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EASI ZERo

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Deliverable

ENVELOPE MATERIAL SYSTEM WITH LOW IMPACT FOR ZERO ENERGY RENOVATION AND CONSTRUCTION

Deliverable ID	**D4.2**
Deliverable name	**"Prototypes and wall combination Proof of Concept"**
Deliverable description	This proof of concept was carried out on a fully integrated wall at lab scale, defining optimum combinations of the developed materials and components according to 3 environmental scenarios. This facility was designed in task 4.1, built and validated in task 4.5. This proof of concept work provided the physical structures which are tested in work package 5. The experimental considerations of Work package 5 was thus also an important factor for the prototype design.

WP	4	Construction products development & assembly
Task	4.1, 4.5	4.2: Wall components prototypes 4.3: High energy efficient windows with insulated blind box 4.4: Integration of BIPV in vertical wall

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[1] Dissemination level: **PU** = Public, fully open, **SEN** = Sensitive, limited under the conditions of the Grant Agreement
[2] Nature of the Deliverable: **R** = Report

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ACRONYM

CEA: Commissariat à l'énergie atomique et aux énergies alternatives
DTI: Danish Technological Institute
HUNT: Hunton Fiber AS
INDRE: Indresmat
LFB: Leipfinger-Bader GmbH
USTUTT: University of Stuttgart

1. Executive summary

1.1 *Description of the Deliverable content and objectives*

This deliverable presents the proof-of-concept wall element prototypes developed within EASI ZERo to demonstrate the integration of selected low-impact envelope materials and components in representative construction systems. The prototypes were designed to assess the constructive compatibility and combined performance of the developed solutions in relation to different environmental and application scenarios, covering both renovation and new-build approaches. Specifically, each prototype relates to one of three over-all environmental scenarios: Subartic, Cool-temperate, or Warm-temperate scenario.

1.2 *Deviation from Objectives, Corrective Action*

From the onset of the project, the link between the proof-of-concept prototypes in Task 4.5 and the prototypes for testing in Tasks 5.3, were unclear. As the project unfolded it became clear that only one set of prototype wall elements were to be made, and that the experimental design for the work in Task 5.3 was to be the foundation for the final choice of EASI ZERo products and layout of the wall-elements. These test wall-elements therefore constitute the proof-of-concept prototypes described in this deliverable, fulfilling the work of task 4.5.

1.3 *Technical Progress: Overview of the four "Proof-of-concept" wall element prototypes prototypes*

Four proof-of-concept wall element prototypes were developed within the project in order to demonstrate the integration of selected EASI ZERo products and material combinations in representative envelope assemblies. The prototypes cover both renovation and new-build approaches and include masonry-based as well as lightweight timber-based systems.

The **CEA prototype** represents a renovation-oriented wall configuration based on a heavy existing support with interior insulation. It demonstrates the integration of sprayable Bio-PUR foam and a Bio-PUR window with an insulated wooden blind box in a refurbished wall assembly representative of energy renovation applications, fitting for the warm-temperate environmental scenario.

The **SINTEF prototype** is based on a lightweight timber-frame wall representative of Norwegian construction practice. It demonstrates the use of wood-fibre insulation developed in EASI ZERo by HUNT in both the original wall and an interior refurbishment layer, thereby representing a typical interior insulation upgrade scenario, fitting for the subarctic environmental scenario.

The **USTUTT prototype** consists of four masonry-based wall configurations developed as a comparative proof-of-concept. The assemblies demonstrate the integration of PCM capsules developed by FRAUNHOFER in LFB clay bricks, the aerogel-based insulation render developed jointly

by FRAUNHOFER and SIEVERT, and bio-based insulation materials, alongside reference wall solutions for comparison. This prototype demonstrates a construction representative for the cool-temperate, environmental scenario.

The **DTI prototype** is a lightweight timber-based wall assembly developed to assess the constructive integration of wood-fibre insulation developed by HUNT and mycelium-based interior panels produced by SQIM. The prototype represents a prefabricated framed wall solution combining innovative insulation and interior finishing products in a compact constructive system. This prototype demonstrates an alternative light weight construction, similarly representative for the cool-temperate, environmental scenario.

1.4 *Impact of the Results*

The proof-of-concept work described here is the foundation for the physical testing done in WP 5, as well as the final demonstration of how combinations of individual EASI ZERo products can be combined and how they perform in combination, as part of an actual building envelope. The link to other deliverables are:

- D5.2 “Guideline for test design and experimental techniques”; describes the background for the experiments carried out on the test walls described in D4.2.
- D5.4 “Experimental data” reports the results of the measurement campaigns carried out within WP5.
- D5.5 “Buildability Report” reports on the buildability of the constructed prototypes, detailing elements of the construction and disassembly procedures for the test walls described in D4.2.

1.5 *Dissemination Activities Carried Out / Planned*

The DTI prototype was displayed physically as part of a national stakeholder seminar on energy renovation using the EASI ZERo products (28 Jan. 2026, Aarhus, Denmark).
All prototypes were displayed in images, at the EASI ZERo final conference (28 may 2026, Brussels, Belgium).
All the prototypes also play a prominent role in the final EASI ZERo project video, which is available on the project home page, and otherwise circulating on social media.
As the physical culmination, and final demonstration, of the product development done in EASI ZERo, the D4.2 is an important part of the results obtained in EASI ZERo, and will thus likely be part of all general dissemination if the project results, in the time following the end of the project.

2. Technical content

2.1 *CEA Prototype*

2.1.1 Description of design and EASI ZERo products to be demonstrated

The CEA prototype is configured as a refurbished wall element installed on the CEA test cell. The assembly combines a heavy existing support with interior insulation and integrated EASI ZERo components representative of a renovation scenario. From exterior to interior, the wall build-up consists of an external coating, a 200 mm layer of hollow concrete blocks, a 20 mm EPS layer, a 13 mm gypsum board, a 100 mm layer of Bio-PUR foam, sprayed between wooden studs, and an internal 13 mm gypsum board finish. The wall prototype demonstrated EASI ZERo products: Sprayable Bio-PUR foam and the Bio-PUR window, both from INDRE, while the window was fitted with an integrated wooden blind box from LFB. The VOC removal paint developed by MVIC has been applied on the gypsum board finish

Table 1: CEA prototype materials (EASI ZERo products in green).

Material (indoor to outdoor side)	thickness
Bio-PUR window + wooden blind box	
Gypsum board	13 mm
Bio-PUR foam	100 mm
Gypsum board	13 mm
EPS	20 mm
Hollow concrete blocks	200 mm
Ext. coating	20 mm

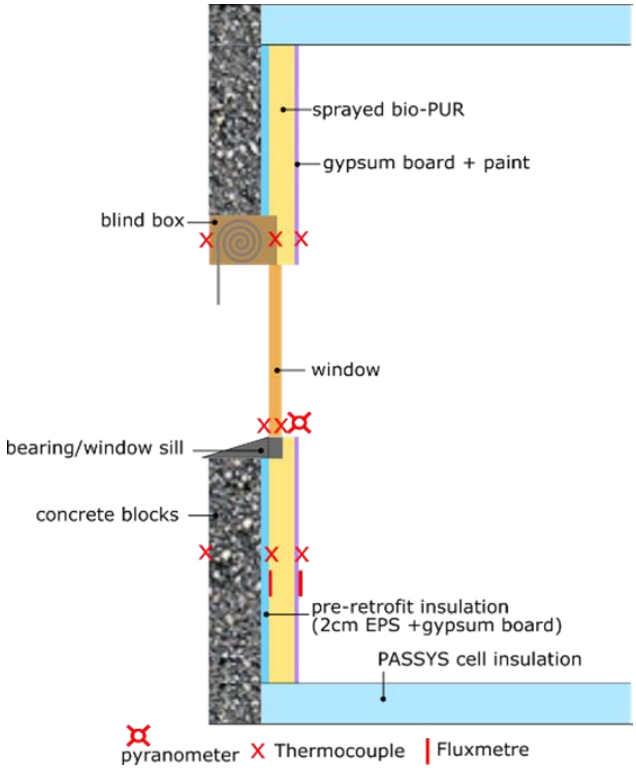


Figure 1: CEA prototype design layout

2.1.2 Construction

The construction proceeded as an energy renovation refurbishment typical for poorly insulated concrete housing, adding insulation to the existing construction from the inside, starting from the gypsum wall. The sprayable foam was applied between wooden studs, layer-by-layer, until the final thickness was obtained. The wall was finished with gypsum boards again.

The principal layout of the CEA prototype is shown in Figure 1 and the finished construction in Figure 2.



Figure 2: left: Application of the sprayable bio-PUR foam. Right: Showing before (top) and after (bottom) retrofitting with EASI ZERo materials.

2.2 *SINTEF Prototype*

2.2.1 Description of design and EASI ZERo products to be demonstrated

The prototype investigated in SINTEF in its original configuration consists of a lightweight timber-frame assembly. The assembly included the HUNT wood fibre insulation developed in EASI ZERo. From interior to exterior, the stratigraphy is as follows: a 13 mm gypsum board forms the interior finish layer; immediately outboard is a hygrovariable vapour retarder; the main insulation layer, 98 mm thick, is housed within a timber stud frame (48×98 mm); a wind barrier membrane is placed on the external face of the insulation; a ventilated air gap of approximately 30 mm separates the structural assembly from the outer cladding, which consists of vertical timber boards. The wall is representative of a standard Norwegian light-frame construction practice for residential and low-

rise buildings. Table 2: Overview of materials included in the original (stage 1) SINTEF prototype. resumes the stratigraphy of the original prototype.

Table 2: Overview of materials included in the original (stage 1) SINTEF prototype. (EASI ZERo products in green).

Material (indoor to outdoor side)	thickness
Gypsum Board	13 mm
Vapour barrier	~2 mm
Insulation (wood fibre) + studs	98 mm
Wind barrier	~2 mm
Air gap	30 mm
Cladding (wood)	20 mm

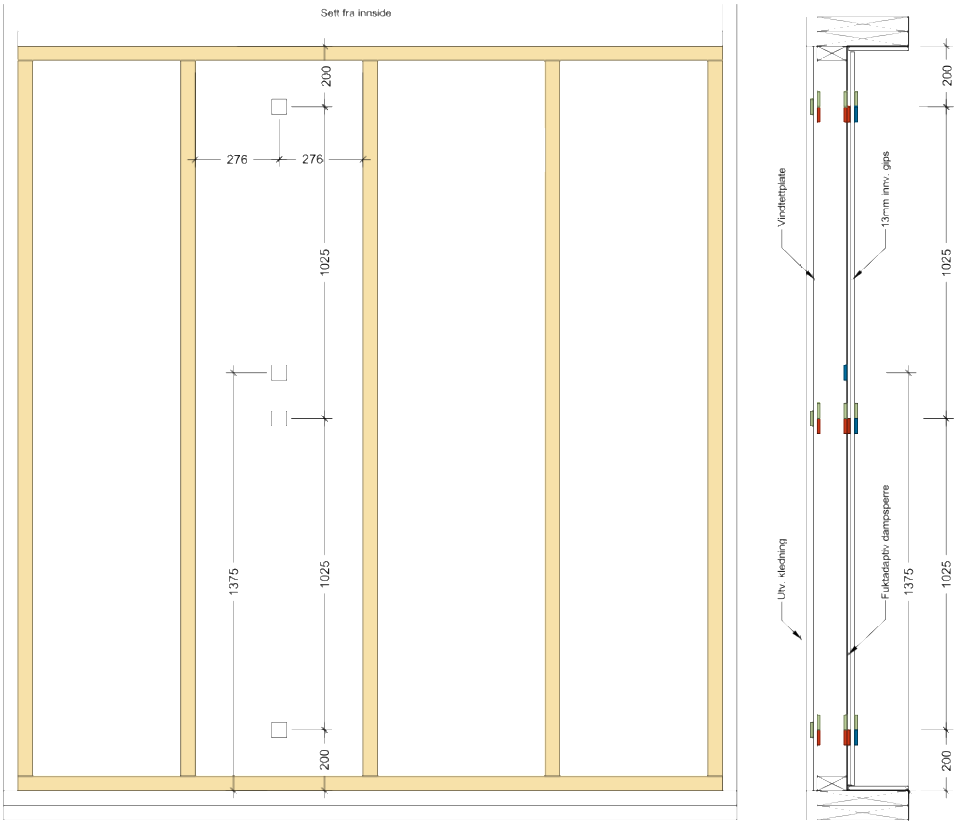


Figure 3: Shows the design and the quotes of the load bearing structure in the SINTEF prototype.

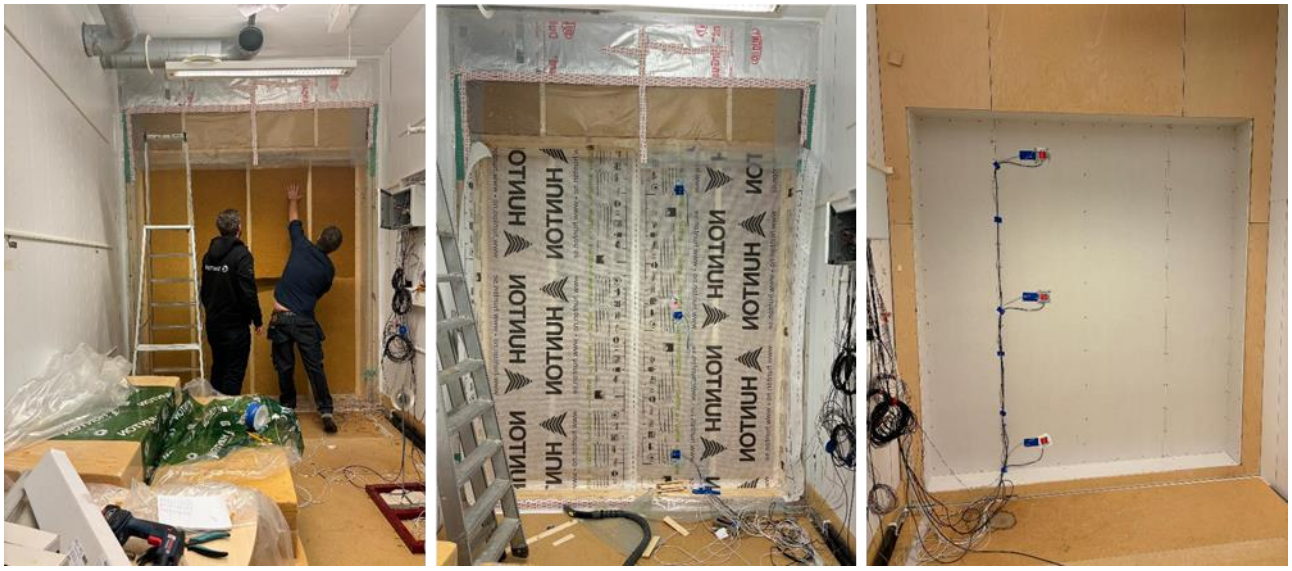


Figure 4: Images of the construction of the SINTEF prototype, with the finished structure on the right.

2.2.2 Construction

The prototype was built in two stages. On the abovementioned original wall, a refurbishment was carried out. The intervention consisted of the addition of a 50 mm layer of insulation on the interior side of the existing vapour retarder. To accommodate this, the original gypsum board was temporarily removed, the new insulation layer was installed between the vapour retarder and the interior surface, and the gypsum board was reinstalled. The remaining layers of the wall (e.g. vapour retarder, structural insulation, wind barrier, air gap and cladding) were left unchanged. The refurbishment represents a typical interior insulation upgrade scenario, aimed at improving the overall thermal resistance of the envelope while retaining the existing external cladding system. The total opaque thickness of the wall increased from approximately 125 mm to approximately 175 mm following the intervention.

The final prototype tested at the SINTEF facility is shown in

Table 3: Recap the stratigraphy of the stage 2 SINTEF test wall (EASI ZERo products in green).

Material (indoor to outdoor side)	thickness
Gypsum Board	13 mm
New insulation (wood fibre) + studs	50 mm
Vapour barrier	~2 mm
Insulation + studs	98 mm
Wind barrier	~2 mm

Air gap	30 mm
Cladding (wood)	20 mm

2.3 *USTUTT Prototype*

2.3.1 Description of design and EASI ZERo products to be demonstrated

The prototype investigated at USTUTT consists of four masonry-based wall configurations developed as a comparative proof-of-concept for conventional and innovative envelope systems. The objective of the prototype is to assess the influence of different material solutions on the thermal and constructive performance of mineral-based wall assemblies representative of renovation and new-build applications.

The four configurations were defined to investigate distinct strategies for improving envelope performance within the EASI ZERo framework. These include the integration of PCM capsules developed by FRAUNHOFER within clay masonry units supplied by LFB, the application of the aerogel-based insulation render developed jointly by FRAUNHOFER and SIEVR, and the use of bio-based insulation materials in combination with masonry substrates. In addition, a reference insulation render system is included to enable comparison with the project-developed aerogel render under consistent boundary conditions. Together, the assemblies provide a structured basis for comparing innovative material combinations against reference masonry wall solutions.

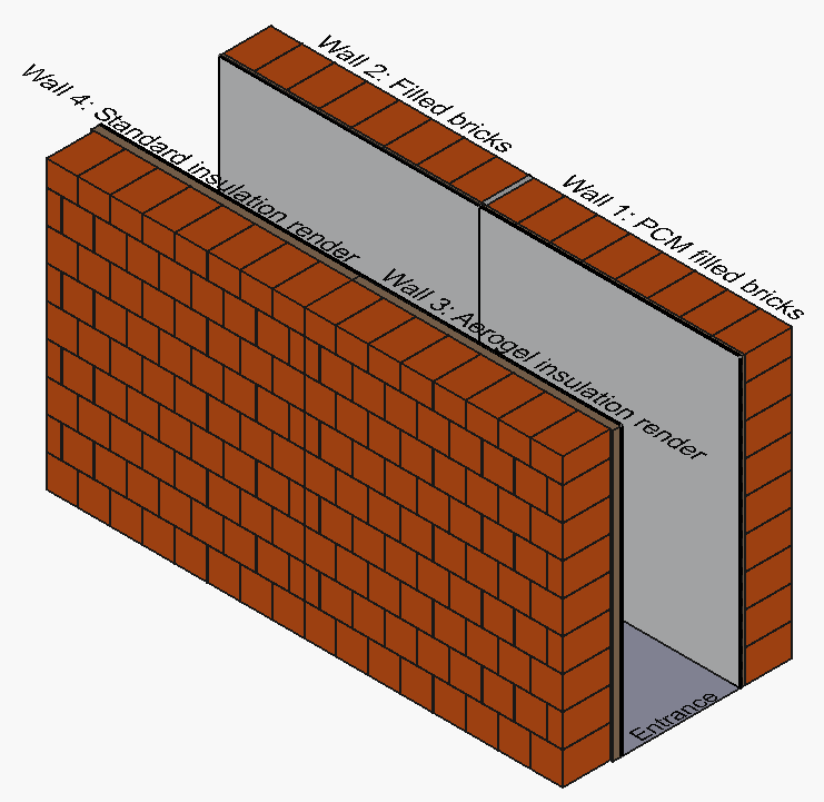


Figure 5: Schematic of the USTUTT prototype walls.

Table 4(a-d): The materials included in the 4 respective wall prototypes, build in the USTUTT laboratories (EASI ZERo products in green).

Wall 1: **Material (indoor to outdoor side)**	**Thickness**
PCM filled bricks	365 mm
Non-insulation render	20 mm
Fiberglass reinforced mortar	10 mm
Plaster primer	1 mm
Finishing render	5 mm
Paint	1 mm

Wall 2: **Material (indoor to outdoor side)**	**Thickness**
Regular bricks	365 mm

Non-insulation render	20 mm
Fiberglass reinforced mortar	10 mm
Plaster primer	1 mm
Finishing render	5 mm
Paint	1 mm

Wall 3: **Material (indoor to outdoor side)**	**Thickness**
Hollow bricks	365 mm
Aerogel insulation render	60 mm
Fiberglass reinforced mortar	10 mm
Plaster primer	1 mm
Finishing render	5 mm
Paint	1 mm

Wall 4: **Material (indoor to outdoor side)**	**Thickness**
Mycelium woodfibre boards	47 mm
Hollow bricks	365 mm
Trio-Therm insulation render	60 mm
Fiberglass reinforced mortar	10 mm
Plaster primer	1 mm
Finishing render	5 mm
Paint	1 mm

2.3.2 Construction

The USTUTT prototype comprises four wall configurations with different material stratigraphies.
Wall 1 consists, from indoor to outdoor side, of 365 mm clay bricks incorporating PCM capsules, 20 mm non-insulating render, 10 mm fiberglass reinforced mortar, 1 mm plaster primer, 5 mm finishing render, and 1 mm paint. This configuration is intended to evaluate the integration of latent heat storage capacity directly within the masonry component. The masonry unit is based on LFB brick technology, while the PCM capsules were developed by FRAUNHOFER.
Wall 2 represents the reference configuration and consists of 365 mm regular clay bricks, 20 mm non-insulating render, 10 mm fiberglass reinforced mortar, 1 mm plaster primer, 5 mm finishing render, and 1 mm paint. This assembly provides the baseline for comparison with the enhanced wall solutions and is based on the corresponding LFB masonry system without PCM integration.
Wall 3 consists of 365 mm hollow clay bricks combined with a 60 mm aerogel insulation render, followed by 10 mm fiberglass reinforced mortar, 1 mm plaster primer, 5 mm finishing render, and 1 mm paint. This wall is intended to demonstrate the application of the aerogel-based insulation render developed within EASI ZERo by FRAUNHOFER and SIEVR in a masonry-based envelope configuration using LFB brick elements.
Wall 4 combines 47 mm mycelium wood fibre boards from SQIM with 365 mm hollow clay bricks and an external 60 mm Trio-Therm insulation render. The exterior finishing build-up further includes 10 mm fiberglass reinforced mortar, 1 mm plaster primer, 5 mm finishing render, and 1 mm paint. This configuration is intended to provide a reference case for comparison with the project-developed aerogel insulation render, while also demonstrating the integration of a bio-based insulation layer in a composite masonry wall assembly. The overview of the materials included in the prototype walls are summarized in Table 4(a-d), while the final prototype construction is shown in Figure 6.



Figure 6: Images of the construction of the USTUTT wall prototypes.

2.4 *DTI Prototype*

2.4.1 Description of design and EASI ZERo products to be demonstrated

The prototype investigated at DTI consists of a lightweight timber-based wall configuration developed as a proof-of-concept for the constructive integration of selected EASI ZERo envelope products in a prefabricated wall assembly. The objective of the prototype is to assess the compatibility and buildability of bio-based and low-impact materials within a framed wall system representative of industrialized construction and renovation applications.

The wall configuration was defined to demonstrate the integration of wood-fibre insulation developed by HUNT, mycelium-based interior panels produced by SQIM, and timber-based façade components within a single constructive assembly. Together, these elements provide a representative test case for evaluating the interaction of innovative insulation and interior finishing products in a lightweight wall system under prototype-scale conditions.

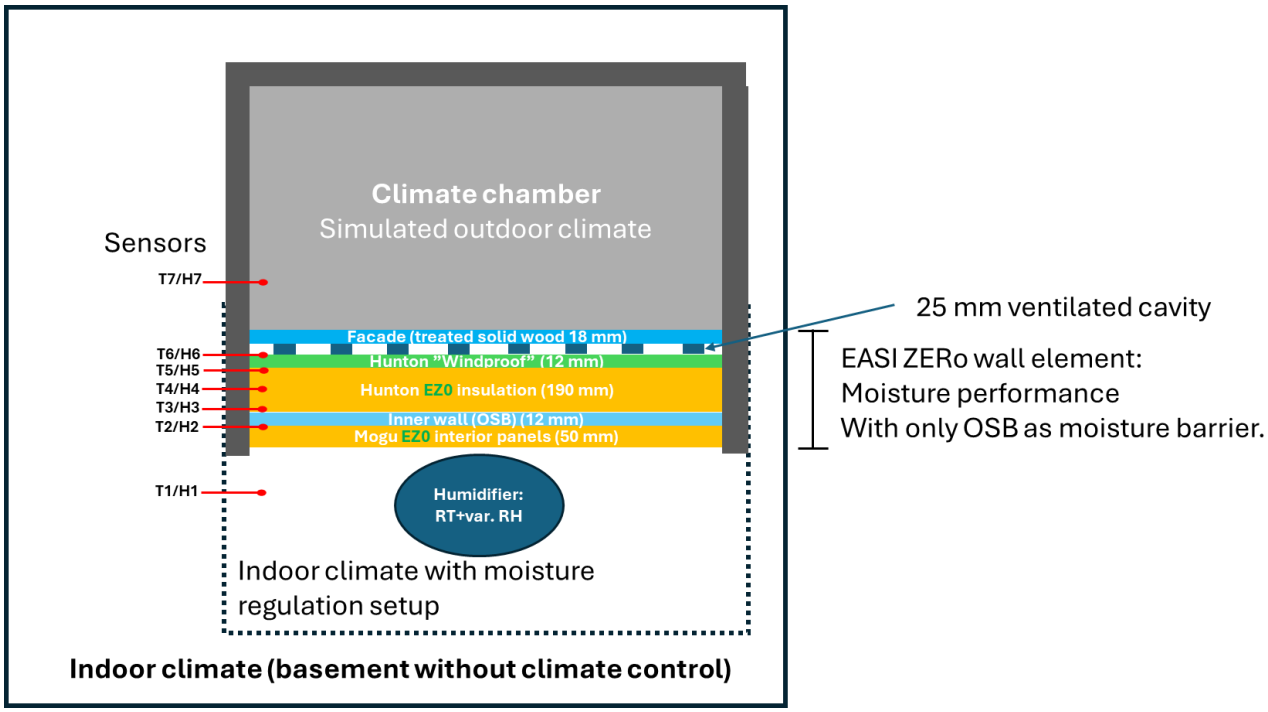


Figure 7: Schematic of the DTI prototype layout.

2.4.2 Construction

The DTI prototype comprises a timber-framed wall assembly with the following material stratigraphy from indoor to outdoor side: 50 mm SQIM EZO interior panels, 12 mm OSB inner wall, 190 mm Hunton EZO insulation placed within the timber stud structure, 12 mm Hunton Windproof board, 25 mm ventilated air gap, and 18 mm treated solid wood façade cladding.

The assembly integrates mycelium-based interior panels produced by SQIM as the internal finish and wood-fibre insulation developed by HUNT as the main insulating layer. The wall build-up is representative of a lightweight prefabricated timber construction system and combines structural, insulation, wind-protective and façade layers in a compact test element. The final prototype is shown in Figure 8 with a summary of the included materials in Table 5.

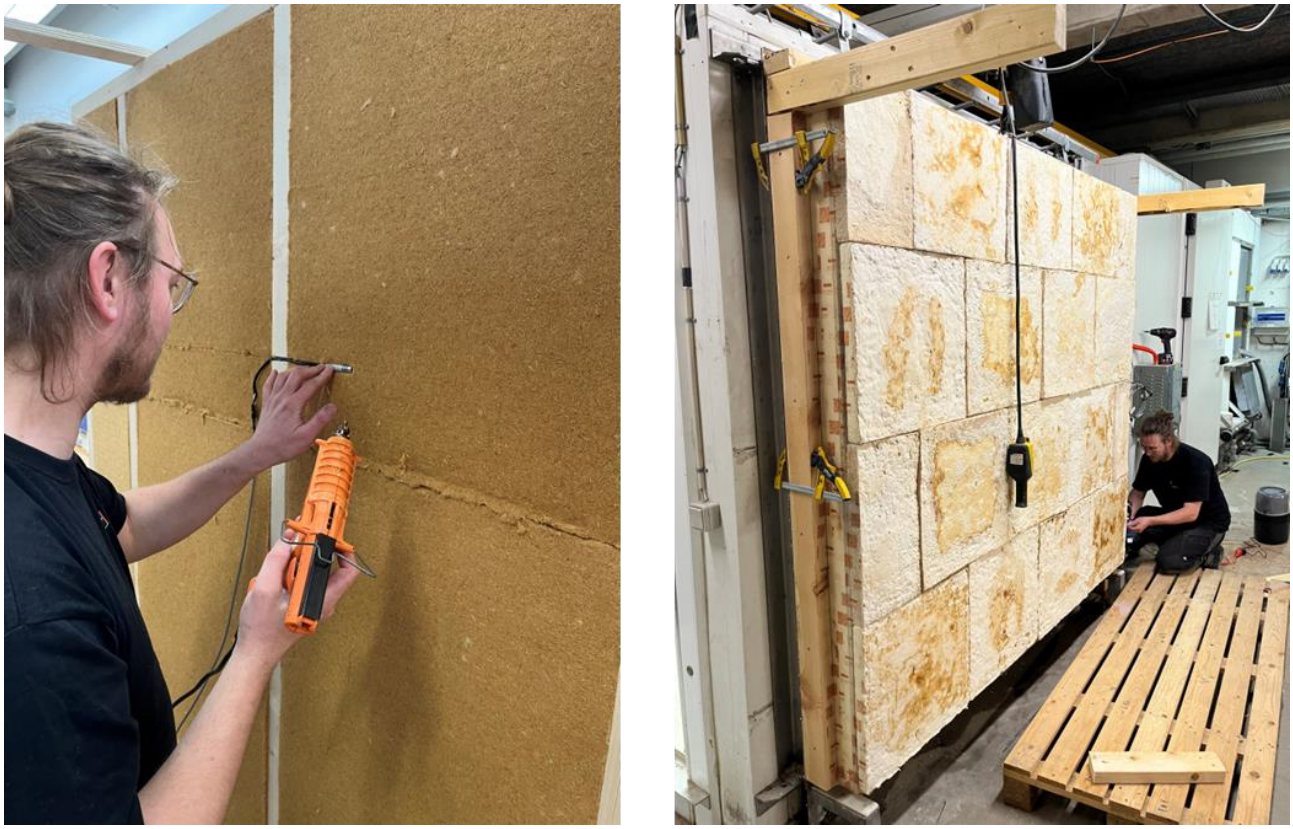


Figure 8: Here is shown images form the construction and of the final DTI prototype (right).

Table 5: List of materials included in the DTI prototype (EASI ZERo products in green).

Material (indoor to outdoor side)	Thickness
SQIM EZO interior panels	50 mm
Inner wall (OSB)	12 mm
Hunton EZO insulation	190 mm
Hunton "Windproof"	12 mm
Air gap	25 mm
Facade (treated solid wood)	18 mm

2.5 *Considering different environmental scenarios*

To reflect the varying climatic and environmental conditions across Europe, the EASI ZERo prototypes were designed for different environmental test scenarios. As the individual research institutes involved in this work, are sufficiently spread out, simply applying local construction practices and climatic conditions, ensured three distinct environmental scenarios:

1: Subartic (Dfc[4]): The SINTEF prototype, tested against local outdoor conditions in WP 5.

2: Cool-temperate (Cfb): The USTUTT and DTI prototypes, tested towards simulated local climate in WP 5.

3: Warm-temperate scenario (Cfa/Cfb): The CEA prototype, tested against local outdoor conditions in WP 5.

3. Conclusion

In conclusion, the proof-of-concept work presented in this deliverable demonstrate the EASI ZERo products developed in Work Package 4 (WP 4) at wall-scale, while also providing the foundation for the physical testing conducted in Work Package 5 (WP 5). This research successfully demonstrates how various individual EASI ZERo products can be integrated in a realistic building envelope. These outcomes directly support subsequent key project deliverables: D5.2 establishes the experimental guidelines and testing methodologies; D5.4 documents the resulting empirical measurement data; and D5.5 evaluates the practical buildability and disassembly of the constructed prototypes. Together, these links ensure a seamless, well-documented transition from initial concept validation to physical performance testing.

[4] Köppen climate classification system