WOOD2WOOD

A Wood-to-Wood Cascade Upcycling Valorisation Approach

» Deliverable 7.3

Final products and initial validation

WP No.	7
WP Title	Cascade Refinement Technologies for Wood Waste Upcycling (TRL5)
WP Leader	NTUA
Due Date:	02/06/2025
Submission Date	17/06/2025
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Contributing Partners	-
Status	Final

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Peer Reviewers	-

GA Number	101138789
Project Full Title	Wood2Wood Project
Project Acronym	W2W
Funding Scheme	Horizon RIA
Start Date	01/01/2024
Duration	48 months
Coordinator	Dr. Angelos Amditis, Research and Development Director, ICCS
Project Website	In progress

PROJECT INFORMATION

REVISION AND HISTORY CHART

Version	Date	Author	Description of changes
0.1	22/03/2024	Alessandro Pracucci, Matteo Giovanardi	Template released
0.2	17/06/2025	Alessandro Pracucci, Matteo Giovanardi	Final Draft
1.0	30/06/2026		Final submitted version
2.0			Revised submitted version (if required)

Dissemination Level		
PU	Public	X
RE	Restricted to a group specified by the consortium	
CO	Confidential, only for members of the consortium (including the European Commission Services)	

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GLOSSARY OF ACRONYMS

Acronym	Extended Definition
CLSM	Confocal Laser Scanning Microscopy
MWBP	Machining wood by-product
NIPU	Non-Isocyanate Polyurethane
NIRS	Near Infrared Spectrometry
PCA	Principal Component Analysis
SE	Steam explosion
SEM	Scanning electron microscopy
UF	Urea-formaldehyde
W2W	Wood2Wood

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EXECUTIVE SUMMARY

The Wood2Wood (W2W) project aims to transform the recycling and upcycling of post-consumer wood (PCW) by developing sustainable, circular solutions for the construction and furniture industries. Deliverable 7.3 focuses on Use Case 1, examining the use of wood construction waste-based panels in prefabricated façade systems.

This demonstrator report presents the main results achieved within Task 7.3 of the W2W project. It focuses on developing and validating prefabricated façade systems that incorporate PLA-based composite panels in off-site building envelope manufacturing. The report documents the validation activities conducted within the W2W project to develop façade systems integrating wood waste panels for the construction sector (Use Case 1). The primary objective is acoustic benchmarking activities, emphasizing absorption coefficient testing and insertion loss evaluation to validate the replacement of conventional façade materials with W2W panels. The report focuses on integrating composite materials into prefabricated façade systems and emphasizes acoustic performance validation through impedance tube testing. Two W2W panels have been developed for comparison with three reference products. This activity supports the definition of three façade configurations (two with conventional on-market products and one with the W2W façade system) that have been developed and are undergoing systematic evaluation to assess their potential application in the construction industry. The 18-month validation timeline prioritizes establishing fundamental performance characteristics and regulatory compliance pathways for these novel composite materials.

This deliverable reports on the results of Task 7.3, which focuses on the development and early-stage validation of composite façade panel components for facade systems incorporating PLA-based composite panels. The ultimate goal is to demonstrate the components' viability as off-site products to support the manufacturing of prefabricated façades and industrial implementation. This deliverable demonstrates and presents three stages: (1) design demonstration integration; (2) cutting and machining of the panels for manufacturing a further façade system; and (3) acoustic characterization of the panels and façade system.

The report serves as a public dissemination document presenting key demonstration activities while preserving sensitive preliminary results for future scientific publications. The primary objective centers on acoustic benchmarking activities, with emphasis on absorption coefficient testing and insertion loss evaluation to validate the potential replacement of conventional facade materials with W2W panels. The scope encompasses material characterization, manufacturing validation, acoustic testing protocols, and system integration analysis, with particular emphasis on benchmarking activities against established market products.

1. INTRODUCTION

1.1. PROJECT INTRO

The construction industry is confronting an unprecedented demand for sustainable, high-performance solutions for building envelopes, driven by stringent environmental regulations and evolving market expectations for resource-efficient construction practices. The W2W project addresses this challenge through the integration of innovative polylactic acid (PLA)-based composite materials into façade systems using a comprehensive validation methodology that accounts for the industry's inherent resistance to technological change.

The construction sector's characteristically slow responsiveness to innovation necessitates rigorous demonstration protocols that validate newly developed construction products through systematic comparison with established market alternatives. This validation imperative forms the foundation of the W2W demonstration strategy, which prioritizes empirical performance assessment and benchmarking against conventional products to establish market credibility and technical acceptance pathways. Demonstration conducted specifically addresses the validation of technical feasibility and performance characteristics of W2W panels as direct replacements for conventional façade materials, particularly, OSB (Oriented Strand Board), and gypsum board products that currently dominate the off-site and prefabricated global facade materials market. The replacement strategy acknowledges the critical importance of performance equivalence or superiority in key technical parameters while maintaining compatibility with existing construction practices and regulatory frameworks. The demonstration approach prioritizes off-site prefabrication capabilities to reduce on-site operations, aligning with contemporary construction industry trends toward modular and prefabricated building systems. W2W panels are designed according to this prefabrication philosophy, offering potential advantages in manufacturing efficiency and installation speed compared to traditional facade materials.

The validation process encompasses comprehensive façade system design optimization and acoustic performance assessment during the early developmental stages of W2W panel technology. This early-stage focus enables identification and resolution of technical challenges before large-scale manufacturing implementation, thereby reducing development risks and accelerating market introduction timelines. Physical prototypes serve as the empirical foundation for testing the feasibility of incorporating W2W composite materials into existing facade industry supply chains and construction methodologies.

Manufacturing process parameters receive particular emphasis within the validation framework, with systematic evaluation of dimensional accuracy, fixing methods, aesthetic finishes, and production scalability. These parameters directly influence the potential applications of W2W panels and their compliance with market requirements as substitutes for existing products. The evaluation addresses both technical performance criteria and practical implementation considerations that determine commercial viability in competitive construction markets.

Acoustic performance assessment represents a critical component of the validation process, focusing specifically on noise reduction capabilities that increasingly influence facade material selection in urban construction applications. This evaluation establishes the quantitative applicability of W2W facade systems in construction markets where acoustic performance constitutes a significant design criterion, particularly in residential, educational, and healthcare building sectors where occupant comfort and regulatory compliance depend on effective acoustic control.

The demonstration approach strategically prioritizes off-site prefabrication capabilities to support reduction of on-site construction operations, directly aligning with contemporary construction industry trends toward modular and prefabricated building systems. This alignment recognizes the industry's increasing emphasis on quality control, weather-independent manufacturing, and labor efficiency optimization that prefabrication methodologies provide. W2W panels are specifically designed according to this prefabrication philosophy, offering demonstrated potential advantages in manufacturing efficiency, dimensional consistency, and installation speed compared to traditional facade materials that typically require extensive on-site processing and assembly.

The scientific rigor of the demonstration activities encompasses standardized testing protocols, statistical validation methodologies, and comparative analysis frameworks that ensure reproducible results and objective performance assessment. This approach supports the generation of scientifically defensible evidence for W2W panel performance characteristics while maintaining transparency in validation procedures and results interpretation. The scope encompasses systematic material characterization, manufacturing process validation, acoustic testing protocol development, and integrated system performance analysis, with particular emphasis on quantitative benchmarking activities against established market products. The demonstration methodology ensures that validation outcomes provide actionable insights for both scientific advancement and commercial implementation of W2W panel technology in sustainable construction applications.

1.2. Expected Outcomes And Validation Criteria

The validation process conducted at this stage aims to establish acoustic performance benchmarks for the W2W panels in relation toto conventional construction approaches. Specific performance criteria include noise reduction coefficients and frequency-dependent absorption characteristics. These parameters will inform the assessment of potential applications in construction markets where acoustic performance represents a design requirement.

Manufacturing process validation encompasses dimensional accuracy assessment, fixing mode evaluation, and aesthetic finish quality control. These technical aspects directly influence the commercial viability and regulatory compliance of the proposed W2W facade systems. The integration of W2W PLA components into developed prefabricated facade systems will demonstrate the practical feasibility of industrial implementation.

The comparison between integrated facade systems and conventional alternatives will quantify the benefits in terms of noise reduction capabilities. This comparative analysis will clarify the potential applicability of innovative composite materials in construction markets, particularly in applications where enhanced acoustic performance provides competitive advantages.

2. DESIGN DEMONSTRATION

2.1. MARKET ANALYSIS AND REFERENCE PRODUCT DEFINITION

The demonstration activities involved a comprehensive analysis of on-market products serving as references for W2W panel replacement applications. Three primary material categories were identified as benchmark standards: OSB3, gypsum board, and cement board products. These materials represent the current market baseline for facade panel applications and establish performance targets for W2W panel development.

The market analysis informed the definition of facade system designs specifically engineered to support off-site manufacturing activities. Conventional facade systems utilizing OSB and gypsum/cement board market products served as the foundation for developing equivalent W2W-based alternatives. This approach ensures direct performance comparability while maintaining compatibility with existing construction practices and regulatory frameworks. Commercial suppliers for benchmark materials were selected based on market availability and representative performance characteristics, though specific supplier identification remains confidential to maintain commercial neutrality in the demonstration activities.

The demonstration investigates two distinct W2W panel technologies, each utilizing different manufacturing processes to address specific application requirements (T7.2 activities). These panels are intended as replacements for conventional panels and include solid panels with a 5 mm thickness, honeycomb panels with a 2 mm solid layer and a 5 mm honeycomb layer, and 2 mm solid panels. Table 1 shows the panels samples for each of the panel*.

Id	Status	Material Type	Thickness (mm)	Application	Images
Panel-01 (P-01)	On-market	OSB3	12	Internal/external	 
Panel-02 (P-02)	On-market	Gypsum Board	12.5	Internal	

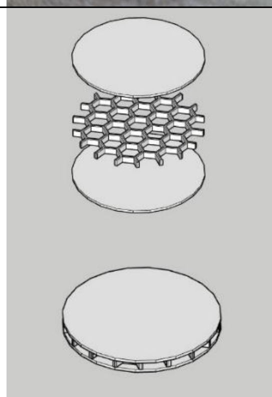
					
Panel-03 (P-03)	On-market	Cement Board	12.5	External	 
Panel-04 (P-04)	Research (W2W) TRL 4	W2W Solid panel	5	External	 
Panel-05[1] (P-05)	Research (W2W) TRL 3	W2W Honeycomb panel	9 (2+5+2)	Internal	

Table 1. Identification of panels adopted in prefabricated facades and W2W panels. The images show sample panels for acoustic tests.

2.2. Façade Systems definition

The market analysis informed the definition of facade system designs specifically engineered to support off-site manufacturing activities. Conventional facade systems utilizing OSB and gypsum board market products served as the foundation for developing equivalent W2W-based alternatives. This approach ensures direct performance comparability while maintaining

[1] Panel-05 W2W honeycomb panel samples under manufacturing by BLOOM.

compatibility with existing construction practices and regulatory frameworks. Based on the market panels selected, the activities identify three distinct facade system configurations, each representing different approaches to composite material integration. The first two systems (Facade System-Market-01 and Facade System-Market-02) incorporate conventional materials as baseline references, while the third system (Facade System-W2W-01) introduces the innovative W2W composite materials. The W2W facade system design emphasizes wood-based product integration, utilizing both W2W panels and wood fiber insulation to create a cohesive sustainable material approach. Thermal insulation specifications maintain equivalence with reference systems to ensure fair performance comparison while adopting well-established market products for non-panel components. The images below show the façade configuration with main building materials summarized in Table 2. An early thermal characterization and glazed diagram have been conducted for the façade system so that comparable systems can be obtained. For this calculation, W2W panels were considered as OSB material for thermal conductivity, but a more detailed analysis is required in particular to define the thermal characterization of W2W panels.

Id	**Panel Components**	**Thickness (mm)**	**Total Insulation Type**	**Thickness (mm)**	**Thermal Conductivity (W/(sqm·K)**	**Acooustic target Performance**
Facade System-Market-01 (FS-M-01)	Gypsum board x 2	12.5	Mineral Wool	200	0.163	R_w = 62 dB
	Cement board	12.5				
Facade System-Market-02 (FS-M-02)	OSB3	12.0	Mineral Wool	240	0.151	R_w = 48 dB
	Cement board	12.5				
Facade System-W2W-01 (FS-W2W-01)	W2W Honeycomb panel	9.0	Wood fiber	240	0.154	Comparable to references
	W2W Solid panel	5.0				

Table 2. Facade System Configuration: main components adoption.

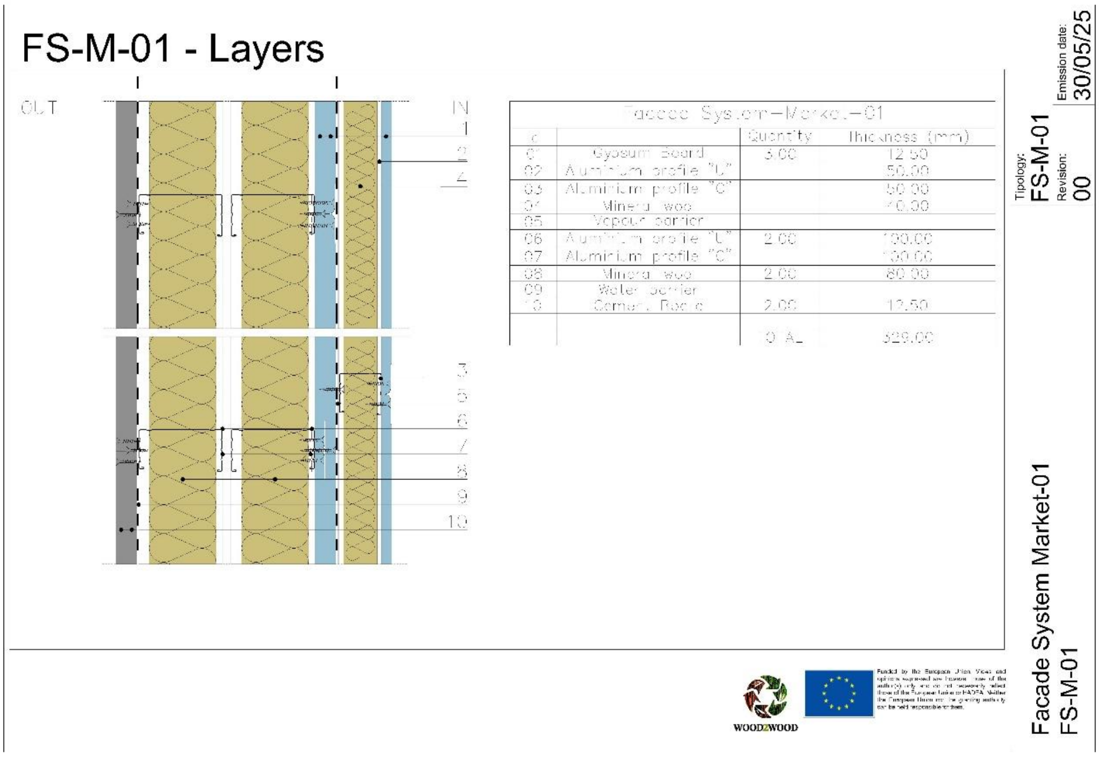


Figure 1. Facade System - Market-01 (FS-M-01) design integration. The facade system adopts gypsum/cement boards products on the market.

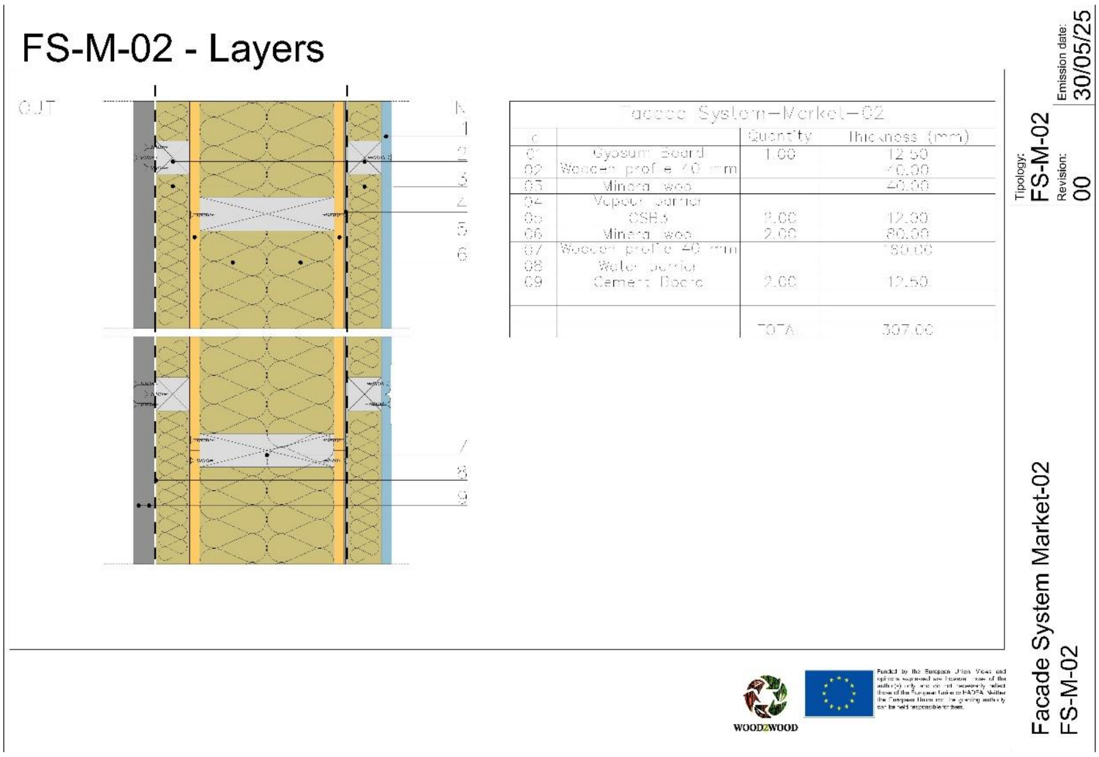


Figure 2. Facade System - Market-02 (FS-M-02) design integration. The facade system adopts OSB2 products on the market.

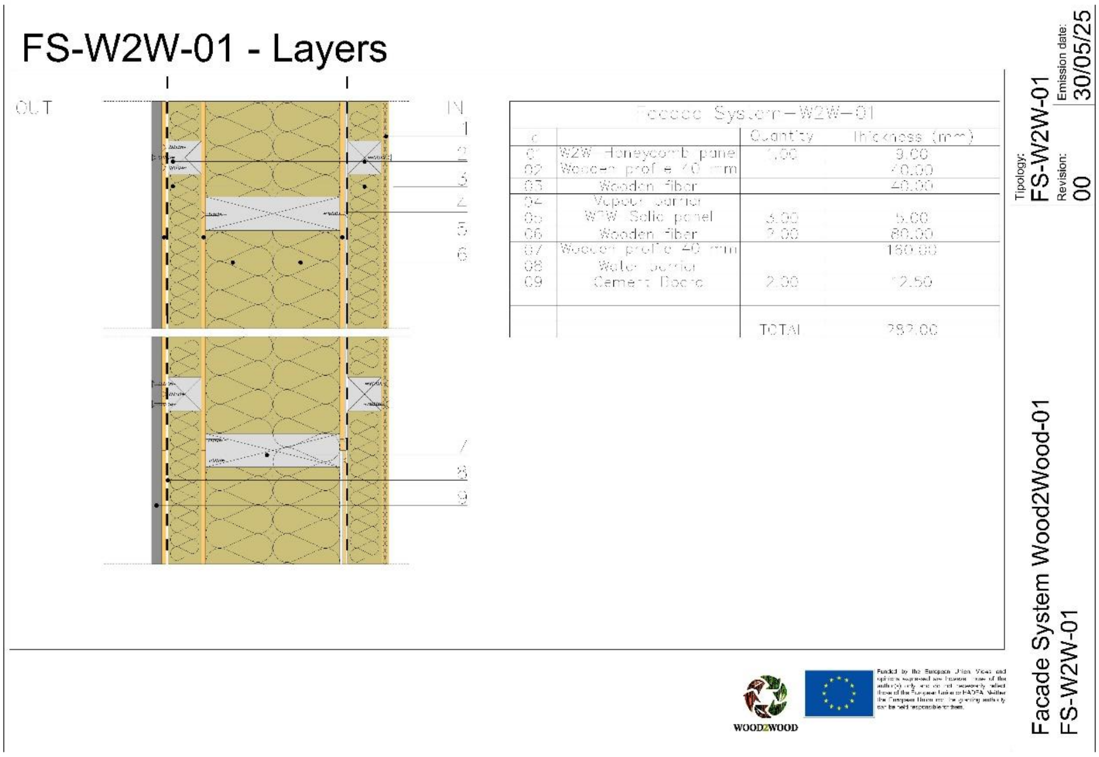


Figure 3. Facade System - W2W-01 (FS-W2W-01) design integration. The facade system integrates W2W panels.

3. MANUFACTURING AND WORKABILITY

3.1. W2W Panels Workability

A critical aspect of the validation process involves the investigation of optimal cutting and machining procedures for W2W PLA composite materials. The demonstration investigates two distinct W2W panel technologies, each utilizing different manufacturing processes to address specific application requirements: W2W solid panels (5 mm thickness) are realized through compression molding techniques, offering uniform density and mechanical properties suitable for facade applications; W2W honeycomb panels are manufactured within W2W project for research and innovation purpose using 3D printing technology (2 mm + 5 mm + 2 mm), providing lightweight characteristics with enhanced acoustic properties through controlled internal geometry. Table 3 reports the panels main characteristics.

Panel Type	Manufacturing	Primary Characteristics	Target Applications
W2W Solid Panel	Compression Molding	Uniform density, structural properties	Mechanical resistance facade elements
W2W Honeycomb Panel	3D Printing	Lightweight, controlled internal geometry	Acoustic optimization applications

Table 3. W2W panels technology comparison.

Manufacturing validation activities focus on demonstrating the machining of W2W PLA materials in comparison to conventional OSB and gypsum board processing requirements. Early validation through small sample preparation for testing objectives revealed that PLA exhibits higher hardness characteristics compared to OSB and gypsum board, potentially supporting enhanced off-site preparation capabilities relative to on-site processing requirements. Initial attempts using conventional electric jigsaws (typical of on-site activities or low-tech offsite processes) designed for wood processing proved ineffective and inadequate for achieving the precision required for acoustic testing samples. This finding necessitated a comprehensive investigation of alternative machining processes to establish suitable fabrication protocols for industrial-scale implementation. The W2W solid panel is adopted as reference to validate the machining potential and specifications of the W2W PAN due to its higher thickness and, consequently, a higher resistance. The investigation encompassed three primary machining approaches, each evaluated for precision, efficiency, and scalability and have been demonstrated for:

1. Water jet cutting machines were evaluated using both air and water at various pressure levels without abrasive addition. This approach demonstrated potential for clean edge finishing but required optimization of pressure parameters to prevent material delamination.
2. Pantograph vacuum machines with adhesive work surface retention were investigated for their capacity to maintain dimensional stability during cutting operations. The vacuum-based workpiece retention system proved particularly effective for thin panel geometries, providing consistent positioning throughout the machining cycle.

3. Milling center operations using end mill cutters represented the most comprehensive investigation. Sample preparation utilized both vise clamping and bracket fixturing systems to secure workpieces during machining operations. The milling approach demonstrated precision and repeatability, enabling the production of circular disc samples with the dimensional accuracy required for impedance tube testing.

Table 4 shows the equipment evaluated and the degree, ranging from 1 (Inadequate) to 5 (Excellent), for evaluating the adoption of equipment for a prefabricated façade system with the workability and the requested accuracy.

Machining Method	Workpiece Retention	Edge Quality	Dimensional Accuracy	Industrial Scalability
Electric Jigsaw	Manual handling	1- Inadequate	1- Inadequate	Not suitable
Water Jet (Air/Water)	Bed support	5-excellent	3-High	2-Moderate
Pantograph Vacuum	Vacuum table	5-excellent	3-High	3-High
Milling Center	Vise/Bracket fixture	5-excellent	Very high	Very High

Table 4. W2W solid panels. The ranking is: 1- Inadequate; 2-Moderate; 3-High; 5-Very high; 5-excellent. If the equipment is "Not suitable"

3.2. Off-Site and On-Site Equipment Identification

Based on the W2W panel demonstration activities for workability, Table 5 reports the panels that were adopted as benchmarks and the W2W panels and activities conducted for off-site and on-site equipment that have been validated thus far for cutting, machining, and workability. The machining process evaluation reveals significant differences in processing requirements between conventional facade materials and W2W PLA-based panels. Conventional materials (gypsum board, cement board, OSB3) demonstrate broad compatibility with both off-site and on-site processing equipment, reflecting decades of tooling optimization and industry experience. W2W PLA panels present distinct processing challenges that favor off-site manufacturing approaches. W2W solid panels are significantly harder than conventional materials, so they require pre-drilling tools and controlled machining parameters. Consequently, limitations of on-site processing include the inadequate performance of conventional electric jigsaws. Despite specific workability activity should be conducted to the 3D printing technique and typical layers, W2W honeycomb panels could exhibit complexity due to their cellular internal structure. This requires specialized fixing and vibration control during machining to prevent structural damage to the honeycomb geometry. The evaluation shows that, although W2W solid panels are compatible with standard assembly fasteners, their processing requirements strongly favor controlled off-site manufacturing environments. In these environments, specialized equipment and process optimization can ensure consistent quality and dimensional accuracy.

	Off-site				On-site					Off-site/On-site		
Panel	**Cutting**			**Machining**	**Cutting**			**Machining**		**Fixing equipment**		**Notes**
	Water jet	Pantograph	Milling center	CNC Router	Utility knife	Electric jigsaw	Circular saw	Manual router	Sanders	Self-tapping screw	Pre-drilling suggested	
P-01	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	X	Low hardness, dust generation
P-02	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	X	Moderate hardness, dust generation
P-03	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	Fiber orientation effects, edge sealing
P-04	✓	✓	✓	✓	X	X	X	X	X	✓	✓	High hardness, heat sensitivity, specialized tooling required
P-05[1]	✓	✓	✓	✓	X	X	X	X	X	✓	✓	Cellular structure vulnerability Edge support critical

Table 5. A comparison of the equipment used for sample preparation and the potential adoption of this equipment for off-site and on-site façade manufacturing. Legend: ✓=applicable; ✗-not applicable.

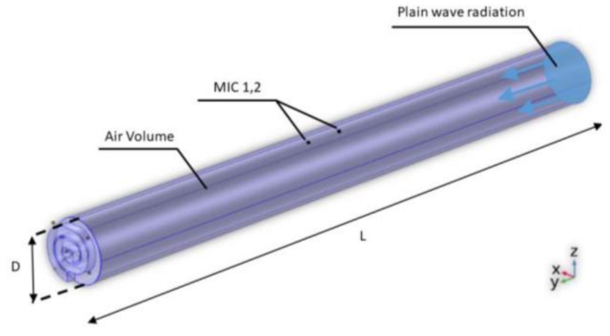
The milling center approach emerged as the optimal solution for precision sample preparation, successfully producing disc samples with dimensional accuracy required for acoustic testing applications. This validation demonstrates that W2W PLA materials can be effectively processed using conventional industrial equipment, supporting prefabrication implementation in manufacturing environments.

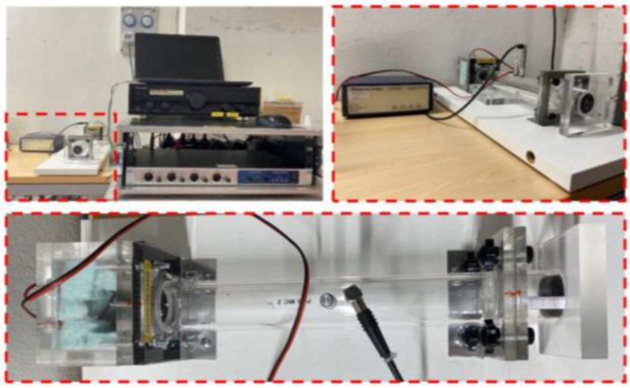
4. ACOUSTIC PERFORMANCE DEMONSTRATION

4.1. Testing Protocol Development

The demonstration employs an acoustic testing protocol designed to evaluate at early stage both individual W2W panel performance and integrated system characteristics in comparison with benchmarking panels and façade systems. Testing activities focus on absorption coefficient measurement and insertion loss evaluation, providing quantitative data for performance benchmarking against reference systems. The validation methodology adopts impedance tube techniques. This approach provides quantitative assessment of the acoustic performance characteristics for early-stage facade system evaluation. The testing protocol follows a two-phase implementation strategy designed to isolate individual material properties before evaluating integrated system performance.

Acoustic testing utilizes impedance tubes for absorption coefficient measurement of panels in compliance with ISO 10534 standards. The testing setup encompasses two impedance tube configurations: 39 mm diameter tubes for high-frequency testing (up to 4000 Hz) and 100 mm diameter tubes for low-frequency evaluation (150 Hz to 500 Hz).





(a) (b)

Figure 4. Impedance tube: (a) schematic of the geometry and the boundary conditions; (b) impedance tube measurement setup.

Insertion loss testing is conducted for the core components of the façade system (Figure 5) in compliance with ISO 354 standards (ISO, 2003). Considering the W2W panel's and the entire façade system's current early stage and relevance to acoustic performance, this preliminary insertion loss test is conducted with façade layers that can achieve similar thermal transmittance to assess their insertion loss. This activity will support the final testing phase of the W2W façade, which is scheduled for implementation in Task 8.3.

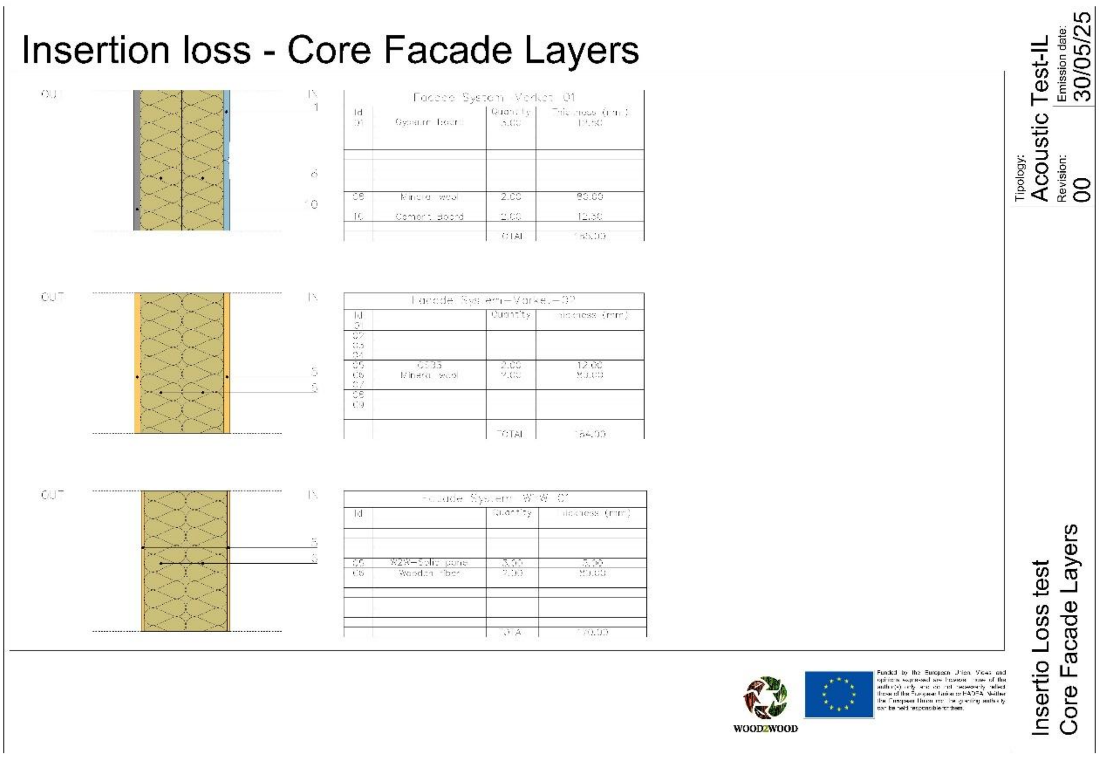


Figure 5. Samples design for insertion loss in impedance tube.

4.2. Sample Preparation

Benchmarking activities utilize commercially available reference materials including gypsum board, cement board, and OSB3 products. Specific supplier identification remains confidential to maintain testing objectivity. The benchmarking strategy addresses variations in product specifications and testing procedures by conducting comparative testing of all materials under identical conditions. This phase focuses on individual panel characterization using standardized sample geometries. Sample preparation involves cutting to achieve diameters of 39 mm and 100 mm, ensuring consistency across all tested materials. This phase encompasses conventional materials including gypsum board (12 mm thickness), and cement board (12 mm thickness), and OSB3 (12 mm thickness), alongside the innovative W2W solid panel (5 mm thickness) and W2W honeycomb panel (9 mm thickness)[1].

On the other side, performance targets for the W2W facade system align with established reference system capabilities. Facade systems incorporating gypsum board and cement board typically achieve Rw = 62 dB (Knauf, n.d.), while OSB-based systems demonstrate approximately Rw = 48 dB (Tonin, n.d.) performance levels. These targets provide quantitative benchmarks for evaluating the W2W system, but they will be compared to the insertion loss test, which is slightly different from the standard adopted for full-scale façade systems and is not possible at this stage.

Current sample availability reflects the outcomes of the machining process investigation and W2W panels manufacturing process (Table 6). The successful validation of milling center operations for W2W solid panels has enabled production of samples meeting the geometric requirements for acoustic testing (39 mm), while larger samples (100 mm) remain under development to accommodate full-scale testing requirements as well W2W Honeycomb panel (Figure 6).

Id	Material Type	Ø 39mm	Ø 100mm	Machining Method	Status
P-01	OSB3	3 samples	3 samples	Electric Jigsaw	Complete
P-02	Gypsum Board	3 samples	3 samples	Electric Jigsaw	Complete
P-03	Cement Board	3 samples	3 samples	Electric Jigsaw	Complete
P-04	W2W Solid panel	3 samples	Pending	Milling center	Partially complete
P-05[1]	W2W Honeycomb panel	Pending	Pending	3D printing	Manufacturing in progress

Table 6. Acoustic tests absorption coefficient samples in impedance tube.

(a)	(b)	(c)	(d)

Figure 6. Sampled for acoustic absorption test (ISO 354): (a) gypsum board; (b) cement board; (c) OSB3; (d) W2W solid panel.

4.3. Testing Activities

The testing program follows a structured timeline on the independence tube for lab testing, after the W2W panels are available for testing. Acoustic coefficient absorption testing began in June 2025 with the characterization of individual panels for P-01, P-02, P-03, and P-04. This test will establish a baseline of acoustic properties for each material component, which will then be compared with the properties of W2W panels.

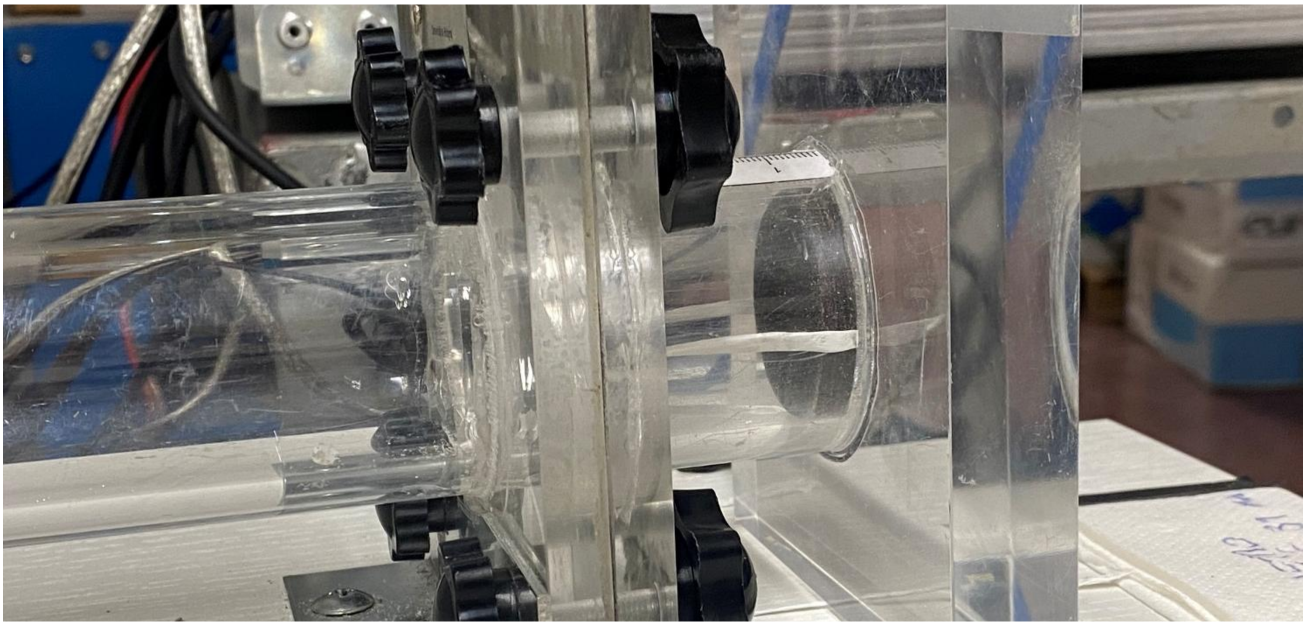


Figure 7. Testing ongoing in Impedance tube for acoustic coefficient absorption of W2W solid panel ⌀ 39 mm. Picture 01.

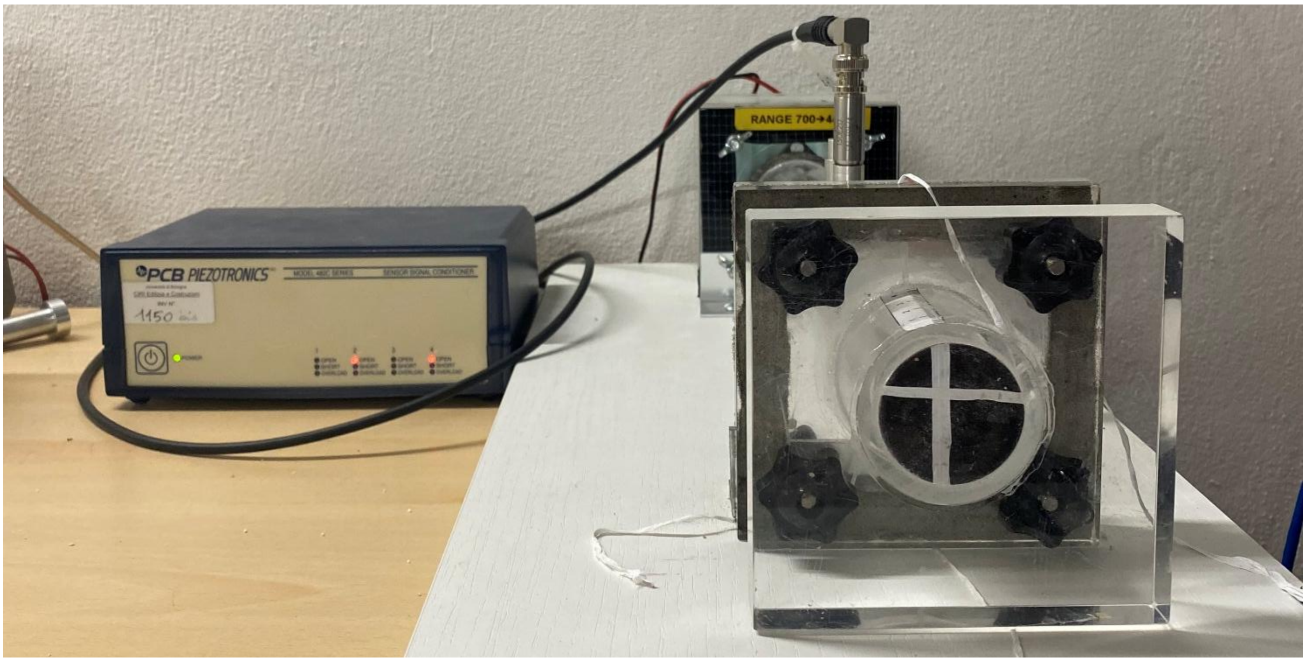


Figure 8. Testing ongoing in Impedance tube for acoustic coefficient absorption of W2W solid panel ⌀ 39 mm. Picture 02.

The second testing phase, scheduled for July-August 2025, involves the finalization of absorption coefficient (P-05) and the comprehensive evaluation of the integrated facade core systems. This phase requires the manufacturing of complete system samples with both 39 mm and 100 mm diameters for each of the three facade configurations. System-level testing will provide critical data on the acoustic performance of assembled facade units, enabling direct comparison between conventional and W2W façade system.

Sample preparation activities for acoustic testing are currently ongoing, with reference facade system samples under preparation for insertion loss testing.

Absorption coefficient testing in impedance tubes has been initiated for individual panel characterization, utilizing the validated milling center protocols for sample preparation. Comprehensive results analysis is planned for completion by September 2025, though detailed results will be preserved for specific scientific publications rather than public dissemination.

5. ADDITIONAL TESTING CONSIDERATIONS

The demonstration scope recognizes additional testing requirements not planned under the W2W project framework but under evaluation to support broader testing development activities. These include thermal transmittance characterization, mechanical property assessment (tensile strength, flexural modulus), and durability evaluation. Regulatory framework analysis and standards compliance evaluation are additional T7.3 activities that are beyond the scope of W2W's work. However, they are recommended to fully characterize the W2W panels and to compare them with on-market products.

6. CONCLUSIONS AND FUTURE WORK

This early-stage validation represents a critical milestone in the development of W2W facade systems within the W2W project framework. The demonstration activities conducted within Task 7.3 successfully establish the foundation for W2W panel integration into facade systems. Manufacturing validation confirms the workability of PLA-based materials using conventional industrial equipment, while acoustic testing protocols provide quantitative benchmarking capabilities against established market products. The systematic approach to acoustic performance characterization provides data for assessing the technological improvement and commercial viability of W2W facade system. Future work in T8.3 will focus on expanding the testing program to include additional performance parameters relevant to facade system applications, including thermal performance, moisture resistance, and structural integrity. The successful completion of acoustic validation will establish the foundation for comprehensive system optimization and technological readiness assessment.

The higher hardness characteristics of W2W PLA materials compared to conventional OSB and gypsum board products suggest potential advantages for off-site prefabrication applications. Assembly system compatibility with existing commercial fastening methods supports practical implementation pathways for construction industry adoption.

Future demonstration phases will focus on comprehensive acoustic performance evaluation and system optimization based on testing results. The established benchmarking methodology provides a robust foundation for quantitative performance comparison and validation of W2W facade system capabilities.

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