Simplified procedure for defining science-based climate change targets for absolute sustainable building design

Downscaling Global Climate Targets to Building Level

INTRODUCTION

In the Paris Agreement the global ambition to limit global warming to 1.5°C or at most 2°C above pre-industrial levels is expressed (UNFCCC 2015). An IPCC report on pathways to achieve the 1.5 degrees target shows that rapid decarbonization is needed, involving all economic sectors and the entire global society (IPCC 2018). In this context, it is necessary to share the effort by defining specific targets at a more granular level than global emissions reductions. Despite the significance of the construction sector, the construction sector is rarely depicted explicitly in mitigation strategies. Sectoral mitigation targets for the building sector cannot be related to whole life carbon emissions for buildings, as they only consider the operational energy (Giesekam et al. 2018). In the absence of applicable sectoral targets, this study will suggest targets at building level, by downscaling global carbon pathways to building level.

The purpose of this study is to provide limit values for upfront carbon emissions for buildings, to enable target setting in early design stages and evaluate current political strategies for embodied carbon.

CURRENT SITUATION—BUILDINGS

Buildings are responsible for approximately 38% of energy related CO_2 emissions of which 10% are material related (GlobalABC 2020). For new buildings great efforts within reducing impacts from operational energy have been accomplished, now calling for a necessity to address the embodied impacts. In fact, the impact of embodied carbon has increased both in relative and absolute terms, which can be explained by the fact that high energy efficient buildings require more materials and services (BPIE 2021). This underlines the importance of having a holistic approach, addressing both operational and embodied emissions.

Quantification of environmental impacts of buildings through Life Cycle Assessments (LCA) has gained broad attention in the building industry in recent years and has helped identifying environmental hotspots and the most eco-efficient design solutions. Today, we set targets for buildings through a bottom-up approach - benchmarking the buildings performance up against existing building LCAs. Bottom-up benchmarks is a relative sustainability comparison, and it can show whether a design is relatively more sustainable than a reference building, however, this method will not secure, that the building design is in line with the Paris Agreement goal of limiting global warming to 1.5 degree Celsius. Therefore, to tackle global climate challenges, there is a need for evaluating building performance in relation to science -based absolute environmental targets.

METHOD

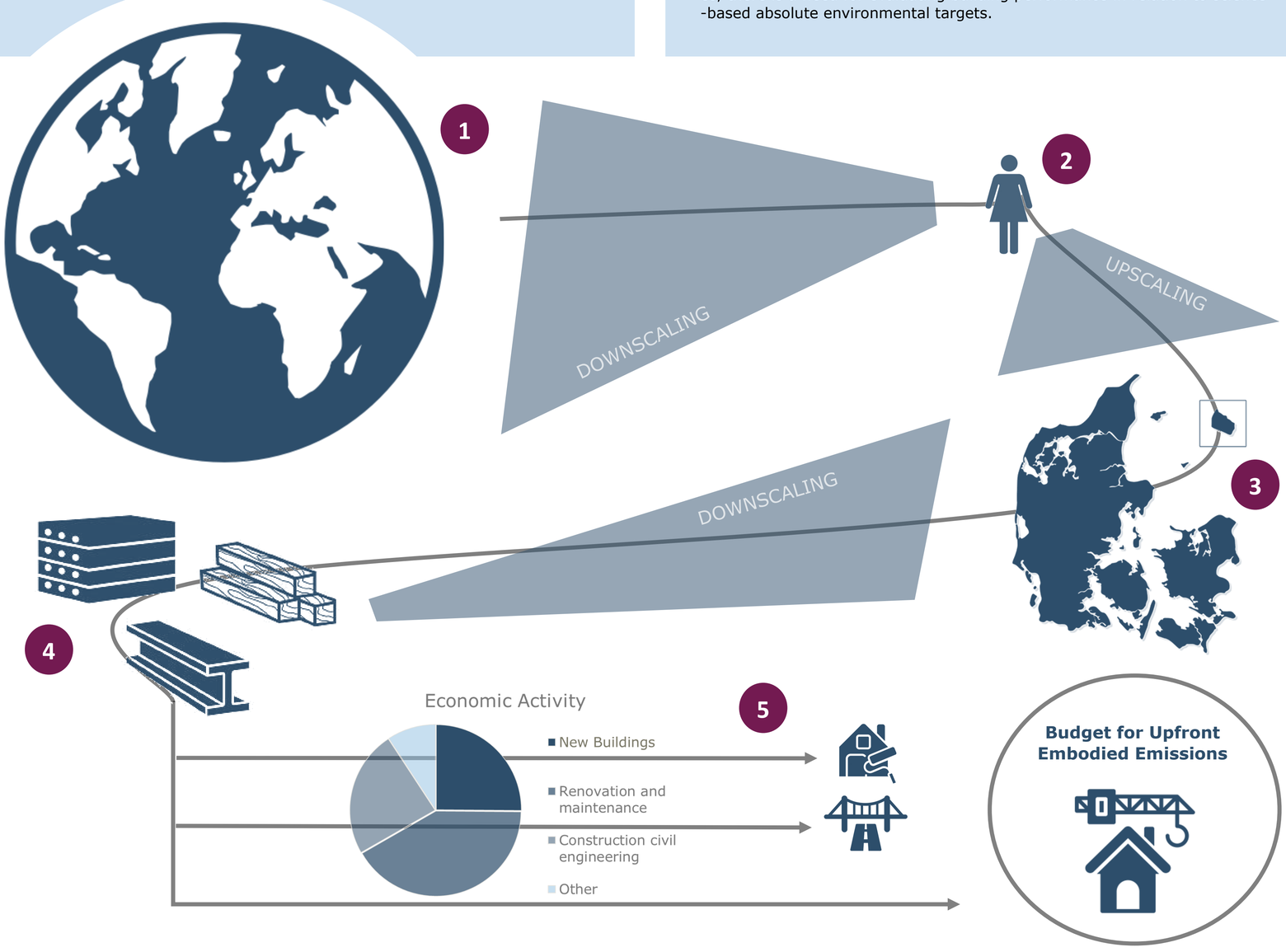
The climate budget of a building project is here determined through a top-down approach aligning targets with the global climate budget. The procedure involves defining the climate budget to the construction sector and further downscaling this to the level of the specific building. Several downscaling steps are performed during this procedure, which involves important choices on how the allocation of the global climate budget to a specific building is performed. It is, therefore, very important to be transparent in communication of these choices as the allocation principles applied are often a question of what is practically possible and ethically reasonable. The sharing principles used in this study apply the following distributive justice principles:

Egalitarianism: All individuals should be equal in terms of for example welfare or resources. Distribution of the environmental safe operating space as a resource. Here we apply an equal distribution of resources. Equal per capita (EPC) is the most common example of egalitarianism.

Utilitarianism: We should maximize the sum of welfare. Utilitarian sharing principles are based on currencies reflecting welfare such as economic value, contribution to happiness or fulfillment of human needs.

Acquired rights: No ethical justification, as the share is based on historical data on how large a share the system/product has previously acquired. Also called the grandfathering principle.

DOWNSCALING THE GLOBAL BUDGET TO BUILDING LEVEL



1. The first step is to define a yearly global carbon budget. The global budget presented is an average of mitigation scenarios consistent with the 1.5°C target. (Rogelj *et al.*, 2018). The mitigation pathways has no or low probability of temperature increases higher than 1.5 are considered consistent (66% probability).

2. The global budget is then downscaled to "equal per capita" (EPC) according to UN population projections (United Nations, Department of Economic and Social Affairs, 2019).

3. In step 3 the budget share is upscaled to national level according to the relative share of the nations population to world population. (United Nations, Department of Economic and Social Affairs, 2019)

4. The budget for building materials is then distributed according to two different sharing principles:
   1) Acquired Rights (AR) based on current distribution of carbon emissions (GlobalABC, 2020).
   2) Utilitarian (U) based construction share in final consumption expenditure in Danish economy (Exiobase version 3)

5. In the final step, the budget is split into activities consuming building materials i.e. new build projects, renovation and maintenance of existing building stock and construction civil engineering. Activity share determined according to economic activity (Dansk Byggeri, 2019).

RESULT

Carbon pathways can be seen as a step-by-step road towards reaching the ultimate goal of carbon neutrality. This study suggests limit values for new buildings for the year 2020 until the end of the 21st century. The values are calculated under the assumption that the building activity and number of square meters built in Denmark will remain at the same levels as in 2015-2020.

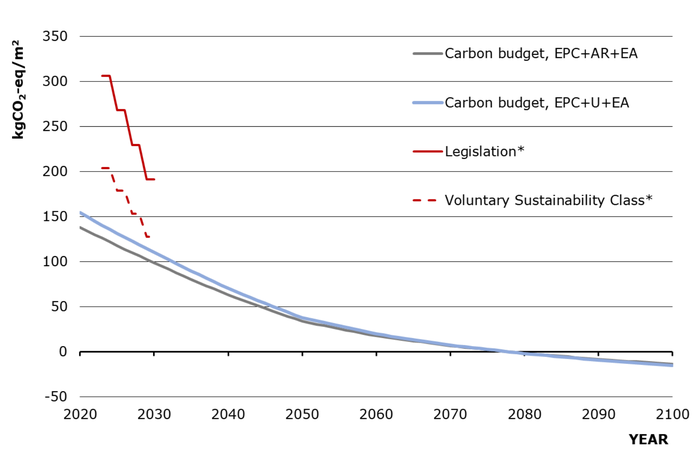
It should be noted that a calculated pathway should be updated regularly, as an exceedance in the calculated budget one year, will require an even steeper slope moving forward, as the pathway is a result of a distributed yearly budget of the total allowable amount of GHG emissions, which will prevent temperature increases higher than 1.5°C.

In 2021, a national strategy for new buildings in Denmark was proposed. The strategy consists of limit values for legislation and "a voluntary sustainability class". The limits cover whole life carbon encompassing both operational and embodied emissions and will be introduced in 2023 with a progressive tightening as illustrated in Graph 1.

TAKE AWAYS

- The study indicates that for the two sharing principles applied, the budget for new build square meters in Denmark should be between 138-154 $kgCO_2$-eq/m^2 in 2020, 99-110 $kgCO_2$-eq/m^2 in 2030, 34-38 $kgCO_2$-eq/m^2 in 2050.
- Under the assumptions presented in this study, the comparison of the calculated values of this study and the estimated values of the national strategy indicates that in 2023 the limit values of the legislation exceed the carbon budget by more than double.

BUDGET FOR UPFRONT EMBODIED CARBON EMISSIONS PER m²



Graph 1: Budget for upfront embodied carbon emissions.

EPC = equal per capita, AR = aquired rights, EA = economic activity, U = utilitarian.

*To enable comparison between the national strategy and the calculated values of this study the following average distribution is assumed: Upfront emissions account for 51% of total life cycle emissions acc. to average values (Zimmermann *et al.*, 2021). Building LCAs conducted to comply with the new proposed standard and the voluntary sustainability class assume a 50 year reference study period, thus, the values from the national strategy are multiplied by 50.

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GLOSSARY

EMBODIED CARBON emissions released during the extraction, manufacture, transportation, assembly, replacement and disposal of materials.

OPERATIONAL CARBON emissions associated with the energy consumption (operational energy) during the use of the building, e.g. heating, cooling, lighting and appliances.

UPFRONT CARBON emissions released during the production and construction of the building.

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