Prefabricated plug&play façade unitized for deep retrofitting: the RenoZEB case study

The RenoZEB case of study

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ARCHITECTURAL BUILDING ENVELOPES
FOCCHI SINCE 1914

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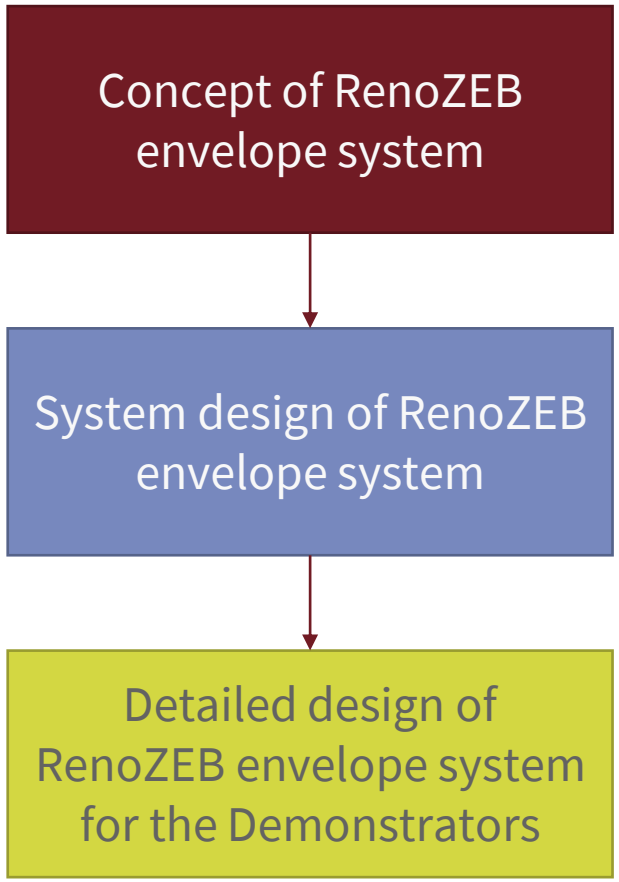
Focchi façade System

OUTLINE

- RenoZEB introduction
- Boundary conditions
- Focchi façade system
- Tests and results
- Conclusions



RenoZEB Introduction

Project timeline
10/2017 03/2021 (09/2021)

Call
H2020-EEB-2017

Call strategy
The European call regards the development of near zero energy building renovation. In this concept strategy for deep retrofitting or technologies for building efficiency are required

Partner
SOLINTEL, Project Coordinator **Michele Vavallo**
TECNALIA, FRAUNHOFER, B+H, UNIVPM, HYPETC, BALKANIKA, VORU, TREU, DURANGO, RINA, CYPE, SALFORD, CSTB, ENERGYPRO, ACE

Focchi is responsable for the plug and play facade

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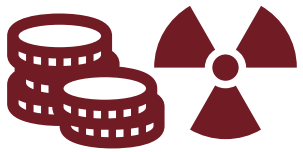
RenoZEB Main Objective

The project aim is to establish a systematic methodology for the energy deep retrofitting for building stock market by developing a BIM based platform and tools for actors of the value chain.

Four pillars of RenoZEb project

Reduction of energy consumption



Reduction of cost and risk

Replicability and adaptability

Increase the property value

Boundary conditions

Building envelope analysis

Building's boundary conditions:

Existing load bearing structure

Existing openings

Identification of facade panels:

Primary panels (window unit)

Secondary panels (opaque, technical units)

Eventual aggregation of units

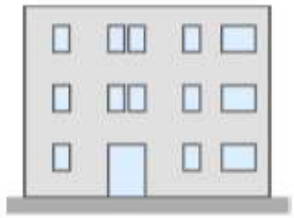


Figure 1: Phase 1 – existing building

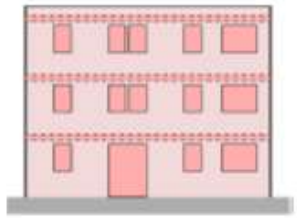


Figure 2: Phase 2 – boundary conditions

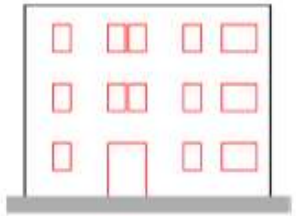


Figure 3: Phase 3 – identification of baseline

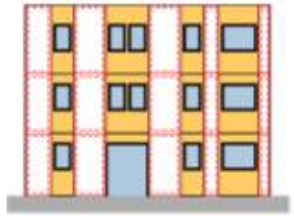


Figure 4: Phase 4a – primary modules designed

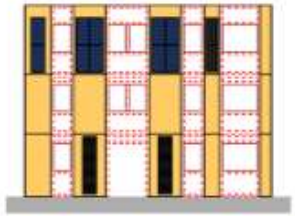


Figure 5: Phase 4b – secondary modules designed

Figure 6: Phase 4c – module aggregation design

Building envelope limitations

Concept of RenoZEB envelope system:

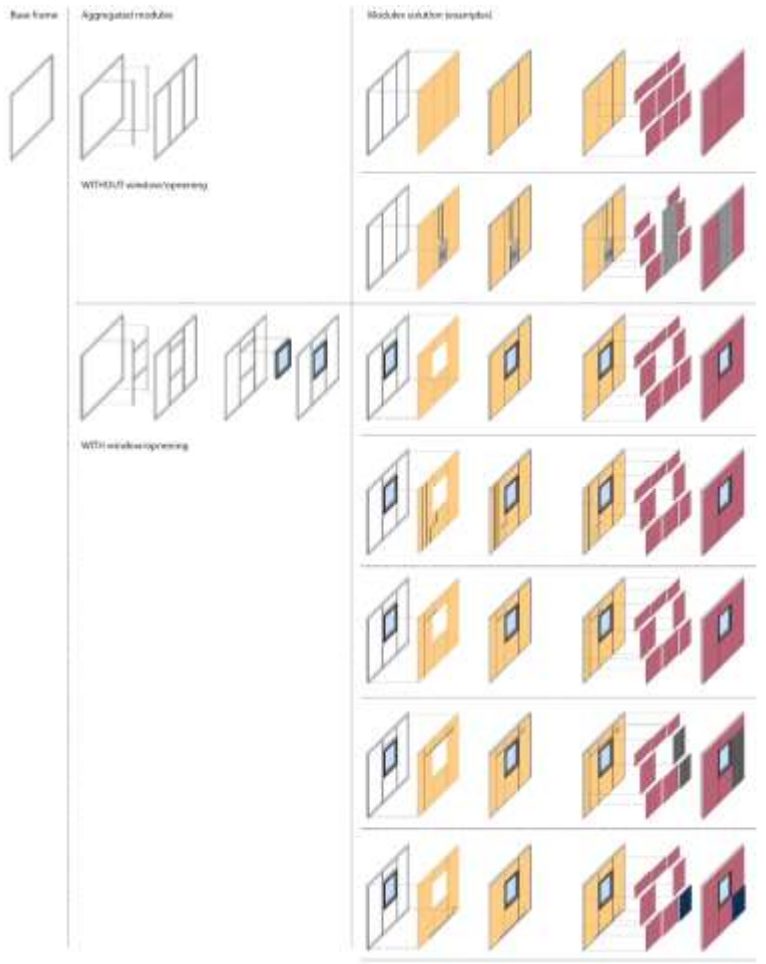
- Identification of limitations in building existing stock

- **Reference to RenoZEB demonstrator** buildings in Durango, Spain and in Voru, Estonia

Façade modules prefabrication catalogue

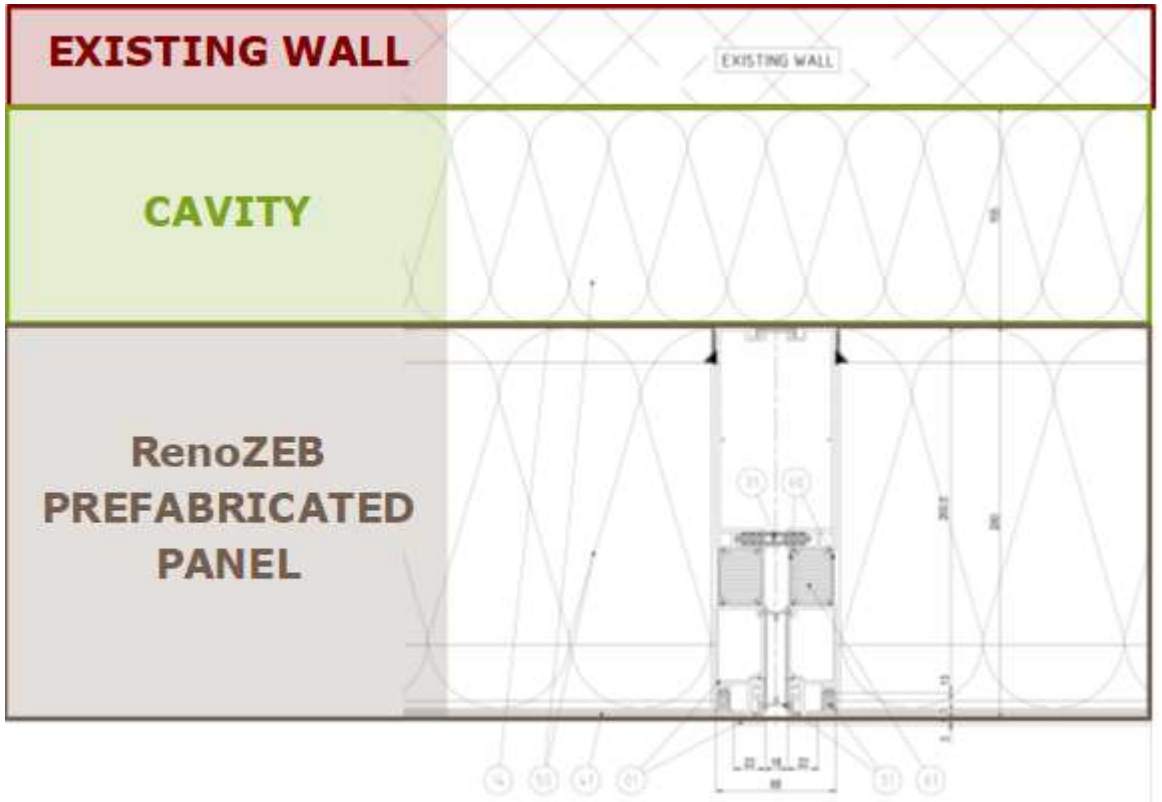
Concept of RenoZEB envelope system:

- Unitized façade system (P&P)
- Different units typologies (multifunctional façade)
- Different external finishing (architectural needs)



Focchi façade system

RenoZEB façade



Material	s [m]	Thermal properties		Vapour Resistivity
		λ [W/mK]	R [m2K/W]	MN.s./g.m
Steel	0.0012	50	0	500000
Mineral fiber	0.217	0.035	6.2	8
Membrane and acquapanel	0.012	0.35	0.036	60

RenoZEB façade – Design

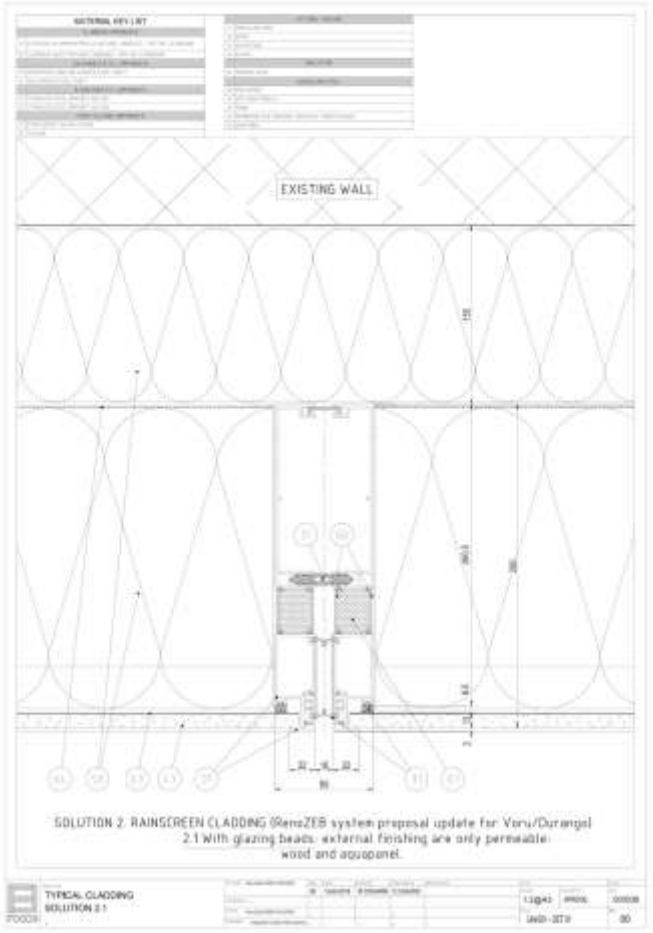
RenoZEB system design

- With glazing bead for the external finishing.

The available finishings are:
- Wood with joined breathable and water resistant membrane;
- Aquapanel with joined breathable and water resistant membrane.

CE certification for UNI EN ISO 13830:2005 curtain wall façade

Material	s [m]	Thermal properties		Vapour Resistivity
		λ [W/mK]	R [m2K/W]	MN.s./g.m
Perforated sheet (or similar)	0.0012	0	0	0
Mineral fiber	0.217	0.035	6.2	8
Air layer	0.040	-	0.18	5
Membrane and aquapanel	0.012	0.35	0.036	60



RenoZEB façade – Design

RenoZEB system design

- Without glazing bead for the external finishing

The available finishings are:
- Fiber Cement with joined breathable and water resistant membrane;
- Porcelain tile with joined breathable and water resistant membrane;
- Glass with joined breathable and water resistant membrane;
- Wood with joined breathable and water resistant membrane.

CE certification for UNI EN ISO 13830:2005 curtain wall façade

Material	**s** [m]	**Thermal properties**		**Vapour Resistivity**
		λ [W/mK]	**R** [m2K/W]	**MN.s./g.m**
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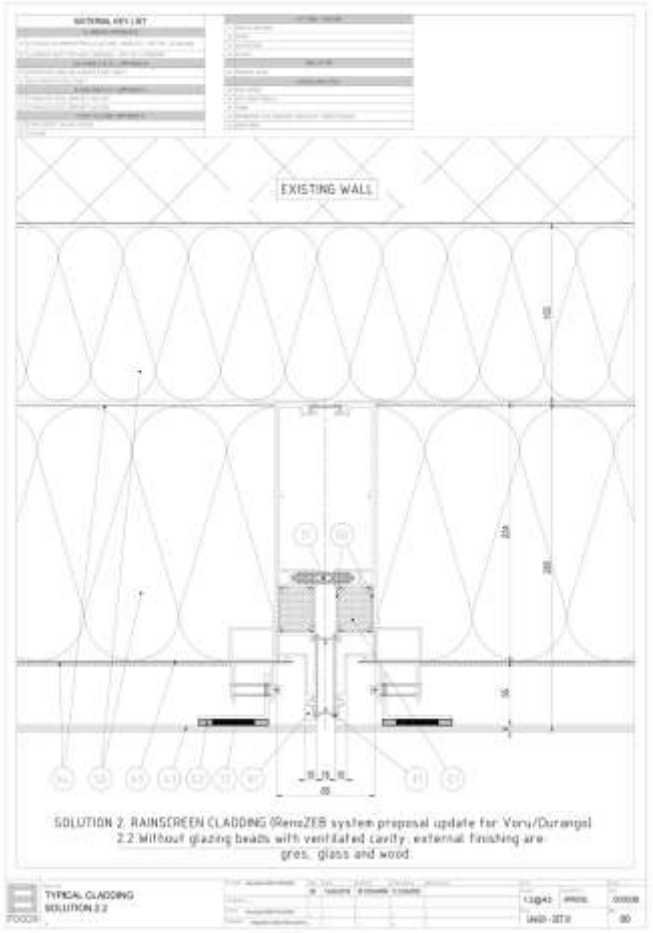
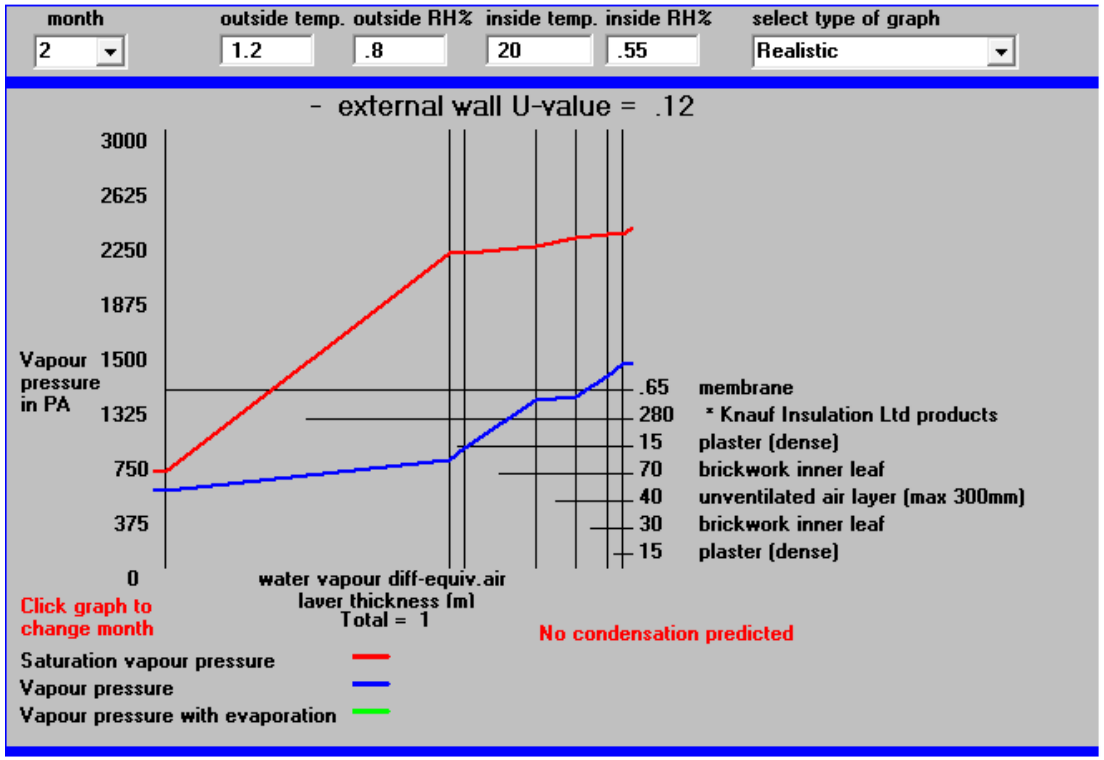
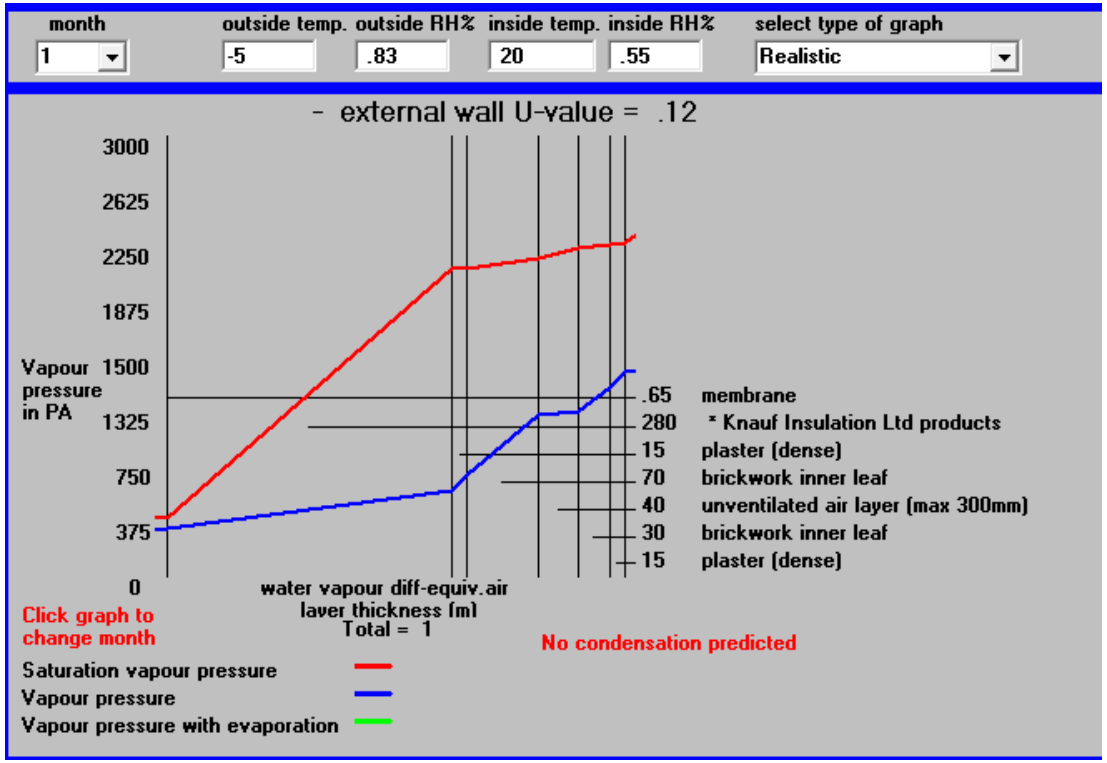


RenoZEB façade – Design 2

RenoZEB system design – Solution 2.0 – **Durango Demo case**



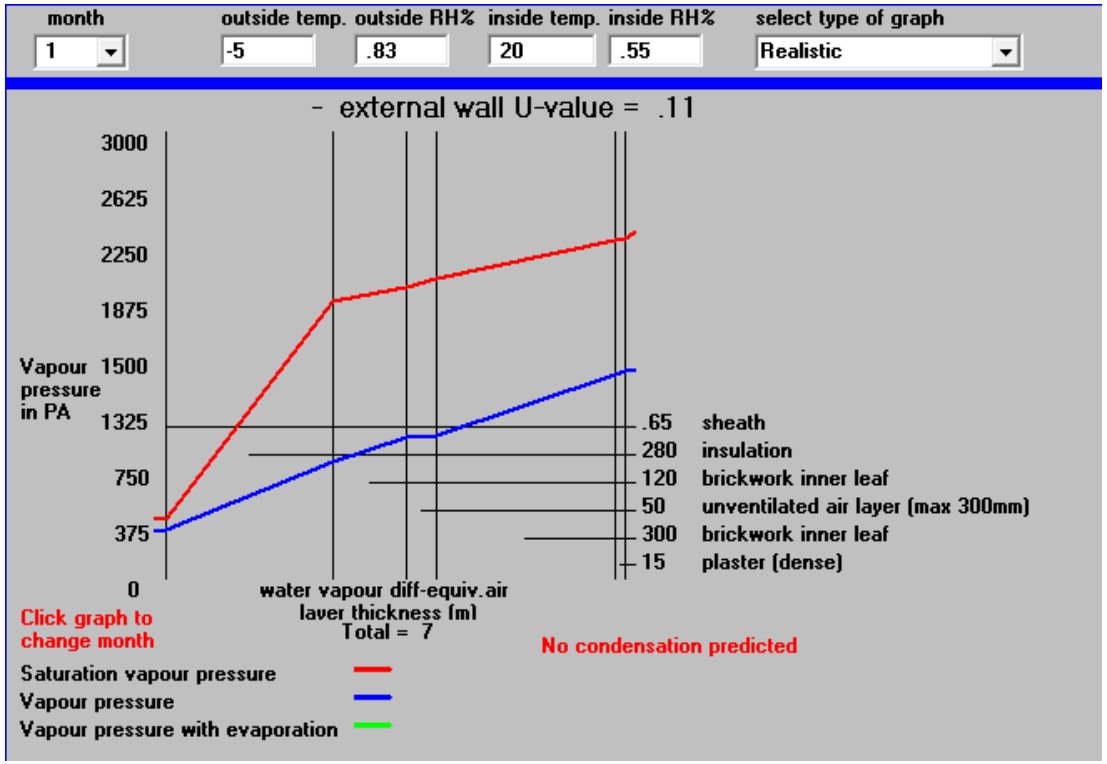


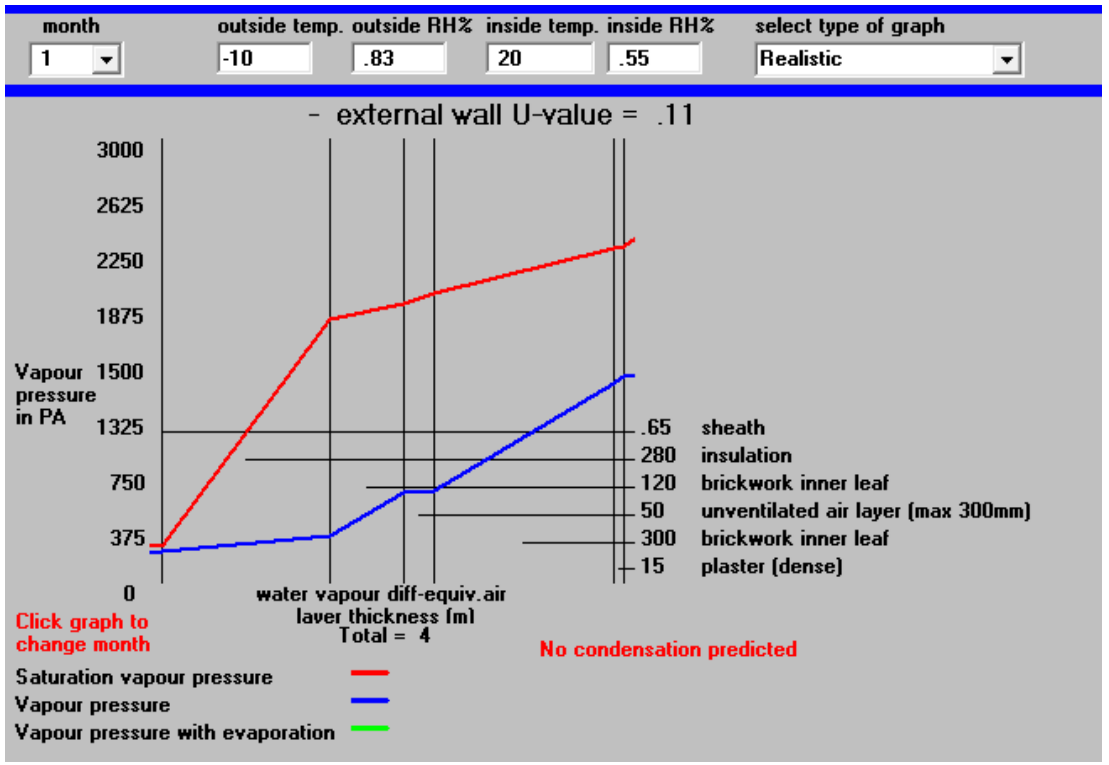
NO CONDENSATION.

The RenoZEB prefabricated panel solution 2.0 is validated and verified for Durango.

RenoZEB façade – Design 2

RenoZEB system design – Solution 2.0 – **Voru Demo case**



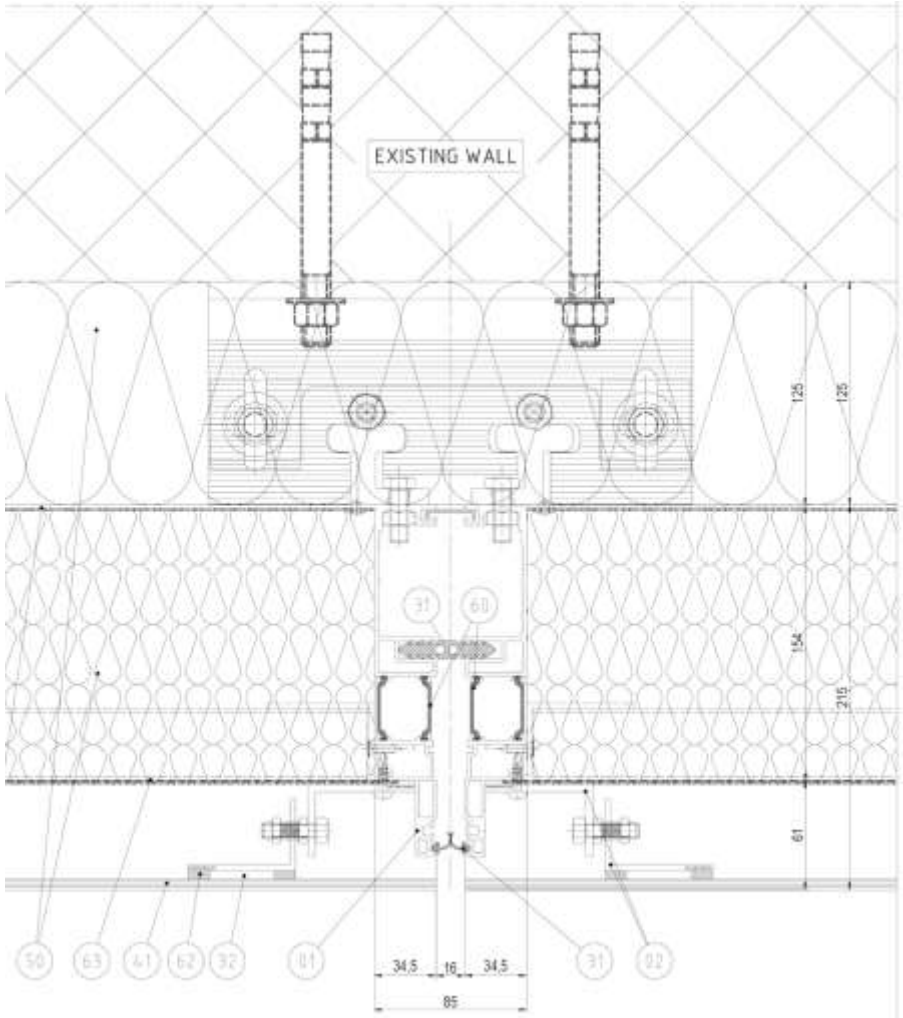


NO CONDENSATION.

The RenoZEB prefabricated panel solution 2.0 is validated and verified for Voru.

RenoZEB façade – Final Design

RenoZEB system design



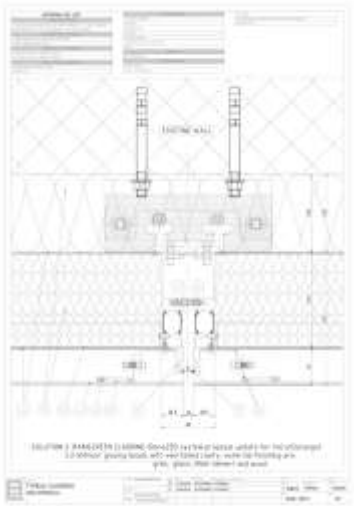
Design and development of RenoZEB envelope system

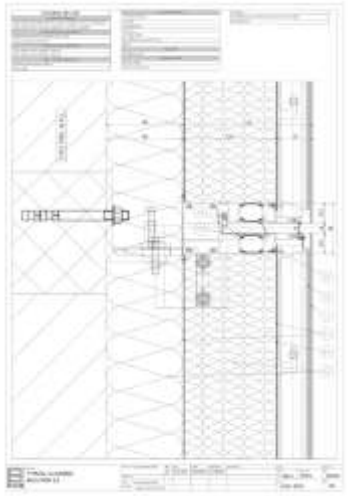
System design of RenoZEB envelope system:

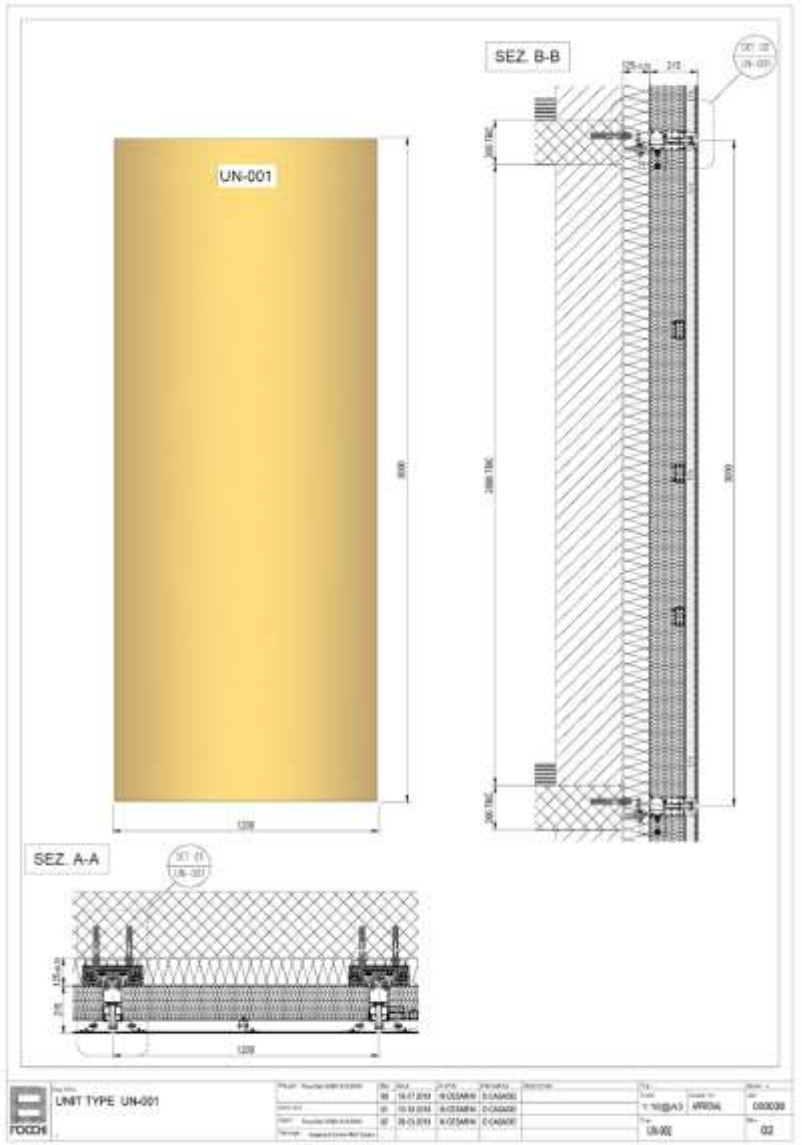
OPAQUE UNIT (max 1200 x 3000 mm)

BASE COMPONENTS:

- Unitized system prefabricated off-site
- Installation on-site on brackets fixed to the slab edge
- Aluminium structure
- External finishing in fibre cement painted
- Mechanical restraint to guarantee the possibility to replace finishing with other materials or technical elements







VALIDATION

- **DURANGO**

U_{CW} = 0,14 W/m²K < 0,28 W/M2k

- **VORU**

U_{CW} = 0,127 W/m2K < 0,13 W/m2K

RenoZEB façade – Final Design

System design of RenoZEB envelope system:

OPAQUE UNIT (max 1200 x 3000 mm)

- Finishings choice
  - Cement Board
  - Wood (slat or panel)
  - Fibercement
  - Porcelain tile

Material	Supplier	Product	Finishing
Cement board	Knauf	Aquapanel Outdoor (eventually to be painted)	
Composite wood panel	La Legnami	Legnotec B01	
Fiber-cement	Etex	Equitone	

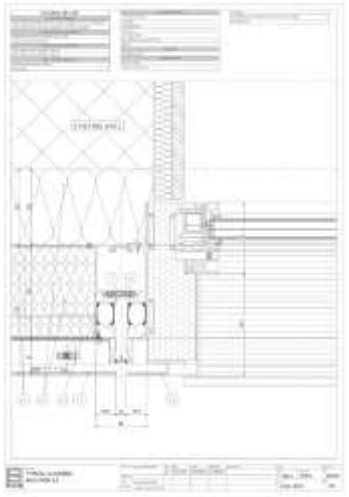
Material	Supplier	Product	Finishing
Porcelain tile	Laminam	Calce: Antracite	
Porcelain tile	Laminam	Calce: Avorio	
Porcelain tile	Laminam	Calce: Bianco	
Porcelain tile	Laminam	Calce: Grigio	
Porcelain tile	Laminam	Calce: Nero	
Porcelain tile	Laminam	Fokos: Piombo	

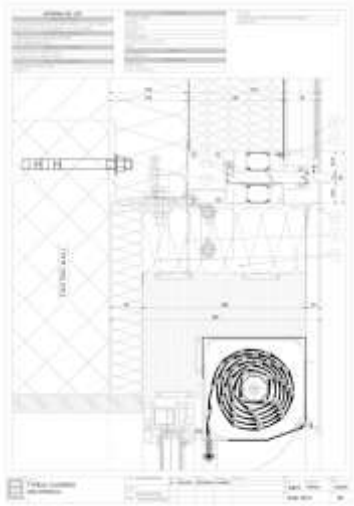
RenoZEB façade – Final Design

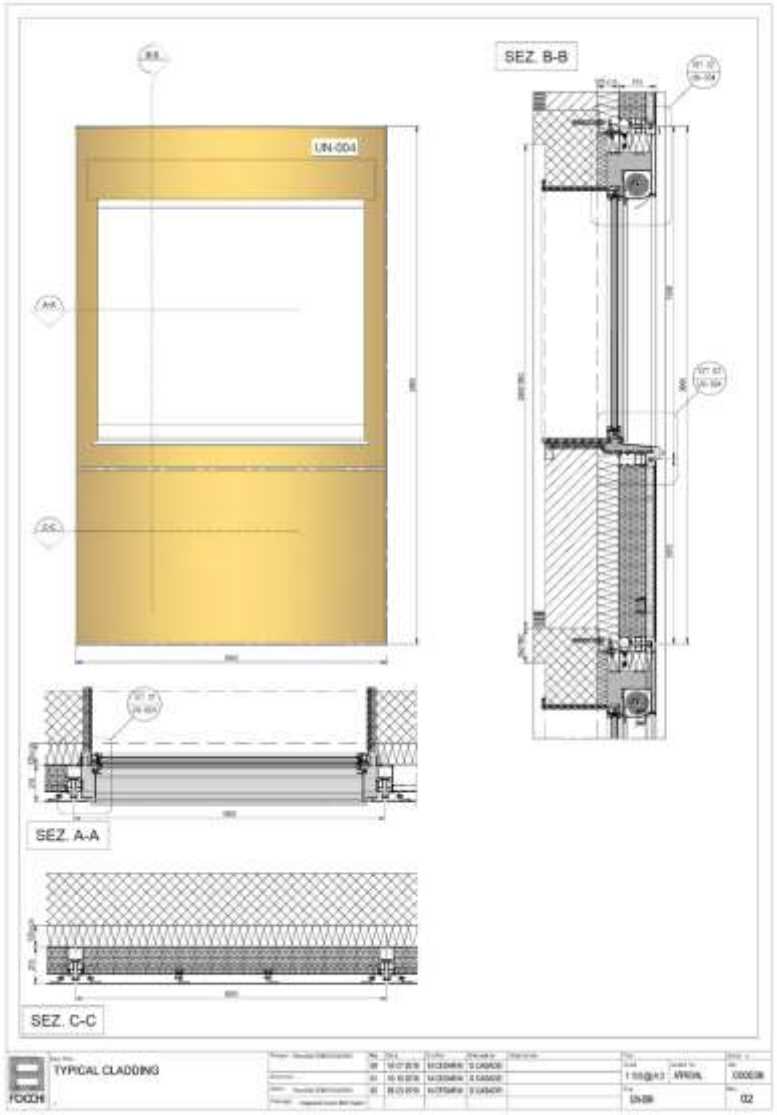
System design of RenoZEB envelope system:

WINDOW UNIT (max 2200 x 3000 mm)

- Each type of window (materials, openings typology), with/without roller shutter integrated
- Eventual ventilation integrated in window monoblock







VALIDATION

- **DURANGO**
  U_{CW} = 0,66 W/m²K < 1 W/m²K

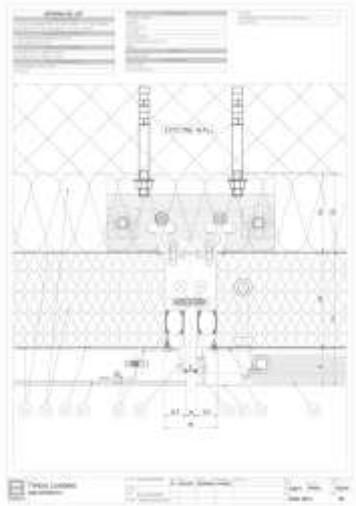
- **VORU**
  U_{CW} = 0,47 W/m²K < 0,63 W/m²K

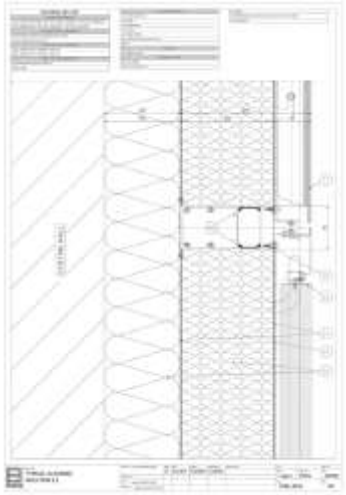
RenoZEB façade – Final Design

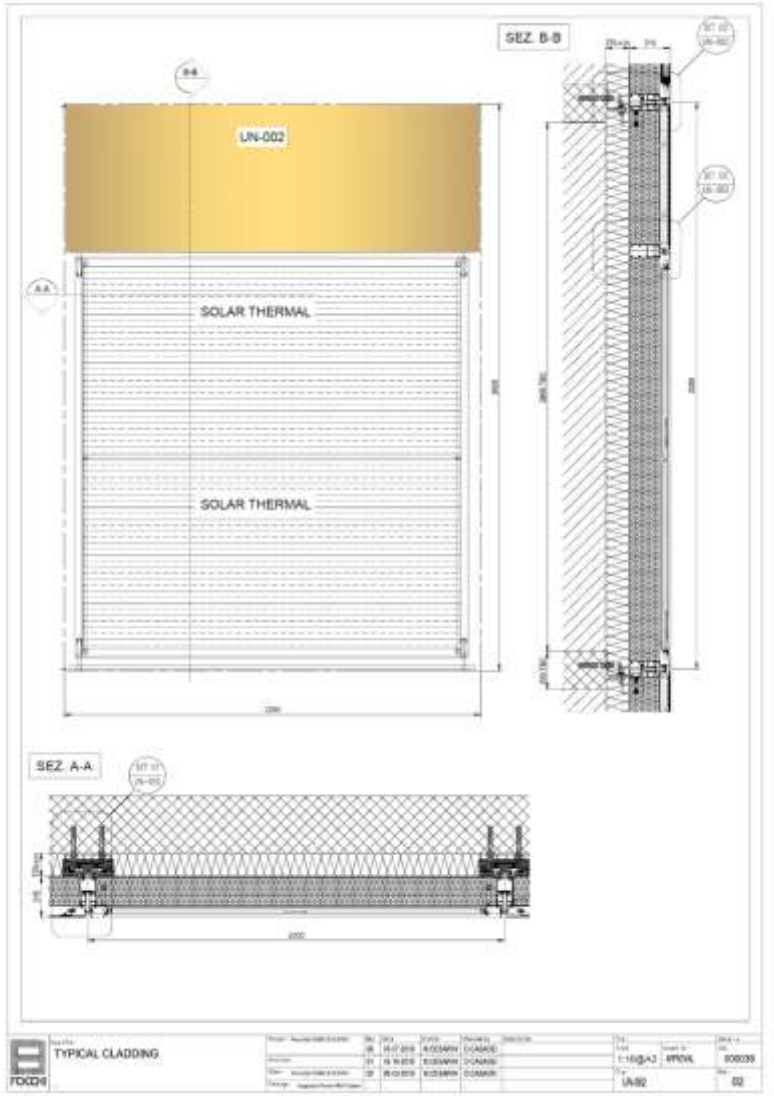
System design of RenoZEB envelope system:

SOLAR THERMAL COLLECTOR UNIT

- Water thermal solar collector with water to be used also for DHW to have higher water temperature







VALIDATION

- **DURANGO**

U_{CW} = 0,139 W/m^{2}K < 0.28 W/m^{2}K

- **VORU**

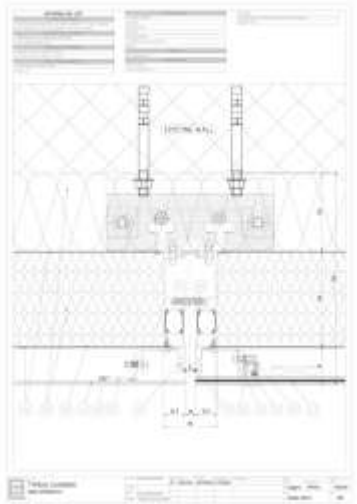
U_{CW} = 0,126 W/m2K < 0,13 W/m2K

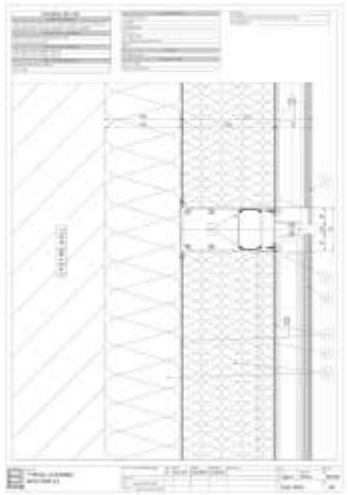
RenoZEB façade – Final Design

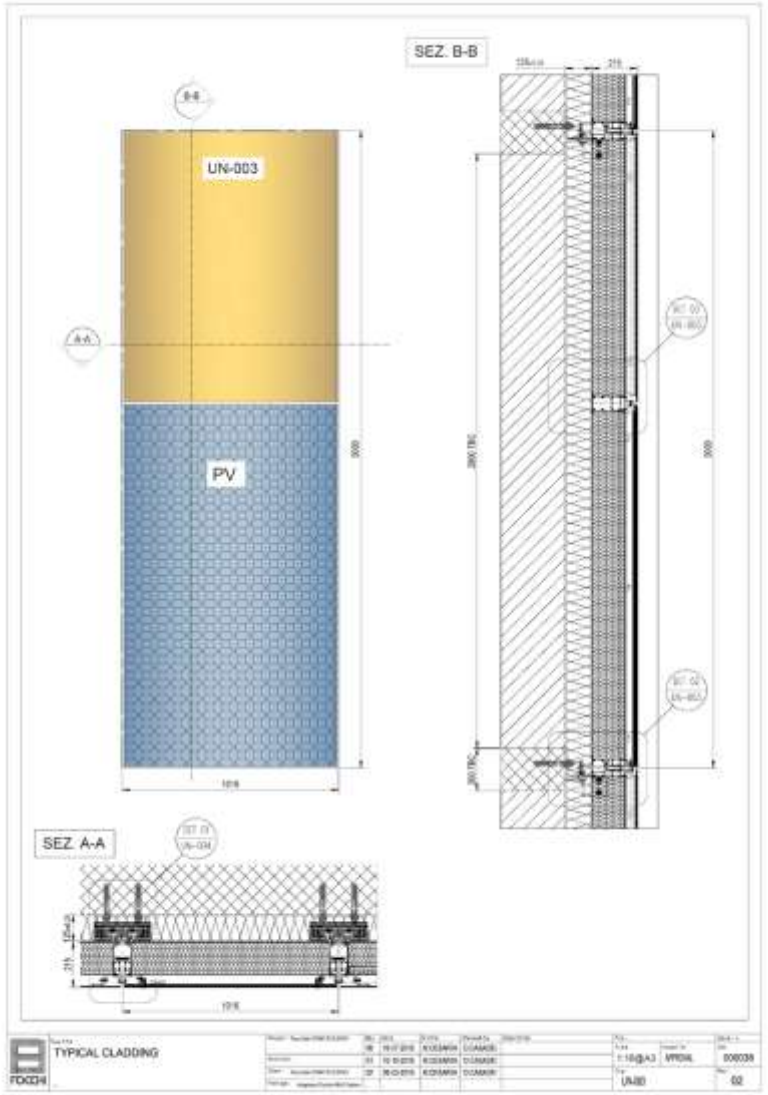
System design of RenoZEB envelope system:

PV Unit

- PV integratred in façade with cavity for ventilation to preserve panel effieciency and eventually to use heated air for ventilation







VALIDATION

- **DURANGO**

U_{CW} = 0,149 W/m^{2}K < 0.28 W/m^{2}K

- **VORU**

U_{CW} = 0,13 W/m2K < 0,13 W/m2K

RenoZEB façade – Final Design

Prototype manufacturing

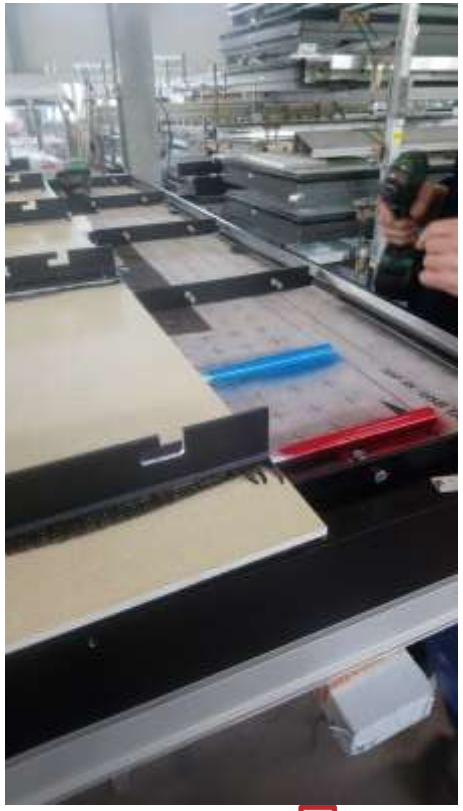




RenoZEB façade – Final Design

Prototype manufacturing



RenoZEB façade – Final Design

Prototype manufacturing

RenoZEB façade – Final Design

Units prototype

Opaque Unit

Window Unit

RenoZEB façade – Final Design

Units prototype

PV Unit

Solar Collector Unit

RenoZEB façade – Final Design

Mock-Up installation





RenoZEB façade – Final Design

Mock-Up installation

Tests and results

Tests

Tests and simulations	Test conducted	Mock-Up
Thermal Behaviour (EN ISO 10077-2:2008)	EN ISO 10077-2:2019 T3.2	**Design and Kubik**
Heat bridges and condensation risks	EN ISO 10077-2:2019 T3.2	**Design and Kubik**
Acoustic improvement of existing envelope	UNI EN ISO 16283-3:2016/EC 1-2016/EC 2-2016 and UNI EN ISO 717-1:2013	**Acoustic Mock-Up (AMU)**
Water-tightness of joints (protection against driving rain (EN12865:2002),	EN ISO 13830:2005 Curtain Wall façade – CE for façade	**Performance Mock-Up (PMU)**
Wind load resistance (ETAG 034 – ER4 – Safety in use)	EN ISO 13830:2005 Curtain Wall façade – CE for façade	**Performance Mock-Up (PMU)**
Reaction to fire (EN 13501-1) (Test under EN 13823, classification SBI)	EN 13501-1 – Indication about Reaction to fire classification	**Fire Mock-Up (FMU)**
Fire resistance (EN1364-3 and EN 1364-4)	Not applicable in ventilated façade	**--**

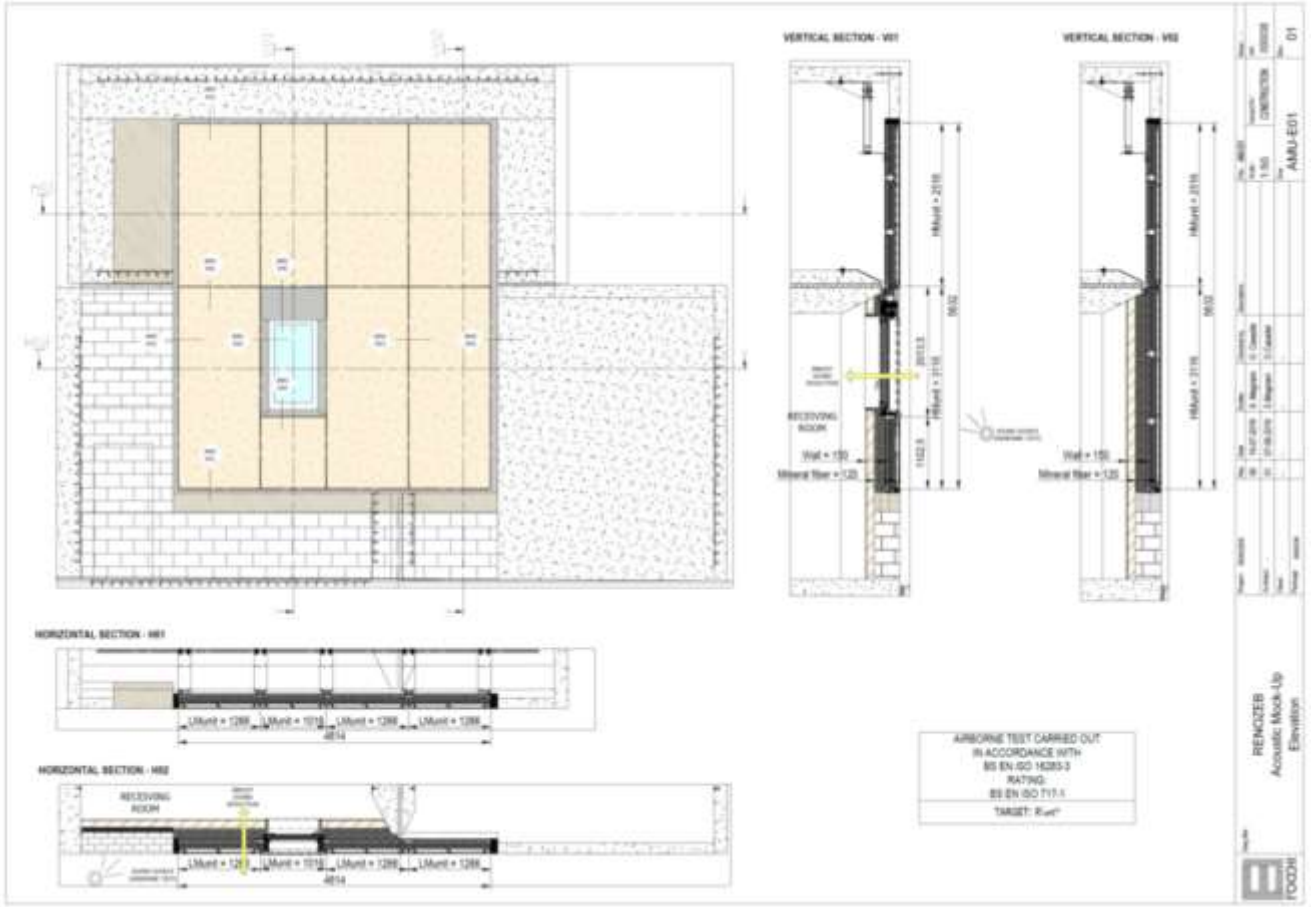
AMU – Acoustic mock-up

Preparation phase

- To demonstrate RenoZEB façade acoustic insulation performance
- To conduct test under UNI EN ISO 16283-3:2016/EC 1-2016/EC 2-2016 and UNI EN ISO 717-1:2013 (IN-OUT test)
- No Flanking test due to existing envelope responsible for horizontal and vertical acoustic sound transmission

Design

- Acoustic Chamber in Focchi premises
- Test conducted by accredited entity
- One brick wall as existing building envelope



AMU – Acoustic mock-up

AMU results

- Report by accredited entity
- Results achieved (R'45°w (C, Ctr)):
  - Configuration 1: 46 (-1, -4) dB
  - Configuration 2: 45 (-2, -5) dB
  - Configuration 3: 57 (-1, -4) dB

Conclusions:

- **Conf.1 vs Conf.2:** benchmark of Configuration 1 with opening was difficult to be defined, therefore no opening was evaluated.
- **Conf.1 vs Conf.3:** Existing envelopes have massive element and achieve good initial result, but openings are critical points. Introduction of RenoZEB opaque panels can improve significantly the acoustic insulation
- 42dB si the target for Curtain Wall façade and RenoZEB façade achieves it

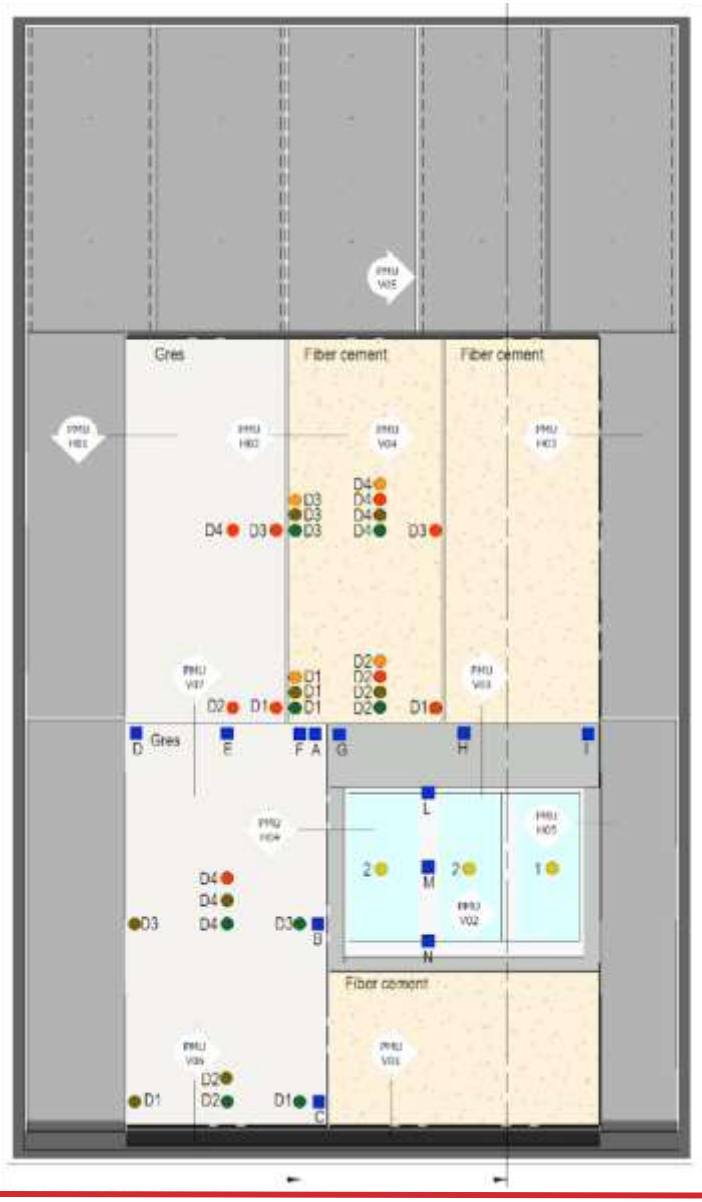
PMU – Performance mock-up

Preparation phase

- Test Chamber in accredited entity premises
- Test conducted by accredited entity
- **NO existing building envelope**. All the performance needs to be achieved by RenoZEB façade itself (*challenge*)

Design

- RenoZEB façade's units:
  - Window unit (n.1)
  - Opaque unit with porcelain tile (n.2)
  - Opaque unit with fibres cement (n.2)



PMU – Performance mock-up

PMU result

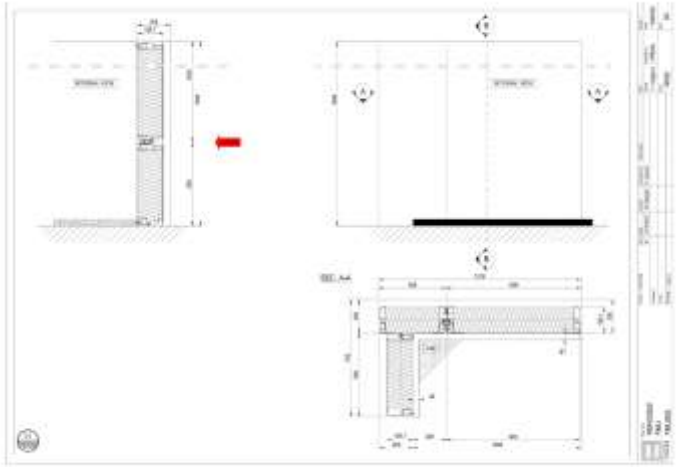
- Report by accredited entity
- Results achieved

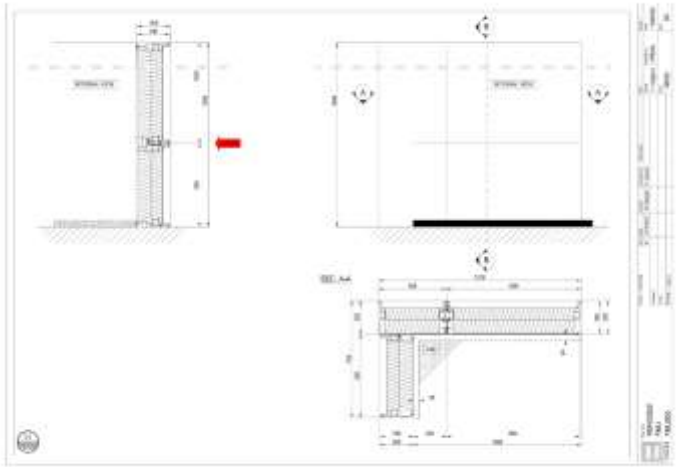
Conclusions:

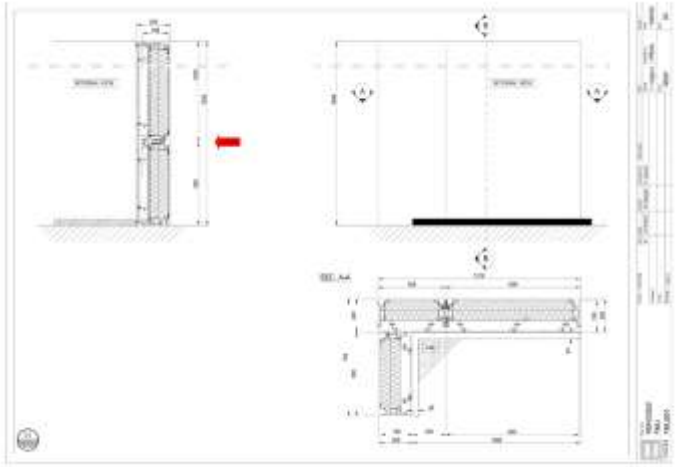
- Innovative ventilated façade tested with EN ISO 13830:2005
- Safety façade demonstrated with different materials (interchangeable)
- CE certification

Activity		Test reference	Classification reference	Class
air permeability through fixed parts	related to overall area	UNI EN 12153	UNI EN 12152	**A4**
air permeability through openable parts	positive pressure	UNI EN 1026	UNI EN 12207	**3**
	negative pressure			**4**
watertightness		UNI EN 12155	UNI EN 12154	**R6**
resistance to wind load under design load +1550 Pa and -1550 Pa		UNI EN 12179	UNI EN 13116	**pass**
resistance of external wall systems to driving rain under pulsating air pressure		UNI EN 12865	UNI EN 12865	**600_A**
resistance to wind load		ETAG 034	ETAG 034	**±2400 Pa**
external impact resistance on gres		ETAG 034	ETAG 034	**category III**
external impact resistance on fiber cement		ETAG 034	ETAG 034	**category I**
internal impact resistance		UNI EN 13049	UNI EN 13049	**5**
external impact resistance		UNI EN 13049	UNI EN 13049	**3**

FMU – Fire mock-up







FMU preparation phase

- Reaction to fire (EN 13501-1) (Test under EN 13823, classification SBI)
- One test for each side where air is present. 5 sides could be tested:
  - **External side to RenoZEB façade [FMU01]**
  - **Ventilated cavity to internal of RenoZEB panel [FMU02]**
  - **Cavity between RenoZEB panel and existing wall to RenoZEB panel [FMU 03]**
- 3 tests schould be carried out to have class of reaction to fire. **Premilinary assessment (one test for each side)** of RenoZEB façade will be done
- 3 tests will be conducted

FMU – Fire mock-up

FMU test

FMU has been done in an **accredited test chamber** and the activities conducted by an independent third party.
The following figures show the FMU **during** different tests
(FMU1 e FMU2)

FMU result

The performance achieved are:
- FMU 01 – potential classification B-s1-d0
- FMU 02 – potential classification C-s2-d0
- FMU 03 – potential classification C-s1-d0

The following figures show the FMU **after** different tests (FMU1 e FMU2)

Real environment test

Kubik, Tecnalia (Derio, Spain)

- To validate installation procedure and generate video for training
- To validate energy performances

Conclusions

Conclusion

- **P&P façade** is a valuable technological solution for building envelope deep-retrofitting (ETICS+ventilation+windows+BIPV, etc)
- **Customization** based on products on market
- High **quality** due to off-site prefabrication
- **Aesthetic and functional** integration;
- Easy and **time-saving** installation on-site;
- **Low intrusive** system able to maintain users inside the building
- **Adaptable** to different climate conditions, building tolerances, energy needs
- Consistent with current building envelope standard for **Curtain Wall façade** solution

Any questions?

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