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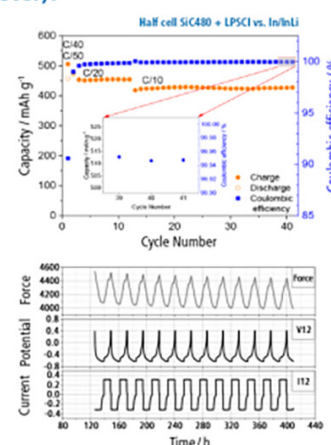
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Promoting the use of wood and bio-based materials in buildings: the case of Lithuania in the context of European countries striving for climate neutrality

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Abstract. The construction sector causes a huge environmental burden. Globally, this sector is responsible for 34 % of global energy demand, around 34 % of CO₂ emissions and approximately one-third of all global waste. This article analyses international practices in the usage of wood and other bio-based construction products in buildings, and presents the progress of the Lithuanian state of the art in this area. The EU promotes the use of wood or other construction products made from organic materials from renewable natural resources in buildings. Lithuania contributes to this global trend. A recent governmental resolution requires that at least 50% of construction products used in public buildings, financed by the state budget of the Republic of Lithuania (including European Union structural funds and other international financial assistance), must consist of wood or other bio-based materials derived from renewable resources. To implement this regulation, a dedicated methodology has been developed to quantify the share of wood and bio-based materials in buildings. The proposed methodology is a useful tool for the practical implementation of policy objectives and contributes to the promotion of green procurement and innovation and technological progress in the construction sector.

1. Introduction

The buildings and construction sector poses a huge environmental burden, as it is responsible for 34 % of global energy demand, around 34 % of CO₂ emissions and approximately one-third of all global waste, according to recent data [1]. Although the urgent need to address the environmental problems of this sector is obvious and supported by many countries, unfortunately, it is observed that progress is being made slowly, fragmented and significantly lag behind the implementation of the requirements of the Paris Agreement [2, 3]. The gap between the strategic climate and circular economy and the real environmental indicators of the construction sector confirms that the problem is far from being solved. An analysis of strategic documents shaping EU economic trends showed that there is a strong politically supported tendency to rely on biological resources to decarbonize the economy and replace fossil fuel-based materials and products [4]. In the latest EU Strategic Framework for a Competitive and Sustainable EU Bioeconomy bio-based building materials (wood, hemp, straw, mushroom/raw material composites, etc.) were identified as having great potential to address large-scale challenges in the development of the bioeconomy. It is believed that the use of bio-based products can significantly reduce embodied carbon and the energy demand in buildings, and the European Commission intends to support industrial and modular timber construction using durable bio-based materials. The research of systematic



literature reviews and quantitative analysis of publications revealed that the number of relevant scientific studies on sustainable wood construction and the impact of wood structures on climate change and its mitigation options has started to increase since 2018 [5]. Scientific studies confirm the benefits of wood as a naturally renewable, recyclable and other sustainability criteria-compliant building material from a climate change perspective. In addition, wood has good mechanical and physical properties, which allow it to be used in the construction sector [6-13].

Taking into account political regulations and the advantages of wood, many EU Member States are encouraging the transition to bio-based construction, thus reducing greenhouse gas/CO₂ emissions into the environment and ensuring both the durability of buildings and the strengthening the circularity in the construction sector. Lithuania has adopted a legally binding requirement, which establishes the obligation to use at least 50% of wood and other construction products based on renewable natural resources in public buildings, financed by the state budget of the Republic of Lithuania (including EU structural funds and other international financial assistance) [14]. This policy change has created a need for robust, transparent, and scientifically sound measures to assess the use of wood in public buildings.

To our knowledge, there is no unified or widely accepted method for quantifying the share of wood and other bio-based materials in buildings, and existing national methods vary significantly. Therefore, it is relevant to analyze the experience and achievements of other countries in supporting the transition from fossil fuel-based to wood and other bio-based materials, to know the EU requirements and possible measures to promote the transformation of the construction sector, and to find solutions to address the existing gap between strategic goals and practice. The aim of the study is to analyze international practice related to the use of wood and other bio-based construction products in buildings, and show Lithuania's progress in this area, presenting the developed methodology that allows for an objective calculation of the share of these materials in buildings, based on the CO₂ balance principle.

2. Methodological principles

The study employs a multilayered qualitative research method, combining document analysis, comparative policy assessment, qualitative content analysis, and technical evaluation (Fig. 1). This method allows for a consistent study of both political and institutional assumptions and practical instruments that promote the use of wood and other bio-based materials in buildings.

Based on the criteria formulated, the EU regulatory context was analysed, including the new version of the EPBD, the revision of the Construction Products Regulation, and other EU climate and circularity strategies. A comprehensive analysis of the Lithuanian national legal system documents related to sustainable construction, and renewable materials requirements was carried out. In order to ensure comprehensive coverage, the review included EU and national legislation, building codes, embedded carbon dioxide requirements, public procurement rules, international reports and strategic policy documents related to wood and bio-based construction. International case studies were selected based on clear criteria, such as legal force of the document, connection with circular construction, provisions on the use of wood or bio-based products, practical implementation mechanisms.

The study included a detailed examination of Lithuania's newly developed method for calculating the amount of wood and other bio-based building materials in buildings in Lithuania, which reveals the technical and practical conditions for implementing sustainable construction in Lithuania. The integrated synthesis revealed Lithuania's compliance with the EU sustainable construction policy, transfer potential, and practical implementation measures.

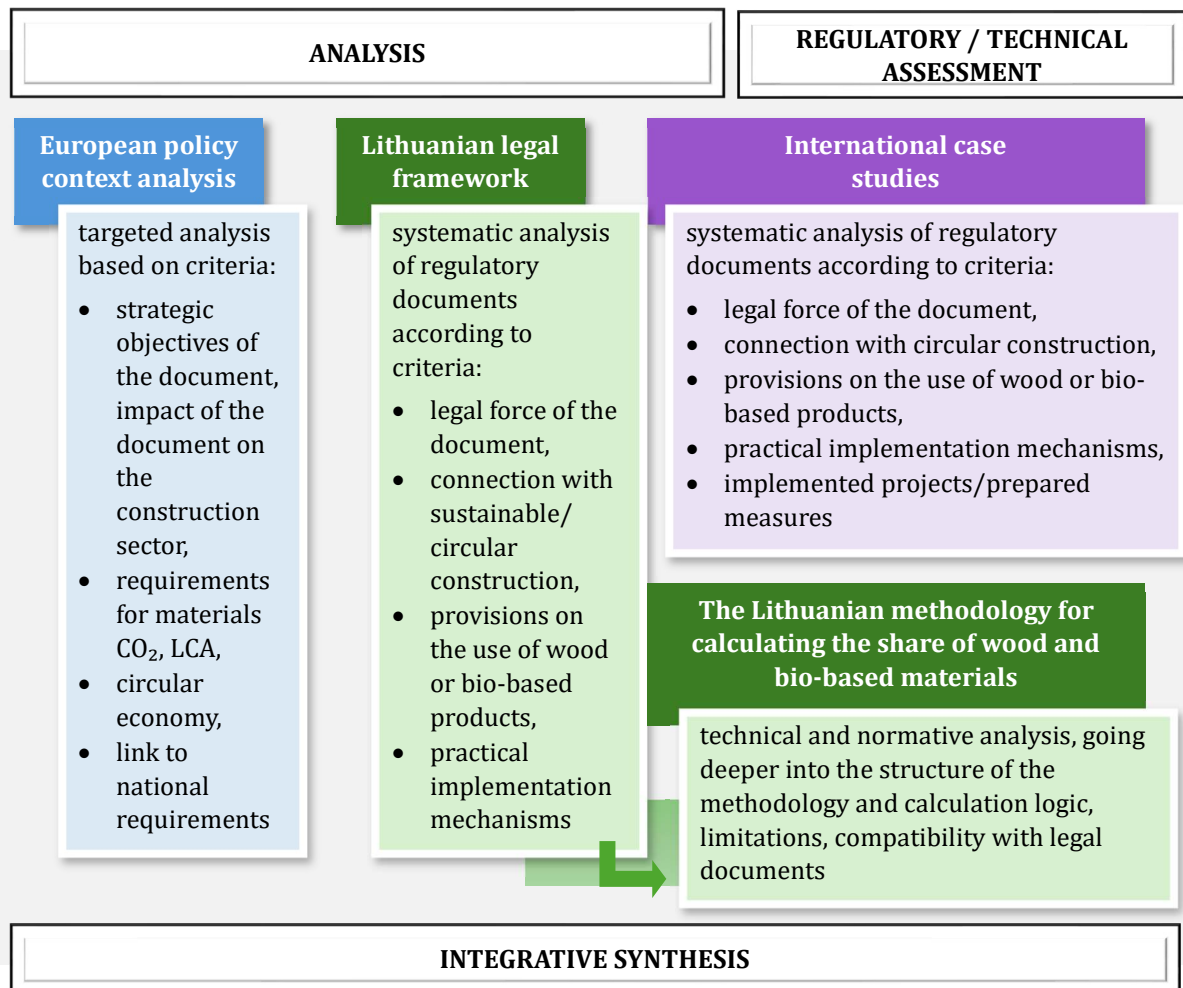


Figure 1. Key components of the research methodology

3. Results and Discussion

3.1 EU policy context in the construction and buildings sector

In order to increase the circularity of the buildings and construction sector, environmental awareness, efficient use of resources, sustainable building design and construction, and to achieve the goals of a circular economy and climate neutrality, the EU promotes in its strategic documents the replacement of fossil raw materials with raw materials from renewable sources, the efficient use of natural resources, including wood, by producing construction products that do not have a negative impact on the environment. Together with [4], the Energy Performance of Buildings Directive (EPBD) [15] and the Opinion of the European Economic and Social Committee (EESC) on 'Wooden construction for the reduction of CO₂ in the building sector' [16] are examples of the political support and the role of the public sector in this area. The EPBD is relevant in the context of climate neutrality and energy efficiency. Although it does not explicitly address wood, it highlights the need to use wood structures and bio-materials, especially when applying criteria for the life cycle and CO₂ emissions management. The EESC calls on EU Member States and public sector institutions to actively promote the use of wood and bio-materials in public buildings in order to reduce CO₂ emissions and contribute to climate goals.

It is argued [17] that the overhauled EPBD (2024/1275) and the revision of the Construction Product Regulation will accelerate the integration of mandatory life cycle carbon assessments in EU Member States, and that public procurement will be a key factor in scaling up timber buildings in line with the 'bio-first' materials policy. The importance of green public procurement in reducing the decarbonization of the construction sector is also highlighted in a background paper prepared by R. Palma et. al. [18].

3.2 International practice and Lithuanian policy model for achieving climate-neutral construction

The transposition of EU legislation to the national level has been implemented to varying degrees in different countries. Based on the literature [1, 19 - 23], the main instruments supporting the use of biobased materials in buildings are summarised in Figure 2. Lithuania is included in this figure to illustrate national policies, while other countries are presented as illustrative examples of broader regulatory approaches.

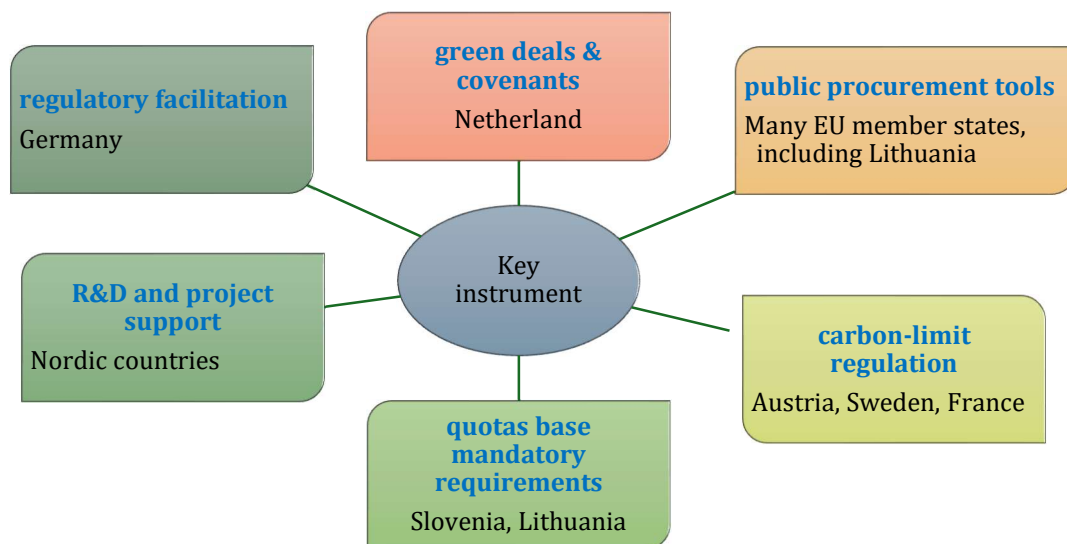


Figure 2. Key instruments to support the use of wood and bio-based materials in buildings

The analysis shows that policy approaches differ considerably between countries, but several dominant instruments can be identified. Public procurement is a key instrument in many EU countries, particularly in the Nordic region, where wood and biobased construction is supported through public procurement requirements, long-term research and development programmes, and building codes. Countries such as France or Austria rely mainly on regulatory approaches based on embodied carbon limits, which indirectly encourage the use of wood and other biobased materials due to their lower embodied carbon content and carbon storage capacity [18]. The Amsterdam Green Deal is an example of how multistakeholder agreements at the national level can set targets for wood use. The German experience demonstrates that removing barriers (e.g., adjusting fire safety codes) combined with training and incentives can accelerate the uptake of biobased materials. Overall, a clear trend is observed that EU member states are increasingly harmonizing requirements for the permissible amount of carbon dioxide with public sector obligations to accelerate the transition toward climate-neutral construction.

In line with the EU policy direction towards climate neutrality and circularity, Lithuania has developed a legal framework that promotes the use of wood and other biobased materials in construction. Similar to other member states, national strategic documents establish a common policy context linking climate goals with resource efficiency and the use of renewable materials.

The Lithuanian National Climate Change Management Agenda (2021) [24] and the Guidelines for the Lithuanian Transition to a Circular Economy by 2035 (2023) [25] emphasise the need to reduce embodied carbon, increase resource efficiency, and expand the use of renewable materials in construction. Taking into account the policy of promoting biobased construction, technical regulations, standards, and other technical documents are being reviewed and updated, including applicable construction technical regulations, fire safety requirements for wooden structures, and timber design guidelines, which ensure that wooden construction in Lithuania is legal, safe, and meets construction requirements.

In 2023, Lithuania adopted a resolution [14], which established that at least 50% of construction products or their components in newly constructed public buildings classified as special and non-special buildings must be made of wood and other organic materials from renewable natural resources. To operationalise this resolution, a CO₂ emissions-based methodology was developed and approved by the Lithuanian Ministry of the Environment, which provides a calculation method for determining the share of wood and other organic materials in a building. As an example of good practice, this methodology is discussed in more detail in the following section. Compared to approaches applied in other European countries, Lithuania's policy combines elements of several dominant regulatory instruments. Similar to Slovakia, Lithuania introduces a quantitative material requirement for the public sector. At the same time, the proposed calculation methodology, based on the balance between CO₂ sequestration and emissions, reflects the broader European trend towards carbon-based regulation, observed in countries such as France and Austria. Furthermore, Lithuania's approach relies mainly on regulatory requirements, focused on market transformation through mandatory public sector leadership.

3.3 From policy to practice: the Lithuanian CO₂-based assessment methodology

In order to implement the national requirement that at least 50% of the materials used in public buildings must be made of wood or other products of biological origin, a dedicated methodology was developed to quantify the share of wood and other organic materials made from renewable natural resources in construction products (hereinafter referred to as methodology) [26]. The main components of a methodology and methodological boundaries are presented in Table 1.

The methodology is based on the calculation of the CO₂ balance of materials, where the share of materials of biological origin is determined by comparing the amount of CO₂ stored in wooden and other organic components, and the embodied CO₂ emissions from non-wood building materials. In this approach, the required 50% threshold is interpreted as a climate-equivalent share, ensuring that the regulation reflects its primary policy objective to promote climate-neutral construction. Scope of application is new public buildings classified as special and non-special structures (public building categories: administrative, transport, culture, science and sports).

The methodology assesses all main load-bearing and non-load-bearing structural elements in within the building life cycle stages A1 – A3. For each main and additional structural category, the amount of CO₂ saved in materials of biological origin is calculated using material-specific sequestration factors and “equivalent volumes”, which is adjusted according to the durability coefficient, facade impact coefficient, and structural purpose.

Non-wood construction materials are assessed using embodied CO₂ emission factors. When calculating the volumes or masses of each construction category, correction factors are applied that reflect durability, materiality, and structural function. Certain parts of the building are excluded from the calculation due to technical or regulatory limitations, such as underground structures, fire-resistant partitions, escape stairs, etc.

Table 1. Summary of the methodology components.

Category	Content
Basis for quantification	the amounts of carbon dioxide that are stored and emitted by the main load-bearing and non-load-bearing internal and external structures in stages A1–A3 of the building's life cycle
Assessed elements	main load-bearing structures and non-load-bearing internal and external elements. Main structural elements: columns, beams, slabs, roofs, internal and external walls. Additional bio-based components: façade wood cladding, interior wood finishes, floor coverings, wooden window frames and door elements, bio-based insulation, and other organic-based products contributing to CO ₂ sequestration. The durability and functionality of the different types of structures are considered in the methodology
Input data	the amount of CO ₂ stored in organic materials of load-bearing structures <i>PM</i> and in organic materials of additional structures <i>PNM</i> the amount of CO ₂ emissions generated from production of main inorganic structures <i>PNM</i> equivalent and total volumes of structures, total area of glass façade, coefficient of the durability of structures, coefficient assessing the façade type, material types (wood, concrete, eco-concrete, steel, masonry, glass)
Calculations	$PM = V_{ML} \cdot P_{CO2}$, where P_{CO2} is the amount of CO ₂ (kg) stored in 1m ³ of organic and wooden materials, V_{ML} is equivalent volume of wooden load bearing structures (m ³), $PNM = V_{NML} \cdot P_{CO2}$, where V_{NML} is equivalent volume of additional non-bearing wooden structures (m ³) $PN = V_{GL} \cdot PG_{CO2} \cdot k_{G,ilg} + \frac{M_{PL}}{D_{PL}} \cdot PP_{CO2} \cdot k_{P,ilg} + V_{BL} \cdot PB_{CO2} \cdot k_{G,ilg} + V_{EBL} \cdot PEB_{CO2} \cdot k_{G,ilg} + A_{SF} \cdot PS_{CO2} \cdot k_{P,ilg}$, where PG_{CO2} is the amount of CO ₂ (kg) emitted from 1m ³ of concrete and reinforced concrete structures, PP_{CO2} is the amount of CO ₂ (kg) emitted from 1m ³ of steel structures PB_{CO2} is the amount of CO ₂ (kg) emitted from 1m ³ of masonry structures, PEB_{CO2} is the amount of CO ₂ (kg) emitted from 1m ³ of eco-concrete, PS_{CO2} is the amount of CO ₂ (kg) emitted from 1m ² of glass facade, V_{GL} is the total volume of concrete and reinforced concrete structures, M_{PL} – the total mass of the steel structures, D_{PL} is steel density, V_{BL} is the total volume of masonry structures, V_{EBL} is the total volume of eco-concrete, A_{SF} is the total area of glass façade
Final output	percentage share of wood and bio-based materials in the building P_w

The core calculation steps (Figure 3) include the calculation of CO₂ sequestration in bio-based materials (main and auxiliary structures), the calculation of embodied CO₂ emissions from non-wood materials (concrete, eco-concrete, steel, masonry, glazed facades) and the assessment of the overall CO₂ balance. The final share of wood and other biologically derived materials in buildings is expressed as a percentage, taking into account that the methodology presented a little bit differentially evaluates the cases when the threshold percentage of wood and other organic construction products is less than 50 % and more than 50 %. When 50 % is exceeded, the amount of wood and other organic construction products is reduced according to the ratio $(PM+PNM)/PN$, notation as in Figure 3.

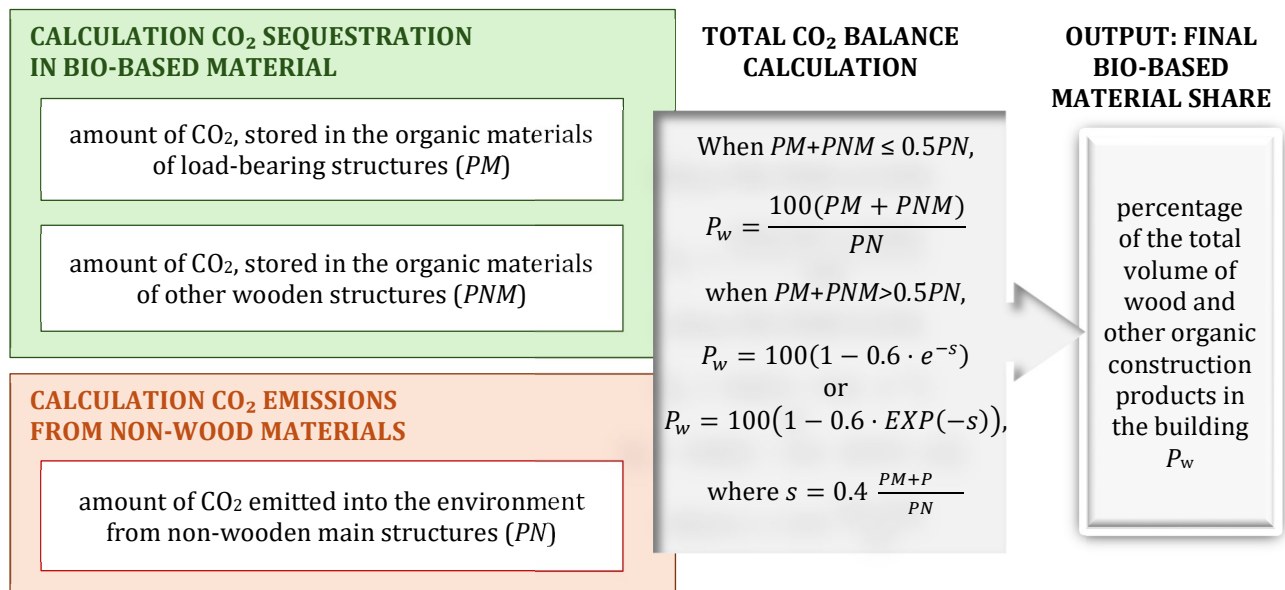


Figure 3. Key steps to determine the share of wood and bio-based materials in buildings

4. Conclusions

The legal documents of the EU emphasise the need to expand the use of sustainable building materials, and the trend to increase the share of renewable materials in buildings is increasingly established. EU member states choose different promotion instruments when transferring EU requirements into national law. In Lithuania, the promotion of wood and bio-based materials in the construction sector is also a sustainable development direction, and the Lithuanian legal environment is consistent with the EU goals and is favourable for expanding the use of biomaterials in the construction sector. A governmental resolution requires that at least 50 % of construction products used in new public buildings must consist of wood or other biobased materials derived from renewable resources. To realize this regulation, Lithuania has implemented an innovative CO₂ balance-based methodology, which is a useful tool for the practical implementation of policy objectives, contributes to the promotion of green procurement and innovation, and technological progress in the construction sector. Together, these documents create a coherent and legally binding framework in which wood and other bio-based materials are considered key tools for achieving Lithuania's climate neutrality and circular economy goals. Furthermore, the Lithuanian case illustrates an EU policy model that combines quantitative public sector requirements with carbon-based assessment tools to accelerate the market transition to bio-based construction.

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