

Wooden buildings as a strategy for carbon neutrality in Portugal



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Abstract

To promote a sustainable alternative solution to conventional materials supportive to the carbon neutrality strategy until 2050, this research proposes the development of a construction system for up to 5-storey buildings based on prefabricated wooden panels for successful application in the Portuguese context. It is expected to design, evaluate and optimise the system behaviour in structural, functional, and logistic terms, validating its performance in different scenarios; enhance and expand the prefabrication process and, consequently, its benefits; and finally, measure its sustainable performance through a life cycle assessment, mainly in terms of carbon emissions.

Motivation

GLOBAL CONTEXT

Carbon neutrality strategy until 2050
Portugal commits to reducing greenhouse gas (GHG) emissions by between 85%-90% by 2050

Review of conventional models replicated by the construction sector
40% of energy demand, 36% of GHG emissions, 40% of raw material consumption and 33% of waste. Cement and steel are responsible for 4%-7% and 5%, respectively, of global CO₂ emissions/year

Population and urban expansion dictates the need for increasingly dense forms
230bi m² of new construction by 2060
Transforms cities into opportunities for sustainable development

The European forest volume continues to grow, especially in the southwest mainland
34900mi m³, 84% of which are in forests available for the supply of wood

Introduction of Engineered Wood Products
It has optimized the structural properties of wood and overcome many of its limitations, reinventing and boosting the industry with competitive products to concrete and steel

CAD/CAM technology, CNC equipment and integrated performance of BIM specialties
Raised the degree of precision and quality of wooden products

PORTUGUESE CONTEXT

Low social acceptance

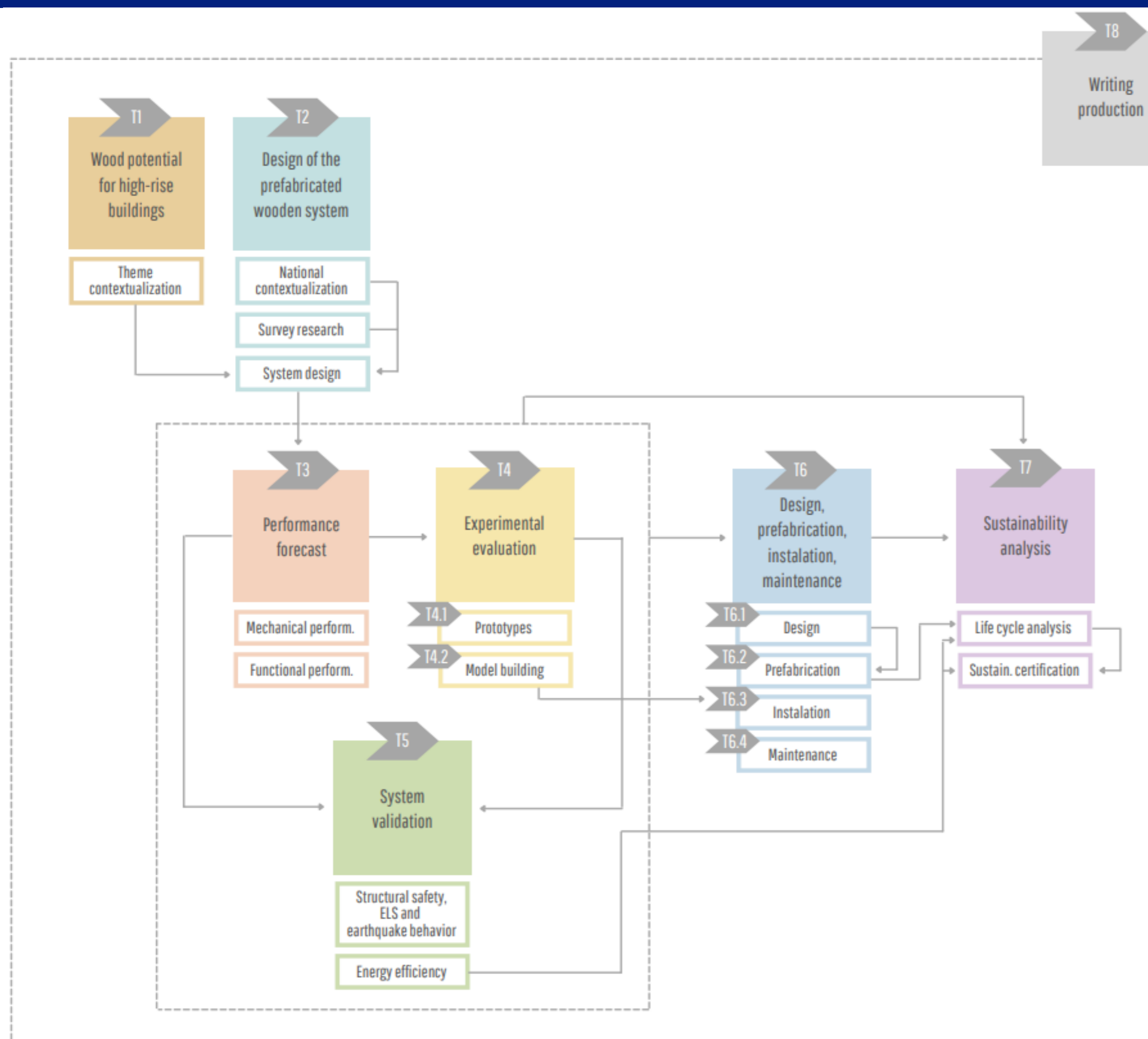
The shrinking market for wood construction
Shortage of specialized technicians in the sector
Lack of specific regulations

Only a fraction of native wood resources are used
Import of softwood from central and northern Europe for construction

Knowledge gaps
They are the main agents in the deprivation of the use of structural wood
Driven by the recent nature of modern wood construction techniques, particularly for tall buildings

Diffusion of tall wooden buildings in countries with a more rigorous climate
Systems do not properly apply to the Portuguese reality

Workflow of main tasks



Objectives

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USE OF WOOD
PREFABRICATION
PORTUGUESE CONTEXT

A sustainable alternative solution to conventional materials (namely concrete and steel)

Strengthen the local bioeconomy through native forest resources

Optimize the use of materials through the prefabrication process

Development of a construction system for up to 5-storey buildings based on prefabricated wooden panels for successful application in the Portuguese context

A tool for meeting the national carbon neutrality targets

Fill the knowledge gaps (promote scientific enrichment in the theme of wood structural use in buildings)

Promote greater acceptance and expansion of the use of wood, a natural, renewable, carbon sink material

Thesis outline

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6
Analysis of material, human and technological resources of the wood industry in Portugal	Proposal of a constructive system in prefabricated wooden panels that comply with national regulations and regulatory requirements in terms of construction, structural, functional, and logistics	Structural and functional validation and verification of the system for different national locations	Expansion of the prefabrication chain (incorporation of mechanical, electrical, and plumbing components in factory)	Provision of design rules and a construction and maintenance plan	Assessment of the system sustainable performance
1	Qualitative research to contextualize the theme, to know its development stage and forecasts for its implementation in the world scenario. The different existing solutions are compiled and analyzed to deepen the understanding of the behavior, limitations, and potential of the material for its application in high-rise buildings. Examination of the applicable regulations, species and products, sector prefabrication technologies, and transport conditions in Portugal. Surveys with the public and specialists are also conducted to identify the advantages and obstacles associated with using wood in tall buildings in the national context.				
2	Definition of the architectural, functional, and logistical goals/limitations for the constructive system. Design of the technical details of wall panels, floors, roof, and core for lifts and stairs. Identification of the building design constraints that must be satisfied in order to apply the constructive system.				
3	The mechanical and functional performance is predicted, and the construction elements optimized using calculation methods and simulations. Physical and mechanical tests are carried out on specimens of different scales, including a model building. Numerical simulations are used for the final validation of the system (structural safety and energy efficiency). Thus, a parametric study is developed considering different locations (Bragança, Porto, Lisbon, Faro), varying seismic intensity, sun exposure, climate, etc.				
4	The BIM methodology is used to optimize the prefabrication process and extend its reach, matching specialties, optimizing the use of materials, and enabling the incorporation of the MEP components to the panels still in the prefabrication phase based on preferences/restrictions and considering ideal cutting patterns. Parameterization of a set of pre-approved data capable of communicating in a direct feed flow with CAM and CNC platforms.				
5	The project design rules (architectural, structural, and functional) are compiled. The durability design is formulated with the prescriptions that influence the longevity and hygiene of the construction (exposure classes, humidity control, etc). The construction plan is elaborated, considering the prescriptions for application on-site suggested by the new generation of Eurocodes, and the maintenance plan is detailed, considering the good practices indicated in the literature and the industry of the system's materials.				
6	Quantification of the environmental impacts of the system's life cycle and evaluation of its sustainable performance against the use of conventional materials. Life cycle assessment and energy certification are performed.				

Output

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