4RinEU

Reliable models for deep renovation

DEEP RENOVATION JOINT WORKSHOP

ROME, 5/10/2018

Deep renovation and prefabricated solutions: the EU H2020 project 4RinEU

Roberto Lollini

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723829

eurac research

The Consortium

R&D

IT eurac research

NO SINTEF

Applied Research Centres

DEMO OWNERS

NL WOONZORG NEDERLAND

NO BOLIGBYGG

ES Agència de l'Habitatge de Catalunya

Social housing agencies

CONSULTANCY

IT adermalocatelli WE ANCHOR BUILDING TO THE FUTURE — Energy audit

ES acciona Infraestructuras — Construction company

IT R2M RESEARCH TO MARKET SOLUTION — Research to market

ES AIGUASOL

NL Trecodome

Engineering companies

TECHNOLOGY PARTNERS

DE gumpp & maier solutions made of timber — Manufacturer - prefab timber facades

IT Thermics — Manufacturer - H&C + RES

UK IES — Software developer

Start date: 1 October 2016 - **Duration:** 48 months

The project 4RinEU

Robust&Reliable technology concepts and business models for triggering deep Renovation of Residential buildings in EU

4RinEU is developing cost-effective **deep renovation packages** based on three pillars:

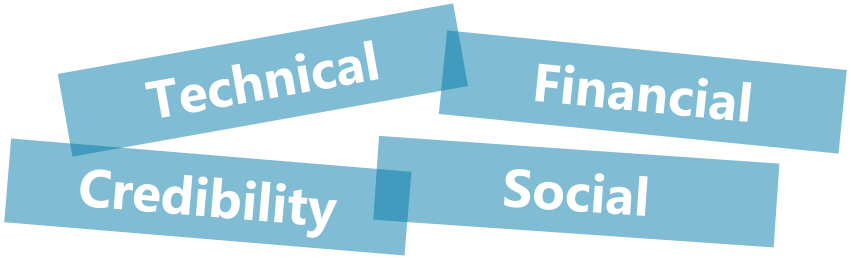
- Robust Technologies
- Usable Methodologies
- Reliable Business Models

Field of Action: **Residential buildings**

Project Website:
http://4rineu.eu/

Project overview

NEEDS/BARRIERS



Fact: we are far from the targeted 3% EU building stock renovation rate

4RinEU ANSWERS

- ROBUST TECHNOLOGIES
- USABLE METHODOLOGIES
- RELIABLE BUSINESS MODELS

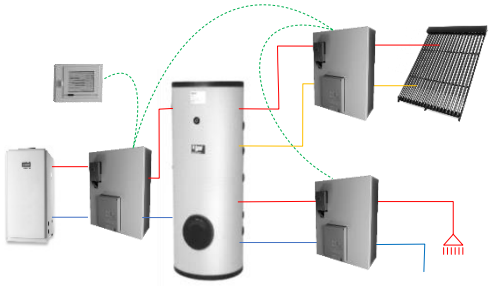
Impact: to increase efficiency of the whole deep renovation process

4RinEU technologies

TO REDUCE ENERGY DEMAND

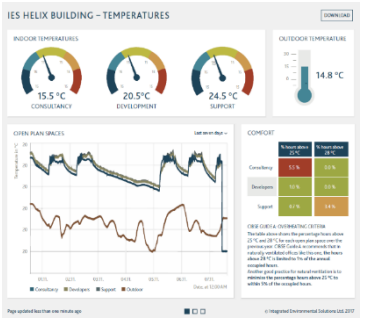
Prefabricated Multifunctional facade

TO IMPROVE ENERGY EFFICIENCY



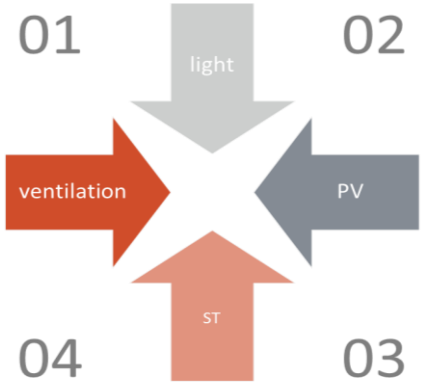
Plug&Play Energy Hub

TO IMPROVE OPERATION



Sensible Data Handler

Comfort ceiling fan operation



Early Reno

end-of-life management

eurac research

4RinEU

4RinEU methodologies

To support the stakeholders along the **whole renovation process**, helping to understand renovation issues and associated potentials, to ensure an effective and **participated design**, to manage the construction site and **reduce the working time and the associated failures**.

TO ACCURATELY UNDERSTAND THE RENOVATION POTENTIALS

Cost-Optimal Energy Audit

TO ENSURE EFFECTIVE AND PARTICIPATED DESIGN

Investor and user-oriented design platform

TO REDUCE CONSTRUCTION TIME AND FAILURES

Deep renovation implementation management

4RinEU business models

Fed into by the technologies and the methodologies.
They drive the investors in deep renovation decision process, considering **technology risks and performances**, in a comprehensive approach

TO IDENTIFY THE LEVEL OF RISKS AND TO ENABLE WELL-FOUNDED INVESTMENTS

Cost-Effective rating system

The project approach

TECHNOLOGY DEVELOPMENT

- Close collaboration among owners, advisors, contractors and researchers to improve the technology solutions, grouped in systemic package

PARTICIPATIVE APPROACH

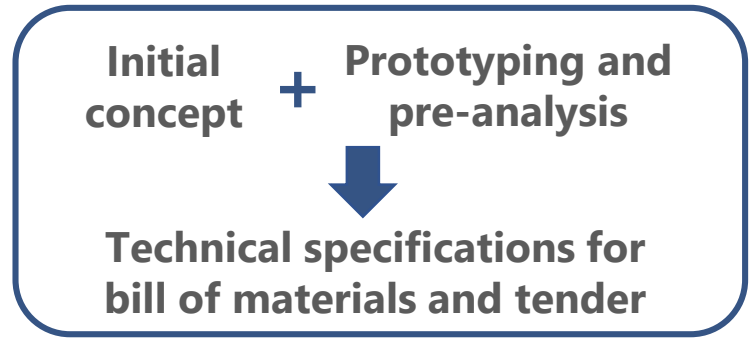
- Tenants and authorities awareness and motivation

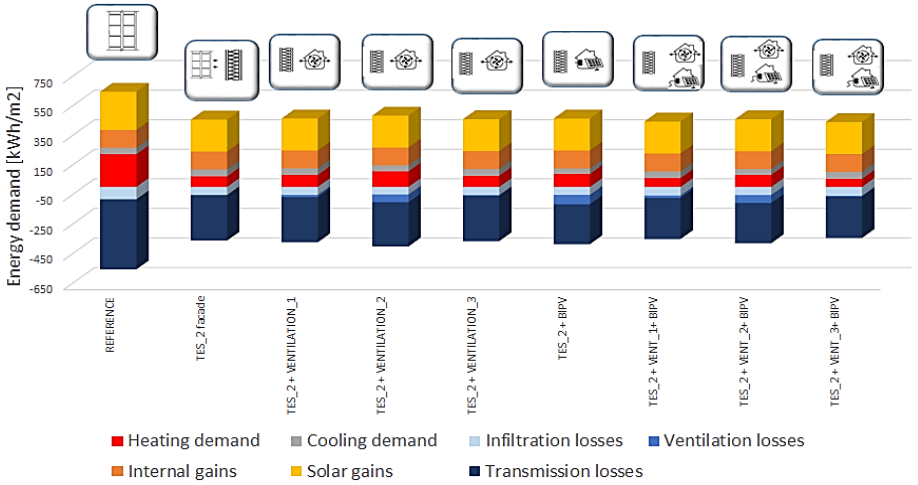
QUANTITATIVE PERFORMANCE EVALUATION

- Laboratory test
- Modelling&Simulation

PERFORMANCE-BASED PROCUREMENT AND IMPLEMENTATION

- Design, production and installation

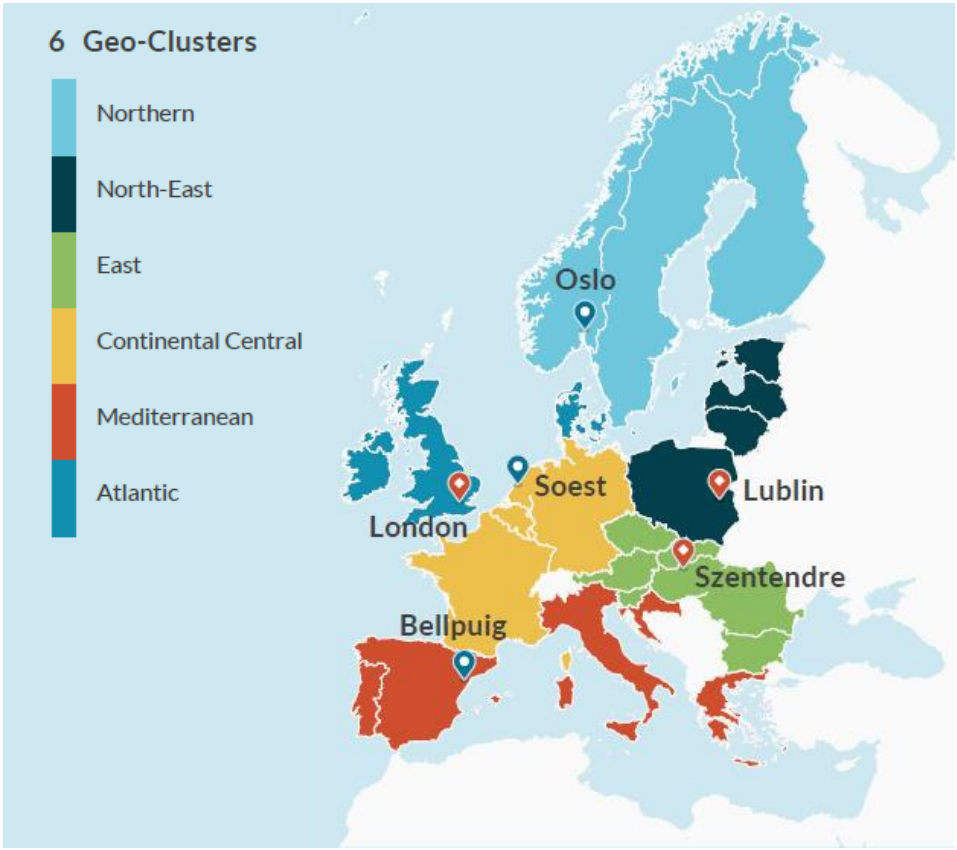




4RinEU geoclusters

Reference from previous projects (FP7 Inspire, H2020 More-Connect) → fine-tuning according to the specific needs

- National boundaries → minimum requirements for the renovation
- Features of the building stock: single/multi family → evaluation of the impact on the bui stock
- Climate conditions → tailored renovation packages



- **6 geoclusters**
- **6 reference countries**: Norway, Spain, The Netherlands, Poland, Hungary and UK.
- **6 Reference cities**: Oslo, Lleida, Amsterdam, Lubiana, Budapest, London

Performance assessment of the project results

3 levels of implementation:

- Demo Cases
- Early Adopters
- Building Archetypes

following all the phases of the deep renovation process:

1. Audit
2. Deep renovation concept definition
3. Performance assessment: simulations and tests
4. Detailed design
5. Procurement and installation of the renovation packages
6. Monitoring of the performances pre and post renovation

DEMO CASES

HAUGERUDSENTERET
Oslo - Norway

MARIËNheuvel
Soest – The Netherlands

Bellpuig - Spain

Performance assessment of the project results

3 levels of implementation:

- Demo Cases
- Early Adopters
- Building Archetypes

3 Local teams supported by 4RinEU to develop feasibility studies on real buildings:

1. Audit
2. Renovation concept definition
3. Performance assessment
4. Detailed design

EARLY ADOPTER TEAM

Hungary

ÉMI

Poland

FUNDACJA ROZWOJU LUBELSZCZYZNY
rok założenia 1990

UK

BUROHAPPOLD ENGINEERING

Performance assessment of the project results

- 3 levels of implementation:
- Demo Cases
- Early Adopters
- Building Archetypes

24 building archetypes in 6 reference countries → rapresentative of the national building stock + suitable for the 4RinEU renovation approach

1. Definition of the renovation concepts
2. Performance assessment of a set of variants

BUILDING ARCHETYPES

Geocluster 1	Reference Country	Norway
	Reference City	Oslo
	4RinEU Code	**G1_NO_SFH_02**
	Tabula_Code:	NO.N.SFH.02.Gen
	Building Size Class:	SFH
	Construction Period:	1956 … 1970
	Reference Floor Area:	228 m²
	4RinEU Code	**G1_NO_SFH_03**
	Tabula_Code:	NO.N.SFH.03.Gen
	Building Size Class:	SFH
	Construction Period:	1971 … 1980
	Reference Floor Area:	152 m²
	4RinEU Code	**G1_NO_TH_01**
	Tabula_Code:	NO.N.TH.01.Gen
	Building Size Class:	TH
	Construction Period:	… 1955
	Reference Floor Area:	216 m²
	4RinEU Code	**G1_NO_AB_02**
	Tabula_Code:	NO.N.AB.02.Gen
	Building Size Class:	MFH
	Construction Period:	1956 … 1970
	Reference Floor Area:	1526 m²

The archetypes are selected from the IEE project TABULA

Performance assessment of the project results

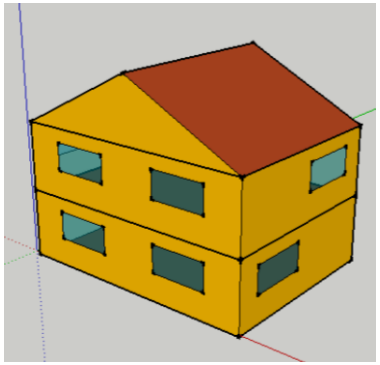
Identification o a set of Key Performance Indicators in 5 thematic areas:

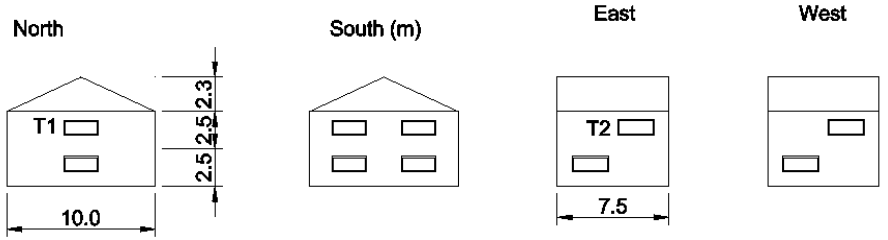
- Energy
- Environment
- Comfort & IAQ
- Economics
- Building site management (time)

KPIs	
Energy	
Energy demand for heating/cooling/ventilation/DHW production	[kWh/m^2]
Energy produced via PV system	[kWh/m^2 PV surface]
Electricity self-consumption	[kWh/m^2]:
Energy produced via ST systems	[kWh/m^2] - [kWh/m^2 ST surface]
ST energy balance	[kWh/m^2] - [kWh/m^2 ST surface]
Environment	
Co_2 Emissions	kg CO_2/year
Comfort & IAQ	
Number of hours category IV cold/IV hot	[h]
Overheating Degree Hours	[°C]
N. hours where CO2 concentration is higher than limits Category I	[h]
Economic issues	
Net Present Value of the renovation (25 years)	[€/m^2]
Investment cost for the renovation	[€/m^2]
Energy Costs (Before/After Renovation)	[€/m^2]
Building site management	
Total work duration /Task duration	[d], [h]

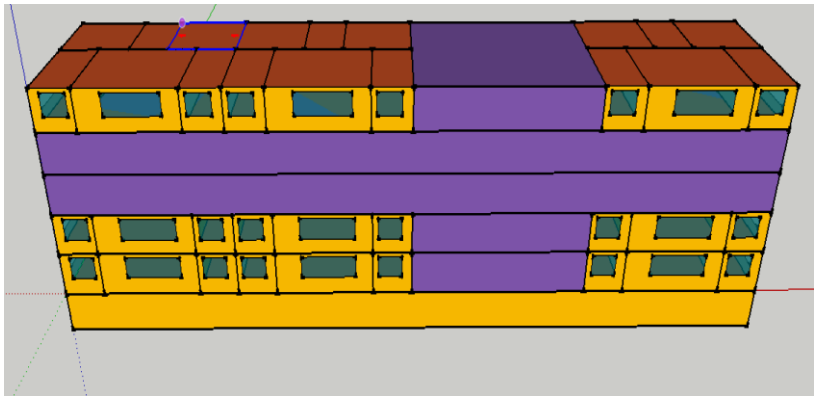
Features of the building archetypes

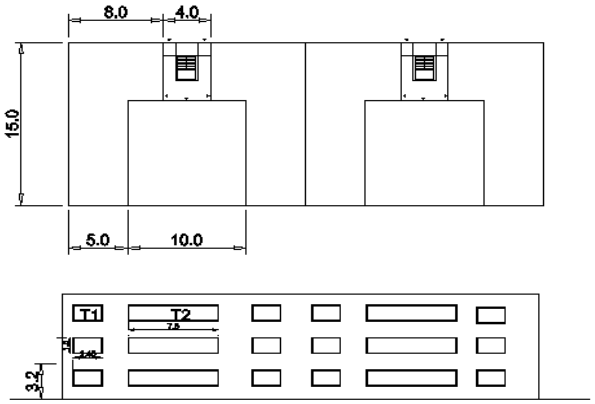
Definition of technical and geometric features of the buildings → numerical models





Wall					
	λ [W/mK]	s [m]	ρ [kg/m³]	C [kJ/kgK]	R m²K/W
Wooden frame	0.12	0.01	450		0.08
Mineral wool	0.045	0.1	130	1.03	2.86
Vapour barrier	0.4	0.02	500	1.8	0.05
Wooden frame	0.12	0.01	450		0.08
Trnsys				U [W/m²K]	0.38



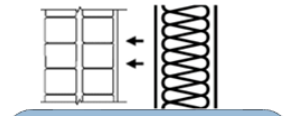


Qualitative and general information

↓

Quantitative and specific features

4RinEU Renovation packages



TES

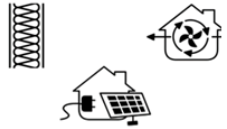
- TES_1
- TES_2
- TES_3

TES+VENT

- TES_1+VENT_1
- TES_1+VENT_2
- TES_1+VENT_3
- TES_2+VENT_1
- TES_2+VENT_2
- TES_2+VENT_3
- TES_3+VENT_1
- TES_3+VENT_2
- TES_3+VENT_3

TES+BIPV

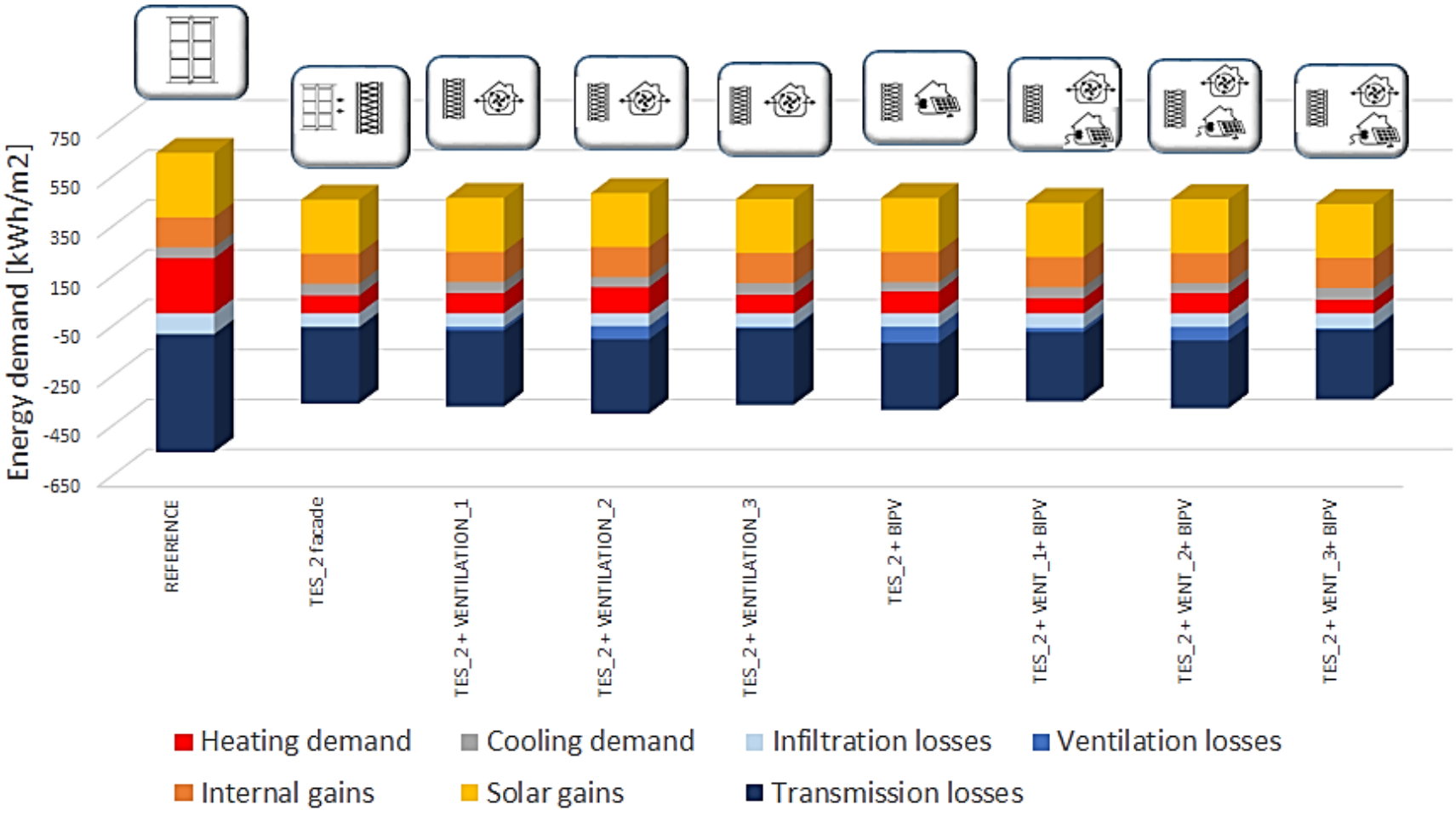
- TES_1+BIPV
- TES_2+BIPV
- TES_3+BIPV



TES+VENT+BIPV

- TES_1+VENT_1+BIPV
- TES_1+VENT_2+BIPV
- TES_1+VENT_3+BIPV
- TES_2+VENT_1+BIPV
- TES_2+VENT_2+BIPV
- TES_2+VENT_3+BIPV
- TES_3+VENT_1+BIPV
- TES_3+VENT_2+BIPV
- TES_3+VENT_3+BIPV

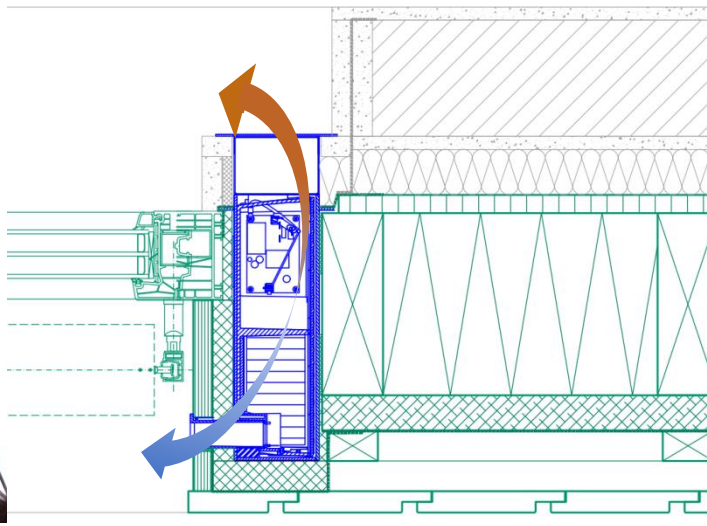
4RinEU Renovation packages - results



4RinEU Renovation packages - Repository

For each building archetypes – comparative analysis of the renovation packages
Definition of the most suitable intervention according to the priority (energy, environment, comfort, economics, building site management)

Existing building - G3_NL_AB_01		KPIs		Performances of the renovation packages			
Geocluster 3	**Reference Country: the Netherlands (Amsterdam)**	**Energy**		**RP1**	**RP2**	**…**	**RPn**
	Building size class: MFH	Energy demand for heating/cooling/ventilation/DHW production	[kWh/m^2]				
	Construction period: 1945-1965	Energy produced via PV system	[kWh/m^2 PV surface]				
	Reference floor area: 4219 m^2	Electricity self-consumption	[kWh/m^2]:				
	Main renovation needs: low insulation, mould, low indoor air quality	Energy produced via ST systems	[kWh/m^2] - [kWh/m^2 ST surface]				
Building performances before renovation		ST energy balance	[kWh/m^2] - [kWh/m^2 ST surface]				
Energy		**Environment**					
Energy demand for heating/cooling/ventilation/DHW production	[kWh/m^2]	Co_2 Emissions	kg CO_2/year				
Environment		**Comfort & IAQ**					
Co_2 Emissions	kg CO_2/year	Number of hours category IV cold/IV hot	[h]				
Comfort & IAQ		Overheating Degree Hours	[°C]				
Number of hours category IV cold/IV hot	[h]	N. hours where CO2 concentration is higher than limits Category I	[h]				
Overheating Degree Hours	[°C]	**Economic issues**					
CO2 concentration	[ppm]	Net Present Value of the renovation (25 years)	[€/m^2]				
		Investment cost for the renovation	[€/m^2]				
		Energy Costs (Before/After Renovation)	[€/m^2]				
		Building site management					
		Total work duration /Task duration	[d], [h]				



Maximilian Schlehlein, Gumpp & Maier GmbH

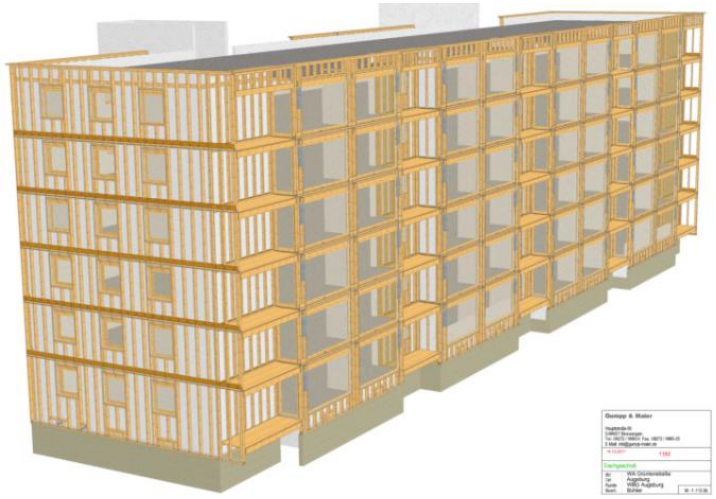
Off-site technology:
Prefabricated multifunctional timber-frame façade

gumpp & maier
solutions made of timber

4RinEU

Prefabricated facade elements for renovation

- New building skin – fits like a stamp to the existing façade openings
- More than mere thermal insulation
- Deep renovation approach for buildings at the end of their lifetime
- Reach state like new built with new lifetime
- Systematic approach: produce fitting facade elements for each individual building in a fluent digital workflow
- Maximize the level of prefabrication
- Minimize works on site and disturbance of tenants



Pictures show renovation project in Grüntenstraße, Augsburg, Germany. Source: Gumpp & Maier GmbH

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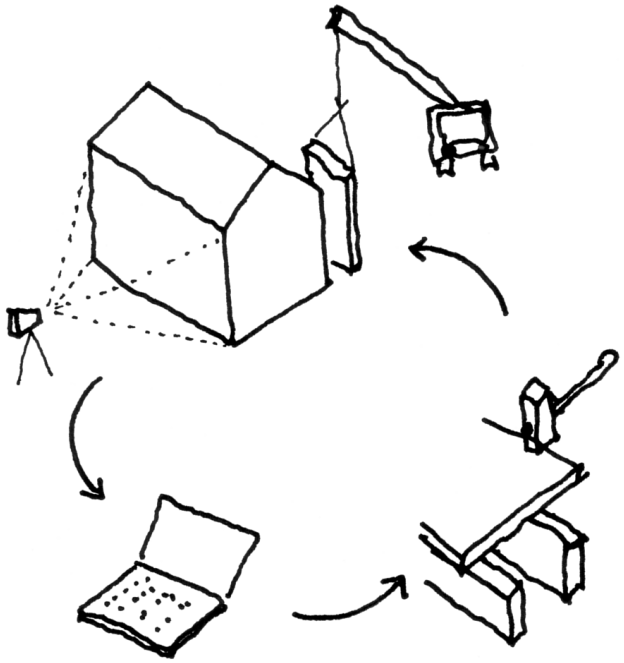
Digital workflow and systematic aproach

- Defined renovation process with systematic workflow
- Digital measurement of the building, 3D design- and production planning
- CNC supported production, prefabrication in the workshop
- Transport, mounting and finishing works on the site

1. Digital Measurement

2. CAD/CAM 3D Modell



4. Mounting

3. Prefabrication

Source: TES Manual, TU München

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Maximized level of prefabrication

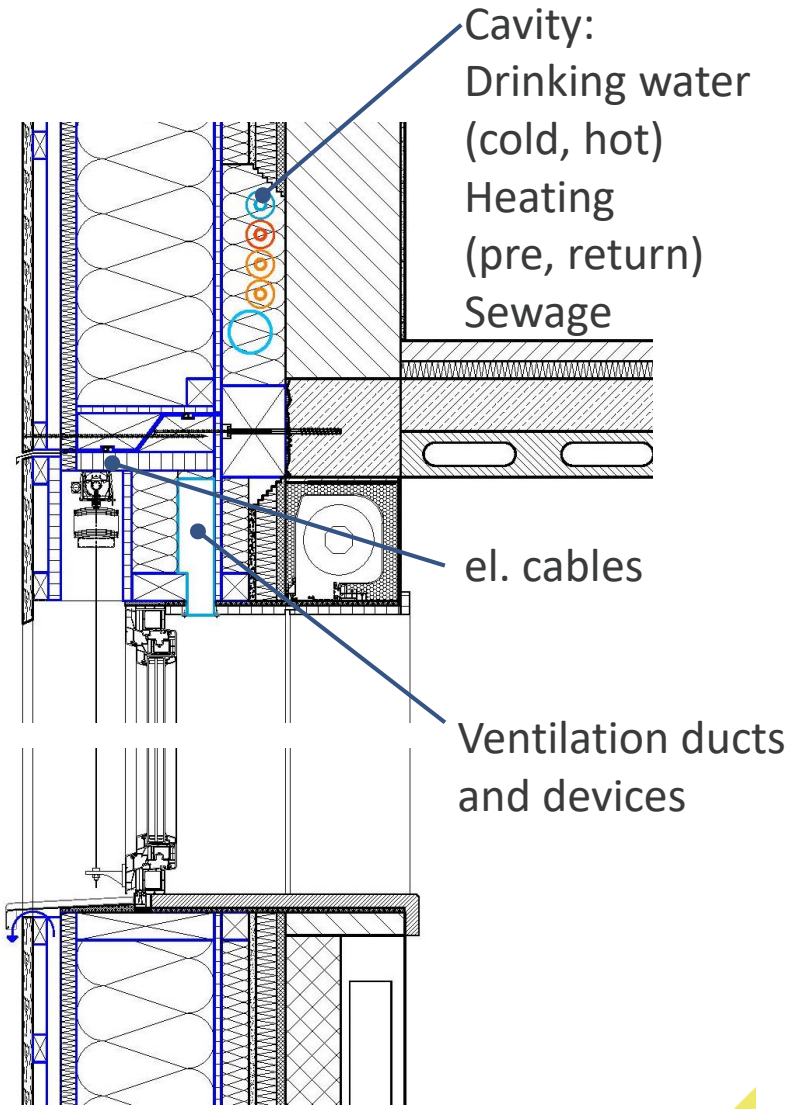
Demonstration wall element developed within 4RinEU project

Prefabricate and transport elements with:

- Cladding
- Windows
- Sun shading
- Decentralized ventilation device with heat recovery
- Solar thermal panel already connected to water pipes

Multifunctional timber-frame facade elements

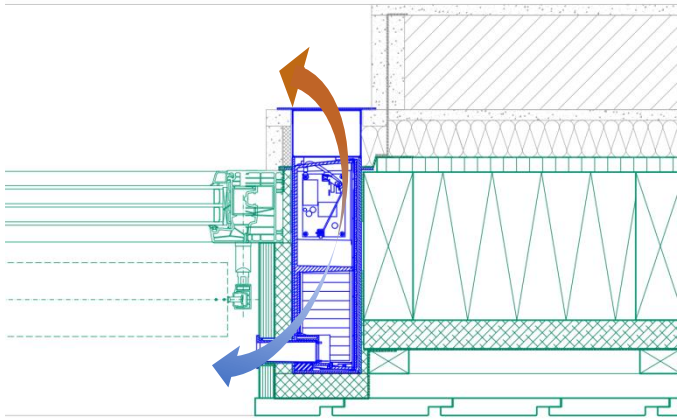
- Integrate the renovation of building services in the renovation process with prefabricated facade elements
- Reduce works inside the building
  - lower disturbance of tenants
  - Shorter construction time
  - Better quality and easier work through prefabrication inside the workshop
- Integrate building services inside the elements
- Use the cavity between new façade elements and existing facade



Current development

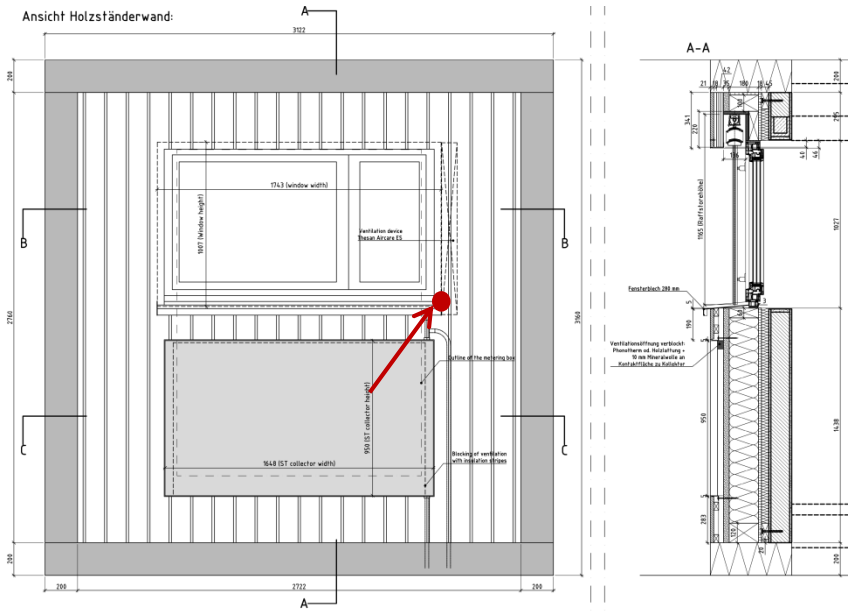
- Construction of prototype wall elements
- Decentralized ventilation device with cross flow heat recovery integrated together with mounting of the window
- Testing in climate chamber at Eurac laboratories, Bolzano, Italy
- Climate chamber provides indoor and outdoor climate and simulates sun irradiation

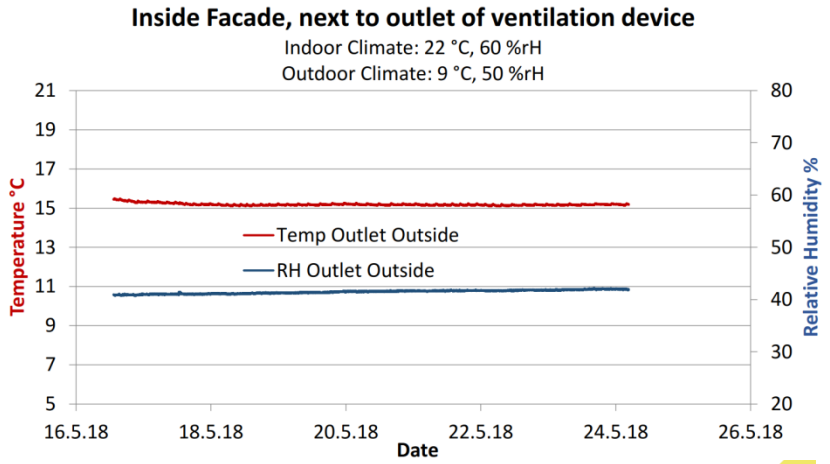
- ST: Panda super slim, Construzioni Solari
- Ventilation: Aircare ES, Thesan



Testing and simulation

- Observe temperature and humidity in different layers and positions of the wall element
- Prove that there will be no issues of condensation or thermal bridges - which has been successfully done in the first test runs
- Analyse the effectivity and performance of ventilation device and solar thermal panel
- Testing provides calibration data for computational simulations of further applications and layouts





Conclusion: Prefabricated multifunctional timber-frame façade

- The technology of renovation with prefabricated timber-frame facade elements is mature and applicated several times each year (not only) at Gumpp & Maier in Germany
- Within 4RinEU three demo projects across Europe are about to apply this renovation approach (NO, NL, SP)
- Renovating with prefabricated elements is defining and following a design and construction process
- In order to design and build elements with integrated building services, it is necessary to form a good working integrative planning team of planners and manufacturers

gumpp & maier
solutions made of timber

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Vera Lukina, BOLIGBYGG - Municipality of Oslo

Lessons learnt: implementation on a case study

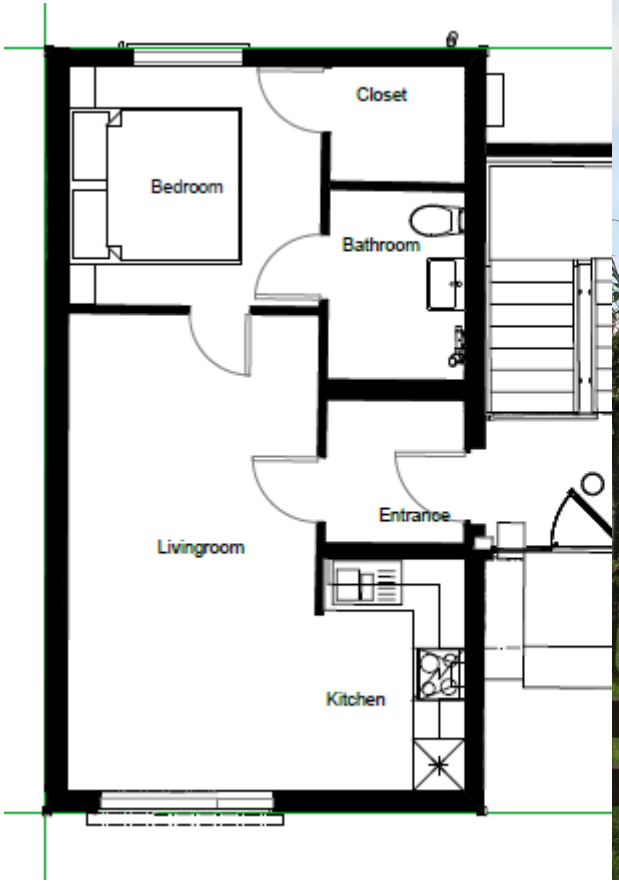
Out targets and motivation to take part in 4RinEU

- Innovation and development
- New experiences, international cooperation
- New technologies

Choice of building for the demo

- 2 floors
- 8 small dwellings
- Simple geometry
- Enough space around

- Construction of walls and foundation



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Main goals of the local project

- **Use of prefabricated facade**
  - First time for renovation in Norway
  - Bring the technology to a local provider
- **Max energy saving**
  - Not passive house dew to no space under 1st floor
  - New roof to insulate the whole envelope
- **As little tenant disturbance as possible**
  - No changes in electrical and water systems

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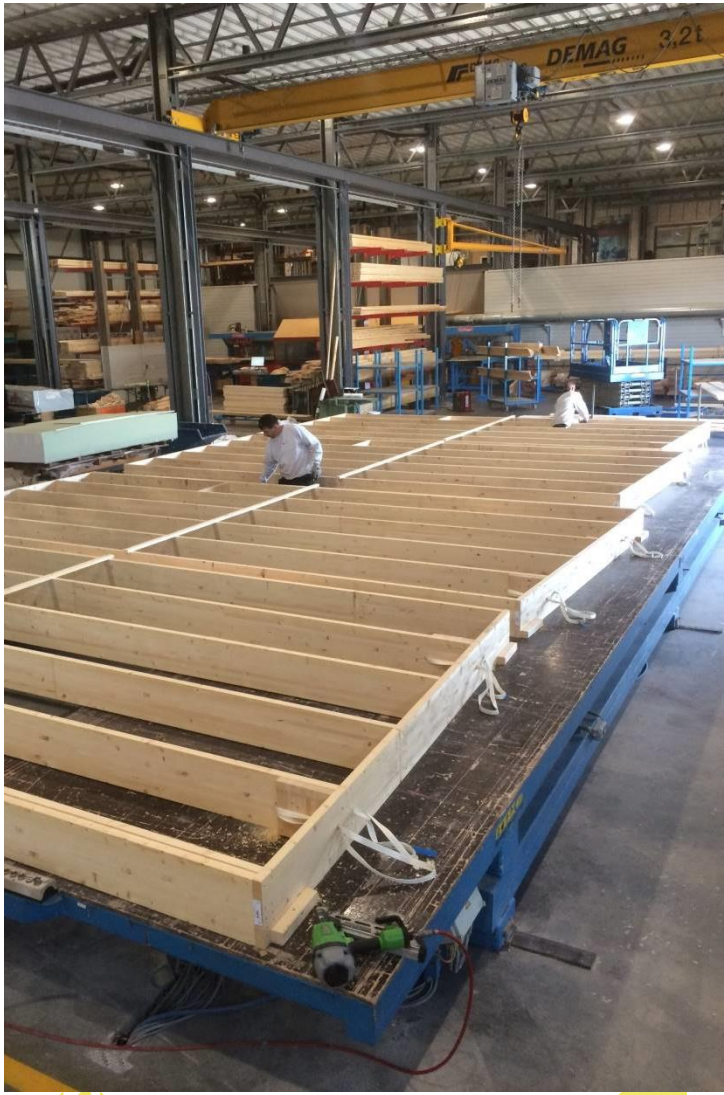
Manufacturer procurement

- Strong marked
- Preferably norwegian manufacturer
- Strategical motivation
- Over a year search before contracting

LINDAL TREINDUSTRI



Picking the design team

- Design group leader
- Architect
- Construction engineer
- Timber & element specialist
- Energy designer

- HVAC engineer
- Electrical designer
- +++

BOLIGBYGG

Design phase – collaboration with 4RinEU partners: EURAC and Gumpp&Mayer

- Coordinating 4RinEU targets vs. local limitations
- EarlyRENo tool to design and check PV locations
- G&M's experience in details and good questions at right time

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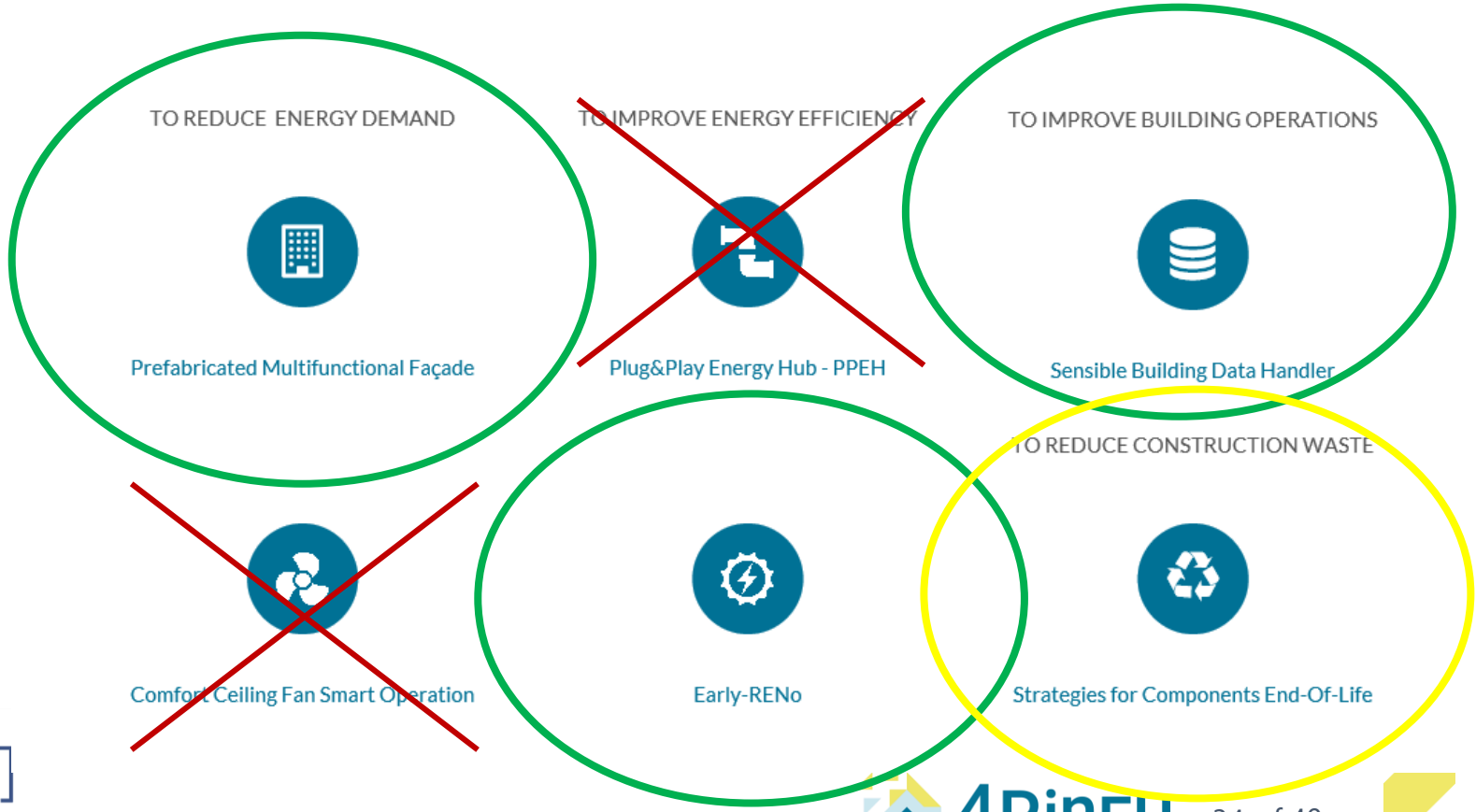
Design phase – support from SINTEF

- Local marked support
- Experience in EU projects
- Deep research support in building physics
  - Keep the cladding
  - Tight insulated roof
  - Fire regulations
- Research background (post-monitoring)

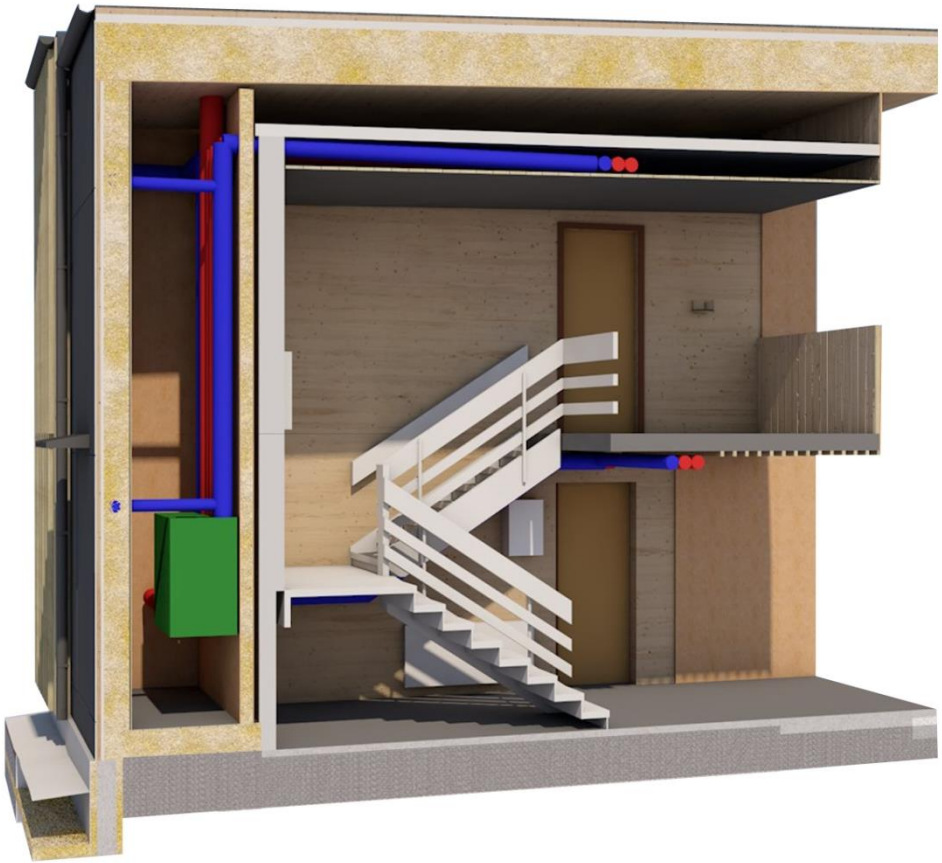
Design phase – choice of renovation package

- Correct choice is important – what, how and when
- Which technologies to integrate



Design phase – collaboration with the manufacturer

- BIM in use, from scanning to timber cut
- Crucial to have good communication between general construction design and detailed element design



Production phase

- Automatical cut, manual element building
- Focus on careful transportation right-on-time, in correct order
- About 3-4 hours transportation to the construction place

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Building phase - mounting

- Carefully planned order
- Think through the details
- Good coordination
- Skilled workers

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Building phase – work with the tenants

- On of the main success factors in social buildings
- Requires special resourse planning
- Explanation in advance, much communication in process
- Focus on safety

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Oslo demo – overall results

- Good quality of the building, much better insulation, PV, balanced ventilation
- Relatively short building time, though longer than planned
- Lindal is working torwards certification of the system in Norway

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http://4rineu.eu/

THANK YOU!

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723829