Coastal bio-diversity, Ocean acidification	- Develop shore shoreline management plans including M&E programs - Identify, declare, collect information and prepare maps on vulnerable areas to extreme events and inundation - Conduct awareness programs on sea level rise and extreme events to coastal communities to empower them for facing the risks of climate change
Health: Climate altering pollutants, Diseases: Spread and outbreaks, Hazardous events: Health impacts, Heat/thermal stress	- Develop research institutes' capacity conducting research on health impacts of climate change - Strengthen the mechanisms for sharing information between disaster management and health management agencies - Launch awareness programs on climate and health risks for healthcare workers and the public
Human settlements and infrastructure: Urban settlements and infrastructure, Rural settlements and infrastructure, Estate settlements and infrastructure, Coastal settlements and infrastructure	- Promote climate resilient building designs - Revise building approval systems to increase the climate resilience - Conduct research studies on climate resilient building designs, green building concepts and alternative materials - Conduct training programs on climate resilient buildings for industry stakeholders - Prepare hazard preparedness plans for urban, rural and estate settlements
Industry, energy and transportation	- Diversify the energy mix with increased share of renewable energy - Conduct research studies on climate change impacts on industry, energy and transportation
Cross-cutting needs of adaptation	- Develop policy recommendations necessary for addressing vulnerability to impacts of climate change in all development /management projects - Create a National Adaptation Fund with the collaboration of the Ministry of Finance to support the implementation of NAP actions and supportive programs - Initiate a joint island wide program for identification of religious, cultural and archaeological assets vulnerable to climate change impacts and conservation of threatened assets - Conduct training programs for government officers, CSO members, and private sector employees on climate change adaptation

	- Establish a national research program on climate modeling for long term climate projections

2.10.2.5. Summary of stakeholders consultation

AFD team in Colombo has already discussed the Programme PEEB Cool with the Climate Change Secretariat (NDA), ERD and one potential future implementing agency (SLSEA), who confirmed their interests in the Programme and the opportunity for Sri Lanka. A meeting with another potential future implementing agencies (UDA) will be planned.

Identified stakeholders for the projects are the followings:

The Department of National Planning (NPD) is committed to policy development, planning and implementation, to accelerate Sri Lanka's economic growth and social progress. In parallel, ERD, the External Resources Department under the Ministry of Finance, conducts consultations and negotiations with donors and ministries to identify development assistance strategies and priorities.

The Ministry of Environment and the Climate Change Secretariat are the Nationally Designated Authority (NDA) for the Green Climate Fund in Sri Lanka.

The Sri Lanka Sustainable Energy Authority (SLSEA), under the Ministry of Power, was established in 2007 by an Act of Parliament in order to drive the concept of energy efficiency on a national scale.

The Urban Development Authority (UDA), under the Minister of Finance, Urban Development & Housing, is in charge of the implementation/enforcement of standards and requirements for energy efficiency and green buildings.

2.10.3. Project description

2.10.3.1. Project’s objectives and description

Based on collaboration experience and consultations of both GIZ and AFD with national stakeholders, a number of tentative activities have already been identified and tentatively defined. These will be reviewed and refined in a national consultation process at program start. A list of tentative activities, including several potential projects as well as a need for policy support from PEEB Cool, is described below.

In these activities, PEEB Cool advise shall take into account stakeholder feedback from experiences in project implementation in order to minimize challenges that may de facto impede the enforcement of a regulation (such as feasibility of minimum standards, bureaucratic hurdles, etc.) or its financial feasibility for (future) owners or inhabitants, and propose incentive schemes where this may become necessary. PEEB Cool will also take a holistic approach at policy development in order to sustainably stimulate investments in energy efficiency buildings by seeking linkages with existing and planned policies on renewable energy production, efficient cooling techniques, and public transport connectivity.

Component 1: Investment Facility

AFD considers mobilizing first GCF’s Grant for technical assistance, especially for institutional arrangements, project preparation activities and technical assistance to PMUs for incorporation of energy efficiency measures in ongoing projects.

Further support could then entail:

- Identifying and funding a loan for a new project of developing solar cooling equipment and/or insulation in public buildings
- Providing a credit line to public banks to fund subsidized loans in order to create financial incentives for proper insulation and use of sustainable building/insulation materials in private sector

The below tables outline the GHG baseline emissions and emissions reductions for a Sri Lanka office case. Full calculations can be found in Annex 22c.

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	27,355
Emissions - 20% reduction case	18,733
Emissions - 40% reduction case	15,995
GHG reductions - 20% reduction case	8,622
GHG reductions - 40% reduction case	11,361
GHG reductions - average of 20% and 40% reduction case	9,992

GHG emissions without EE measures:	Source of information	Unit	Value
Mali			
Type of building			Offices
m2 impacted	A	m2	15,000
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	200
Natural gas	C1	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.468
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	93.6
Natural gas	G1 = C1 x E	kgCO2/m2	0.0
Building materials	H1	kgCO2/m2	419.4
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	1,404
Natural gas	J1 = G1 x A	tCO2/yr	-
Electricity	I1 = F1 x A x L	tCO2 over lifetime	21,065
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	-
Building materials	K1 = H1 x A	tCO2 over lifetime	6,291

Total		tCO2 over lifetime	27,355

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	125
Natural gas	C2	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.468
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	59
Natural gas	G2 = C2 x E	kgCO2/m2	0.0
Building materials	H2	kgCO2/m2	371.2
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	878
Natural gas	J2 = G2 x A	tCO2/yr	-
Electricity	I2 = F2 x A x L	tCO2 over lifetime	13,165
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	-
Building materials	K2 = H2 x A	tCO2 over lifetime	5,567
Total		**tCO2 over lifetime**	**18,733**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	99
Natural gas	C3	kWh/m2/yr	0
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.468
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	46
Natural gas	G3 = C3 x E	kgCO2/m2	0.0
Building materials	H3	kgCO2/m2	371.2
Total GHG emissions			

Electricity	I3 = F3 x A	tCO2/yr	695
Natural gas	J3 = G3 x A	tCO2/yr	-
Electricity	I3 = F3 x A x L	tCO2 over lifetime	10,427
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	-
Building materials	K3 = H3 x A	tCO2 over lifetime	5,567
Total		**tCO2 over lifetime**	**15,995**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	527
Natural gas	J1 - J2	tCO2/yr	-
Electricity	(I1 - I2) x L	tCO2 over lifetime	7,899
Natural gas	(J1 - J2) x L	tCO2 over lifetime	-
Building materials	K1 - K2	tCO2 over lifetime	723
Total	**Sum of 20% case**	**tCO2 over lifetime**	**8,622**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	709
Natural gas	J1 - J3	tCO2/yr	-
Electricity	(I1 - I3) x L	tCO2 over lifetime	10,638
Natural gas	(J1 - J3) x L	tCO2 over lifetime	-
Building materials	K1 - K3	tCO2 over lifetime	723
Total	**Sum of 40% case**	**tCO2 over lifetime**	**11,361**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	618
Natural gas	Average 20% and 40% case	tCO2/yr	-
Electricity	Average 20% and 40% case	tCO2 over lifetime	9,269
Natural gas	Average 20% and 40% case	tCO2 over lifetime	-
Building materials	Average 20% and 40% case	tCO2 over lifetime	723
Total	**Sum of above**	**tCO2 over lifetime**	**9,992**

Component 2: Enabling Facility

The enabling facility is directly linked to the sectors of intervention of the investment facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration.

The PEEB Cool enabling Facility will offer implementation of support activities in all three output areas, namely 1) development of sectoral investment frameworks 2) support for public policies and 3) capacity building for building sector actors. The support of the enabling Facility within the framework of PEEB Cool in Sri Lanka could therefore tentatively tackle the following areas:

2.1. Development of sectoral investment frameworks

An indicative activity could be the development of sectoral frameworks or initiatives for mobilizing investments for implementing mitigation targets and adaptation measures in the building sector (and particular regarding insulation) for the NDC 2025 and the related buildings and construction roadmap 2025 – 2050.

2.2. Support for public policies

A number of public policies are in place or foreseen and may benefit from additional support within the PEEB Cool enabling Facility, for example:

- Revising the *Code of Practice for Energy Efficient Buildings* : higher standard, broader scope, incorporation of incentives for the use of sustainable building materials, etc
- Advisory on EE policies (e.g. National Regulations and energy performance label system)
- Updating and adapting the Green Building Certification's requirements to the private sector ;
- Roadmap for the implementation of green building certification and registry scheme for the private sector

2.3. Capacity building for building sector actors

Capacity building activities for building sector professionals could consist of the following:

- Capacity Building for the Urban Development Authority (UDA) to strengthen the implementation of energy efficiency and green buildings standards
- Providing technical assistance to PMU (in ongoing projects) to incorporate green building requirements and energy efficiency measures in the construction of buildings (trans-sector: energy, water, urban development), and to plan and estimate the costs and results of energy efficiency measures, in particular linked to the projects of component 1.
- Trainings for technical professionals in the areas of building and cooling technologies, with a special emphasis on maintenance requirements and procedures. This activity in particular may creative synergies with existing GIZ projects supporting vocational training centers.
- Capacity building for 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.

2.10.3.2. Paradigm shift potential

The built space is constantly evolving, with numerous high rise buildings being constructed for private luxury apartments, offices or commercial purposes. Similarly there is a critical need for new housing in Colombo. Given the rapid developments in the building and construction sector it is compulsory that a comprehensive set of energy efficiency requirements is adopted for the private sector as well. In the public sector, the *Green Building Certification* has been compulsory since 2017 but could be reinforced with the appropriated implementing Agency.

Several challenges slow the introduction of energy efficiency measures in housing and commercial/industrial buildings, and the development of green buildings :

- Regulatory : no national emission reduction target in the building sector ; a lack of modern and ambitious regulation in the private sector and housing ; and a very recent regulation in the public sector ; lack of clarity and assistance to comply with relevant standards
- Structural : Lack of clarifications on the responsibilities of each Agency and coordination between sectors
- Financial : No financial incentive to develop energy efficiency in private buildings (commercial, industrial, residential)
- Technical : developers and planners lack knowledge on planning and implementation of EE

The PEEB Cool funding will address these key barriers :

- Regulatory : Introduction of sectoral frameworks for reaching mitigation objectives for the building sector; Development of an adapted regulation in the private sector and support for the implementation in the public sector with capacity trainings and guidance for the implementing Agency
- Structural : Development of a comprehensive regulatory framework of energy efficiency in the building sector (Residential, Commercial, Industrial) with dedicated entity, and raising awareness about the benefits of energy efficiency
- Financial : Providing concessional loan and grant to fund replicable projects
- Technical : Providing Technical Assistance to the project teams to develop relevant energy efficiency measures in the buildings included in their project, to plan and estimate the costs and results of energy efficiency measures, and to build expertise in this area.

The traditional Sri Lankan building design and construction methodologies, made famous by world renown Sri Lankan architect Geoffrey Bawa, offer good examples of natural efficient cooling systems suited for the tropical environment, using sustainable materials, indoor/outdoor designs, and air movement. A potential paradigm shift could be to re-integrate in the modern western-inspired architecture with some guidelines of the traditional architecture (with passive design measures), adapted to the tropical climate conditions of Sri Lanka. In parallel, raising awareness about the need and benefit of proper insulation is a first step towards more energy efficiency measures

2.10.3.3. Sustainable development potential

<u>Economic & social co-benefits:</u> Thanks to energy efficiency investments (passive or active), the electricity bill at the end of the month will be less than it would have been without them. That would benefit both for private and public sector's expenditures. For vulnerable populations, improvement of the design of housing or better insulation will allow them to afford better indoor environment, with natural cooling and reduced electricity expenditures.

Environmental co-benefits: Improving the cooling system, the insulation and the energy efficiency of a building will have a direct impact on the energy consumption of this building, and globally will contribute to slow down the increase in energy demand. With around 5% of increase per year, the constant increase of energy demand in Sri Lanka is met by the introduction of coal power station and petroleum, which produce more GHG emissions than the traditional hydro-power electricity does. Industrial air conditioning systems produce gases with global warming potential. The re-introduction of passive design measures, efficient insulation or solar cooling could decrease the use of industrial AC and its GHG emissions.

2.11. Tunisia

National Designed Authority	Ministry of Local Affairs and Environment
Project title	PEEB Cool Tunisia
Name and typology (public/private) of the institutions	Potential institutions: MALE, MEHAI, ANME
End beneficiaries (households, students…)	Households
Mitigation/adaptation focus	Cross cutting

2.11.1. Climate profile

2.11.1.1. Historic climate data

Tunisia has a variety of climate zones: subhumid to the far north; semi-arid in the north-west; arid in central Tunisia and desert in the entire southern part. The highly arid nature of the country means temperatures are typically high, especially in summer, with limited annual rainfall.

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.[70] However, temperatures in recent decades have risen significantly, by an average of 0.37°C per decade over the last 30 years.[71] This combined with fewer cool periods and an increase in energy consumption on hot days threatens the health of vulnerable groups.

2.11.1.2. Future climate projections

Warmer temperatures are expected by the end of the century along with a rise in the number of hotter nights. Table 21 highlights future estimates in Tunisia's capital city, Tunis.[72]

Table 21 Projected future climate indicators under different emission scenarios for Tunis, Tunisia

Time Period and Emission Scenario	Tropical Nights (Days)	Max. Temperature (Change in °C)	Temperature (Change in °C)	Heating Degree (°C)
2011-2040 (RCP 4.5)	14	1.00	0.78	-110
2041 – 2070	24	1.70	1.40	-190

[70] World Bank. 2019. Climate Change Risk Profile: Tunisia.

[71] World Bank Climate Change Knowledge Portal.

[72] Data from Climate Information. Site-specific Report: Tunisia.

(RCP 4.5)				
2071-2100 (RCP 4.5)	30	1.90	1.80	-250
2011 – 2040 (RCP 8.5)	13	1.10	0.81	-140
2041 – 2070 (RCP 8.5)	33	2.30	2.10	-270
2071 – 2100 (RCP 8.5)	56	4.00	3.60	-430

Data for Tunis highlights an increase in tropical nights and temperature changes (both maximum and minimum) under both medium and high emission future scenarios. Higher temperatures and warmer nights are associated with health risks (discussed in more detail later), such as higher chances of strokes or heart attacks in the elderly, lower quality sleep and respiratory illnesses. A decrease in cool periods compounds these challenges throughout the century. These effects are expected to be pronounced in cities, like Tunis, but the country as a whole is predicted to experience significant warming. Please see Table 22 for country-level data.

Table 22 Projected climate indicators at the national level (World Bank data)

Time Period and Emission Scenario	Hot Days (over 35°C)	Heat Index	Probability of Heat Wave	Cooling Degree Days (°C)
2020-2039 (RCP 2.6)	7.16	2.86	0.01	180.47
2040-2059 (RCP 2.6)	9.62	3.88	0.02	245.11
2060-2079 (RCP 2.6)	10.36	3.58	0.02	239.91
2080-2099 (RCP 2.6)	9.68	4.20	0.02	234.48
2020-2039 (RCP 4.5)	7.17	2.62	0.02	203.14
2040-2059	11.23	4.40	0.03	312.76

(RCP 4.5)				
2060-2079 (RCP 4.5)	15.09	6.22	0.04	402.74
2080-2099 (RCP 4.5)	17.35	7.05	0.05	445.81
2020-2039 (RCP 8.5)	7.69	3.32	0.02	213.00
2040-2059 (RCP 8.5)	14.21	7.30	0.04	396.12
2060-2079 (RCP 8.5)	23.04	12.09	0.08	653.85
2080-2099 (RCP 8.5)	34.08	17.91	0.13	947.87

Climate indicators at the national level show strong upward trends in heat, the number of hot days and a greater likelihood of heat waves. A higher heat index tends to cause heat-related stress and illness that can be detrimental to health. Additionally, the warming trend shows a significant increase in cooling degree days. That is when temperatures are warmer the demand for cooling surges and puts pressure on energy infrastructure. Hotter outdoor temperatures are associated with warmer indoor temperatures, especially in buildings with insufficient cooling mechanisms. Under a high emission scenario, there is a sharp rise in the likelihood of a heat wave throughout the century.

The projected change of warm periods is 0.117 for 2040-2070 under a medium emission scenario (RCP 4.5), this measures the count of consecutive days when the daily maximum temperature exceeds the 90th percentile of maximum temperatures within a 5-day window during the baseline period (1960-1990).[73]

The future climate scenarios bring with them higher vulnerability to extreme weather events, especially those related to hotter temperatures and aridity like heat waves and drought. Modelling shows an increase in the probability of heat waves from 1% to 19% between 2020 and 2099.

The German Climate Service Center (GERICS) analysed 32 climate models and found the increase in higher temperatures would likely yield longer lasting and more intense heat waves, causing up to 78 additional heat wave days each year by the 2080s.[74]

[73] ND-Gain Index.

[74] GERICS. Climate Fact Sheet Tunisia.

Research from WHO expects an even larger number of warm spell days. Under their projections, an increase of 180 days on average will be the norm by 2100, compared to 1990, under the RCP 8.5 scenario (WHO, 2015). While this number will still rise under lower emissions, it is expected warm spells will be limited to 40 days. (See Figure 20 for future projections).

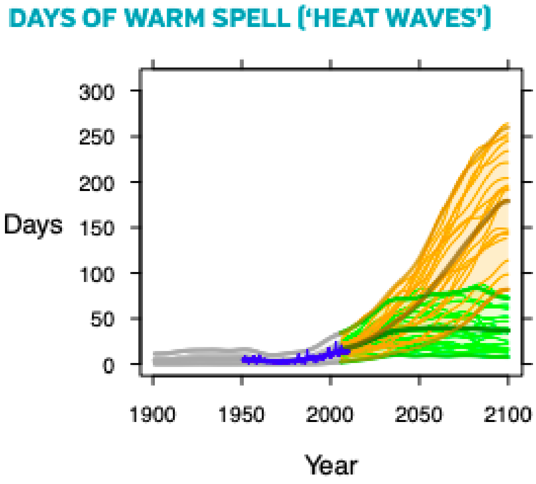

Figure 19 Additional heat wave days (WHO data)

Moreover, models produced by the Global Facility for Disaster Recovery and Reduction expect Tunisia to suffer a high risk of extreme heat. This classification suggests that "prolonged exposure to extreme heat, resulting in heat stress, is expected to occur at least once in the next five years."[75] (See Figure 21 for the vulnerability map).

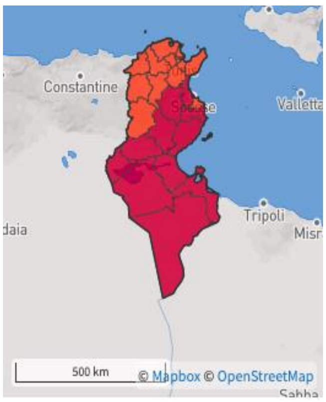

Figure 20 Extreme heat risk, Tunisia (GFDRR)

Unless significant changes to adaptive mechanisms are made to help people cope under such extreme temperatures, the country could experience large economic shocks and enormous health challenges.

2.11.1.3. The impact of high temperature on health

[75] Think Hazard. Tunisia. Available at https://thinkhazard.org/en/report/248-tunisia/EH

Equally, impacts on health are worrying. Under a high emission scenario, 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 over 65 population (WHO, 2015). Under a low emission scenario, heat-related mortality gradually declines in the same period (see Figure 22 for more information).

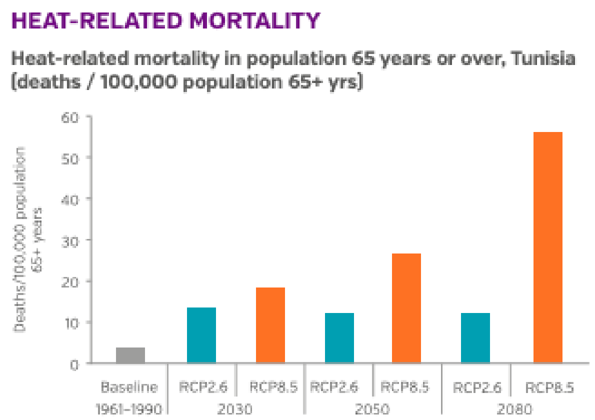

Figure 21 Heat-related mortality in Tunisia under different emission scenarios (World Health Organization data)

Children, the poor and those with chronic illnesses are also expected to suffer significantly. 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 (World Bank, 2017). To offset some of these risks, it is vital to have access to cooling mechanisms indoors during the hottest periods. This helps regulate temperature and comfort and lowers vulnerability to respiratory stress.

2.11.1.4. Economic Vulnerability

In a broader vulnerability context, it is thought that Tunisia's exposure will be from more localised and intense disasters impacting basic infrastructure. Tunisia's building sector is expected to grow significantly, with housing stock reaching 3.2 million units by 2030 and 0.8 million of those in the residential sub-sector alone (PEEB, 2017). The country has committed to significant mitigation actions, including the goal of reducing carbon intensity by 40% by 2030, but fewer adaptation measures. For example, thermal regulations are only mandatory for new residential and office buildings and voluntary mechanisms for enhancing energy efficiency are not implemented at a high rate. Therefore, enhancing adaptation measures for cooling must be a focus in the country.

Moreover, Tunisia's large tourism sector accounts for a third of total consumption within the commercial and public services subsector, often due to cooling needs. As warming continues, energy demand is likely to increase especially during peak-hour times when the need for air conditioning is at the highest. According to 2014 figures, around 35% of housing units had air conditioning, with household appliance ownership increasing rapidly (IEA, 2018). Yet, currently, "the existing infrastructure and generation capabilities are ill-prepared to cope with the projected effects of climate change and increased demand" (World Bank, 2017). Energy outages and/or prolonged blackouts can deteriorate human health and lead to social unrest.

Therefore, upscaling the PEEB Cool programme could significantly lighten the burden placed upon the energy grid, especially during peak months.

Links between health, productivity and economic output have been well-established (see introductory literature overview for more details) and the same is true for Tunisia. Tunisia's rapid increase in housing prices has forced those in the lower and middle classes into informal housing "that offer low comfort to residents and increase the burden on the government budget in the long run" (OECD, 2018). With more suffering from heat-related stress or illness, the higher probability that output or productivity will fall. This is especially troubling as the IMF estimates an economic contraction of 4% due to the pandemic. This combined with limited tourism (due to health precautions) and rapidly warming temperatures could put the country at economic risk.

2.11.2. Market context and barriers

2.11.2.1. Strategic context and market potential

Tunisia ratified the **Paris Agreement** in October 2016, committing to reduce by 41 % the carbon intensity of the Tunisian economy by 2030, relative to the year 2010 – according to its **National Determined Contribution** (NDC).

In fact, the net gas emission per inhabitant in Tunisia is estimated around 3 t CO2e, lower than the world average of 5 t CO2e. However, Tunisia is **vulnerable to climate variability and climate change**, i.e. through sea level rise (threatening 1150km of coastline with significant economic activity), water security challenges, a high dependence of GDP on agriculture, as well as the increased probability of heat waves (rising form 1% to 19% between 2020 and 2099).[76]

Current emissions occur mostly in the energy sector (69% of the total GHG emission in 2012). Hence, the NDC's **mitigation targets** (2015) aim at a reduction of the carbon intensity in the energy sector of around 46% by 2030.The contribution of building sector in the reduction of greenhouse gas emissions is about 56% of the total energy efficiency measures foreseen. The financing needed to reach those objectives in the energy sector have been evaluated around 84% of the total funding need, and 39% specially for the energy efficiency sector.

In term of the Tunisian **energy balance**, which reached 8.1 Mtoe in 2018, the building sector is the most important energy consumer and represents 35% of total final energy demand. Heating and cooling accounts for 50% of the total building energy demand and is expected to double over the next decade. In addition, during the summer, electricity consumption and peak demand is growing significantly due to the use of cooling devices. The seasonal variation of the electricity demand and the peak loads experienced during summer oblige the country to make costly investments to install more power capacity and upgrade the grid infrastructure to avoid electricity blackouts. Furthermore, under the combined effects of declining national hydrocarbon production and rapidly growing domestic demand, Tunisia has become, since 2000, a net importer of energy. The primary energy deficit reached 5.7 Mtoe in 2019, which is its highest level. The corresponding primary energy demand of this year climbed to 9.6 Mtoe and the energy independence degraded to 41%.

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[76] According to a climate risk profile prepared by USAID, https://www.climatelinks.org/sites/default/files/asset/document/Tunisia_CRP.pdf

In 2016, the government adopted an **Energy Transition Plan** aiming particularly at developing renewable energy (increasing the share from 3% to 30% by 2030), and improving the demand side management through smart grid infrastructures and the acceleration of the energy efficiency program. The two main public institutions involved in the transition plan are Tunisian Society for Electricity and Gas (Société Tunisienne d'Electricité et de Gaz, STEG), which has the monopoly on gas transportation and distribution as well as electricity distribution, and the National Energy Management Agency (Agence nationale de la Maîtrise de l 'Energie, ANME).

Since the early 2000's, the government accelerated **energy efficiency (EE) policies** aiming at:

- Reducing energy dependency regarding fossil energy thanks to demand side management and the diversification of energy resources (renewable energy)
- Improving security of energy supply
- Improving economic competition thanks to the reduction of energy costs

The country adopted multiple laws and incentive actions in order to promote energy efficiency. In this framework, under the 2005-82 law, the National Energy Management Fund (Fonds National de la Maîtrise de l'Energie, FNME) was created in order to support actions aiming at rationalizing energy consumption (energetic audit, program contract, co-generation, etc.). This fund was transferred into the Energy Transition Fund (Fonds de Transition Energétique, FTE), in 2015. Multiple frameworks have been elaborated of which the National Solar Plan (2010- 2016) is particularly noteworthy as it aims at scaling up the renewable energy and EE programs at the national level.

Based on Law N°2004-72 (called the energy conservation law), **thermal regulation** was introduced that ensures minimum EE standards in specific building types, which are currently collective dwellings (since December 2009) and office buildings (since August 2008). The regulation currently excludes social housing and self-constructed housing units, due to the operators' incapacity of supporting extra costs involved on the housing prices (sales prices being capped).

Law 2004-72 also stipulates **labeling of appliances** and **minimum energy performance standards** (MEPS), which indicate their level of consumption. Labeling started in 2004 with the labeling of refrigerators, freezers and combined devices and was reinforced in 2005, 2008 and 2009, by the publishing of the regulation text related to the minimum energy performance of refrigerators, freezers and combined devices. By the beginning of 2010, each refrigerator sold on the Tunisian market had to have an energy label class of 3 or better which is similar to EU label class B or better. The same strategy was adopted regarding the Labeling and MEPS program of the air conditioning. After the publishing of the Order related to the labeling of individual air conditioning units with a cooling capacity of less than 12 kW in 2009, the regulation text related to the their minimum energy performance was issued in 2009 and 2010 to prohibit the marketing of the air conditioning appliances provided for in article one of the law herein belonging to class 3 of the energetic effectiveness and this as from 1st January 2012.

The policy environment in Tunisia is very conducive to updating and extending **green cooling** initiatives. Tunisia has ratified the Montreal Protocol (1989) and established a National Ozone Committee (2000) for monitoring import quota for ODS banks and HFCs in the future. The ratification of the Kigali Amendment was approved by the Prime Minister and has been sent to the Parliament for approval (expected in October 2020).

The proposed **PEEB Cool programme** aims at transforming the construction sector by advancing energy efficiency and resilient building design, construction and operation. Throughout its activities, PEEB Cool will highlight key thematic areas of energy efficiency in buildings: (i) bioclimatic designs and efficient cooling solutions, (ii) sustainable construction materials, and (iii) broad stakeholders (both public and private sector) mobilisation within the construction ecosystem. **In Tunisia,** PEEB Cool activities would complement the existing context and potential well. Indicatively proposed activities (see section iv below) will put the focus on residential and social housing sectors as well as (district) cooling (both from an investment and an enabling environment perspective).

2.11.2.2. Analysis of relevance of barriers

Barriers type	Country specific relevance
Technical barriers	
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	Project stakeholders such as the ANME have a longstanding history of technical expertise and can rely on a large number of studies conduced by national and international actors to complement their expertise. Construction project owners can access the expertise of ANME through national promotional programs i.e. on expert advice on energy performance of building prior to construction.
Financial barriers	
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	Tunisia is in a difficult economic situation, with causes for this going back prior to the COVID-19 pandemic. Therefore, national government priorities on allocating scarce public resources as well as individual's and companies' consumption and investment choices were and are not focused on the buildings sector.
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	No tailored financial solutions such as green mortgages exist. Some capacity building activities for local banks on financing energy efficiency have been started and could lead to an increased awareness of the finance sector to the benefits of green construction finance and green mortgages.
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 competences in the private sector are well developed and significant innovation potential exist, however, business opportunities remain scarce. This limits current market growth for adapted services.
Regulatory and institutional barriers	

National and sectoral strategies and policies for the decarbonisation of sector often lack clarity (e.g. lack of clear sectorial targets and specific actions)	The core regulation for buildings and appliances is well-developed and available, however, the implementation is very delayed in certain cases. Therefore, updates of existing strategies and instruments are necessary to the current situation, in order to ensure relevance of public policy to tackle the identified objectives.
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	Tunisia has classified its climate zones, and a building code for new buildings exists that covers almost all sectors. Enforcement, however, remains weak. Additional regulatory texts for missing sectors are prepared and fed into the national law-making process but not yet applied. Additionally, updates i.e. on labelling requirements or the development of a regulation on energy efficient renovation is urgently necessary.
Sector stakeholders lack knowledge and awareness on energy efficient and resilient buildings and are highly fragmented	National ministries and federations, as well as line sectoral institutions such as ANME or local authorities have good knowledge energy efficiency and resilient buildings. Yet, reinforcement of the competences is necessary to make sure local capacities are up to date with the newest regulations available, as many of the awareness-raising activities were conducted several years ago.

2.11.2.3. AFD experience in financing buildings construction of refurbishment projects

AFD in Tunisia, is particularly involved in financing of construction and/or refurbishement of **hospitals and urban public facilities**. Within the Programme for Energy Efficiency in Buildings (PEEB), an initiative by the French and German governments, support was mobilized for two hospital projects in Tunisia in order to implement energy efficiency measures (described below).

Since 2016, AFD is supporting the **health sector by financing the construction and the refurbishment of two hospitals** in Gafsa (through a debt restructuring of 80 M€) and Sidi Bouzid (since 2018, through a sovereign loan of 76 M€). Those two constructions will be categorized as the first two “green” hospitals, complying with eco design requirements and energy efficiency measures. Each operation is benefiting from a grant of 1 million € from the European Union and a grant of 300k € from the PEEB program, in order to finance respectively the extra cost generated from energy efficiency investment and the technical assistance. Through the PEEB, the technical assistance consultants produced a report in order to (i) verify the eco conception measures in regard of international certifications (ii) realize a carbon assessment comparing the existing functioning systems in the hospitals and the impact of the two hospitals in construction (iii) propose an environmental performance scheme (iv) propose guidelines for the health Ministry in the establishment of an orientation for high energetic performance constructions for their health buildings.

Furthermore, AFD is the historical donor in the **urban development sector** in Tunisia. For 25 years, AFD has been financing urban regeneration operations (for a total amount of 345M€). Two programs of urban rehabilitation on the national level have been financially supported. They consist in the rehabilitation of roadways and the construction of infrastructures as public collective structures (sport facilities, libraries, etc.). In 2018, a loan of 77M€ was granted to the Tunisian government in order to implement the program in 146 districts. AFD is also working in a close partnership with the "Agence Foncière de l'Habitat" (AFH) (House land agency) in order to promote sustainable urban planning. An operation of around 25M€ is under the examination process, and consists in planning a 264 Ha area in Ezzahra Rades. The operation aims at replying to the housing deficit and the informal urban spread challenges. AFD is also in discussion with the Equipment and Housing Ministry, in order to support their social housing program up to approximately 1000 social housing units while upgrading the quality with energy efficiency measures. This project is currently on standby.

AFD's subsidiary focusing on **private sector**, PROPARCO, is also active in financing, through either debt or equity, projects with a strong focus on **building construction in different sectors**: health, education, tourism, housing or industries, and works actively at promoting the adoption of energy efficiency measures in the design of such projects. For example, an ongoing operation in Tunisia concerns financing an industrial project to improve its access to clean energy while improving the energy efficiency of the production site. This project aims at reducing significantly the overall carbon footprint of the prospect by (i) diversifying its energy mix with solar panels; (ii) reducing water consumption through the recycling of used water, (iii) installing an Energy Management System, enabling real time energy consumption monitoring and controlling. PROPARCO wishes to accompany the prospect through the direct financing of its development plan through debt and a technical assistance to further improve its E&S process.

2.11.2.4. Environmental public policies analysis

Environmental policies related to the building sector

The national contribution aims at -13% of the carbon intensity in 2030 compared to the year 2010 and -41% conditioned on the availability of financing. This reduction will be achieved in particular by:

- -30% of energy demand through EE (-15% building, -8% industry, -7% transport)
- +30% of the share of RE (13.8% wind, 11.9% photovoltaic, 3.5% concentrated thermal solar, 0.8% biomass).

ANME is the entity in charge of EE and energy transition, it manages the Energy Transition Fund (FTE) which finances investments in RE (especially self-consumption projects).

A (basic) thermal regulation for tertiary (2008) and residential (2009) buildings is in place (thermal zoning, performance or prescriptive approaches). Energy labeling has been in place since 2004 with the progressive banning of the least efficient equipment, including air conditioning (EER>3 for non-reversible air-cooled units, higher thresholds for reversible or water-cooled units). The air conditioning market represents between 39 and 48,000 units per year in 2016, 68% are reversible and 11% with inverter systems.

A regulatory framework is in place for the sale of all or part of the PV electricity produced.

Eco-construction and eco-development are topics promoted and managed by different national players which find themselves in dedicated events, through for example the annual eco-construction days which have been taking place for the last twelve years.

Adaptation to climate change policies

The identified climate change related risks are: increase in average temperatures and heat waves, decrease of precipitations (despite localized increase resulting in flooding). The main vulnerabilities are related to the water resources, agriculture and ecosystems, the coast line, fishing and aquaculture, tourism and health. With the exception of the coast line issues, the built environment is neglected within the adaptation policies:

- Water resources: non-conventional water sources (desalinization of sea water, treated water), artificial ground water recharge, water saving strategies (mainly in agriculture)
- Coast line land planning: regulatory measures

2.11.2.5. Summary of stakeholders consultation

The **main public stakeholder in the energy efficiency** sector is the **National Energy Management Agency** (Agence Nationale de la Maîtrise de l'Energie, ANME). ANME is a public structure created in 1986 under the responsibility of the Ministry of Industry and Energy . The ANME is in charge of the implementation of energy saving politics through the development of Energy Efficiency (EE) and renewable energy (RE). Also attached to the same Ministry, STEG (Société Tunisienne d'Electricité et de Gaz) the national electrical company, is a major player in the field.

In terms of **climate transition**, the **Ministry of Environment and Local Affairs** (Ministère des Affaires Locales et de l'Environnement, MALE) has been designated to act as the focal point for Green Climate Fund and has the responsibility to coordinate and implement the United Nation Climate change framework. In relation to the potential **cooling activities** within PEEB Cool, the subordinated agencies **National Agency for Protection of the Environment** (Agence Nationale pour la Protection de l'Environnement, ANPE) and the **National Agency for Waste Management** (Agence Nationale pour la Gestion des Déchets, ANGeD) are additional relevant stakeholders. ANPE is hosting the National Ozone Unit and is responsible for the implementation of the Montreal Protocol and Kigali Amendment.

For the **building sector** and particularly the **housing** sector, the **Ministry for Equipment, Housing and Urban Planning** (Ministère de l'équipement, de l'habitat et de l'aménagement du Territoire, MEHAI), is in charge of residential housings construction. The Urban Rehabilitation and Renewal Agency (Agence de Réhabilitation et de Rénovation Urbaine, ARRU) was created in 1981 in order to rehabilitate deprived neighborhood. When concerning specific types of public buildings, national line ministries such as the Ministry of Culture (i.e. for the introduction of an energy efficiency heritage label) are relevant stakeholders.

Within the context of the preparation of PEEB Cool Tunisia, consultations were held with the key stakeholders mentioned above.

A number of other stakeholders intervene with regards to specific aspects of the buildings sector and will be involved in the implementation of the program.

- The national laboratory called Technical Center for Mechanical and Electrical Industries (Centre technique des industries mécanique et électrique, CETIME), with energy certification laboratories for household appliances: refrigerator, washing machine, and air conditioners <12Kw.

- The Ministry of Trade, with the responsibility of controlling the domestic market related to labelling program
- The National Certification body (Institut National de la Normalisation et de la Propriété Industrielle, INNORPI) as the entity responsible for the adoption and transposition of international norms and standards.
- AL BUHAIRA INVEST as a semi-state company under the responsibility of the MEHAI and a private group which is responsible for the territorial development of the Lake Tunis area, and which works in close collaboration with the ANME for the development of district cooling and heating network (RFU: Réseau du froid urbain) in the area where the feasibility study funded by the French cooperation FASEP has shown that the power of the cooling and heating network is 20Mw refrigeration as potential for this area.

2.11.3. Project description

2.11.3.1. Project’s objectives and description

39% of the total funds to reach Tunisia’s NDC objectives is needed in the EE sector in order to reach the goal of carbon intensity reduction of the energy sector by 46% by 2030, and of the total economy by 41% by 2030. In this context, Tunisia (and in particular ANME) is welcoming the support from PEEB Cool. The following thus summarizes the results of stakeholder consultations about potential activities that could be supported within PEEB Cool’s project and policy facilities.

3. Investment Facility

Three potential projects for the investment facility of PEEB Cool are listed below (the list is not exclusive), depending on the discussion’s progress. Those projects could benefit from PEEB Cool support and depict country ownership with regard to addressing energy efficiency challenges. PEEB Cool program being based on a demand-based approach, the project that would be eventually supported will depend on the discussion’s progress with local stakeholders as well as country’s current priority.

- **PROMO-ISOL project:** The current regulation introduces energy efficiency measures only for the new constructions. PROMO-ISOL aims the reduction of heating and cooling energy consumption in individual homes, reducing significant GHG emissions and creating jobs. PROMO-ISOL consists of the implementation of a financial mechanism to promote thermal insulation of 65 000 roofs for individual housing units, of which two thirds in existing housing units and one third in new housing units. The mechanism offers up to 20% of grants for roofing isolation constructions. PROMO-ISOL will contribute to the energy savings of around 422.5 ktoe over the life time of the thermal solution and avoid GHG emissions of around 990 ktCO2. PEEB Cool support could aim at the financial mechanism of PROMO-ISOL program, capacity (5MEuros), Capacity building (200k Euros), and MRV in the housing sector (100k Euros).
- **Social housing:** The project consists in supporting MEHAI in the implementation of the social housing programs (20 000 of social housing units), by financing around 1000 social housing units in different areas of the country, while scaling up the quality by integrating energy efficiency measures. The objective aims at impacting the design and construction of social housing in order to allow sustainable technical and economic integration of energy efficiency performance. The project could be financed through a credit line to the MEHAI. In addition, (i) a grant from the PEEB could finance technical assistance and (ii) a grant from the UE, could finance the extra cost of energy efficiency investment. AFD’s support is still under discussion (3MEuros).

- **Development of the lake area with the SPLT** (Development company of the Tunis Lake. Société de promotion du Lac de Tunis, SPLT): SPLT is a public private company owned at 50% by the state and 50% by Dallah El Baraka Group, a Saudi investor, created in the 1985, aiming at developing the banks of the lake. The SPLT plans and elaborates the different planning studies, equips the lands, and commercialize them to private developers. The Lake area under the SPLT is around 11,1 million of m² with about half dedicated to housings (around 34 000 housings) (10MEuros).
- **Others:** AFD has been recently approached by the European Union (DG Near) with the BEI in order to discuss about the AFD and BEI's interest in collaborating in the implementation of UE project "CLIMAMED". The project consisted in a technical assistant in order to establish Sustainable Energy and Climate Action Plan (SECAP). 116 SECAP have been established and different projects have been identified (each project going from 200 K € to 8M€). A new technical assistant has been mobilized in order to study the bankability of the projects. The conclusions of this technical assistant will allow the AFD to have a position on whether to collaborate or not.

The below tables outline the GHG baseline emissions and emissions reductions for a Tunisia residential case, followed by a hospital case. Full calculations can be found in Annex 22c.

Residential case:

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	346,089
Emissions - 20% reduction case	261,838
Emissions - 40% reduction case	237,098
GHG reductions - 20% reduction case	84,251
GHG reductions - 40% reduction case	108,991
GHG reductions - average of 20% and 40% reduction case	96,621

Emissions without EE measures (baseline):	Source of information	Unit	Value
Tunisia			
Type of building			Residential
m2 impacted	A	m2	340,000
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	69
Natural gas	C1	kWh/m2/yr	60
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.404
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			

Electricity	F1 = B1 x D	kgCO2/m2	27.9
Natural gas	G1 = C1 x E	kgCO2/m2	13.9
Building materials	H1	kgCO2/m2	391.8
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	9,479
Natural gas	J1 = G1 x A	tCO2/yr	4,712
Electricity	I1 = F1 x A x L	tCO2 over lifetime	142,189
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	70,686
Building materials	K1 = H1 x A	tCO2 over lifetime	133,214
Total		**tCO2 over lifetime**	**346,089**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	48
Natural gas	C2	kWh/m2/yr	50
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.404
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	19
Natural gas	G2 = C2 x E	kgCO2/m2	11.6
Building materials	H2	kgCO2/m2	305.9
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	6,594
Natural gas	J2 = G2 x A	tCO2/yr	3,927
Electricity	I2 = F2 x A x L	tCO2 over lifetime	98,914
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	58,905
Building materials	K2 = H2 x A	tCO2 over lifetime	104,019
Total		**tCO2 over lifetime**	**261,838**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	48
Natural gas	C3	kWh/m2/yr	29
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.404
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	19
Natural gas	G3 = C3 x E	kgCO2/m2	6.7
Building materials	H3	kgCO2/m2	305.9
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	6,594
Natural gas	J3 = G3 x A	tCO2/yr	2,278

Electricity	I3 = F3 x A x L	tCO2 over lifetime	98,914
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	34,165
Building materials	K3 = H3 x A	tCO2 over lifetime	104,019
Total		**tCO2 over lifetime**	**237,098**

GHG reductions- 20% reduction case			
Electricity	I1 - I2	tCO2/yr	2,885
Natural gas	J1 - J2	tCO2/yr	785
Electricity	(I1 - I2) x L	tCO2 over lifetime	43,275
Natural gas	(J1 - J2) x L	tCO2 over lifetime	11,781
Building materials	K1 - K2	tCO2 over lifetime	29,195
Total	Sum of 20% case	tCO2 over lifetime	**84,251**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	2,885
Natural gas	J1 - J3	tCO2/yr	2,435
Electricity	(I1 - I3) x L	tCO2 over lifetime	43,275
Natural gas	(J1 - J3) x L	tCO2 over lifetime	36,521
Building materials	K1 - K3	tCO2 over lifetime	29,195
Total	Sum of 40% case	tCO2 over lifetime	**108,991**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	2,885
Natural gas	Average 20% and 40% case	tCO2/yr	1,610
Electricity	Average 20% and 40% case	tCO2 over lifetime	43,275
Natural gas	Average 20% and 40% case	tCO2 over lifetime	24,151
Building materials	Average 20% and 40% case	tCO2 over lifetime	29,195
Total	Sum of above	tCO2 over lifetime	**96,621**

Hospital case:

GHG emissions summary (tCO2 over lifetime)

Emissions without EE measures (baseline)	169,495

Emissions - 20% reduction case	144,181
Emissions - 40% reduction case	128,399
GHG reductions - 20% reduction case	25,315
GHG reductions - 40% reduction case	41,096
GHG reductions - average of 20% and 40% reduction case	33,206

GHG emissions without EE measures:	Source of information	Unit	Value
Tunisia			
Type of building			Hospital
m2 impacted	A	m2	68,779
Lifetime of investment	L	Years	15
Baseline			
Characteristics of building			
Energy consumption			
Electricity	B1	kWh/m2/yr	256
Natural gas	C1	kWh/m2/yr	137
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.404
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F1 = B1 x D	kgCO2/m2	103.4
Natural gas	G1 = C1 x E	kgCO2/m2	31.6
Building materials	H1	kgCO2/m2	438.0
Total GHG emissions			
Electricity	I1 = F1 x A	tCO2/yr	7,114
Natural gas	J1 = G1 x A	tCO2/yr	2,177
Electricity	I1 = F1 x A x L	tCO2 over lifetime	106,717
Natural gas	J1 = G1 x A x L	tCO2 over lifetime	32,650
Building materials	K1 = H1 x A	tCO2 over lifetime	30,128
Total		**tCO2 over lifetime**	**169,495**

20% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B2	kWh/m2/yr	254
Natural gas	C2	kWh/m2/yr	39
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.404
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F2 = B2 x D	kgCO2/m2	103
Natural gas	G2 = C2 x E	kgCO2/m2	9.0
Building materials	H2	kgCO2/m2	421.7
Total GHG emissions			
Electricity	I2 = F2 x A	tCO2/yr	7,059

Natural gas	J2 = G2 x A	tCO2/yr	620
Electricity	I2 = F2 x A x L	tCO2 over lifetime	105,884
Natural gas	J2 = G2 x A x L	tCO2 over lifetime	9,294
Building materials	K2 = H2 x A	tCO2 over lifetime	29,003
Total		**tCO2 over lifetime**	**144,181**

40% reduction case			
Characteristics of building			
Energy consumption			
Electricity	B3	kWh/m2/yr	219
Natural gas	C3	kWh/m2/yr	34
GHG emissions factors			
Electricity	D	kgCO2/kWh	0.404
Natural gas	E	kgCO2/kWh	0.231
Total GHG emissions per unit			
Electricity	F3 = B3 x D	kgCO2/m2	88
Natural gas	G3 = C3 x E	kgCO2/m2	7.9
Building materials	H3	kgCO2/m2	421.7
Total GHG emissions			
Electricity	I3 = F3 x A	tCO2/yr	6,086
Natural gas	J3 = G3 x A	tCO2/yr	540
Electricity	I3 = F3 x A x L	tCO2 over lifetime	91,293
Natural gas	J3 = G3 x A x L	tCO2 over lifetime	8,103
Building materials	K3 = H3 x A	tCO2 over lifetime	29,003
Total		**tCO2 over lifetime**	**128,399**

GHG reductions - 20% reduction case			
Electricity	I1 - I2	tCO2/yr	56
Natural gas	J1 - J2	tCO2/yr	1,557
Electricity	(I1 - I2) x L	tCO2 over lifetime	834
Natural gas	(J1 - J2) x L	tCO2 over lifetime	23,355
Building materials	K1 - K2	tCO2 over lifetime	1,126
Total	**Sum of 20% case**	**tCO2 over lifetime**	**25,315**

GHG reductions - 40% reduction case			
Electricity	I1 - I3	tCO2/yr	1,028
Natural gas	J1 - J3	tCO2/yr	1,636
Electricity	(I1 - I3) x L	tCO2 over lifetime	15,424
Natural gas	(J1 - J3) x L	tCO2 over lifetime	24,547
Building materials	K1 - K3	tCO2 over lifetime	1,126
Total	**Sum of 40% case**	**tCO2 over lifetime**	**41,096**

GHG reductions - average of 20% and 40% reduction case			
Electricity	Average 20% and 40% case	tCO2/yr	542
Natural gas	Average 20% and 40% case	tCO2/yr	1,597
Electricity	Average 20% and 40% case	tCO2 over lifetime	8,129
Natural gas	Average 20% and 40% case	tCO2 over lifetime	23,951
Building materials	Average 20% and 40% case	tCO2 over lifetime	1,126
Total	**Sum of above**	**tCO2 over lifetime**	**33,206**

4. Enabling Facility

The enabling facility is directly linked to the sectors of intervention of the investment facility, and is expected to mobilize additional investments and extend the climate impact of PEEB Cool beyond the program duration. Tunisia is a current PEEB country and ongoing support has allowed to identify likely future needs and potentials. The following non-exhaustive examples of activities could potentially be supported but will have to be agreed upon depending on the financed projects with the project partner at program start.

2.1. Sectoral investment frameworks

This output aims at strengthening public and private investment towards energy efficiency and resilience in buildings through support in the development of key sectoral and private sector led roadmaps, investment plans, engagements and/or initiatives in sectors targeted by the investment facility's technical activities, such as the social housing or district cooling sectors in Tunisia.

2.2. Support for public policies

Despite the fact that Tunisia has an interesting regulative framework on energy efficiency in buildings as the building code, energy audit, incentive mechanism, several programs in place, further refinement is needed to propel large-scale transformation in the building sector. This includes for example an update and generalization of the energy efficiency building code, the development of energy certificates for buildings, as well as the improvement of the framework conditions for cooling. The potential for usage of local and climate-adapted building materials to decrease the carbon footprint of the buildings and construction sector as well as to provide opportunities for local economic development could be analyzed more in depth and result in policy recommendations. The following options for public policy support will be subject to the discussions at program start:

- **Update of the energy building code**, which is currently based on the energy need, with **a priority on sub-sectors such as social housing (addressed within the investment facility)**. The new version will take into consideration the energy consumption of the building and it will be focused on the main energy users such as cooling and heating. The results of this updating could form a baseline by building sub-sector in terms of Kwh / m^2 / year in order to achieve the objectives of the NDC's. The mains topics to develop are a) establishment of the legal frame work regarding the labeling and minimum requirements on the energy performance of new buildings and existing buildings, b) a methodology of calculation of the energy performance of buildings: Calculation of energy consumption for space heating and cooling, domestic hot water, ventilation, lighting, integrated building automation and controls, envelope, c) the development of sophisticated software and d) the development of the energy balance of building (total indicative budget: 100k EUR – 200k EUR)
- **Introduction of energy certification of buildings,** this means developing a certification process with inspections or audits, and the definition of validity periods, as well as the setting up of third party financing for energy investments in the public sector, and the introduction of an incentive for the private sector to improve the energy performance of buildings and the certification of buildings. **Early starting sectors could again be social housing sector or municipal buildings, in order to guarantee the interlinkages with the investment facility**. According to the EU's experience with Energy Performance Certificates, while they do not directly reduce emissions, they contribute to the overall energy transition by increasing the awareness of renters and buyers of their future dwelling's energy and emission footprint[77]. If additionally, EPC data is centralized in a database, targeted policy options (i.e.

[77] https://ec.europa.eu/energy/sites/ener/files/documents/20130619-energy_performance_certificates_in_buildings.pdf

to decrease emissions in certain building types even further) could be developed (total indicative budget: 100k – 500k EUR)
- Developing an **enabling framework for district energy**, by developing best practice policies, mobilizing policy and finance support, and developing a technically feasible project pipeline across the country. **This is directly linked to the potential financing extended to the Development Company of the Tunis Lake (SDLT**). District Energy consist of joining heating and cooling demand with district heating and cooling system (DHC) in areas of high urban density: industrial and touristic zones, and areas with high density of buildings. Through this, Tunisia could benefit from reduced stress on the electric grid, energy efficiency improvements due to economics of scale, use of local and renewable resources, improved air quality, lower refrigerant emissions and reduced CO2 emissions for heating and cooling, contributing to the Paris Agreement and the Kigali Amendment to the Montreal Protocol (estimated budget: 100 - 500k EUR)
- **Labeling of air conditioners** with a cooling capacity of more than 12 kW (this covers i.e. central air conditioning units). This would include the implementation of legal framework related the labeling of the air conditioning appliances of a cooling power more than 12 KW, the implementation of testing facilities (with CETIME), and the establishment of the technical specifications related to the procurement of air conditioners. **First labeling efforts could be implemented in close cooperation with experiences from industrial energy efficiency projects that include improvement of energy efficiency of air conditioning systems.** Direct emission savings will be achieved through improvement of the energy efficiency ratio of the new ACs by approx. by 20%, as well as by measures promoting low GWP gases in manufacturing (total indicative budget: (500-1MEUR)
- Introduction of a **building label for heritage buildings**, adapting the French label "Effinergie Patrimoine". Activities would include mapping of historic buildings, adapting the label to the Tunisian context, implementing a case study, generalizing a technical guide, and mainstreaming the labeling process. This could be implemented by ANME, the Ministry of Culture and the Ministry of Equipment in collaboration with the National School of Architecture and Urban Design, the startup dB Sense and ENIT, a real estate developer, and the French Effinergie collective (total indicative budget: 50-100k EUR)

2.3. Capacity building for sector actors

Within this activity, a number of capacity development measure could be foreseen, such as:

- The already initiated Tunisian National Alliance for Buildings and Construction could be strengthened in terms of activities, membership engagement and stakeholder rallying for the sector's transformation, **therefore contributing to an improved investment framework.**
- On the job training for municipalities, verification offices, and seconded experts to e**nsure proper application of the thermal regulation could be reinforced and extended nationwide**.
- Capacity building and awareness raising activities are furthermore relevant for accompanying 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.
- If a building certificate is introduced, capacity building activities for public sector employees as well as engineers and architects is necessary for a speedy adoption of this instrument.

As a consequence, Tunisian actors in the buildings and cooling sectors are better equipped to integrate energy efficiency aspects into their professional activities (total indicative budget: 20 – 200k EUR).

2.11.3.2. Impact potential

The impact potential of PEEB Cool is described at program level in the funding proposal. Due to the multi-country nature of PEEB Cool, these impacts are calculated based on a portfolio approach and not on a country by country basis.

The program is expected to have impacts at mitigation and adaptation level.

- At mitigation level, the program will improve the energy performance of buildings targeted in the projects, both directly (through direct financing of energy efficiency measures) and indirectly (through updated regulations on buildings). To assess total program impact:
    - AFD has taken into account the avoided GHG emissions per square meter in all PEEB Cool countries at projects operation phase and construction phase. This has been performed by assessing energy consumption by building and climate zone, energy reduction for each type of building and calculation of avoided CO2 emissions per square meter considering the CO2/kWh ratio of all PEEB Cool countries.
    - Those avoided emissions per square meter have been combined with an assessment of investment area (total square meter) of PEEB Cool based on PEEB experience.
    - Indirect impact expand those impacts in countries that already have a thermal regulation in buildings being effectively implemented.
- At adaptation level, direct and indirect beneficiaries have been assessed by identifying the beneficiaries for each building type.

Consultations with Tunisian authority has led to a list of three potential projects for the investment facility as well as example for potential activities that could be carried out in the enabling facility. Once the program is approved by GCF and AFD board, bilateral discussions will be hold to further precise how PEEB Cool will be implemented in Tunisia. Based on this information, it will be possible to assess the mitigation and adaptation impacts of PEEB Cool activities in Tunisia.

2.11.3.3. Paradigm shift potential

Potential for scaling up and replication*:* PEEB Cool provides both financial instruments and technical assistance at project and national levels, and therefore targets both financing of large scale building projects as well as the establishment of incentive programs and improved public policies for the buildings sector to accompany the activities on the national level. This makes program activities easily scalable (i.e. by later attracting additional financing for similar building typologies from other financing institutions) and replicable (i.e. in other buildings that are to be constructed under the business as usual scenarios). Additionally, PEEB Cool is not limited to one national partner. In fact, the program will target stakeholder involvement and capacity building in energy efficiency measures in a variety of different actors from energy generation (STEG) to waste management (ANGeD). PEEB Cool could also renew the dynamic around the social housing project with the Ministry of Equipment. Tunisia needs an additional 40 000 housing units a year in order to cover demand, leading to a large replication potential for both simple and more complex energy efficiency measures in the housing sector in particular. A support in the development of a national district energy strategy and the identification of a pipeline for district cooling cooling could furthermore be the start of a new sub-industry and lead to replication and scale-up across the country.

Potential for knowledge and learning: PEEB Cool enables the creation of knowledge through the demonstration of financial and technical feasibility of projects, and therefore provides ample learning opportunities for integrating energy efficiency aspects as a standard into buildings projects – be it through a generalization of trainings supports within the project through all municipalities in Tunisia, ANME regional antennas, or health facility managers. These learnings will furthermore be collected and presented in the investment facility's activities. Within the investment facility, project technical assistance is designed to provide training to stakeholders (project owner as well as engineers) in how to design and construct green buildings.

Contribution to the creation of an enabling environment: Activities of PEEB Cool on the investment facility level through financing for promotional mechanisms, and lending towards construction and industry projects pave the way for better technical, managerial and financial understanding of energy efficiency in buildings and therefore improve the market's capacity to absorb and develop further projects. Activities of PEEB Cool on the enabling facility such as improvement of the building code, district cooling strategies, or energy performance certificate introduction provide the framework for the enabling environment. The establishment of a credit line for the PROMO-ISOL project would allow the beneficiary households to have access to subsidized financing with advantageous rates where the profitability of the project is guaranteed. This would allow to reach the objectives set by this project in terms of energy impact and quantities and anchor this construction practice in the local economy.

Contribution to regulatory framework and policies*:* The entire PEEB Cool policy component targets an improvement of the regulatory framework and policies in place. An national level, PEEB advises governments to improve the policy framework for energy efficiency initiatives. This includes establishment of standards and regulations for energy efficiency in buildings and equipment standards. In Tunisia, one of the defaults in the legal energy efficiency framework is that it doesn't cover the whole real estate sector. One of the proposed activities could therefore support ANME and other line ministries in extending the coverage to i.e. residential social housing projects. For example, the existing energy building code is included in the current NDC, but it is based only on cooling and heating demand. The update of the energy building code based on energy consumption of main usage such as cooling, heating, lighting and hot water is therefore considered a paradigm shift that would make possible he achievement of the NDC objectives for cooling and heating, additional to other equipment. The current energy certification strategy concerns air conditioning equipment <12 kw. Adopting energy certification standards for air conditioning equipment with a power greater than 12Kw will allow having a complete EE strategy in the refrigeration sector

2.11.3.4. Sustainable development potential

Environment co-benefits: PEEB Cool supports energy efficiency measures in existing and newly constructed buildings as well as in industry. These measures reduce energy demand, and therefore lower emissions associated to energy generation. Additionally, by targeting the cooling sector, PEEB Cool supports reducing reliance on and handling of refrigerant gases with significant global warming potential as well as ozone depleting substances for refrigeration and air conditioning, therefore reducing the negative impact on the atmosphere. The cross-cutting theme of low carbon building materials is another area in which PEEB Cool aims to achieve environmental co-benefits, by decreasing emissions due to extraction, production, usage and disposal of materials with a high carbon footprint. For estimates on expected tCo2e reductions, please refer to the funding proposal.

Social co-benefits: Among the projects already supported by PEEB (or the ideas of projects that could be supported by PEEB Cool), are hospitals and health centers as well as social housing which. Thanks to energy efficiency investments such as passive design measures, this will allow for more comfortable indoor ambient temperatures and therefore a better environment for vulnerable populations. In addition, several of the potential projects are located in "interior" regions of Tunisia that are less wealthy, therefore contributing to a just development in the different regions. Technical assistance will also strengthen local expertise by ensuring the transfer of knowledge and technical skills among local experts.

Economic co-benefits: Knowing that (i) air conditioning is one of the main consumption line in the energy demand in Tunisian households, (ii) and that two third of the STEG total costs is gas purchase, the program contributes to slowing down the increase in energy demands and will allow a smoothing of the energy balance especially, and hence an optimization of public expenditures in the energy sector. Furthermore, it will reduce the households and public companies bills, and will contribute to reduce the unpaid electricity bill. PEEB Cool will also act as a stimulus to the Tunisian construction sector through the new constructions foreseen, and which help to create local economic value.

Gender-sensitive development impact: PEEB cool activities contribute to integrating a gender approach into public policies and sectoral strategies. Tunisia ranks first among Arab countries and 119th in the world in terms of gender equality, according to the annual report on gender parity of the World Economic Forum (WEF) entitled "The Gender Gap" (Global Gender Gap 2018). At the strategic level, Tunisia has put in place several strategies to ensure equal opportunities at the national and sectoral levels, but the participation of women in the formulation, advocacy and implementation of environmental policies remains low, even though the international community has recognized that there can be no sustainable development without the full participation of women. In the energy sector, women are very poorly represented in management positions (5% to 6%) compared to their weight in the overall workforce (28%). Support in the form of awareness-raising and training for project partners is therefore of paramount importance. They will thus serve as multipliers, in order to be able to contribute to reducing the gap between women and men in the sector at the level of decision-making positions, the presence at the level of sub-sectors (solar, thermal, energy saving lamps, design offices (control, audit, etc.) and by department (administrative, technical and commercial).The promotion of women in the energy sector could only have positive effects. However, care must be taken to ensure that this promotion respects the context of the country / region in question, its values, its culture, etc

2.11.3.5. Needs of recipient

Section i) strategic context and market potential has shown the vulnerability of Tunisia’s population and economy to climate change and therefore the need to both mitigate its effects as well as advance in adaptation efforts. The building segments most concerned by this are residential, educational and health buildings. While the core regulatory framework for more energy efficiency and resilience in buildings is already in place, there exists a great need and potential to strengthen the investment and regulatory framework further, through more financed projects with energy efficiency measures, improved awareness and competence development in sectoral stakeholders.

2.11.3.6. Country ownership

The Tunisian context is very favourable to activities of PEEB Cool, as the country features a strong set of committed institutions and national resources, as well as the structure of the legal and financial framework necessary for implementation and upscaling energy efficiency and resilience in buildings as demonstrated in section i) strategic context and market potential. PEEB Cool in Tunisia would also complement the existing and planned NDC readiness programs well.

PEEB Cool Tunisia is further supported by the relevant actors as demonstrated in section iii) Summary of stakeholder consultation and ANME as the key sector stakeholder in particular.

MALE as NDA, as well as ANME and entities entering into financial agreements with AFD and/or Proparco, will be the key national stakeholders during program implementation. Precise governance structures shall be discussed and validates during the first country missions after program start.

2.11.3.7. Efficiency and effectiveness

Investments in energy efficiency at building design and construction phase are typically very efficient and effective due to the long lifetime of buildings. PEEB Cool's efficiency and cost-effectiveness has been demonstrated in the funding proposal at the programme level based on typical projects. Efficiency, effectiveness, economic and financial rates of return will additionally be evaluated at the level of each identified project prior to approval. Due to the global nature of the program, best practises can easily be transferred and applied among PEEB Cool partner countries and beyond.

2.11.3.8. Logical framework and monitoring, reporting and evaluation

Due to the programme approach of PEEB Cool, the logical framework, general progress monitoring, reporting and evaluation activities are developed, monitored and evaluated at programme level (not at country level).

As such, general programme monitoring will measure achievement of the performance indicators and report on the implementation progress of the GCF project while it is being implemented. Performance indicators are identified at programme level according to the principles established in the GCF Initial Results Management Framework linking time-bound sets of activities to a set of agreed results. The inception report at the programme level will be delivered after 4 months of program start. An annual programme level performance report (APR) will be submitted to the GCF following reporting requirements under the Accreditation Master Agreement (AMA) and Funded Activity Agreement (FAA). Project mid-term (MTE) and final (FE) evaluations will be commissioned and managed by the AFD. The MTE will assess (1) the relevance, effectiveness, efficiency and likelihood of impact and sustainability, (2) the coherence in climate finance delivery, (3) gender equity and social inclusion (minorities), and (4) country ownership. The FE will assess (1) the relevance, effectiveness, efficiency and likelihood of impact (2) the coherence in climate finance delivery, (3) gender equity and social inclusion (minorities), (4) country ownership, (5) innovativeness in result areas, and (6) replication and scalability.

All details are laid out in the funding proposal (section E7) as well as in the monitoring and evaluation plan (annex 11 of the funding proposal).

2.11.3.9. Project indicative financing

The below table gives an indicative overview over the preliminary financing possible for PEEB Cool activities in Tunisia. All numbers will be confirmed once the program/projects approved by GCF and AFD.

	Total Amount (a+b)	Currency	GCF amount (a)	AFD amount (b)

1. Senior loan	180	Million EUR	25	155
2. Grant (technical support)	1.85 – 3.3	Million EUR	1.85 – 3.3	0
Total project financing (1+2)	181.85 – 183.3	Million EUR	26.85 – 28.3	155

This amounts are provisional at this stage and are still to be discussed

3. EDGE Simulation Results

1.1. Health centers

All climates

	Baseline	*20% EE scenario*	*40% EE scenario*
Water consumption			
(m^3/patient.year)	230,16	201,64	201,64
(L/patient.day)	631	553	553
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

Equatorial climate (Abidjan, Côte d'Ivoire):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	162	139	104
Air conditioning (cooling + fan + pumps)	56	24	18

Laundry	13	13	10
DHW	20	17	12
Lighting	17	17	13
Other equipment	68	68	51
CO2 Emissions			
kgCO2/m²/year	**71**	**60**	**45**

Tropical climate (Ziguinchor, Senegal):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**169**	**140**	**106**
Air conditioning (cooling + fan + pumps)	53	28	21
Laundry	13	13	10
DHW	18	14	11
Lighting	17	17	13
Other equipment	68	68	51
CO2 Emissions			
kgCO2/m²/year	**28**	**23**	**17**

Desert climate (Djibouti, Republic of Djibouti):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			

Total final energy consumption	**171**	**141**	**107**
Air conditioning (cooling + fan + pumps)	57	30	22
Laundry	13	13	10
DHW	16	13	11
Lighting	17	17	13
Other equipment	68	68	51
CO2 Emissions			
kgCO2/m²/year	**108**	**90**	**68**

Humid subtropical climate (Buenos Aires, Argentina):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**162**	**145**	**110**
Heating	14,5	12	10
Air conditioning (cooling + fan + pumps)	14,5	7	5
Laundry	13	13	10
DHW	35	28	21
Lighting	17	17	13
Other equipment	68	68	51
CO2 Emissions			
kgCO2/m²/year	**56**	**51**	**38**

Mediterranean climate (Tunis, Tunisia):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**164**	**146**	**110**
Heating	15	12	10
Air conditioning (cooling + fan + pumps)	18	9	6
Laundry	13	13	10
DHW	33	27	20
Lighting	17	17	13
Other equipment	68	68	51
CO2 Emissions			
kgCO2/m²/year	**53**	**47**	**35**

Mountain or Highland climate (Addis Abeba, Ethiopia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**160**	**145**	**109**
Heating	13	12	10
Air conditioning (cooling + fan + pumps)	12	5	3
Laundry	13	13	10
DHW	37	30	22
Lighting	17	17	13

Other equipment	68	68	51
CO2 Emissions			
$kgCO_2/m^2/year$	**116**	**93**	**70**

Semi-continental climate (Skopje, North Macedonia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**178**	**168**	**126**
Heating	26	26	20
Air conditioning (cooling + fan + pumps)	12	9	6
Laundry	13	13	10
DHW	42	35	26
Lighting	17	17	13
Other equipment	68	68	51
CO2 Emissions			
$kgCO_2/m^2/year$	**148**	**139**	**105**

1.2. Housing

All climates

	Baseline	*20% EE scenario*	*40% EE scenario*
Water consumption			
Water consumption (kL/unit/year)	**260**	**195**	**195**
Embodied energy (MJ/m²)			

Total embodied energy	**2321**	**1649**	**1649**
Floor	1026	1026	1026
Roof	171	171	171
Exterior walls	427	78	78
Interior walls	383	171	171
Ground	65	65	65

Equatorial climate (Abidjan, Côte d'Ivoire):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m^2. year)			
Total final energy consumption	**106**	**79**	**67**
Heating	NA	NA	NA
Air conditioning (+fan energy)	35	17	17
Domestic appliances	27	25	25
Common amenities	5	5	5
Lighting	9	8	8
DHW	30	24	12
CO2 Emissions			
$kgCO_2/m^2$/year	**37**	**28**	**24**

Tropical climate (Ziguinchor, Senegal):

	Baseline	*20% EE scenario*	*40% EE scenario*

Energy consumption (kWh/m². year)			
Total final energy consumption	**111**	**81**	**68**
Heating	NA	NA	NA
Air conditioning (+fan energy)	37	17	17
Domestic appliances	27	25	25
Common amenities	5	5	5
Lighting	9	8	8
DHW	33	26	13
CO2 Emissions			
kgCO2/m²/year	**51**	**37**	**31**

Desert climate (Djibouti, Republic of Djibouti):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**106**	**76**	**68**
Heating	NA	NA	NA
Air conditioning (+fan energy)	43	21	21
Domestic appliances	27	25	25
Common amenities	5	5	5
Lighting	9	8	8
DHW	22	17	9
CO2 Emissions			

kgCO2/m²/year	**54**	**40**	**35**

Humid subtropical climate (Buenos Aires, Argentina):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**134**	**102**	**78**
Heating	7	7	7
Air conditioning (+fan energy)	27	9	9
Domestic appliances	28	25	25
Common amenities	5	5	5
Lighting	9	9	8
DHW	58	47	24
CO2 Emissions			
kgCO2/m²/year	**38**	**30**	**23**

Mediterranean climate (Tunis, Tunisia):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**129**	**98**	**77**
Heating	8	8	8
Air conditioning (+fan energy)	27	10	10
Domestic appliances	28	25	25

Common amenities	5	5	5
Lighting	9	8	8
DHW	52	42	21
CO2 Emissions			
kgCO2/m²/year	**34**	**26**	**21**

Mountain or Highland climate (Addis Abeba, Ethiopia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**135**	**105**	**79**
Heating	5	6	6
Air conditioning (+fan energy)	26	9	9
Domestic appliances	28	25	25
Common amenities	5	5	5
Lighting	9	9	8
DHW	62	51	26
CO2 Emissions			
kgCO2/m²/year	**70**	**55**	**41**

Semi-continental climate (Skopje, North Macedonia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**156**	**117**	**87**

Heating	9	9	9
Air conditioning (+fan energy)	31	9	9
Domestic appliances	28	25	25
Common amenities	5	5	5
Lighting	9	9	8
DHW	74	60	31
CO2 Emissions			
kgCO2/m²/year	**105**	**79**	**59**

1.3. Hospitals

All climates

	Baseline	*20% EE scenario*	*40% EE scenario*
Water consumption			
(m^3/patient.year)	**388,34**	**284,92**	**284,92**
(L/patient.day)	**1065**	**781**	**838**
Embodied energy (MJ/m²)			
Total embodied energy	**1949**	**1886**	**1945**
Floor	1148	1148	1148
Roof	287	287	287
Exterior walls	30	30	30
Interior walls	133	70	65
Ground	199	199	199
Windows and joinery	96	96	120

Insulation	56	56	96

Equatorial climate (Abidjan, Côte d'Ivoire):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**356**	**304**	**248**
Heating	NA	NA	NA
Air conditioning (cooling + fan + pump)	107	80	49
Laundry	9	9	7
DHW	37	12	10
Lighting	24	24	21
Catering	45	45	41
Other equipment	134	134	120
CO2 Emissions			
kgCO2/m²/year	**155**	**131**	**108**

Tropical climate (Ziguinchor, Senegal):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**416**	**342**	**276**
Heating	NA	NA	NA
Air conditioning (cooling + fan + pump)	172	120	77

Laundry	9	9	8
DHW	32	10	8
Lighting	24	24	22
Catering	45	45	41
Other equipment	134	134	120
CO2 Emissions			
kgCO2/m²/year	**68**	**56**	**45**

Desert climate (Djibouti, Republic of Djibouti):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**404**	**330**	**268**
Heating	NA	NA	NA
Air conditioning (cooling + fan + pump)	163	109	69
Laundry	9	9	8
DHW	28	9	8
Lighting	25	24	22
Catering	45	45	41
Other equipment	134	134	120
CO2 Emissions			
kgCO2/m²/year	**258**	**210**	**171**

Humid subtropical climate (Buenos Aires, Argentina):

	Baseline	*20% EE scenario*	*40% EE scenario*

Energy consumption (kWh/m². year)			
Total final energy consumption	**394**	**292**	**255**
Heating	80	28	22
Air conditioning (cooling + fan + pump)	37	33	26
Laundry	11	10	9
DHW	63	18	17
Lighting	24	24	20
Catering	45	45	41
Other equipment	134	134	120
CO2 Emissions			
kgCO2/m²/year	**137**	**101**	**89**

Mediterranean climate (Tunis, Tunisia):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**393**	**293**	**253**
Heating	76	21	19
Air conditioning (cooling + fan + pump)	43	42	29
Laundry	10	9	9
DHW	61	18	15
Lighting	24	24	20
Catering	45	45	41

Other equipment	134	134	120
CO2 Emissions			
kgCO2/m²/year	**126**	**94**	**81**

Mountain or Highland climate (Addis Abeba, Ethiopia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**394**	**288**	**253**
Heating	82	27	19
Air conditioning (cooling + fan + pump)	30	29	26
Laundry	12	9	8
DHW	67	20	18
Lighting	24	24	21
Catering	45	45	41
Other equipment	134	134	120
CO2 Emissions			
kgCO2/m²/year	**253**	**184**	**161**

Semi-continental climate (Skopje, North Macedonia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**525**	**334**	**290**

Heating	190	61	54
Air conditioning (cooling + fan + pump)	43	38	27
Laundry	11	8	8
DHW	78	24	20
Lighting	24	24	20
Catering	45	45	41
Other equipment	134	134	120
CO2 Emissions			
$kgCO_2/m^2/year$	**437**	**278**	**241**

1.4. Education

<u>All climates</u>

	Baseline	*20% EE scenario*	*40% EE scenario*
Water consumption			
(m^3/jour)	**35**	**35**	**35**
Embodied energy (MJ/m^2)			
Total embodied energy	**2319**	**2319**	**2335**
Floor	1148	1148	1148
Roof	574	574	574
Exterior walls	52	52	44
Interior walls	105	105	105
Ground	193	193	193
Windows and joinery	247	247	247

Roof insulation	-	-	24

Equatorial climate (Abidjan, Côte d'Ivoire):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**34**	**24**	**21**
Heating	NA	NA	NA
Mechanical ventilation (fan energy)	17	7	6
DHW	4	4	3
Lighting	5	5	4
Catering	6	6	6
Other equipment	2	2	2
CO2 Emissions			
kgCO2/m²/year	**8**	**8**	**8**

Tropical climate (Ziguinchor, Senegal):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**37**	**24**	**22**
Heating	NA	NA	NA
Mechanical ventilation (fan energy)	21	8	7

DHW	3	3	3
Lighting	5	5	4
Catering	6	6	6
Other equipment	2	2	2
CO2 Emissions			
kgCO2/m²/year	**3**	**3**	**2,5**

Desert climate (Djibouti, Republic of Djibouti):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**44**	**28**	**24**
Heating	NA	NA	NA
Mechanical ventilation (fan energy)	29	13	10
DHW	2	2	2
Lighting	5	5	4
Catering	6	6	6
Other equipment	2	2	2
CO2 Emissions			
kgCO2/m²/year	**10**	**10**	**9,4**

Humid subtropical climate (Buenos Aires, Argentina):

	Baseline	*20% EE scenario*	*40% EE scenario*

Energy consumption (kWh/m². year)			
Total final energy consumption	**32**	**26**	**19**
Heating	3	4	2
Mechanical ventilation (fan energy)	11	4	1
DHW	5	5	4
Lighting	5	5	4
Catering	6	6	6
Other equipment	2	2	2
CO_2 Emissions			
$kgCO_2/m^2/year$	**7**	**7**	**7**

<u>Mediterranean climate (Tunis, Tunisia):</u>

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**35**	**27**	**20**
Heating	4	5	2
Mechanical ventilation (fan energy)	13	4	2
DHW	5	5	4
Lighting	5	5	4
Catering	6	6	6
Other equipment	2	2	2
CO_2 Emissions			

$kgCO_2/m^2/year$	**7**	**7**	**6,4**

Mountain or Highland climate (Addis Abeba, Ethiopia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**26**	**21**	**18**
Heating	1	2	1
Mechanical ventilation (fan energy)	7	1	1
DHW	5	5	4
Lighting	5	5	4
Catering	6	6	6
Other equipment	2	2	2
CO_2 Emissions			
$kgCO_2/m^2/year$	**12**	**13**	**12**

Semi-continental climate (Skopje, North Macedonia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Consommations énergétiques (kWh/m².an)			
Total final energy consumption	**28**	**25**	**23**
Heating	6	4	4
Mechanical ventilation (fan energy)	4	3	3
DHW	4	4	4

Lighting	5	5	4
Catering	6	6	6
Other equipment	3	3	2
CO2 Emissions			
$kgCO_2/m^2/year$	**23**	**21**	**19**

1.5. Offices

<u>All climates</u>

	Baseline	*20% EE scenario*	*40% EE scenario*
Water consumption			
(liter/m^2.an)	**838**	**620**	**620**
Embodied energy (MJ/m^2)			
Total embodied energy	**2129**	**2146**	**2146**
Floor	1148	1148	1148
Roof	383	383	383
Exterior walls	159	159	159
Interior walls	164	164	164
Ground	199	199	199
Windows and joinery	76	76	76
Roof insulation	-	17	17

<u>Equatorial climate (Abidjan, Côte d'Ivoire):</u>

	Baseline	*20% EE scenario*	*40% EE scenario*

Energy consumption (kWh/m². year)			
Total final energy consumption	**169**	**111**	**88**
Heating	NA	NA	NA
Air conditioning (including fans and pumps)	113	55	43
Lighting	14	14	11
Other equipment	42	42	34
CO2 Emissions			
kgCO2/m²/year	**75**	**49**	**40**

Tropical climate (Ziguinchor, Senegal):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**200**	**125**	**99**
Heating	NA	NA	NA
Air conditioning (including fans and pumps)	143	68	54
Lighting	14	14	11
Other equipment	43	43	34
CO2 Emissions			
kgCO2/m²/year	**38**	**23**	**19**

Humid subtropical climate (Buenos Aires, Argentina):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	125	91	73
Heating	7	6	5
Air conditioning (including fans and pumps)	62	29	23
Lighting	14	14	11
Other equipment	42	42	34
CO2 Emissions			
kgCO2/m²/year	**46**	**33**	**26**

Desert climate (Djibouti, Republic of Djibouti):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	197	125	100
Heating	NA	NA	NA
Air conditioning (including fans and pumps)	141	69	55
Lighting	14	14	11
Other equipment	42	42	34
CO2 Emissions			
kgCO2/m²/year	**126**	**80**	**64**

Semi-continental climate (Skopje, North Macedonia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**118**	**95**	**75**
Heating	1	1	1
Air conditioning (including fans and pumps)	69	46	36
Lighting	14	14	11
Other equipment	34	34	27
CO2 Emissions			
kgCO2/m²/year	**97**	**78**	**61**

1.6. Hotels

All climates

	Baseline	*20% EE scenario*	*40% EE scenario*
Water consumption			
(liter/m².an)	**2052**	**2213**	**2162**
Embodied energy (MJ/m²)			
Total embodied energy	**1700**	**1700**	**1700**
Floor	1148	1148	1148
Roof	52	52	52
Exterior walls	130	130	130
Interior walls	87	87	87

Ground	199	199	199
Windows and joinery	68	68	68
Roof insultation	16	16	16

Equatorial climate (Abidjan, Côte d'Ivoire):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	253	212	179
Heating	NA	NA	NA
Air conditioning (including fans and pumps)	73	44	36
Laundry	47	47	43
DHW	26	18	7
Lighting	25	21	19
Catering	77	77	69
Other equipment	5	5	5
CO2 Emissions			
kgCO2/m²/year	**113**	**95**	**80**

Humid subtropical climate (Buenos Aires, Argentina):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	249	219	176

Heating	2	0	0
Air conditioning (including fans and pumps)	49	36	25
Laundry	47	47	43
DHW	45	34	16
Lighting	25	21	19
Catering	77	77	69
Other equipment	4	4	4
CO2 Emissions			
kgCO2/m²/year	**91**	**80**	**64**

Semi-continental climate (Skopje, North Macedonia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**266**	**232**	**182**
Heating	10	6	4
Air conditioning (including fans and pumps)	47	34	23
Laundry	47	47	43
DHW	55	42	20
Lighting	25	21	19
Catering	77	77	69
Other equipment	5	5	4

CO2 Emissions			
$kgCO_2/m^2/year$	219	191	150

1.7. Retail

All climates

	Baseline	*20% EE scenario*	*40% EE scenario*
Water consumption			
(m^3/m^2)	**7,2**	**7,1**	**4,1**
Embodied energy (MJ/m^2)			
Total embodied energy	**1852**	**1852**	**1852**
Floor	1148	1148	1148
Roof	230	230	230
Exterior walls	73	73	73
Interior walls	37	37	37
Ground	199	199	199
Windows and joinery	165	165	165
Roof insultation	-	-	-

Equatorial climate (Abidjan, Côte d'Ivoire):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m^2. 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			
kgCO2/m²/year	**94**	**75**	**57**

Humid subtropical climate (Buenos Aires, Argentina):

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**241**	**181**	**137**
Heating	26	11	10
Air conditioning (including fans and pumps)	31	22	14
DHW	29	29	16
Lighting	62	26	21
Refrigeration	11	11	10
Catering	45	45	36
Other equipment	37	37	30
CO2 Emissions			
kgCO2/m²/year	**88**	**66**	**50**

Semi-continental climate (Skopje, North Macedonia) :

	Baseline	*20% EE scenario*	*40% EE scenario*
Energy consumption (kWh/m². year)			
Total final energy consumption	**228**	**186**	**139**
Heating	2	4	4
Air conditioning (including fans and pumps)	34	26	18
DHW	37	37	21
Lighting	62	26	21
Refrigeration	11	11	9
Catering	45	45	36
Other equipment	37	37	30
CO2 Emissions			
kgCO2/m²/year	**188**	**153**	**114**

Summary table of energy consumption, in kWh/m2fa (floor area)

Building type	Package	Equatorial Abidjan	Tropical Ziguinchor	Desert Djibouti	Subtropical Buenos-Aires	Mediter. Tunis	Highlands Addis Abeba	Semi continental Skopje
Housing	baseline	106	111	106	134	129	135	156
	20%EE	79	81	76	102	98	105	117
	40%EE	67	68	68	78	77	79	87
Health centers	baseline	162	169	171	162	164	160	178
	20%EE	139	140	141	145	146	145	168
	40%EE	104	106	107	110	110	109	126
Hospitals	baseline	356	416	404	394	393	394	525
	20%EE	304	342	330	292	293	288	334
	40%EE	248	276	268	255	253	253	290
Schools	baseline	34	37	44	32	35	26	28
	20%EE	24	24	28	26	27	21	25
	40%EE	21	22	24	19	20	18	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

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