INTRODUCING WHOLE-LIFE CARBON METRICS: RECOMMENDATIONS FOR HIGHLY EFFICIENT AND CLIMATE-NEUTRAL BUILDINGS

POLICY BRIEFING

MAY 2021

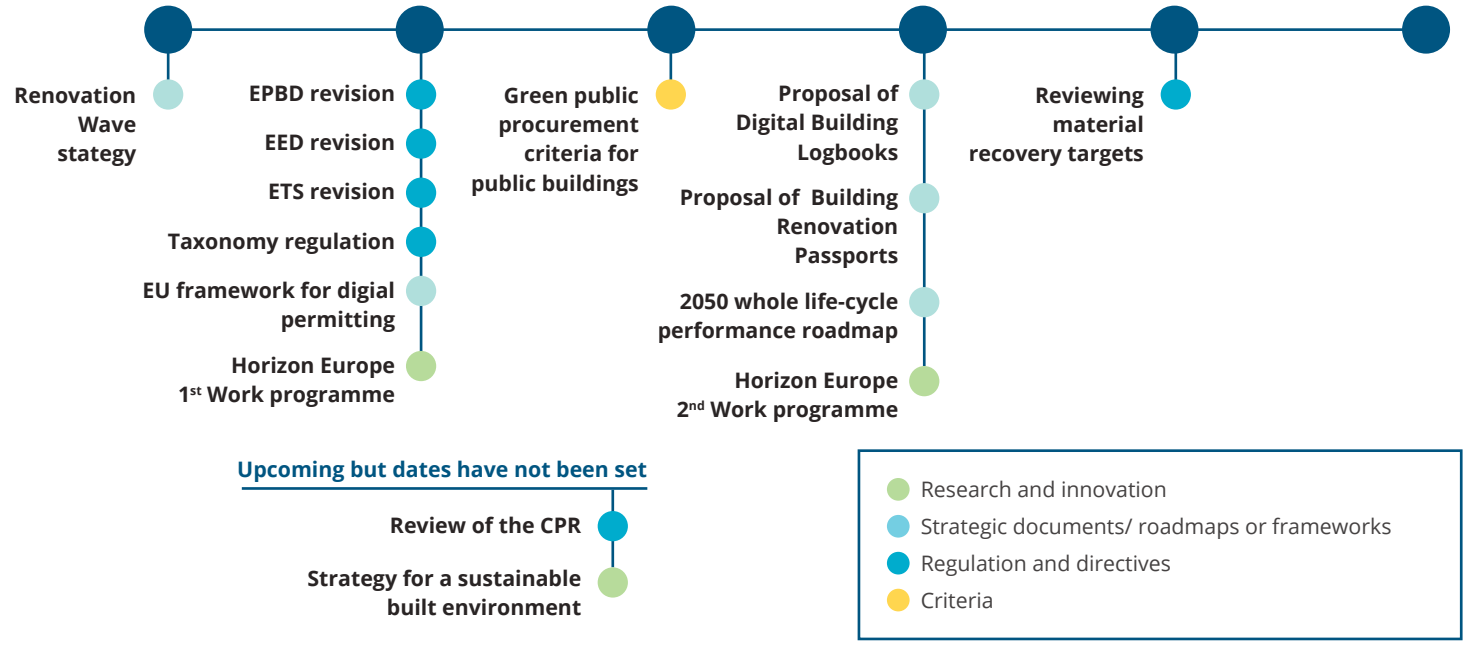
Policy efforts to decarbonise Europe's building stock have, so far, focused on energy efficiency measures and thereby reducing the energy demand, and related carbon emissions, for heating, cooling and lighting of the building during its operational lifetime. This is a well-justified focus but only part of the overall effort needed to achieve a climate-neutral Europe. With the drive towards reducing in-use energy to "nearly zero", the other sources of carbon emissions from buildings become increasingly important and therefore a vital part of future carbon reduction plans. For new buildings built to the highest energy efficiency standards, the extremely low operational energy requirements mean that embodied carbon becomes the most significant area of carbon emissions over the lifetime of the building.

An analysis of 60 new buildings (built between 2013 and 2021) in Denmark,[1] a country with relatively ambitious building regulations, suggests that embodied carbon emissions are on average 2-4 times greater than emissions associated with operational energy use. Another recent study[2] analysing more than 650 lifecycle assessment (LCA) cases revealed that it is possible to design low-carbon buildings without compromising existing building regulations. In other words, **it is possible to enforce very high energy performance standards and also reduce embodied carbon emissions.**

The ongoing review of key policy and legislative files such as the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED) provides a significant opportunity for the European Union to begin consistently integrating whole-life carbon (WLC) principles in the regulatory framework. Actions at the building level must also be well-coordinated and aligned with policy actions upstream on raw materials and construction products, as well as with end-of-life policies addressing waste and closing the loop/increasing circularity. Equally, setting carbon disclosure and reporting obligations at the market level will help establish WLC accounting and management practices as well as help identify risks and allocate capital to climate-neutral solutions and investments.

[1] Kjær Zimmermann, R. et al. (2020) Klimapåvirkning fra 60 Bygninger (in English: Climate impact of 60 buildings). Aalborg University. (Available: *Online*)
[2] Röck, M. et al. (2020) "Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation", *Applied Energy* 258.

Figure 1: Policy anchor points at the EU level (developed based on the Renovation Wave Annex [COM(2020) 662 final]).



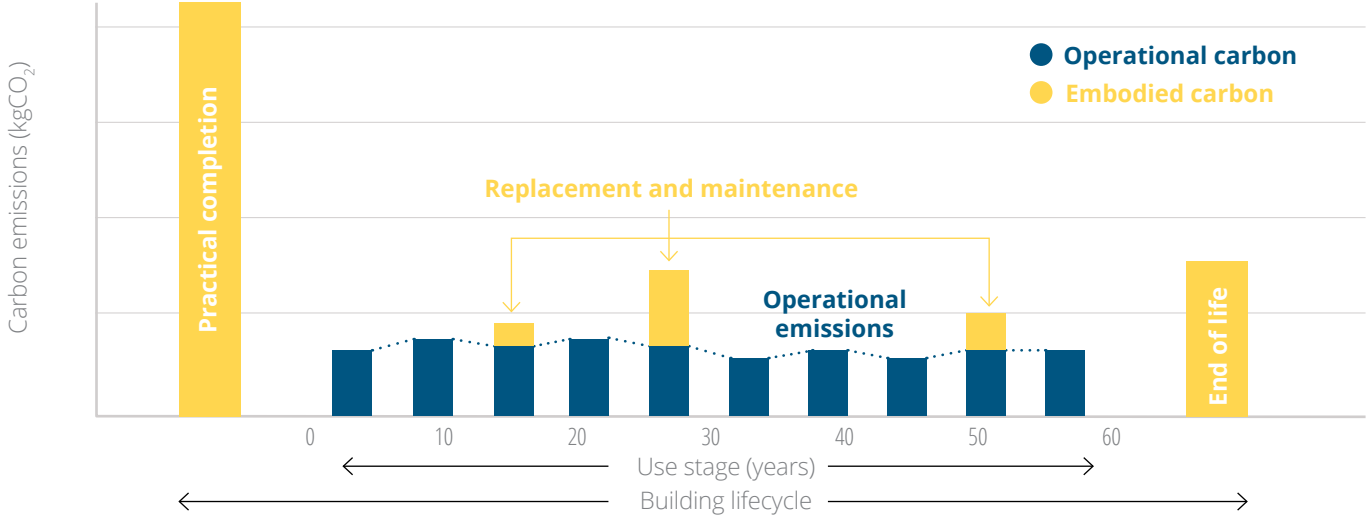
GENERAL CONSIDERATIONS

Carbon metrics are needed to align building policies and incentives with carbon-neutrality goals. Energy and carbon are correlated and interdependent but the metrics are not interchangeable. Energy efficiency will certainly deliver significant carbon emissions reductions, but not necessarily zero emissions. This is because emissions from the manufacturing, construction and renovation processes are not accounted for, and because not all carbon emissions are energy related.

Energy and carbon metrics are complementary. Having both energy and carbon metrics will help with understanding the relationship between improving operational emissions and the related carbon costs of doing so. Both metrics are required to avoid easy substitutions and carbon offsetting in place of improvements to the building envelope and efficiency. Disregarding WLC runs the risk that construction and renovation decisions ignore these hidden emissions. Considering lifecycle carbon is equally relevant for new construction and renovations, and it can inform which materials and services should be used to achieve lower emissions over the entire lifecycle of the asset.

> **Energy and carbon metrics are complementary. Having both energy and carbon metrics will help with understanding the relationship between improving operational emissions and the related carbon costs of doing so.**

Figure 2: Breakdown of embodied and operation carbon in buildings. Source: LETI Embodied Carbon Primer



The introduction of carbon metrics alongside the existing energy performance indicators is a first step to raise awareness and improve transparency, professional knowledge and decision-making. The availability of WLC metrics is expected to create more transparency and build up comparable and reliable data. The long-term aspiration is to strengthen WLC performance by introducing mandatory accounting, reporting and benchmarking as soon as data and knowledge are widely available.

Finding the right balance between simplicity (uncertainty) and the required robustness of metrics will be essential to manage the complexity, interdisciplinarity and comprehensiveness involved in the definition and deployment of carbon metrics. Methodological consistency must be maintained across all details and levels of analysis, avoiding gaps and double-counting. As most of the current policies are designed in silos and only target individual stages of the lifecycle with no coherent links between the stages, aligning the complexity of interests will be crucial to manage the process and design as well asenforce effective policies.

Finally, WLC accounting is an entry point to encourage the wider use of LCA and the consideration of other environmental impacts (and potential trade-offs) such as water or air pollution. Mitigating WLC emissions generally contributes to limiting resource depletion and reducing pollution. The principles and actions involved in reducing WLC are similar to improving circularity (e.g. reuse, reduce, avoid over-specifications, consider local aspects and passive solutions, improve building resilience, flexibility and adaptability, extend the lifespan of buildings and components, improve recyclability).

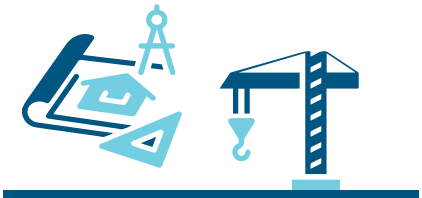
Table 1: Overview of potential intervention points to embedding WLC principles in the regulatory framework.

Corporate & market level

- Introduce WLC reporting and disclosure requirements
- Provide preferential financing and taxonomy eligibility

Material and product level

- Introduce material passports and product certification to enable recovery and reuse
- Roll out environmental product declarations (EPDs) to improve data availability and quality of LCA results
- Set requirements on embodied impacts and environmental sustainability
- Improve enforceability and validation of in-use product performance



Building level

- Set carbon metrics and targets in addition to existing energy indicators
- Define net-zero carbon new buildings and renovation standards
- Gradually require LCA and lifecycle costing (LCC), lead by example in public procurement
- Encourage the use of building information modelling (BIM) and building logbooks to improve the traceability of materials
- Ensure WLC is considered in the mandatory minimum energy performance standards

POLICY RECOMMENDATIONS

1. INTRODUCE OPERATIONAL AND EMBODIED CARBON METRICS

The central objective of the Renovation Wave and other key EU building-related legislations is to decarbonise the building stock, which cannot be done without the adoption of appropriate carbon metrics. The carbon metrics can be developed starting from the existing energy metrics, as their scopes are complementary.

- Operational carbon metrics should be based on in-use verified data on energy consumption, if available, or on realistic estimates of operational energy use of the building. As in the case of energy metrics, it is important to reduce potential carbon performance gaps, i.e. difference between (i) the carbon consumption predicted in design in the early phases of the production of a building; and (ii) the actual carbon released once the building is completed and occupied.
- Embodied carbon metrics can be based on estimates of quantities of materials, products and processes in the building as well as their respective environmental impact coefficient (carbon footprint) for each lifecycle stage of the building. In addition, developing benchmarks and indicative targets for operational and WLC targets for various building types and decarbonisation pathways will be useful for practical implementation and wherever granular data is not available.

2. REQUIRE THE LONG-TERM RENOVATION STRATEGIES TO CONSIDER ALL CARBON EMISSIONS FROM THE BUILDING STOCK

The long-term renovation strategies should make clear that the 2050 target means net-zero emissions over the whole lifecycle. This requires a definition of what a "highly energy efficient and decarbonised building stock" is, which would make it clear what is expected from the building stock by 2050 (i.e. 100% reduction of GHG emissions), at the European level, Member State level, regional level, district level and individual building level. Carbon budgets and science-based decarbonisation targets will need to be downscaled from global and European levels to the local levels and different building types. Public authorities should set out strategies and plans for achieving net-zero carbon emissions by 2050 for their entire building stock. The ambition for the existing building stock must be to raise the annual deep renovation rate by 2030 from 0.2% to 3% while ensuring optimisation of the carbon reduction, including both operational and embodied emissions.

3. UPGRADE THE NEARLY ZERO-ENERGY BUILDING (NZEB) DEFINITIONS TO NET-ZERO CARBON

Updates to the NZEB definitions should gradually converge towards net-zero carbon requirements. If the entire stock is meant to be net-zero carbon by 2050, it follows that buildings built between 2021 and 2050 must be net-zero carbon in order for the overall target to be met. New buildings will need to be built to meet the zero carbon standard as of now to avoid retrofitting before 2050. Definition of net-zero carbon should clarify boundaries and scope of emissions, including embodied carbon, carbon offsetting and sequestration. To truly achieve a zero-carbon building stock, we need to move away from considering the design, construction and operation of buildings independently from one another, and move the whole construction and real estate industries towards a circular economy.

POLICY RECOMMENDATIONS

4. ENABLE CIRCULARITY BY KEEPING TRACK OF ALL RELEVANT BUILDING DATA OVER THE LIFECYCLE

The different stages of the building lifecycle represent various opportunities to collect data but also imply different data needs. Market participants along the building value chain need access to accurate data which can seamlessly be integrated into each aspect of the lifecycle. For the construction sector to leverage the power of structured data, the information will need to be transferred and available integrally from the beginning to the end of the cycle. Better data and better collaboration among the construction value chain are needed to enable the accounting of WLC and environmental impacts. This will also facilitate effective recycling of materials and building components, as well as efficient use of the buildings throughout their lifecycle. The Renovation Wave strategy positively references the digital building logbook as a common repository for all relevant building data. The digital building logbook is a dynamic tool that allows a variety of data, information and documents to be recorded, accessed, enriched and organised, including information about the quality, origin and location of materials and products. This provides insight into the material, circular and financial (residual) value of a building.[3]

5. BUILDING RENOVATION PASSPORTS CAN FACILITATE THE CONSIDERATIONS OF WLC IN DEEP RENOVATIONS

Renovation advice services, such as building renovation passports, can facilitate the integration of WLC into renovation decisions. A building renovation passport provides a long-term, tailored renovation roadmap for a specific building, following a calculation based on available data and/or an on-site audit by a building expert. The instrument identifies and outlines the deep renovation scenario(s), including steps to implement measures that could improve the building's environmental performance over a defined period.[4] The building renovation passport is typically based on a detailed audit, which opens the opportunity to integrate whole-life carbon considerations. The roadmap can be extended to include the net-zero carbon objective and effectively become a "climate-neutrality passport", where the final target is aligned with the EU/national/regional definition of what a "highly energy efficient and decarbonised building stock" requires.

6. ENSURE WLC IS CONSIDERED IN THE MANDATORY MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS) TRIGGERED RENOVATIONS

Mandatory minimum energy performance standards (MEPS) for existing buildings can be an effective policy instrument to ensure that the worst-performing part of the stock is upgraded. MEPS need to be designed with progressive requirements in mind, including whole-life carbon targets, to make sure long-term climate objectives are met. MEPS ought to be accompanied by tailored renovation advice (e.g. building renovation passports) leading to low-carbon refurbishment over the entire lifecycle.

[3] Volt, J., Toth, Z. et al. (2020) *Definition of the digital building logbook*. European Commission.
[4] Fabbri, M. et al. (2020). *Technical study on the possible introduction of optional building renovation passports.* European Commission.

POLICY RECOMMENDATIONS

7. SET REQUIREMENTS FOR THE SUSTAINABILITY PERFORMANCE OF PRODUCTS AND MATERIALS

The framework establishing requirements for materials and construction products should be revised, including reducing the carbon footprint and fostering greater transparency through the availability of EPDs and material passports. In both new and existing buildings, most of the embodied carbon is contained in a few major elements, usually around the building structure and fabric. Product-level policy could focus on these carbon hotspots as a starting point for reducing embodied carbon footprints.

8. PREPARE THE MARKET WITH A SOFT INTRODUCTION AND VOLUNTARY LIMITS; INCENTIVISE PUBLIC BUILDINGS MOVE FIRST

New constructions and public building should be required to assess and disclose information on embodied carbon emissions. Three European countries have put LCA requirements in place for public buildings, while five countries are planning to introduce wider WLC regulations. Making LCAs compulsory for all project bids and gradually requesting material EPDs will allow the construction sector to become familiar with WLC accounting and sourcing/supplying EPDs without placing an undue burden on the industry. The introduction of WLC requirements for new buildings must be announced well before they come into force to provide the market with sufficient lead time to prepare. Denmark announced its whole-life carbon regulation well in advance and accompanied it with a voluntary WLC class to incentivise even higher performance goals (around 33% more ambitious) than the statutory requirements.[5] The voluntary class can be, for example, used in public procurement and private certification schemes together with additional financial incentives.

9. IMPROVE UNDERSTANDING OF WLC ACCOUNTING AND MITIGATION STRATEGIES

There is lack of knowledge in the built environment surrounding embodied carbon reduction strategies and calculations. In addition, responsibility for carbon data management varies greatly between construction stakeholders and is often unclearly defined within projects. Therefore, there is a need to further explore and overcome barriers to effective information management and construction processes.

[5] The requirement starts at 12kg CO2-eq/m2/year and the voluntary class at 8kg CO2-eq/m2/year. Both thresholds will be strengthened progressively over time.

Authors	Zsolt Toth Jonathan Volt
Reviewed by	Barney Jeffries Caroline Milne Hélène Sibileau Maria Stambler Sibyl Steuwer Oliver Rapf Mariangiola Fabbri
Graphic design	Ine Baillieul

Funding
This briefing has been made possible thanks to the support of the Laudes Foundation.

Laudes Foundation

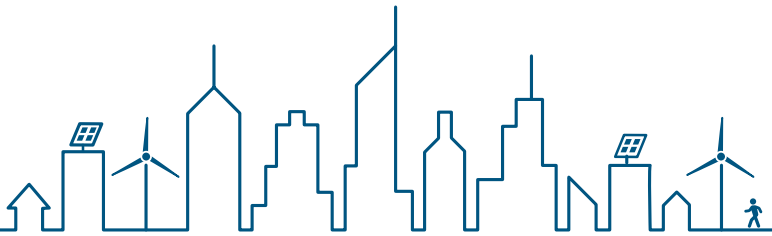
How to cite this briefing: BPIE (Buildings Performance Institute Europe) (2021). Introducing whole-life carbon metrics: recommendations for highly efficient and climate-neutral buildings. Available at: https://www.bpie.eu/publication/introducing-whole-life-carbon-metrics-recommendations-for-highly-efficient-and-climate-neutral-buildings/.

BUILDINGS PERFORMANCE INSTITUTE EUROPE

Rue de la Science 23
B-1040 Brussels Belgium

Sebastianstraße 21
D-10179 Berlin Germany

www.bpie.eu



BPIE (Buildings Performance Institute Europe) is a leading independent think tank on energy performance of buildings. Our vision is a climate-neutral built environment, aligned with the ambition of the Paris Agreement, and in support of a fair and sustainable society. We provide data-driven and actionable policy analysis, advice, and implementation support to decision-makers in Europe and globally.