



An analytic approach for the identification of technologies
to be integrated in façade prefabricated unit
The RenoZEB case of study

**SUSTAINABLE
PLACES 2020**
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Digital Event

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ARCHITECTURAL
BUILDING
ENVELOPES



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RenoZEB Introduction



Project timeline

10/2017 03/2021 (new end 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 responsible for the plug and play facade



28th of October 2020

Laura Vandi – FOCCHI
 Sustainable place 2020 – Digital event



RenoZEB Main Objective

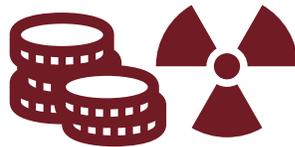


The project aim is to establish a systematic methodology for the energy deep retrofitting for building stock market by developing a BIM based platform and tools for actors of the value chain.

Four pillars of RenoZEB project



Reduction of energy consumption



Reduction of cost and risk



Replicability and adaptability



Increase the property value

RenoZEB Plug and Play Facade – as Result



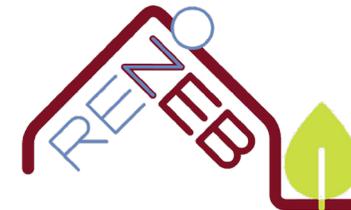
PLUG&PLAY FACADE: Modularity, Prefabbrication



MACRO-TECHNOLOGIES which compose the plug and play facade :

- **WINDOWS**
- **MULTIFUNCTIONAL INSULATION BOARDS**
- **VENTILATION UNITS WITH HEAT RECOVERY**
- **BUILDING INTEGRATED PHOTOVOLTAICS**
- **BUILDING INTEGRATED SOLAR THERMAL SYSTEMS**
- **INTELLIGENT FAÇADE CONTROLLER**
- **“CLICK-IN” FIXING MECHANISMS**

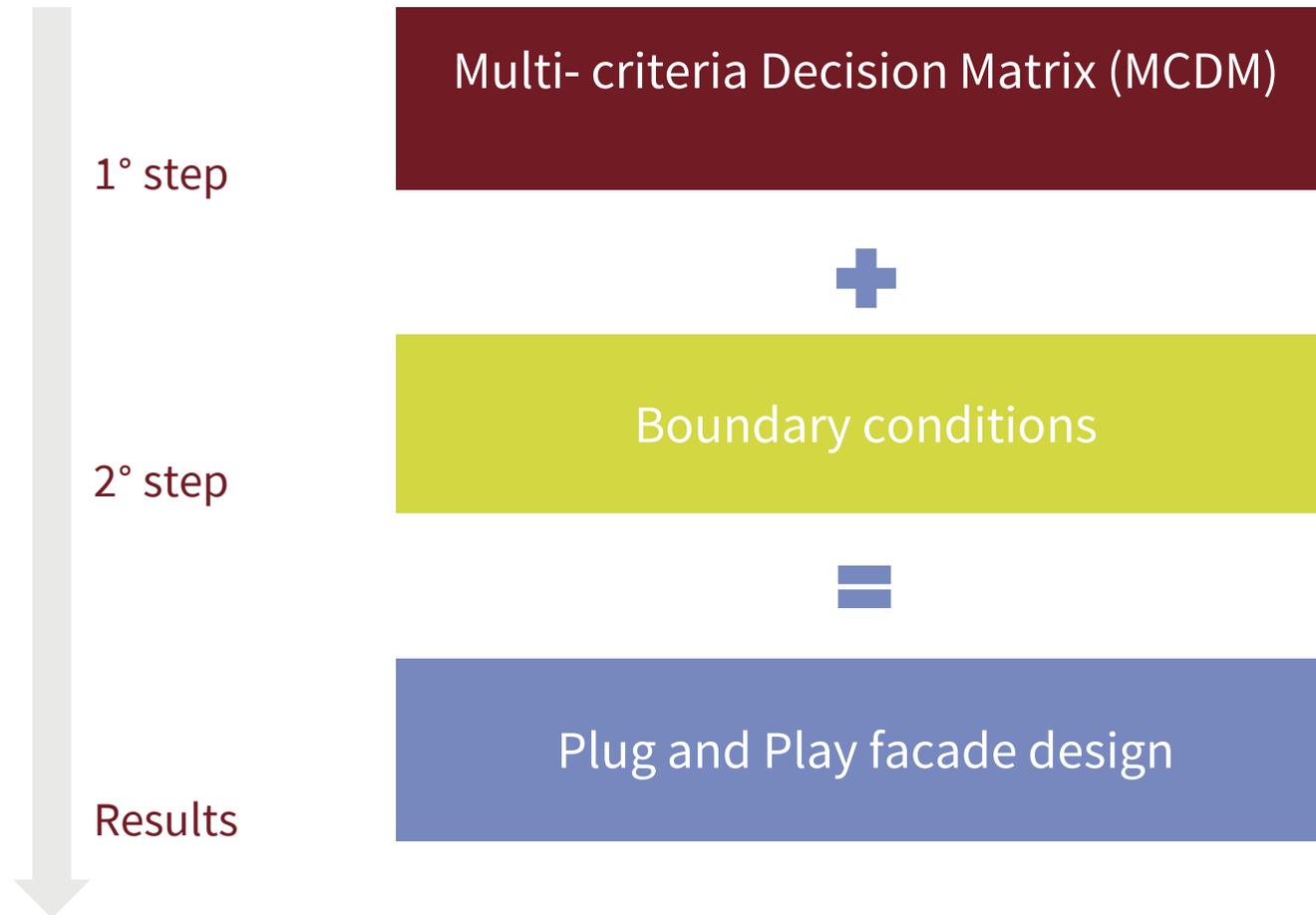
To move from the plug and play concept to the design phase



How is it possible to select different technologies
which are in the market?



Methodology



Multi-criteria Decision Matrix

Requirements



- Objectives of the RenoZEB project (Raws)
- Main requirements in **bold** and eventually sub requirements in *italic*

RENOZEB EXPECTATION → MATRIX REQUIREMENTS

VENTILATED FAÇADE
 PLUG AND PLAY
 LOW COST MULTIFUNCTIONAL INSULATED BOARD
 COMMERCIALY AVAILABLE PV MODULES
 COMMERCIALY AVAILABLE SOLAR THERMA COLLECTOR
 INTEGRATION OF HYDRAULIC, ELECTRIC AND HVAC
 MODULAR – PRE-CAST AND EASY ASSEMBLY-DISASSEMBLY
 INDUSTRIALIZATION
 LESS INTRUSIVE SYSTEM
 AESTETIC AND FUNCTIONAL INTEGRATION
 INTEGRATION AND ADAPTATION OF MULTIFUNCTIONALS INSULATION
 INTEGRATION OF THERMAL AND PV MODULES
 CONNECTION ELEMENTS
 DEVELOPMENT OF THE SMART-IoT FAÇADE MODULE

→ 1

| Requirements | Proposed component/facade system | | | | |
|----------------------------------------------------------------------------------------------------------------|----------------------------------|-----------------|-----------------|-----------------|-----------------|
| | 1 <i>n</i> | 2 <i>n+1</i> | 3 <i>n+2</i> | 4 <i>n+3</i> | 5 <i>n+4</i> |
| Ventilated façade | | | | | |
| Plug and play | | | | | |
| Low-cost multifunctional insulation boards | | | | | |
| Commercially available PV modules | | | | | |
| Commercially available solar thermal collectors | | | | | |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | | | | | |
| Integration of hydraulic, electric and HVAC | | | | | |
| Modular, Pre-cast and Easy Assembly-Disassembly | | | | | |
| <i>minimize on-site work</i> | | | | | |
| <i>improve product quality</i> | | | | | |
| <i>reduce costs</i> | | | | | |
| Industrialization | | | | | |
| <i>minimize on-site work</i> | | | | | |
| <i>cost reduction</i> | | | | | |
| <i>improve quality</i> | | | | | |
| <i>increased safety</i> | | | | | |
| Less intrusive system | | | | | |
| <i>prioritize outdoor interventions</i> | | | | | |
| <i>avoid interruption in the dwellings</i> | | | | | |
| <i>reduce the duration of the interventions</i> | | | | | |
| <i>off-site manufacturing</i> | | | | | |
| <i>plug-and-play solutions</i> | | | | | |
| <i>optimized building processes</i> | | | | | |
| Aesthetic and functional integration | | | | | |
| <i>harmonizing architectonic rehabilitation with social acceptance</i> | | | | | |
| <i>expectations of the architects</i> | | | | | |
| Integration and adaptation of multifunctional insulation | | | | | |
| <i>use of recycled material</i> | | | | | |
| <i>recyclability of the final solution</i> | | | | | |
| <i>reduction of heat and pressure losses</i> | | | | | |
| <i>fire protection</i> | | | | | |
| <i>prefabricated window insulation frames</i> | | | | | |
| <i>minimum of heat losses</i> | | | | | |
| Integration of thermal and PV modules | | | | | |
| <i>integration into the RenoZEB envelop and building concept</i> | | | | | |
| Connection elements | | | | | |
| <i>Integrate subsystems in a holistic approach</i> | | | | | |
| Development of the Smart-IoT façade module | | | | | |
| <i>Low-cost sensors</i> | | | | | |
| <i>Low-intrusive installation</i> | | | | | |
| <i>Embedding in the module</i> | | | | | |
| <i>Integration with PV and battery system</i> | | | | | |
| <i>Data collections system with common protocols</i> | | | | | |
| <i>Plug & play solution</i> | | | | | |
| Points achieved | 0 | 0 | 0 | 0 | 0 |

Multi-criteria Decision Matrix

Products



Market products (Columns)

- PREFABRICATED WINDOW MODULE AND ROLLER SHUTTER;**
Product 1- Product 2- Product 3- Product 4- Product 5
- MULTIFUNCTIONAL INSULATION BOARD;**
Product 1- Product 2- Product 3- Product 4- Product 5
- VENTILATION DEVICES;**
Product 1- Product 2- Product 3- Product 4- Product 5
- BUILDING INTEGRATED PHOTOVOLTAICS (BIPV) AND BATTERIES;**
Product 1- Product 2- Product 3- Product 4- Product 5
- BUILDING INTEGRATED SOLAR THERMAL;**
Product 1- Product 2- Product 3- Product 4- Product 5
- FAÇADE CONTROLLER;**
Product 1- Product 2- Product 3- Product 4- Product 5
- FAÇADE-INTEGRATED SENSORS;**
Product 1- Product 2- Product 3- Product 4- Product 5
- FIXING MECHANISMS**
Product 1- Product 2- Product 3- Product 4- Product 5

| Requirements | Proposed component/facade system | | | | |
|---------------------------------------------------------------------------------------------------------|----------------------------------|----------|----------|----------|----------|
| | 1 n | 2 n+1 | 3 n+2 | 4 n+3 | 5 n+4 |
| Ventilated façade | | | | | |
| Plug and play | | | | | |
| Low-cost multifunctional insulation boards | | | | | |
| Commercially available PV modules | | | | | |
| Commercially available solar thermal collectors | | | | | |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | | | | | |
| Integration of hydraulic, electric and HVAC | | | | | |
| Modular, Pre-cast and Easy Assembly-Disassembly | | | | | |
| minimize on-site work | | | | | |
| improve product quality | | | | | |
| reduce costs | | | | | |
| Industrialization | | | | | |
| minimize on-site work | | | | | |
| cost reduction | | | | | |
| improve quality | | | | | |
| increased safety | | | | | |
| Less intrusive system | | | | | |
| prioritize outdoor interventions | | | | | |
| avoid interruption in the dwellings | | | | | |
| reduce the duration of the interventions | | | | | |
| off-site manufacturing | | | | | |
| plug-and-play solutions | | | | | |
| optimized building processes | | | | | |
| Aesthetic and functional integration | | | | | |
| harmonizing architectonic rehabilitation with social acceptance | | | | | |
| expectations of the architects | | | | | |
| Integration and adaptation of multifunctional insulation | | | | | |
| use of recycled material | | | | | |
| recyclability of the final solution | | | | | |
| reduction of heat and pressure losses | | | | | |
| fire protection | | | | | |
| prefabricated window insulation frames | | | | | |
| minimum of heat losses | | | | | |
| Integration of thermal and PV modules | | | | | |
| integration into the RenoZEB envelop and building concept | | | | | |
| Connection elements | | | | | |
| Integrate subsystems in a holistic approach | | | | | |
| Development of the Smart-IoT façade module | | | | | |
| Low-cost sensors | | | | | |
| Low-intrusive installation | | | | | |
| Embedding in the module | | | | | |
| Integration with PV and battery system | | | | | |
| Data collections system with common protocols | | | | | |
| Plug & play solution | | | | | |
| Points achieved | 0 | 0 | 0 | 0 | 0 |

2



Multi-criteria Decision Matrix

Score

Score system

| Correspondence | | |
|----------------------|-------|--------|
| Degree | Value | Symbol |
| Not Applicable (N/A) | 0 | ○ |
| Low | 1 | ● |
| Medium | 2 | ●● |
| High | 3 | ●●● |

| Requirements | Proposed component/facade system | | | | |
|----------------------------------------------------------------------------------------------------------------|----------------------------------|----------|----------|----------|----------|
| | 1 n | 2 n+1 | 3 n+2 | 4 n+3 | 5 n+4 |
| Ventilated façade | | | | | |
| Plug and play | | | | | |
| Low-cost multifunctional insulation boards | | | | | |
| Commercially available PV modules | | | | | |
| Commercially available solar thermal collectors | | | | | |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | | | | | |
| Integration of hydraulic, electric and HVAC | | | | | |
| Modular, Pre-cast and Easy Assembly-Disassembly | | | | | |
| <i>minimize on-site work</i> | | | | | |
| <i>improve product quality</i> | | | | | |
| <i>reduce costs</i> | | | | | |
| Industrialization | | | | | |
| <i>minimize on-site work</i> | | | | | |
| <i>cost reduction</i> | | | | | |
| <i>improve quality</i> | | | | | |
| <i>increased safety</i> | | | | | |
| Less intrusive system | | | | | |
| <i>prioritize outdoor interventions</i> | | | | | |
| <i>avoid interruption in the dwellings</i> | | | | | |
| <i>reduce the duration of the interventions</i> | | | | | |
| <i>off-site manufacturing</i> | | | | | |
| <i>plug-and-play solutions</i> | | | | | |
| <i>optimized building processes</i> | | | | | |
| Aesthetic and functional integration | | | | | |
| <i>harmonizing architectonic rehabilitation with social acceptance</i> | | | | | |
| <i>expectations of the architects</i> | | | | | |
| Integration and adaptation of multifunctional insulation | | | | | |
| <i>use of recycled material</i> | | | | | |
| <i>recyclability of the final solution</i> | | | | | |
| <i>reduction of heat and pressure losses</i> | | | | | |
| <i>fire protection</i> | | | | | |
| <i>prefabricated window insulation frames</i> | | | | | |
| <i>minimum of heat losses</i> | | | | | |
| Integration of thermal and PV modules | | | | | |
| <i>integration into the RenoZEB envelop and building concept</i> | | | | | |
| Connection elements | | | | | |
| <i>Integrate subsystems in a holistic approach</i> | | | | | |
| Development of the Smart-IoT façade module | | | | | |
| <i>Low-cost sensors</i> | | | | | |
| <i>Low-intrusive installation</i> | | | | | |
| <i>Embedding in the module</i> | | | | | |
| <i>Integration with PV and battery system</i> | | | | | |
| <i>Data collections system with common protocols</i> | | | | | |
| <i>Plug & play solution</i> | | | | | |
| <i>Points achieved</i> | 0 | 0 | 0 | 0 | 0 |



3 ←

Multi-criteria Decision Matrix

Result analysis



Results

MULTI CRITERIA DECISION ANALYSIS

| Requirements | Proposed component/facade system | | | | |
|----------------------------------------------------------------------------------------------------------------|----------------------------------|----------|----------|----------|----------|
| | 1 n | 2 n+1 | 3 n+2 | 4 n+3 | 5 n+4 |
| Ventilated façade | | | | | |
| Plug and play | | | | | |
| Low-cost multifunctional insulation boards | | | | | |
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| Integration of hydraulic, electric and HVAC | | | | | |
| Modular, Pre-cast and Easy Assembly-Disassembly | | | | | |
| <i>minimize on-site work</i> | | | | | |
| <i>improve product quality</i> | | | | | |
| <i>reduce costs</i> | | | | | |
| Industrialization | | | | | |
| <i>minimize on-site work</i> | | | | | |
| <i>cost reduction</i> | | | | | |
| <i>improve quality</i> | | | | | |
| <i>increased safety</i> | | | | | |
| Less intrusive system | | | | | |
| <i>prioritize outdoor interventions</i> | | | | | |
| <i>avoid interruption in the dwellings</i> | | | | | |
| <i>reduce the duration of the interventions</i> | | | | | |
| <i>off-site manufacturing</i> | | | | | |
| <i>plug-and-play solutions</i> | | | | | |
| <i>optimized building processes</i> | | | | | |
| Aesthetic and functional integration | | | | | |
| <i>harmonizing architectonic rehabilitation with social acceptance</i> | | | | | |
| <i>expectations of the architects</i> | | | | | |
| Integration and adaptation of multifunctional insulation | | | | | |
| <i>use of recycled material</i> | | | | | |
| <i>recyclability of the final solution</i> | | | | | |
| <i>reduction of heat and pressure losses</i> | | | | | |
| <i>fire protection</i> | | | | | |
| <i>prefabricated window insulation frames</i> | | | | | |
| <i>minimum of heat losses</i> | | | | | |
| Integration of thermal and PV modules | | | | | |
| <i>integration into the RenoZEB envelop and building concept</i> | | | | | |
| Connection elements | | | | | |
| <i>Integrate subsystems in a holistic approach</i> | | | | | |
| Development of the Smart-IoT façade module | | | | | |
| <i>Low-cost sensors</i> | | | | | |
| <i>Low-intrusive installation</i> | | | | | |
| <i>Embedding in the module</i> | | | | | |
| <i>Integration with PV and battery system</i> | | | | | |
| <i>Data collections system with common protocols</i> | | | | | |
| <i>Plug & play solution</i> | | | | | |
| <i>Points achieved</i> | 0 | 0 | 0 | 0 | 0 |

4



Façade system technologies identification

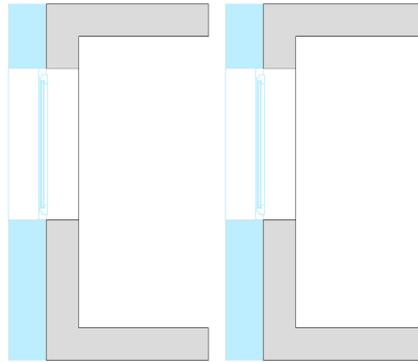
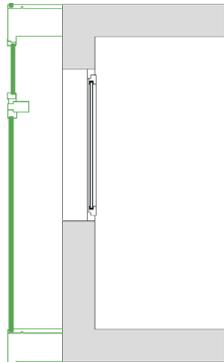
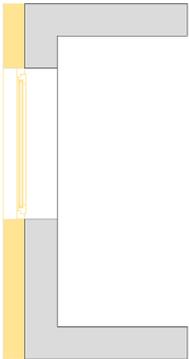
1.External re-insulation

2.Double-skin façade

3.Curtain wall

3.1 Stick system

3.2 Unitized system



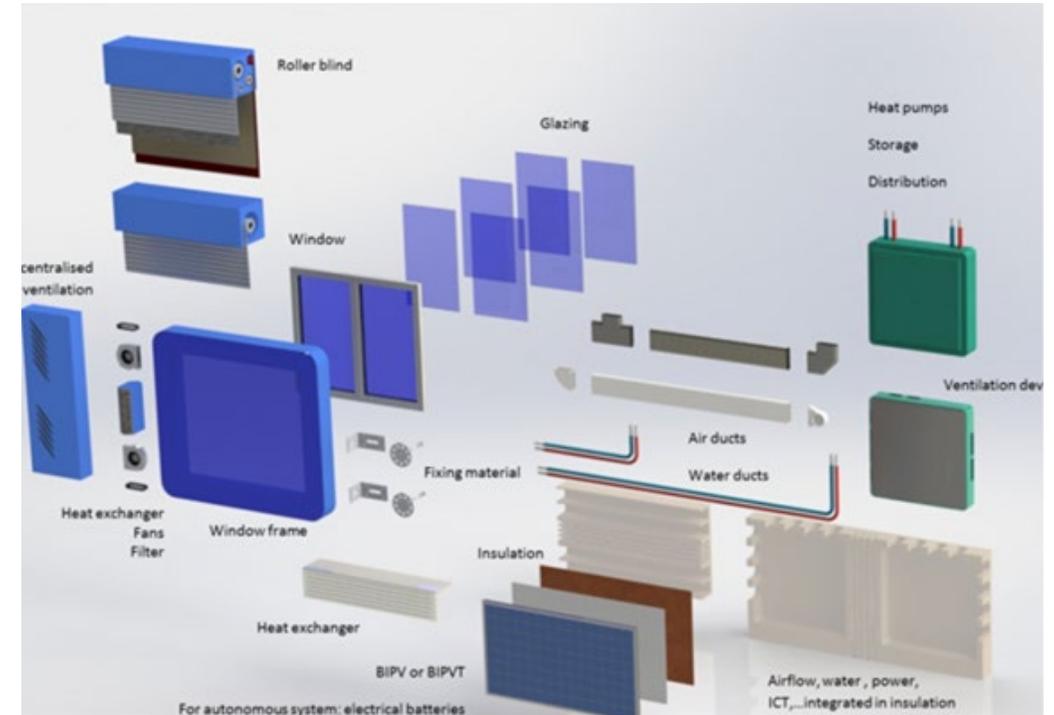
| Requirements | Proposed façade solution | | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------|--------------------|----------------------------|-------------------------------|
| | 1 | 2 | 3a | 3b |
| | External re-insulation | Double-skin façade | Curtain Wall: Stick System | Curtain Wall: Unitized System |
| Ventilated façade | N/A | ••• | ••• | ••• |
| Plug and play | ••• | N/A | • | ••• |
| Low-cost multifunctional insulation boards | •• | N/A | •• | ••• |
| Commercially available PV modules | N/A | •• | ••• | ••• |
| Commercially available solar thermal collectors | N/A | N/A | • | ••• |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | N/A | ••• | ••• | ••• |
| Integration of hydraulic, electric and HVAC | N/A | ••• | ••• | ••• |
| Modular, Pre-cast and Easy Assembly-Disassembly | •• | •• | • | ••• |
| <i>minimize on-site work</i> | ••• | •• | • | ••• |
| <i>improve product quality</i> | • | •• | •• | ••• |
| <i>reduce costs</i> | ••• | • | • | ••• |
| Industrialization | N/A | •• | • | ••• |
| <i>minimize on-site work</i> | N/A | •• | • | ••• |
| <i>cost reduction</i> | N/A | • | • | ••• |
| <i>improve quality</i> | N/A | •• | •• | ••• |
| <i>increased safety</i> | N/A | ••• | • | ••• |
| Less intrusive system | •• | ••• | • | ••• |
| <i>prioritize outdoor interventions</i> | ••• | ••• | •• | ••• |
| <i>avoid interruption in the dwellings</i> | •• | ••• | •• | ••• |
| <i>reduce the duration of the interventions</i> | • | •• | • | ••• |
| <i>off-site manufacturing</i> | • | ••• | • | ••• |
| <i>plug-and-play solutions</i> | ••• | ••• | • | ••• |
| <i>optimized building processes</i> | • | •• | • | ••• |
| Aesthetic and functional integration | •• | • | •• | •• |
| <i>harmonizing architectonic rehabilitation with social acceptance expectations of the architects</i> | •• | • | •• | •• |
| | N/A | N/A | N/A | N/A |
| Integration and adaptation of multifunctional insulation system | ••• | •• | ••• | ••• |
| <i>use of recycled material</i> | ••• | ••• | ••• | ••• |
| <i>recyclability of the final solution</i> | •• | •• | •• | •• |
| <i>reduction of heat and pressure losses</i> | ••• | •• | ••• | ••• |
| <i>fire protection</i> | •• | • | •• | •• |
| <i>prefabricated window insulation frames</i> | N/A | N/A | ••• | ••• |
| <i>minimum of heat losses</i> | ••• | •• | ••• | ••• |
| Integration of thermal and PV modules | N/A | • | •• | •• |
| <i>integration into the RenoZEB envelop and building concept</i> | N/A | • | •• | •• |
| Connection elements | N/A | • | •• | ••• |
| <i>Integrate subsystems in a holistic approach</i> | N/A | • | •• | ••• |
| Development of the Smart-IoT façade module | N/A | •• | •• | ••• |
| <i>Low-cost sensors</i> | N/A | •• | •• | •• |
| <i>Low-intrusive installation</i> | N/A | ••• | •• | ••• |
| <i>Embedding in the module</i> | N/A | • | • | ••• |
| <i>Integration with PV and battery system</i> | N/A | • | • | ••• |
| <i>Data collections system with common protocols</i> | N/A | ••• | ••• | ••• |
| <i>Plug & play solution</i> | N/A | •• | • | ••• |
| Points achieved | 17 | 28 | 33 | 46 |

Components technologies identification



In line with RenoZEB concept the components that are included in the RenoZEB concept are:

- a. Prefabricated window module and roller shutter;
- b. Multifunctional insulation board;
- c. Ventilation devices;
- d. Building Integrated Photovoltaics (BIPV) and batteries;
- e. Building Integrated Solar Thermal;
- f. Façade controller;
- g. Façade-integrated sensors;
- h. Fixing mechanisms.



Components technologies identification



| Requirements | Proposed Technology/solution | | | |
|----------------------------------------------------------------------------------------------------------------|------------------------------|--------------|------------------|--------------------------------|
| | 1 | 2 | 3 | 4 |
| | Compact SA | Roka Compact | HELLA TRAV FRAME | ILLBRUCK Vorwandmontage system |
| | | | | |
| Ventilated façade | N/A | *** | N/A | N/A |
| Plug and play | *** | *** | *** | • |
| Low-cost multifunctional insulation boards | • | • | • | •• |
| Commercially available PV modules | N/A | N/A | N/A | N/A |
| Commercially available solar thermal collectors | N/A | N/A | N/A | N/A |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | N/A | N/A | N/A | N/A |
| Integration of hydraulic, electric and HVAC | N/A | N/A | N/A | N/A |
| Modular, Pre-cast and Easy Assembly-Disassembly | *** | *** | •• | • |
| <i>minimize on-site work</i> | *** | *** | •• | • |
| <i>improve product quality</i> | *** | *** | •• | •• |
| <i>reduce costs</i> | •• | •• | •• | • |
| Industrialization | *** | *** | •• | • |
| <i>minimize on-site work</i> | *** | *** | •• | • |
| <i>cost reduction</i> | •• | •• | •• | • |
| <i>improve quality</i> | •• | •• | •• | • |
| <i>increased safety</i> | •• | •• | •• | • |
| Less intrusive system | *** | *** | •• | •• |
| <i>prioritize outdoor interventions</i> | *** | •• | •• | •• |
| <i>avoid interruption in the dwellings</i> | *** | •• | •• | •• |
| <i>reduce the duration of the interventions</i> | •• | •• | •• | • |
| <i>off-site manufacturing</i> | •• | •• | •• | • |
| <i>plug-and-play solutions</i> | •• | •• | •• | • |
| <i>optimized building processes</i> | •• | •• | •• | • |
| Aesthetic and functional integration | *** | •• | •• | •• |
| <i>harmonizing architectonic rehabilitation with social acceptance</i> | *** | • | • | •• |
| <i>expectations of the architects</i> | *** | •• | •• | •• |
| Integration and adaptation of multifunctional insulation | *** | •• | •• | •• |
| <i>use of recycled material</i> | •• | •• | •• | •• |
| <i>recyclability of the final solution</i> | •• | •• | •• | •• |
| <i>reduction of heat and pressure losses</i> | •• | •• | •• | • |
| <i>fire protection</i> | •• | •• | •• | •• |
| <i>prefabricated window insulation frames</i> | •• | •• | •• | • |
| <i>minimum of heat losses</i> | •• | •• | •• | • |
| Integration of thermal and PV modules | •• | • | • | • |
| <i>integration into the RenoZEB envelop and building concept solution</i> | •• | • | • | • |
| Connection elements | •• | •• | •• | •• |
| <i>Integrate subsystems in a holistic approach</i> | •• | •• | •• | •• |
| Development of the Smart-IoT façade module | N/A | N/A | N/A | N/A |
| <i>Low-cost sensors</i> | N/A | N/A | N/A | N/A |
| <i>Low-intrusive installation</i> | N/A | N/A | N/A | N/A |
| <i>Embedding in the module</i> | N/A | N/A | N/A | N/A |
| <i>Integration with PV and battery system</i> | N/A | N/A | N/A | N/A |
| <i>Data collections system with common protocols</i> | N/A | N/A | N/A | N/A |
| <i>Plug & play solution</i> | N/A | N/A | N/A | N/A |
| <i>Points achieved</i> | 22 | 22 | 16 | 13 |

Prefabricated window module and roller shutter

| Requirements | Proposed component | | | |
|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------------------------------|
| | 1 | 2 | 3 | 4 |
| | Simplest "low-cost" variant: no ducts in the insulation, the ventilation is done using the window-integrated ventilator with heat exchanger from B+H | Pre-shaped mineral wool or EPS insulation modules (RetrokIt Project 2016), (LOWEX-BEST ANDSGEWERBE BAUTEN 2017). | Prefabricated retrofit module (IEA 2011). | Telescopic ducts used in timber prefabricated facade/Bigger facade module (IEA 2011). |
| | | | | |
| Ventilated façade | *** | *** | •• | •• |
| Plug and play | •• | •• | •• | •• |
| Low-cost multifunctional insulation boards | •• | •• | • | • |
| Commercially available PV modules | N/A | N/A | N/A | N/A |
| Commercially available solar thermal collectors | N/A | N/A | N/A | N/A |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | •• | •• | •• | •• |
| Integration of hydraulic, electric and HVAC | •• | •• | •• | •• |
| Modular, Pre-cast and Easy Assembly-Disassembly | •• | •• | •• | •• |
| <i>minimize on-site work</i> | •• | • | •• | •• |
| <i>improve product quality</i> | •• | •• | •• | •• |
| <i>reduce costs</i> | •• | •• | • | • |
| Industrialization | •• | •• | •• | •• |
| <i>minimize on-site work</i> | •• | • | •• | •• |
| <i>cost reduction</i> | •• | • | • | • |
| <i>improve quality</i> | •• | •• | •• | •• |
| <i>increased safety</i> | •• | •• | •• | •• |
| Less intrusive system | •• | •• | •• | •• |
| <i>prioritize outdoor interventions</i> | •• | •• | •• | •• |
| <i>avoid interruption in the dwellings</i> | •• | •• | •• | •• |
| <i>reduce the duration of the interventions</i> | •• | •• | •• | •• |
| <i>off-site manufacturing</i> | •• | • | •• | •• |
| <i>plug-and-play solutions</i> | •• | •• | •• | •• |
| <i>optimized building processes</i> | •• | •• | •• | •• |
| Aesthetic and functional integration | •• | •• | •• | •• |
| <i>harmonizing architectonic rehabilitation with social acceptance</i> | •• | •• | •• | •• |
| <i>expectations of the architects</i> | •• | •• | •• | •• |
| Integration and adaptation of multifunctional insulation | •• | •• | •• | •• |
| <i>use of recycled material</i> | •• | •• | • | •• |
| <i>recyclability of the final solution</i> | •• | •• | •• | •• |
| <i>reduction of heat and pressure losses</i> | •• | •• | •• | •• |
| <i>fire protection</i> | •• | •• | •• | •• |
| <i>prefabricated window insulation frames</i> | •• | •• | •• | • |
| <i>minimum of heat losses</i> | •• | •• | •• | •• |
| Integration of thermal and PV modules | •• | •• | •• | •• |
| <i>integration into the RenoZEB envelop and building concept solution</i> | •• | •• | •• | •• |
| Connection elements | •• | •• | •• | •• |
| <i>Integrate subsystems in a holistic approach</i> | •• | •• | •• | •• |
| Development of the Smart-IoT façade module | N/A | N/A | N/A | N/A |
| <i>Low-cost sensors</i> | N/A | N/A | N/A | N/A |
| <i>Low-intrusive installation</i> | N/A | N/A | N/A | N/A |
| <i>Embedding in the module</i> | N/A | N/A | N/A | N/A |
| <i>Integration with PV and battery system</i> | N/A | N/A | N/A | N/A |
| <i>Data collections system with common protocols</i> | N/A | N/A | N/A | N/A |
| <i>Plug & play solution</i> | N/A | N/A | N/A | N/A |
| <i>Points achieved</i> | 53 | 51 | 45 | 49 |

Multifunctional insulation board



Components technologies identification



Ventilation device

| Requirements | Proposed Technology/solution | | | | |
|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| | 1 | 2 | 3 | 4 | 5 |
| | Regenerative ventilation system with heat exchanger integrated in window frame | Decentralized Regenerative ventilation system with heat exchanger integrated in room wall | Decentralized Regenerative ventilation system with heat exchanger integrated in room wall, already integrating small PV | Balanced ventilation system with heat exchanger integrated in room wall | Centralised ventilation system with air ducts in insulation layer (RetroKit Project 2016), (LOWEX-BESTANDSGEWERBE BAUTEN 2017) |
| | | | | | |
| Ventilated façade | *** | *** | *** | *** | *** |
| Plug and play | *** | *** | *** | *** | *** |
| Low-cost multifunctional insulation boards | N/A | N/A | N/A | N/A | N/A |
| Commercially available PV modules | N/A | N/A | ** | N/A | N/A |
| Commercially available solar thermal collectors | N/A | N/A | N/A | N/A | N/A |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | N/A | N/A | N/A | N/A | ** |
| Integration of hydraulic, electric and HVAC | ** | ** | ** | ** | ** |
| Modular, Pre-cast and Easy Assembly-Disassembly | ** | ** | ** | ** | ** |
| <i>minimize on-site work</i> | ** | ** | ** | ** | * |
| <i>improve product quality</i> | ** | ** | ** | ** | ** |
| <i>reduce costs</i> | ** | ** | ** | ** | ** |
| Industrialization | ** | ** | ** | ** | ** |
| <i>minimize on-site work</i> | ** | ** | ** | ** | * |
| <i>cost reduction</i> | ** | ** | ** | ** | ** |
| <i>improve quality</i> | ** | ** | ** | ** | ** |
| <i>increased safety</i> | ** | ** | ** | ** | ** |
| Less intrusive system | ** | ** | ** | ** | ** |
| <i>prioritize outdoor interventions</i> | ** | ** | ** | ** | ** |
| <i>avoid interruption in the dwellings</i> | ** | ** | ** | ** | ** |
| <i>reduce the duration of the interventions</i> | ** | ** | ** | ** | ** |
| <i>off-site manufacturing</i> | ** | ** | ** | ** | * |
| <i>plug-and-play solutions</i> | ** | ** | ** | ** | * |
| <i>optimized building processes</i> | ** | ** | ** | ** | ** |
| Aesthetic and functional integration | ** | ** | ** | ** | ** |
| <i>harmonizing architectural rehabilitation with social acceptance</i> | ** | ** | ** | ** | ** |
| <i>expectations of the architects</i> | ** | ** | ** | ** | ** |
| Integration and adaptation of multifunctional insulation | ** | ** | ** | ** | ** |
| <i>use of recycled material</i> | ** | * | * | * | ** |
| <i>recyclability of the final solution</i> | ** | ** | ** | ** | ** |
| <i>reduction of heat and pressure losses</i> | ** | ** | ** | ** | ** |
| <i>fire protection</i> | ** | ** | ** | ** | ** |
| <i>prefabricated window insulation frames</i> | ** | N/A | N/A | N/A | N/A |
| <i>minimum of heat losses</i> | ** | ** | ** | ** | ** |
| Integration of thermal and PV modules | ** | ** | ** | ** | ** |
| <i>Integration into the RenoZEB envelop and building concept solution</i> | ** | ** | ** | ** | ** |
| Connection elements | ** | ** | ** | ** | ** |
| <i>Integrate subsystems in a holistic approach</i> | ** | ** | ** | ** | ** |
| Development of the Smart-IoT façade module | N/A | N/A | N/A | N/A | N/A |
| <i>Low-cost sensors</i> | N/A | N/A | N/A | N/A | N/A |
| <i>Low-intrusive installation</i> | N/A | N/A | N/A | N/A | N/A |
| <i>Embedding in the module</i> | N/A | N/A | N/A | N/A | N/A |
| <i>Integration with PV and battery system</i> | N/A | N/A | N/A | N/A | N/A |
| <i>Data collections system with common protocols</i> | N/A | N/A | N/A | N/A | N/A |
| <i>Plug & play solution</i> | N/A | N/A | N/A | N/A | N/A |
| Points achieved | 26 | 22 | 25 | 21 | 24 |

Building Integrated Photovoltaics (BIPV) and batteries

| Requirements | Proposed component | | |
|----------------------------------------------------------------------------------------------------------------|---------------------------|------------------------------------------|-----------------------|
| | 1 BIPV semitransparent | 2 BIPV Crystalline partially in glass | 3 BIPV crystalline |
| | | | |
| Ventilated façade | *** | *** | *** |
| Plug and play | *** | *** | *** |
| Low-cost multifunctional insulation boards | * | * | * |
| Commercially available PV modules | ** | ** | ** |
| Commercially available solar thermal collectors | N/A | N/A | N/A |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | ** | ** | ** |
| Integration of hydraulic, electric and HVAC | ** | ** | ** |
| Modular, Pre-cast and Easy Assembly-Disassembly | ** | ** | ** |
| <i>minimize on-site work</i> | ** | ** | ** |
| <i>improve product quality</i> | ** | ** | ** |
| <i>reduce costs</i> | ** | ** | ** |
| Industrialization | ** | ** | ** |
| <i>minimize on-site work</i> | ** | ** | ** |
| <i>cost reduction</i> | ** | ** | ** |
| <i>improve quality</i> | ** | ** | ** |
| <i>increased safety</i> | ** | ** | ** |
| Less intrusive system | ** | ** | ** |
| <i>prioritize outdoor interventions</i> | ** | ** | ** |
| <i>avoid interruption in the dwellings</i> | ** | ** | ** |
| <i>reduce the duration of the interventions</i> | ** | ** | ** |
| <i>off-site manufacturing</i> | ** | ** | ** |
| <i>plug-and-play solutions</i> | ** | ** | ** |
| <i>optimized building processes</i> | ** | ** | ** |
| Aesthetic and functional integration | ** | ** | ** |
| <i>harmonizing architectural rehabilitation with social acceptance</i> | ** | ** | ** |
| <i>expectations of the architects</i> | ** | ** | ** |
| Integration and adaptation of multifunctional insulation | * | * | * |
| <i>use of recycled material</i> | * | * | * |
| <i>recyclability of the final solution</i> | * | * | * |
| <i>reduction of heat and pressure losses</i> | N/A | N/A | N/A |
| <i>fire protection</i> | N/A | N/A | N/A |
| <i>prefabricated window insulation frames</i> | N/A | N/A | N/A |
| <i>minimum of heat losses</i> | N/A | N/A | N/A |
| Integration of thermal and PV modules | ** | ** | ** |
| <i>Integration into the RenoZEB envelop and building concept solution</i> | ** | ** | ** |
| Connection elements | ** | ** | ** |
| <i>Integrate subsystems in a holistic approach</i> | ** | ** | ** |
| Development of the Smart-IoT façade module | ** | ** | ** |
| <i>Low-cost sensors</i> | N/A | N/A | N/A |
| <i>Low-intrusive installation</i> | * | * | ** |
| <i>Embedding in the module</i> | ** | ** | ** |
| <i>Integration with PV and battery system</i> | ** | ** | ** |
| <i>Data collections system with common protocols</i> | N/A | N/A | N/A |
| <i>Plug & play solution</i> | ** | ** | ** |
| Points achieved | 35 | 35 | 35 |



Components technologies identification



| Requirements | Proposed component | |
|---------------------------------------------------------------------------------------------------------|--------------------|------------|
| | 1 | 2 |
| | BIST (water) | BIST (air) |
| | | |
| Ventilated façade | .. | *** |
| Plug and play | . | *** |
| Low-cost multifunctional insulation boards | . | *** |
| Commercially available PV modules | N/A | N/A |
| Commercially available solar thermal collectors | *** | *** |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | . | *** |
| Integration of hydraulic, electric and HVAC | .. | .. |
| Modular, Pre-cast and Easy Assembly-Disassembly | . | .. |
| <i>minimize on-site work</i> | . | *** |
| <i>improve product quality</i> | . | . |
| <i>reduce costs</i> | . | .. |
| Industrialization | .. | .. |
| <i>minimize on-site work</i> | .. | *** |
| <i>cost reduction</i> | .. | .. |
| <i>improve quality</i> | . | . |
| <i>increased safety</i> | .. | .. |
| Less intrusive system | .. | *** |
| <i>prioritize outdoor interventions</i> | *** | *** |
| <i>avoid interruption in the dwellings</i> | . | .. |
| <i>reduce the duration of the interventions</i> | . | .. |
| <i>off-site manufacturing</i> | .. | *** |
| <i>plug-and-play solutions</i> | .. | *** |
| <i>optimized building processes</i> | .. | .. |
| Aesthetic and functional integration | .. | .. |
| <i>harmonizing architectonic rehabilitation with social acceptance</i> | .. | .. |
| <i>expectations of the architects</i> | .. | .. |
| Integration and adaptation of multifunctional insulation | .. | .. |
| <i>use of recycled material</i> | .. | .. |
| <i>recyclability of the final solution</i> | .. | *** |
| <i>reduction of heat and pressure losses</i> | .. | *** |
| <i>fire protection</i> | N/A | N/A |
| <i>prefabricated window insulation frames</i> | N/A | N/A |
| <i>minimum of heat losses</i> | .. | .. |
| Integration of thermal and PV modules | .. | .. |
| <i>integration into the RenoZEB envelop and building concept solution</i> | *** | *** |
| Connection elements | *** | *** |
| <i>Integrate subsystems in a holistic approach</i> | *** | *** |
| Development of the Smart-IoT façade module | . | *** |
| <i>Low-cost sensors</i> | N/A | N/A |
| <i>Low-intrusive installation</i> | .. | *** |
| <i>Embedding in the module</i> | . | *** |
| <i>Integration with PV and battery system</i> | N/A | N/A |
| <i>Data collections system with common protocols</i> | N/A | N/A |
| <i>Plug & play solution</i> | . | .. |
| Points achieved | 26 | 38 |

Building Integrated Solar Thermal (BIST)

| Requirements | Proposed comp. |
|---------------------------------------------------------------------------------------------------------|----------------|
| | 1 |
| | Hybrid BIST+PV |
| | |
| Ventilated façade | *** |
| Plug and play | *** |
| Low-cost multifunctional insulation boards | .. |
| Commercially available PV modules | *** |
| Commercially available solar thermal collectors | N/A |
| "Click in system" for air ducts, heat exchangers for ventilation, pipes and/or electrical or ICT cables | *** |
| Integration of hydraulic, electric and HVAC | *** |
| Modular, Pre-cast and Easy Assembly-Disassembly | .. |
| <i>minimize on-site work</i> | *** |
| <i>improve product quality</i> | .. |
| <i>reduce costs</i> | .. |
| Industrialization | *** |
| <i>minimize on-site work</i> | *** |
| <i>cost reduction</i> | *** |
| <i>improve quality</i> | .. |
| <i>increased safety</i> | .. |
| Less intrusive system | *** |
| <i>prioritize outdoor interventions</i> | *** |
| <i>avoid interruption in the dwellings</i> | *** |
| <i>reduce the duration of the interventions</i> | *** |
| <i>off-site manufacturing</i> | *** |
| <i>plug-and-play solutions</i> | *** |
| <i>optimized building processes</i> | .. |
| Aesthetic and functional integration | .. |
| <i>harmonizing architectonic rehabilitation with social acceptance</i> | .. |
| <i>expectations of the architects</i> | .. |
| Integration and adaptation of multifunctional insulation | .. |
| <i>use of recycled material</i> | . |
| <i>recyclability of the final solution</i> | .. |
| <i>reduction of heat and pressure losses</i> | *** |
| <i>fire protection</i> | N/A |
| <i>prefabricated window insulation frames</i> | N/A |
| <i>minimum of heat losses</i> | .. |
| Integration of thermal and PV modules | *** |
| <i>integration into the RenoZEB envelop and building concept solution</i> | *** |
| Connection elements | *** |
| <i>Integrate subsystems in a holistic approach</i> | *** |
| Development of the Smart-IoT façade module | *** |
| <i>Low-cost sensors</i> | N/A |
| <i>Low-intrusive installation</i> | *** |
| <i>Embedding in the module</i> | *** |
| <i>Integration with PV and battery system</i> | N/A |
| <i>Data collections system with common protocols</i> | N/A |
| <i>Plug & play solution</i> | .. |
| Points achieved | 38 |

Hybrid solution for BIPV and BIST

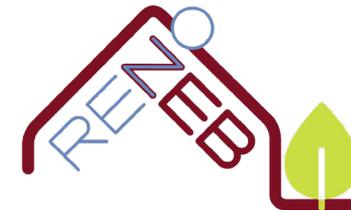


Results



| Technological component | RenoZEB envelope system's component |
|---------------------------------------------------------------|----------------------------------------------------------------------|
| Prefabricated window module and roller shutter | 1. Compact SA |
| Multifunctional insulation board | 4. Telescopic ducts |
| Ventilation devices | 5. Centralized ventilation system with air ducts in insulation layer |
| Building Integrated Photovoltaics (BIPV) and batteries | 3. BIPV crystalline <u>Eventually hybrid BIPV-BIST</u> |
| Building Integrated Solar Thermal | 2. BIST with air |
| Façade controller | FENER webtool |
| Façade-integrated sensors | Solar radiation and light sensors |
| Fixing mechanisms | TBD during system design on specific building structure |





What are the pitfalls of building envelope solutions for retrofitting?

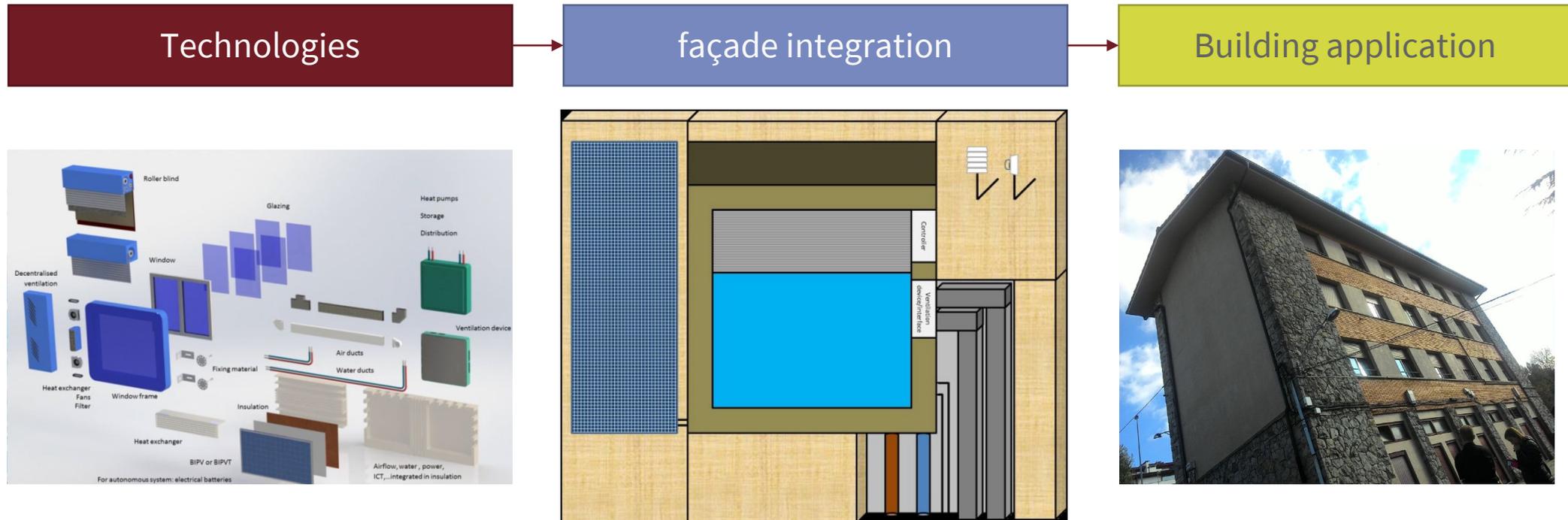


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Boundary conditions



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

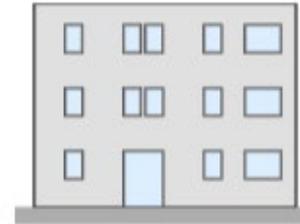


Figure 1: Phase 1 - existing building

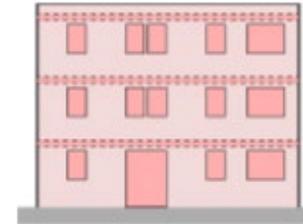


Figure 2: Phase 2 - boundary conditions

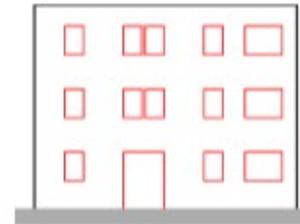


Figure 3: Phase 3 - identification of baseline

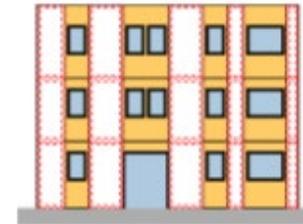


Figure 4: Phase 4a - primary modules designed

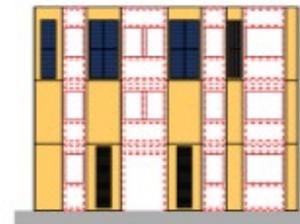


Figure 5: Phase 4b - secondary modules designed



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)



Result: Guide lines



- The method presented underline key elements for the designing process:
 1. DEFINITION OF BASELINE OF THE ENVELOPE CONDITIONS
 2. FRAMEWORK DEFINITION
 3. MULTIFUNCTIONAL INSULATION SYSTEM
 4. CLADDING SYSTEM
 5. MODULE AGGREGATION



Conclusion



Advantages:

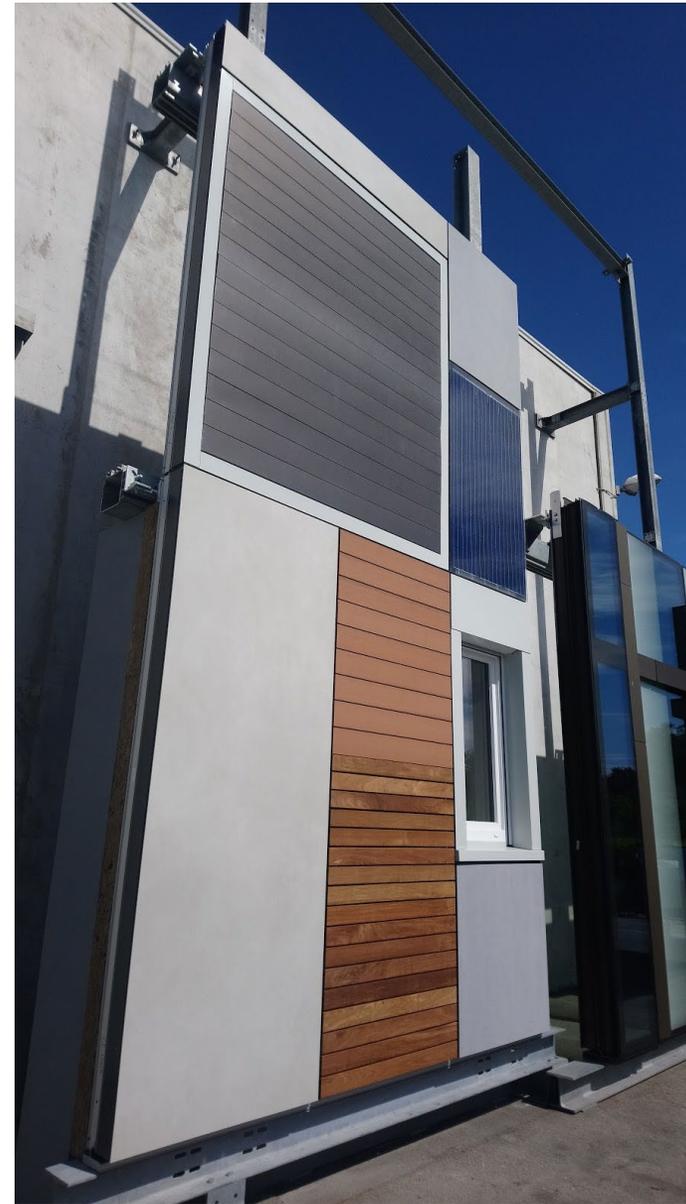
- The method is valid for the **selection** of the best solution within the market which it would be difficult without a qualitative analysis
- The method defines a **guide line** for the design process for the plug&play façade

Disadvantages:

- The approach could be furtherly implemented for quantitative analysis to better support the further engineering phase.



RenoZEB





Any
questions?



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