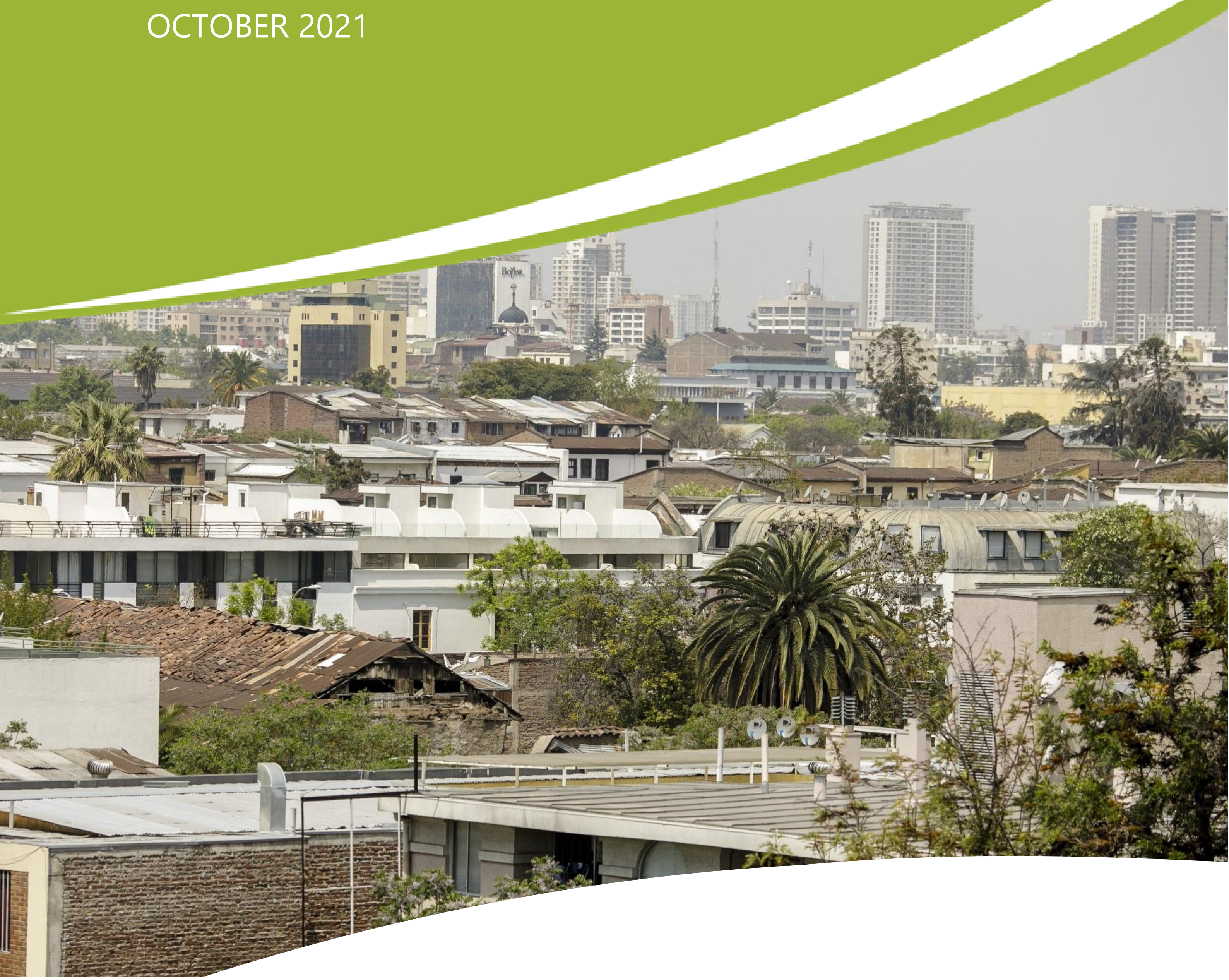
BUILDING SECTOR EMISSIONS IN HOT CLIMATES

APPROACHES FOR THE MOST EFFECTIVE EMISSION MITIGATION IMPACTS

OCTOBER 2021



EEDUS
Energy Efficiency for Sustainable Urban Development

PEEB
PROGRAMME FOR ENERGY EFFICIENCY IN BUILDINGS

1. WHY IS DECARBONISATION IN HOT CLIMATES IMPORTANT

The buildings and construction sector combined accounted for 38% of global energy-related CO_2 emissions in 2019[1]. Energy demand and emissions from buildings are expected to continue to grow strongly, mainly in countries in hot climates, where strong population growth and increasing prosperity will lead to higher energy needs, especially for space cooling.

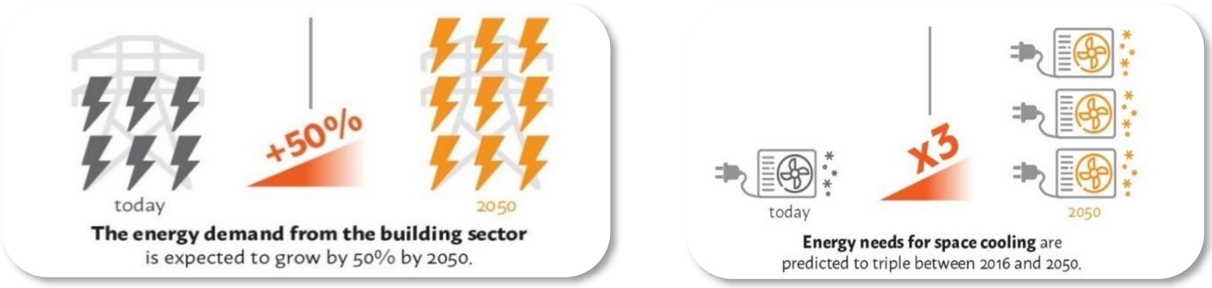


Figure 1: Projected growth of global energy demand and cooling needs by 2050 (Source: Elaboration by PEEB based on: IEA World Energy Statistics and Balances. 2016)

Policy makers face the challenge of aligning their climate policies for the building sector to achieve the most cost-effective CO_2 reductions for new construction and retrofits of existing buildings. But which measures will have the greatest impact, and which building types need to be addressed first?

Modeling the building energy demand for different building design measures shows where the greatest CO_2 reductions can be achieved and helps to direct efforts where they will be most effective. It also helps analyze the potential and reasonableness of net-zero buildings in different climate zones to meet the climate goals of the Paris Agreement.

In the following, **effective decarbonization approaches** for main building types in hot climate zones are presented. The approaches are based on a technical expert study about effective decarbonization approaches in hot climates conducted by the global *Programme for Energy Efficiency in Buildings (PEEB)* and the *Project for Energy Efficiency for Sustainable Urban Development (EEDUS)* in Brazil. For furher details of the study and methodology, consult the paper ***"Building Decarbonisation in Hot Climates"*****.**

[1] Global Alliance for Buildings and Construction (GlobalABC). 2020 Global Status Report.

2. WHICH CLIMATE ZONES OFFER THE HIGHEST MITIGATION POTENTIAL?

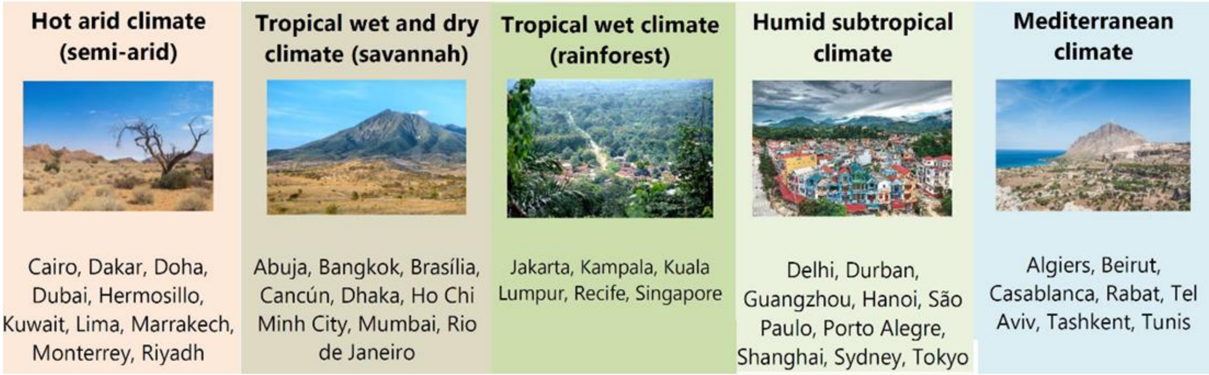


Figure 2: Main hot climate zones worldwide and representative cities (Source: Elaboration by PEEB)

The different climate zones lead to significantly different electrical energy demand and resulting CO_2 emissions. In absolute terms, the **hottest climates**, hot arid and tropical climate zones, have the **highest** energy savings and CO_2 reduction potentials for all building types.

	Climate zone	Energy demand	CO_2 reduction potential
1	Hot arid climate (semi-arid)	**Very high cooling demand**	**Very high**
2	Tropical wet and dry climate (savannah)	Medium cooling demand	Medium
3	Tropical wet climate (rainforest)	**Very high cooling demand**	**Very high**
4	Humid subtropical climate	Low cooling demand	Low
5	Mediterranean climate (hot summer)	Low cooling demand	Low

Table 1: CO_2 reduction potential of hot climate zones (Source: Österreicher, Seerig 2020: Building Climate Study)

Due to **global warming** with increasing average temperatures, the cooling demand for all building types in all hot climates will generally increase. The building energy modeling shows that therefore the **highest increase** in energy demand and CO_2 emissions will occur in the **hottest climates** if no energy efficiency measures are implemented.

In contrast, in **subtropical and mediterranean climates**, the decrease in **heating demand** due to global warming will be **negligible**.

The modeling also shows that the **relative differences** in energy demand and CO_2 reduction potentials between the different scenarios and building types are **similar** for the current and projected 2050 climate states.

3. WHAT ARE THE MOST EFFECTIVE BUILDING MEASURES?

Energy efficient retrofits of existing buildings:

- The greatest impact can be achieved through building envelope improvements, particularly **improved windows** with high-performance glazing and **external shading**, and reflective coatings on roofs and facades.

Energy efficient construction of new buildings:

- Based on the general passive measures such as a high-performance building envelope, appropriate building orientation, opening ratio of facades and natural ventilation, the greatest effect of all **active measures** can be achieved by **improved split units** (or their replacement with a central compression system) in combination with **night cooling**.
- As part of the **renewable energy measures**, the use of **hot water through solar thermal** has the greatest impact, especially in buildings where hot water plays an important role, such as residential buildings and hotels. Another important measure is the use of **photovoltaics** in combination with **heat pumps**.

	Building measures	Scenario S1	Scenario S2	Scenario S3
Building design	Improved building shell	▪		
	High performance building shell		▪	▪
	Standard windows			
	Improved windows	Most effective		
	High performance windows		▪	▪
	No external shading			
	Fixed external shading	Most effective		
	Flexible external shading - manual	Most effective	▪	
	Flexible external shading - automatic			▪
	Light coloured reflective coatings	▪	▪	▪
Energy systems	Decentralized split units			
	Improved decentralized split units	▪	Most effective	
	Central compression system			▪
	Ceiling fan	▪	▪	
	Night cooling - natural	▪	Most effective	
	Night cooling - mechanical		Most effective	
	Controlled ventilation with heat recovery			▪
Renewables	Domestic hot water by solar thermal	▪	▪	Most effective
	Photovoltaics			Most effective
	Solar heating			▪
	Solar cooling			▪
	Heat pump (heating & cooling)			Most effective

***Table 2: Most effective building measures in combination with the other measures** (Source: Österreicher, Seerig 2020: Building Climate Study)*

Regarding the **additional costs** of the above-mentioned measures, improved windows and heat pumps cause medium costs, which, however, are quickly amortised during the building's operation. External shading, improved decentralised split units and photovoltaics represent low additional investment costs, while reflective coating, night cooling and solar thermal are considered cost-neutral. However, costs can vary greatly due to local condition and economy.

4. WHICH BUILDING TYPES HAVE THE HIGHEST MITIGATION POTENTIAL?

Different building types, such as residential buildings, office and administration or commercial buildings, do have different energy demands due to the purpose, respective use and user behaviour patterns. For simplification, the large variety of different residential and non-residential building typologies can be grouped into five building types.

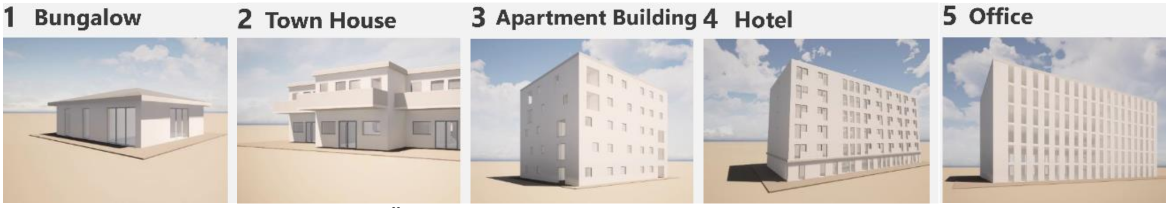


Figure 3: Main building types (Source: Österreicher, Seerig 2020: Building Climate Study)

In absolute terms, the highest energy and emission savings per area can be achieved in the **bungalow and hotel** building types, followed by the **townhouse**. In the case of bungalows and townhouses, this is due to the relatively high and unfavourable surface-to-volume ratio which results in higher energy losses through the building envelope and thus high energy consumption for space cooling. There is also a high consumption of domestic water, comparable to the water consumption in hotels – the latter ones are characterised by a high energy demand for cooling and hot water.

In comparison, the energy-saving and mitigation potentials of **apartments and offices** are lower, due to the more compact building design. Though offices have high internal loads (equipment and lighting), domestic hot water plays only a minor role. Increasing energy efficiency in this type of building can be achieved – in addition to passive building design measures – primarily through more efficient space cooling (night cooling and controlled ventilation with heat recovery) and the use of energy-efficient lighting.

	Building type	Energy-saving and CO_2 reduction potentials
1	**Bungalow**	**High due to high surface-to-volume ratio**
2	**Townhouse**	**Medium**
3	**Apartment building**	Low
4	**Hotel**	**High due to high cooling and hot water demand**
5	**Office**	Low

Table 3: Energy-saving potential of building types (Source: Österreicher, Seerig 2020: Building Climate Study)

5. WHICH BUILDING TYPES ACHIEVE ZERO CARBON EASILY?

In the **bungalow and townhouse** building types, high ambitious improvements can easily achieve zero-carbon buildings in all climate zones. This is directly related to the relatively large available area for photovoltaic (PV) systems as these building types have huge surfaces exposed to the sun.

The **apartment building type** can almost achieve near-zero carbon building with much effort, but ambitious measures would be needed to achieve full carbon neutrality within the selected climate zones.

The most difficult building types to achieve carbon neutrality are **office buildings and hotels,** as the energy loads are generally higher and the potential area to incorporate renewable energy systems is smaller. To achieve zero carbon requires the use of additional areas or district solutions for PV systems, which are feasible but represent a greater effort.

For office buildings and hotels, the mediterranean, subtropical, and savanna climate zones are best suited for achieving a zero-carbon building.

	Building type	**Zero carbon achievability**
1	**Bungalow**	**Zero carbon can be achieved with high standards in all climate zones**
2	**Townhouse**	**Zero carbon can be achieved with high standards in all climate zones**
3	**Apartment building**	Zero carbon can **almost** be reached with few additional measures
4	**Hotel**	**Difficult** building type to achieve carbon neutrality, Easier reachable in the mediterranean, subtropical and savannah climates
5	**Office**	**Most difficult** building type to achieve carbon neutrality, Easier reachable in the mediterranean, subtropical and savannah climates

Table 4: Zero-carbon potential of building types (Source: Österreicher, Seerig 2020: Building Climate Study)

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