EVALUATION REPORT ON RINNO PILOTS

Report

Quantitative and Qualitative Evaluation of Demonstrators (KPI Measurement)

Deliverable D6.7: Quantitative and Qualitative Evaluation of Demonstrators (KPIs Measurement)
Work Package 6

Authors
Elsebeth Terkelsen, EGC, Kamil Maszczyk, K-FLEX, Devani Perera, BOUYGUES, Evdoxia Eirini Lithoxoidou, Vassilios Sougakis, CERTH, Elisa Crocco and Jairis Arleen Alvarez Trujillo, RINA-C
August 2025

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 892071

DOCUMENT INFORMATION

Title	RINNO – Quantitative and Qualitative Evaluation of Demonstrators (KPIs Measurement)
Author(s)	Elsebeth Terkelsen and Rasmus Hedegaard, EGC, Kamil Maszczyk, K-FLEX, Devani Perera, Christian de Nacquard and Alexandre Picot, BOUYGUES, Evdoxia Eirini Lithoxoidou and Vassilios Sougakis, CERTH, Elisa Crocco and Jairis Arleen Alvarez Trujillo, RINA-C
Editor(s)	Elisa Crocco and Jairis Arleen Alvarez Trujillo, RINA-C
Reviewed by	EKOLAB, NAPE
Document Nature	Report
Date	29/08/2025
Dissemination Level	Public
Status	Final
Copyright	RINNO
Grant Agreement Number	892071
Lead Beneficiary	RINA-C

REVISION HISTORY

Version	Editor(s)	Date	Change Log
0.1	EGC	25/12/2023	Elsebeth Terkelsen
0.2	EGC	31/03/2025	Elsebeth Terkelsen
0.3	EGC	05/07/2025	Elsebeth Terkelsen
0.4	EGC	31/07/2025	Rasmus LT Hedegaard
0.5	EGC	12/08/2025	Elsebeth Terkelsen
0.6	CERTH	15/08/2025	Vassilios Sougakis
0.7	CERTH	28/08/2025	Eirini Lithoxoidou
0.9	EKOLAB	01/09/2025	Diana Olesen
0.10	NAPE	01/09/2025	Katarzyna Rajkiewicz
1.0 (final)	EGC	02/09/2025	Elsebeth Terkelsen

EXECUTIVE SUMMARY

This report evaluates the RINNO project's implementation of technologies and IT tools at the demo sites, measuring progress against the Key Performance Indicators (KPIs) defined in the Grant Agreement.

While the integrated use of RINNO IT tools at demo sites has been limited, the report documents both achieved results and lessons learned. The evaluation combines quantitative KPI-based data with qualitative insights from two surveys, covering:

- Implementation of RINNO IT tools
- Implementation of RINNO technologies
- Project impact at demo sites
- User satisfaction

Findings highlight both successes and areas for improvement, providing a foundation for future deployment of RINNO solutions.

Partners: EGC, K-FLEX, CERTH, BOUYGUES, CIRCE, RINA-C.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

ABBREVIATIONS

AEC	Architecture, Engineering, and Construction
API	Application Programming Interface
BEM	Building Energy Modelling
BIM	Building Information Modelling
BIPV	Building Integrated Photovoltaics
BREEAM	Building Research Establishment Environmental Assessment Method
DHW	Domestic Hot Water
DSS	Decision Support System
EC	European Commission
EE	Energy Efficient
EPD	Environmental Product Declaration
EPDM	Ethylene Propylene Diene Monomer (synthetic rubber)
GA	General Assembly
GA	Grant Agreement
GUI	Graphical User Interface
IoT	Internet of Things
JSO	Job Scheduling Optimiser
KPI	Key Performance Indicators
LCA	Life Cycle Assessment
LCC	Life Cycle Costs
LCI	Life Cycle Inventory
LEED	Leadership in Energy and Environmental Design
LON	Local Operating Network (automation protocol)
MQTT	Message Queuing Telemetry Transport (lightweight messaging protocol)

O&M	Operation & Maintenance
PES	Primary Energy Savings
QR	quick response (QR-code)
RES	Renewable Energy Source
RFID	Radio Frequency Identification
RPDA	RINNO Planning & Design Assistant
RRM	Retrofitting (or Renovation) Process Manager
S-LCA	Social Life Cycle Assessment
TDS	Tabular Data Stream – protocol used to communicate with database servers
TRL	Technology Readiness Level
WP	Work Package

1 INTRODUCTION

The present report evaluates the implementation of the RINNO SUITE and the RINNO technologies at the demo sites including the user satisfaction.

The RINNO project is an ambitious and wide-reaching initiative comprising numerous components. RINNO aims to deliver a framework solution to accelerate the rate of deep renovation in energy-inefficient buildings across Europe, targeting an ambitious long-term renovation rate of 3.5% per year (over 5+ years)."

To deliver this ambition, the project has developed a portfolio of innovative IT tools and technologies.

The solutions, forming the RINNO Renovation Suite, have – to the widest possible extend - been tested, demonstrated and evaluated during the RINNO project at the four demo sites in France, Greece, Poland and Denmark.

During the project, we successfully completed the renovation works, with the exception of some remaining tasks at the Polish pilot site. All planned technologies have been implemented, and the IT tools have been presented to the teams and local stakeholders involved in the renovation activities. In addition, we conducted a survey among stakeholders, tenants, building owners, and technicians to evaluate user satisfaction.

This report presents the results of the technology implementation at the demo sites, the evaluation of the IT tools, and an assessment of user satisfaction.

2 STRUCTURE OF THE DELIVERABLE

The four pilot projects in RINNO, basis for the evaluation, are located in:


Lille, France


Athens, Grece


Rajszew, Poland


Slagelse, Denmark

This deliverable presents a comprehensive evaluation of the RINNO project outcomes, structured across three main categories:

- **Evaluation of the IT tools** (Chapter 3)
- **Evaluation of the RINNO technologies** (Chapter 5)
- **Evaluation of the impact on the demo sites** (Chapter 7)

Each evaluation chapter is followed by a dedicated section on **user satisfaction surveys** (Chapters 4, 6, and 8), providing insights from the stakeholders directly involved.

The evaluation methodology is based on the **Key Performance Indicators (KPIs)** defined in the Grant Agreement. For each category, the assessment includes:

- An introduction to the scope of the evaluation,
- A statement on the progress achieved within RINNO,
- An overview of KPI achievements, and
- Additional observations or comments.

RINNO has developed and tested a suite of **15 IT tools** across three core areas:

1. RINNO Planning and Design Assistant (WP3)
2. RINNO Retrofitting Manager (WP4)
3. RINNO Building Lifecycle Renovation Manager (WP5)

In parallel, **eight innovative technologies** have been designed and tested within the following categories:

- Modular plug-and-play solutions
- Renewable energy harvesting solutions
- Storage solutions
- Multi-functional hybrid retrofitting solutions

Of these, five technologies have undergone two test cycles, resulting in a total of **14 evaluations across demo sites**, with active feedback from the stakeholders involved.

The impact of IT tools and technologies on the demo sites has been evaluated across 7 impact dimensions, represented by 27 key performance indicators (KPIs). Additionally, a **general user satisfaction survey** has been conducted, with conclusions and statements from the four demo sites presented at the end of the report.

3 EVALUATION OF THE IMPLEMENTATION OF THE IT-TOOLS AT THE DEMO SITES

The RINNO project has successfully developed a suite of IT tools aligned with the Key Performance Indicators (KPIs) outlined in the Grant Agreement. These tools were designed to support and enhance deep renovation processes across the demo sites.

However, due to significant delays in the overall development timeline, it has not been feasible to fully deploy and integrate all the IT tools into the renovation activities at the demo sites as originally intended. Despite this, the development team has actively utilized data from the demo sites as test cases and illustrative examples during the design and testing phases, ensuring that the tools are grounded in real-world contexts.

Engagement with local stakeholders has also been limited in terms of direct application of the tools in ongoing renovations. As detailed in Deliverable 6.5 – Training of Stakeholders, stakeholders were introduced to the RINNO IT tools and provided opportunities to test several of them online. While the training facilitated awareness and preliminary feedback, the tools could not be synchronized with the actual renovation timelines and processes at the demo sites. Only the AR tool was used at the demo sites.

This chapter, therefore, focuses on the original intentions behind the tools and the extent to which they have been achieved. It also presents the surveys conducted in connection with the introduction of the tools. Graphs from the surveys in WP3 can be found I ANNEX I.

Stakeholder comments from the qualitative survey highlight both general understanding and the contextual challenges faced during implementation. These insights are presented in Chapter 4.

The IT tools are the following:

1. RINNO Planning and Design Assistant (WP3)
• Digital Twin
• INTEMA.building
• VERIFY (LCA/ LCC)
• Techno-Economic Assessment tool
• Renovation Scenario DSS
• Job Scheduling Optimizer
• Social-LCA tool
2. RINNO Retrofitting Manager (WP4)
• **On/Off site**
• E-LOGISTICS Platform
• COCKPIT Platform
• AR Training Suite
3. RINNO Building Lifecycle Renovation Manager (WP5)
• Performance Dashboard
• Sensor-Enabled Building Model
• Marketplace
• Social Collaboration – Knowledge Platform

Figure 1 Overview of the RINNO SUITE's IT-tools

3.1 RINNO planning and design assistant (WP3)

The first set of IT tools in the RINNO SUITE is the Planning and Design Assistant. Below is a diagram illustrating the interrelation between the six steps/tools in the Planning and Design Assistant, leading to the selection of the *best renovation scenario* and the *optimum sequence of works*.

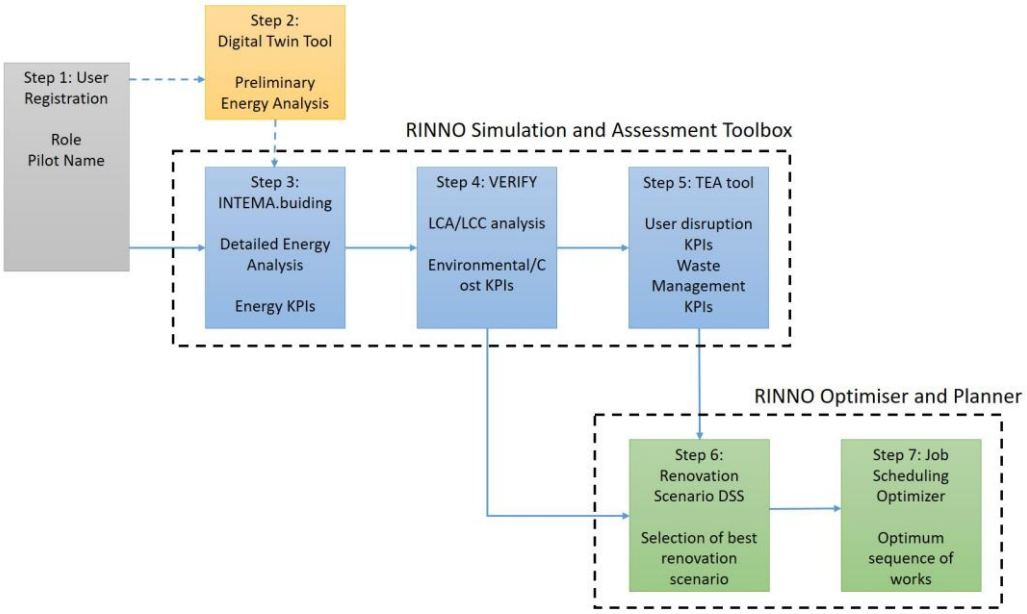


Figure 2 Interrelation between the IT-tools in the RINNO Planning and Design Assistant

All the tools within the RINNO PLANNING AND DESIGN ASSISTANT were used to develop the renovation scenarios for the four demo sites - see D6.2 Pilot planning and set up. The scenarios were inspirational and supported the decision process for the building owners and consultants.

3.1.1 Digital Twin

The Digital Twin Renovation Modelling module of the RINNO Suite is part of VTT's research platform, which offers renovation choices and options for building owners and stakeholders to make informed renovation decisions. The tool provides rough simulation results: if the tool's advice is followed, some 'estimated/simulated' benefits are possible.

A digital Twin as the illustrated below has been developed for all four demo sites.

Figure 3 Digital Twin model of the Danish pilot site - exterior and interior – illustration of microventilation

Progress achieved through RINNO

During RINNO, VTT has upgraded the existing Digital-Twin toolkit, which now provides a reliable foundation for building large and adjustable datasets and is easy to adapt to other modules offering interoperability with external BIM tools.

KPIs

- Average time to model renovation scenarios
- Accuracy of simulations compared to detailed energy analysis

Comments

It has not been possible to set a percentage for how much the average time to model renovation scenarios has been reduced, and the accuracy of simulations has been improved. Anyway, user satisfaction (professional users / partners in RINNO) is high.

3.1.2 INTEMA.building

INTEMA.building tool can estimate with high accuracy the electrical and heating needs of the building. INTEMA.building is also able to achieve cost savings as well as several other advantages compared to similar tools, e.g. time savings, accuracy, easy access, user-friendliness among others.

The following KPIs were identified as the selling points of INTEMA.building:

- **Time savings in design.** INTEMA.building has several features which support time savings in design, namely i) BIM to BEM functionality. By loading the BIM file, the tool is able to read the basic geometric characteristics and material properties of the building and automatically develop the model of the building for the simulation leading to significant time savings compared to manual development of the simulation model, ii) the tool is based on object oriented programming language. This results in significant time savings owed to inherent adjustability for the development of new innovative components and subcomponents, especially addressing innovative systems, and iii) The tool facilitates the quick development of new systems taking advantage of the user interactive interface of the Dymola environment
- **Accuracy**. Several features of INTEMA.building that contribute to superior accuracy among energy simulation tools: i) the solver has adjustable timestep which increases accuracy in complex systems, ii) it uses accurate dynamic solvers, iii) tthe tool supports advanced control systems, and iv) it Supports variable fluid and thermo-physical properties
- **User friendly even to non-experts**. The following features of INTEMA.building ensure the user-friendliness of the tool: i) there is direct and clear visualization of results, ii) preselected results graphs and KPIs are presented to the user for quick evaluation of the results, iii) the tool allows the direct comparison of different scenarios,and iii) possibility for using ready components for unfamiliar users, as well as the possibility for customizing the existing components for using the INTEMA tool in different projects of the energy sector
- **Cross sector simulation engine**. The tools offer the capability to expand on district level simulations including multi-energy grids (electricity, heating, cooling). This aids the investigation of energy communities where various buildings are involved
- **Interoperability.** The tool has the ability to support multiple data formats (.json, .csv,.xml). This enables the communication of INTEMA.building to other tools (e.g. VERIFY) supporting different types of analysis
- **Ease of access - No installation required**. The tool is a web-based application. As such, no installation is required and there are no requirements regarding the performance of the user's PC. Furthermore, as it is online it imay be accessed through any PC enabling working from different locations (office and remotely)
- **Cost savings**. may be demonstrated by comparison of the INTEMA.building cost against other commercial software. CERTH has conducted a business plan for the exploitation of INTEMA.building where the pricing model of the tool was determined. According to this model, two different plans have been identified for industry: i) Pro plan available at €700 +VAT per annum, and ii) Enterprise plan (includes all capabilities of pro plan plus additional ones available at €1800 + VAT per annum. This price is lower than other commercial software. Indicative examples include: i) TRNSYS 18: $5,060 (single user license). This includes additional costs for libraries purchases as well as for future version upgrade ii) EDSL Tas: £2,400.00 + VAT

Whilst some of the above selling points are self-evident and may be demonstrated with merely a justification of the tool's features, others may also be quantified through receiving feedback from users.

CERTH has conducted a series of activities for demonstrating the tool to third parties and receiving their feedback on whether the tool achieves the advantages promised. These include:

- Conducting a training workshop to members of the RINNO Consortium and external stakeholders
- Demonstrating the tool to undergraduate Mechanical Engineering students at NTUA
- Making the tool available to postgraduate students at IHU to be used for their assignment

Results from these activities are presented below.

Feedback from Training workshop (Day 1)

On the 24th of September 2024 a training workshop was conducted where the INTEMA.building tool was demonstrated to members of the RINNO Consortium and external participants from the renovation industry, The purpose of that workshop was to train the stakeholders on the use of the tools but also receive feedback that would help prove and/or quantify some of the benefits claimed by the development team. Results from this activity (based on 12 responses) are presented below

User friendliness

Participants were asked to answer several questions to evaluate the user-friendliness of the tool.

Results from this survey showed that >60% of user consider user-friendliness was achieved with many of the aspects achieving 75% or more positive feedback. It should be noted that there was almost no negative feedback as those who did not express positive opinion were mostly neutral (neither agree nor disagree) which may be attributed to the fact that they did not test the tool themselves. It is suggested that in general the tool was considered user-friendly.

Time savings

A 20% time savings target has been set for the INTEMA.building tool. Two questions were posed to the participants in order to assess whether the INTEMA.building results in time savings compared to other software. The first questions were general and aimed to capture the view of the participants on whether the tool may result in time savings and the next question was aimed at quantifying these perceived time savings. Results are presented below.

Results suggested that many of the respondents (50%) considered that the workflow and use of INTEMA.building has the potential to reduce the time needed for the energy analysis of a renovation project. However, almost an equal amount (41.7%) could not reach a conclusion (neither positive nor negative feedback). When asked to quantify these time savings, the respondents were mostly neutral as 54.5% could not reach a conclusion on perceived time savings. 27.3% of respondents considered that the tool may achieve time savings >20%. Therefore, it can be concluded that there is indication but no solid evidence that the tool may reach the target of 20% time savings. For more robust results it would be required to have the users test the INTEMA.building tool using a real case study rather than just demonstrating its functionalities, but this was not possible due to the lack of interest from the participants.

Feedback from demonstrating the INTEMA.building to NTUA students

A workshop was held on the 21st of December 2023 to undergraduate Mechanical Engineering students at the National University of Athens attending the 'Thermal Behaviour of Buildings' module The INTEMA.building tool was demonstrated, and the students provided their feedback following the completion of the workshop; overall 20 responses were collected.

The analysis considered addressing the main selling points defined for INTEMA.building:

- User friendliness
- Accuracy

- Time savings
- Ease of access

Results are presented in the following graphs:

User friendliness
In terms of user friendliness, the evaluation of the students showed that the tool is user friendly with satisfactory user interface and workflow (85% positive responses, 15% neutral), suitable functionalities (75% positive feedback, 25% neutral) with students considering the they could easily follow the steps for the simulation (63% positive, 37% neutral) and clear and easy to interpret results.

Time savings
With regard to time savings 75% of students considered that the tool results in reduced time required for conducting a simulation study with 83% considering that the time savings would be more than 20% compared to a similar software that they were using. The difference in these percentages, which may seem contradictory (75% against 83%) was due to the fewer responses received in the latter question.

Ease of access
Finally, the tool was well received in general by the students as 73% found it easily accessible and would consider its use in the future.

Feedback from postgraduate students at the International Hellenic University
As a final activity in identifying and quantifying the benefits of INTEMA.building, the tool was made available to students at the International Hellenic University attending the 'Efficient Refurbishment of Buildings' of the postgraduate course Msc in Energy Building Design. The students used the tool and provided their feedback completing relevant feedback forms. Three responses out of the five students using the tool were provided. Despite the small sample, this survey provided valuable input based on the use of the tool on a case study.

Results showed that the users found the tool:

- User friendly, with satisfactory user interface and workflow which is easy to complete the simulation steps and provides clear and easy to interpret results
- Was able to lead to time savings in the energy simulation - more than 30% although this was based on two answers whilst the third was not able to quantify them.

Comments
The activities conducted for obtaining feedback on the use of the tool showed in general that the benefits of the tool were in general confirmed by the users. The participants of all the surveys found the tool to be user friendly, accurate, easily accessible and was able to deliver time savings in design with the target of 20% time savings considered by most participants to be reached and/or exceeded.
INTEMA has been demonstrated by developing renovation scenarios for the four demo sites. See D6.2 Pilot planning and set up. Stakeholders are satisfied with the results (70%) and find that the scenarios have reduced the time for planning the renovation (See chapter 4 SURVEY ON THE IMPLEMENTATION OF THE IT-TOOLS).

3.1.3 VERIFY (LCA/LCC toolkit)

VERIFY is a web-based platform designed to provide a holistic methodology and evaluation for the Lifecycle Assessment (LCA) and Lifecycle Cost (LCC) analysis performed on planned building renovations. The platform provides extensive analysis to support the user in deciding the best renovation plan for a building in terms of environmental and economic factors, by comparing its performance to that of the current building's infrastructure.

LCA (Life Cycle Analysis) is a complex and time-consuming process that entails gathering and analyzing a wide range of data on the materials, energy, and other resources used in the manufacturing, operation and disposal stage of a product. The most time-consuming stage of running an LCA assessment is the stage concerning the data gathering (Life Cycle Inventory - LCI). In VERIFY, there

is no need to conduct a full inventory analysis, since LCI for multiple technologies is already included. There is automated data import of energy profiles from INTEMA and VERIFY can communicate with INTEMA.building.

KPIs
VERIFY offers several benefits compared to other LCA.LCC tools available on the market. The following selling points were identified:

- **Ease of access - No installation required**. The tool is a web-based application. As such, no installation is required and there are no requirements regarding the performance of the user's PC. Furthermore, as it is online it may be accessed through any PC enabling working from different locations (office and remotely)
- **User friendly even to non-experts**. i) there is direct and clear visualization of results and ii) preselected results and KPIs are presented in graphsto the user for quick evaluation of the results. Various KPIs are presented to the user for quick evaluation of the results.for the baseline, the renovation scenario under investigation as well as a comparison of the two to determine the effect of the renovation so that the user (even non-experts) can easily assess the renovation scenario.
- **Cost savings. T**he expected cost savings achieved will be determined through price comparison to other commercial software. To this end, CERTH has conducted a business plan for the exploitation of VERIFY where the pricing model of the tool was determined. According to this model, the VERIFY plan which includes all RINNO functionalities (Business) costs €1500/y/building. This price is lower than other commercial software. For example the OneClick LCA license (competitive tool for conducting LCA in the building sector) for the concurrent user costs €3500/year. Additional cost savings may be achieved as a result of the time savings achieved as described below.
- **Time savings.** The following features of VERIFY support the time savings during the design stage: i) there is no need to conduct full inventory analysis as LCI for multiple technologies is already included. LCA is a complex and time-consuming process that entails gathering and analyzing a wide range of data on the materials, energy, and other resources used in the manufacturing, operation and disposal stage of a product. The most time-consuming stage of running an LCA assessment is the stage concerning the data gathering (Life Cycle Inventory - LCI). Sometimes this requires expert knowledge. In VERIFY, there is no need to conduct a full inventory analysis, since LCI for multiple technologies is already included. ii) Automated data import of energy profiles from INTEMA. VERIFY is able to communicate with INTEMA.building and receive the necessary timeseries of energy consumption/production related to the use phase of the building. As a result, the user has to import only technical specifications of the used equipment and simplified data regarding the operation. Hence the time consuming for the stage of data gathering is minimized. iii) Direct results interpretation. There is a direct visualization of the results by providing the specific KPIs to be evaluated. So, the user does not need extra time to calculate the required KPIs.
- **Dynamic LCA/LCC analysis using real time data including a data lake space.** VERIFY is able to connect to monitoring sensors and conduct dynamic LCA/LCC analysis using. The dynamic in time analysis provides the possibility to make decisions prior to the installation and/or during operation of each energy system. The output of this analysis is the real time visualization of continuously updated KPIs and graphs. At the moment, there are no competitors in this field; VERIFY is the only tool that provides this service
- **Interoperability.** The tool has the ability to support multiple data formats (.json, .csv,.xml). This enables the communication of VERIFY to other tools (e.g. INTEMA.building) to facilitate the analysis and contributes to time savings as described above. In addition, External APIs can be connected to the VERIFY platform, to receive data automatically in real time through communication channels (e.g., Action Cable and MQTT protocol.

Whilst some of the above selling points are self-evident and may be demonstrated with merely a justification of the tool's features, others may also be quantified through receiving feedback from users. CERTH has conducted a series of activities for demonstrating the tool to third parties and receiving their feedback on whether the tool achieves the advantages promised. These include:

- Conducting a training workshop to members of the RINNO Consortium and external stakeholders
- Making the tool available to postgraduate students at IHU to be used for their assignment

Feedback from Training workshop (Day 2)
On the 25th of September 2024 a training session (Day 2 of the RPDA training workshop) was conducted where the VERIFY tool was demonstrated to members of the RINNO Consortium and external participants from the renovation industry. Participants were then requested to provide feedback on the use and functionalities of the tool. Results from this activity (based on 6 responses) are presented below. It should be noted that only 2 out of the six respondents had previous experience of the use of LCA/LCC software.

User friendliness
Participants were asked to answer several questions to evaluate the user-friendliness of the tool.

Results showed that all respondents (100% positive feedback) considered that the VERIFY tool is a user-friendly software that is easy to use and with clear and easy to interpret results. In a separate question 50% of the participants considered that VERIFY includes all functionalities required for conducting an LCA/LCC analysis whilst the remaining 50% were neutral.

Time savings
A target was set for the VERIFY tool to achieve 20% time savings for conducting LCA/LCC analysis compared to similar software. Two questions were posed to the participants in order to assess whether VERIFY results in time savings compared to other software. The first questions were general and aimed to capture the view of the participants on whether the tool may result in time savings and the next question was aimed at quantifying these perceived time savings. Results are presented below.

With regard to time savings 83.3% of the respondents were neutral and did not express an opinion whether the VERIFY tool may lead to time savings for conducting LCA/LCC compared to other software. This may be attributed to the fact that most participants did not have previous experience with the use of LCA/LCC software. Only 1 out of the six respondents (16.7%) considered that the tool leads to time savings and estimated that these time savings are between 20% – 30% compared to other software (1 out of just 2 responses on the follow-up question).
For this reason, it cannot be concluded from the responses of this particular survey that the VERIFY tool leads to 20% savings.

Feedback from postgraduate students at the International Hellenic University
As a final activity in identifying and quantifying the benefits of VERIFY, the tool was made available to students at the International Hellenic University attending the 'Efficient Refurbishment of Buildings' of the postgraduate course Msc in Energy Building Design. The students used the tool and provided their feedback completing relevant feedback forms. Three responses out of the five students using the tool were provided. Despite the small sample, this survey provided valuable input based on the use of the tool on a case study.

Results showed that the users found the tool:
- user friendly, with satisfactory functionalities which is easy to complete the simulation steps and provides clear and easy to interpret results
- Able to lead to time savings in the energy simulation – although none of the students was able to quantify these time savings.

Comments
The activities conducted for obtaining feedback on the use of the tool showed in general that the benefits of the tool were in general confirmed by the users. The participants of all the surveys found the tool to be user friendly, accurate, easily accessible and able to deliver time savings in design. However, the target of 20% time savings could not be quantified.

VERIFY has been demonstrated with the four demo sites as examples. See D6.2 Pilot planning and set up.

3.1.4 Sustainable and Cost-efficient renovation evaluation toolkit (TEA tool)

The TEA tool is a unique tool with no competition in certain aspects (user disruption). It has a Revit plug-in. . This tool quickly estimates a) renovation duration, b) waste production and management, and c)) occupants' expected disruption time and level. The information included is aggregated to be used in a wizard mode ("Wizard Mode" is a special bonus mode / stage which can only be started after completing a series of tasks), while considering available BIM data. Only limited data are needed from the building owner (e.g. structure/wall material, surrounding area information, building age), while extracting important data from the building's BIM. Its utilization promotes renovation to end-users via a simplified GUI (Graphical User Interface).

Progress achieved through RINNO
During RINNO, the TEA tool has advanced to be supported by a GUI and exchange information with the rest of afore-mentioned tools (including input from LCC-S-LCA), towards a highly applicable qualified solution.

KPIs

- Optimization of the design process with the BIM model.
- Facilitation of the users with a better interface
- Assembly/disassembly easiness for RINNO technologies to be integrated
- A better annual turnover provided by a better design process

RINA-C presented the TEA tool to third parties and members of the RINNO Consortium for receiving their feedback on the 25th of September 2024.Some key results are presented in the following table:

In general, there were mixed responses on the user-friendliness and the results clarity. It is concluded that there needs to be better guidance to the user on using the tool whilst results interpretation may be improved.

Comments
The TEA tool has been demonstrated with the four demo sites as examples. See D6.2 Pilot planning and set up. Since the TEA tool has a topic that is new to the market, we cannot compare the TEA tool with any other. The tool needs to be further developed to be used for different kinds of buildings.

3.1.5 Renovation Scenario DSS

The Renovation Scenario DSS is a Decision Support System, developed for the purposes of RINNO to select the optimum renovation scenario. The tool has been specifically designed for the RINNO project and there are no commercial tools against which the performance of the tools can be assessed.

Progress achieved through RINNO
During the RINNO project, the tool was refined/amended to select the optimum renovation scenario.
.

KPIs

- **Ease of access – no installation required.** The tool is a web-based application. As such, no installation is required and there are no requirements regarding the performance of the user's PC. Furthermore, as it is online it may be accessed through any PC enabling working from different locations (office and remotely)
- **User friendly even to non-experts. T**he following features of Renovation Scenario DSS ensure the user-friendliness of the tool: i) there is direct and clear visualization of results. Specific KPIs selected by the user are presented in a clear manner as well as the score in each KPI and category. The optimum renovation scenario is clearly presented along with a graph demonstrating the score of the scenarios in each category, ii) It requires minimal user effort. The user merely selects the scenarios to be assessed, the KPIs to be included in the analysis

and the weight of the categories. Data import and calculation is automatic and takes only a few seconds.

- **Time savings.** Renovation Scenario DSS enable automatic data import (KPIs of renovation scenarios) from the rest of the WP3 tools. The user selects the scenarios to be examined and all data are automatically imported (therefore no manual data entry required). The comparison of the alternative scenarios and the calculation of the optimum one takes only a few seconds. Therefore, significant time savings are achieved following this process. As there is no alternative software to conduct this calculation, the alternative is for the user to manually calculate the best result. Obviously, this will be a significantly more time-consuming process.

A survey was conducted following the WP3 training workshop (Training session of Day 3 held on the 2nd of October 2025) where the Renovation Scenario DSS was demonstrated to member of the RINNO Consortium and the external participants. The survey aimed at assessing whether the following KPIs were achieved:

- User friendliness
- Time savings

Results of this survey are presented below (based on five responses).

User friendliness
Participants were asked to answer several questions to evaluate the user-friendliness of the tool.

Results suggest that the participants that the Renovation Scenario DSS is a user-friendly software. Between 60-80% considered that they could navigate through the different steps of the analysis and complete the process. In addition, 80% of respondents (4 out of 5) considered that the results were clear and easy to interpret.

Time savings
With regard to perceived time savings from the use of the Renovation Scenario DSS, no conclusive result could be derived. 40% of the respondents (2 out 5) somewhat agreed to the statement that the Renovation Scenario DSS could reduced the time required for the selection of the best renovation scenario whilst the remaining 60% was neutral to this statement (neither agreed nor disagreed) as shown in the following graph.

Comments
No comments.

3.1.6 Job Scheduling Optimizer

JSO is a web-based platform that supports the scheduling of a set of jobs, comprised in a renovation scenario work plan. The tool's purpose is to generate the optimal sequence of the jobs included in a renovation scenario with respect to available resources. JSO is designed to automatically derive the general schedule of works as the output of WP3.

Progress achieved through RINNO
During the RINNO project, the tool was refined/amended to support the detailed planning of day-to-day activities (WP4).

KPIs

- **Cost Savings.** The expected cost savings achieved will be determined through price comparison to other commercial software. The pricing plan for the JSO has not been defined yet, therefore, the target cannot currently be defined
- **Time savings.** The following features of VERIFY support the time savings during the design stage: i)the tool receives information for the analysis from other tools of the RPDA. All relevant jobs and job specifications (duration, cost, disruption, workers needed, prerequisite jobs for each task etc.) are loaded automatically, ii) Minimal input is required from the user. Therefore, the process minimises potential human error which may result in repeating the calculation.iii)

Results of the analysis are stored in the personal account of the user. The user has easy access when needed, and iv) The schedule is generated automatically in a matter of seconds. The overall process of loading the scenario jobs, setting the parameters and generating the schedule is completed in a few minutes as it is fully automated. There is no commercial software that can complete this task automatically (this was done in the JSO for the specific needs in RINNO). Any comparison should be made by manually scheduling importing the jobs (or manually conducting the schedule in excel) and running the analysis. Based on this calculation, it is considered that the target of time savings set (50%) in design is considered conservative and is achieved.

- **Ease of access - No installation required.** The tool is a web-based application. As such, no installation is required and there are no requirements regarding the performance of the user's PC. Furthermore, as it is online it imay be accessed through any PC enabling working from different locations (office and remotely)**User friendly even to non-experts.** The following features of JSO ensure the user-friendliness of the tool: i) Minimal input required from the user for the analysis. The tool is able to communicate and receive all necessary data for the jobs (duration, disruption, CO_2 savings etc) from the rest of the tools in the RPDA. The user only needs to fill in information regarding the available budget and the number of available workers. ii) Direct visualization of result. A Gantt chart is produced demonstrating the derived schedule. iii) Preselected results and KPIs for quick evaluation. iv) Easy to review schedule and to adjust the parameters for deriving new schedule
- **Supports staged renovation and the development of the renovation roadmap.** JSO offers the ability to generate the renovation plan of the building in stages taking into account the available budget. The staged renovation plan is based on a methodology which aims at achieving maximum CO_2 savings and avoiding the lock-in effect. i.e. ensuring that any renovation measures applied at one stage do not exclude the use of other measures in the future. To the best of our knowledge there is competition in this field since no other commercial tool is addressing this need in the market.
- **Interoperability.** The tool offers availability to support multiple data formats (.json, .csv,.xml) and communicate to other RINNO tools for enabling process automation and full functionalities. JSO is able to connect to other tools of the RPDA (VERIFY, TEA tool) to receive the relevant data for the analysis in order to i) generate the general works schedule automatically and ii) support the staged renovation feature. In addition, JSO is also connected to the RRM; The generated schedule is automatically imported by the RRM for the on-site scheduling activities**.**
- **Flexibilty.** JSO is a flexible tool that may be used for high-level planning of a renovation scenario (with preselected renovation actions) to derive the general works schedule or for the planning of the detailed day-to-day jobs. The former is done automatically with minimal input from the user; however, the user still has the ability to tailor the schedule by reviewing the job specifications and make amendments if required and to organize the jobs in specific work packages. The detailed planning of the day-to-day activities is a fully manual process

Apart from the justification provided above, a survey was conducted following the WP3 training workshop (Training session of Day 3 held on the 2nd of October 2025) were the Job Scheduling Optimiser was demonstrated to members of the RINNO Consortium and the external participants. The surney aimed at assessing wherther the following KPIs were achieved:

- User friendliness
- Time savings. A target of 50% time savings (compared to manual scheduling of works) had been set

Results of this survey are presented below (based on five responses).

User friendliness

Participants were asked to answer several questions to evaluate the user-friendliness of the tool.

Results of the analysis showed that only 40% of the respondents considered the JSO a user-friendly software whcih easy to navigate, complete the process and interpret the results whilst the remaining 60% was mostly neutral. In one case, one respondent considered that the results were not clear and easy to interpret.

It can be concluded that the JSO will need to be refined in future advancements in order to become more user-friendly.

Time savings
Participants were asked to answer the following questions to assess whether the tool may achieve time savings in the scheduling of a renovation project.

The results of this analysis showed that the majority of the respondents was not able to decide whether the use of the Job Scheduling Optimiser may result in time savings in the scheduling of the renovation works. Only 1 out 5 respondents considered that this process will reduce the time needed for scheduling (with the remaining 4 respondents not being able to reach a decision) whilst none of the respondents was able to quantify the potetnial time savings.

Comments
No comments.

3.1.7 Social LCA tool

The RINNO Suite Platform uses the Social LCA Assessment tool module to evaluate the social parameters of a building throughout its entire life cycle.

The Social LCA Assessment tool is integrated into the RINNO Suite platform. It is based on the EN 15643:2021 and UNE-EN 16309+A1:2015 standards. Its functionality enables the quantification of the comfort and wellbeing solutions integrated into the project during the feasibility, design project and building phases.

Once the design and construction phases are complete, the S-LCA tool enables the calculation of the number of hours that the building is outside of comfortable and indoor quality ranges. Unlike the questionnaire phase, this evaluation is carried out offline due to the necessary processing of previous data.

KPIs
- Interesting for users
- Fill a trade gap
- Monitoring data for thermal comfort and indoor air quality

Progress achieved through RINNO
The tool was tested by users from different sectors across several diffusion sessions throughout 2024 and implemented in the RINNO demo site projects. The following are the results of the evaluation forms completed by the attendees. The conclusion of the evaluation is the following:

Interesting for users
The tool is interesting for users, and its potential to promote social assessments in the renovation of buildings is recognized. Even users with no previous experience of social assessments rated the tool's usefulness and the convenience of social indicators highly. This suggests that the tool is effective in conveying its purpose and utility, even to users without prior training in social assessment. Its use in areas such as the building renovation process establishes it as a powerful decision-making tool in the construction sector.

Fill a trade gap
A lack of previous experience with similar tools among users reinforces the value of the tool and its potential to fill a trade cap. The fact that none of the respondents had heard of or used an S-LCA tool previously showed how little these kinds of technologies are used in the sector. So, this tool introduces a new functionality and could pave the way for social assessment in traditional sectors that still don’t take it into account, such as architecture and engineering.

Monitoring data for thermal comfort and indoor air quality

When analyzing the KPI results, as well as the percentage of hours with data, it can be concluded that more information is needed on certain variables to draw clear conclusions. Useful additional information would include the amount of time users have spent in the dwellings, the type of activity carried out and behavioral habits such as ventilation time and use of air conditioning systems outside of set times. Such criteria would also need to be established for the obtained data to automate the percentage of annual hours with valid measurements for analyzing results considering the dwellings' behavior and use.

Based on the previous analysis, possible future implementations in the Social LCA tool have been identified to enable more detailed studies and more robust results.

The evaluation concluded that the LCA social tool is useful for calculating offsetting hours for thermal comfort and indoor air quality. This provides a valuable indicator of the indoor conditions during asset operation and helps to identify areas for improvement in future tool developments for more detailed analysis of individual dwellings.

Comments
The tool has been developed from TRL7 to TRL8.

3.2 RINNO retrofitting manager (WP4)

The second set of tools result in the Retrofitting Process Manager (RRM), which includes four tools. The tools get inputs from the Digital Twin, the Renovation scenario DSS and the Job Scheduling Optimizer in WP3.

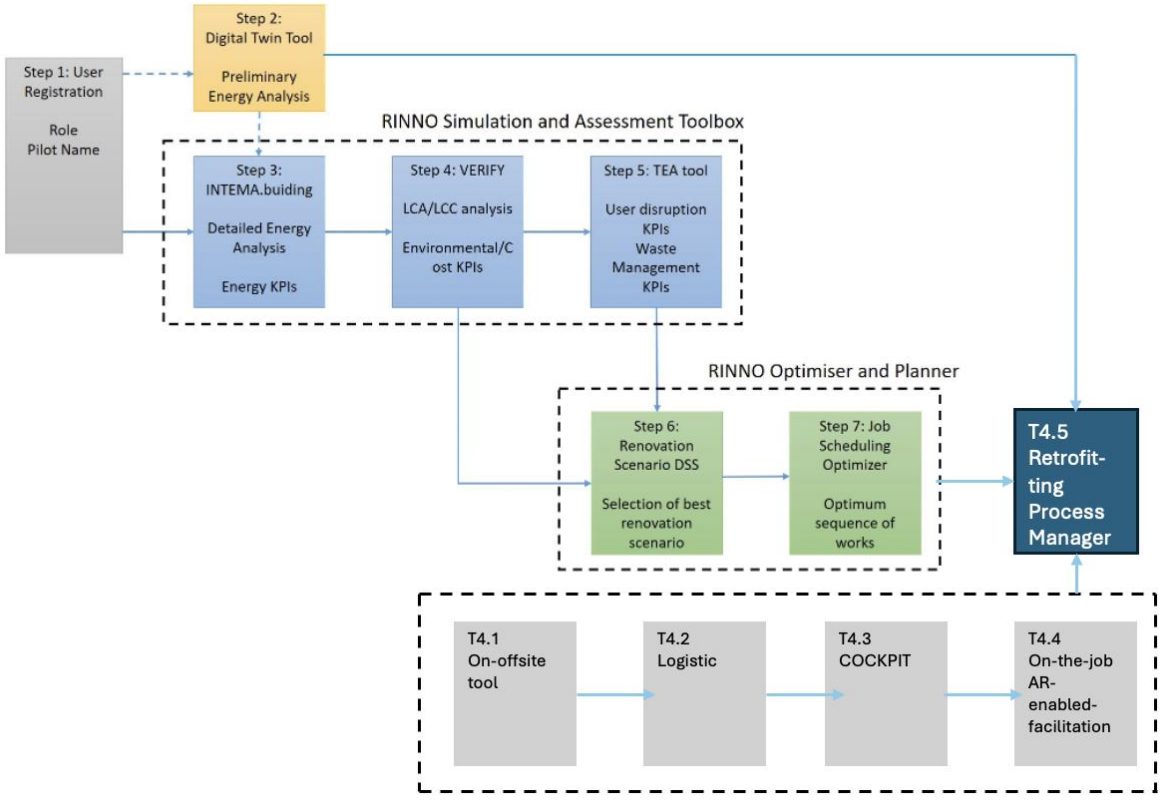


Figure 4 Interrelation between the IT-tools in the RINNO Retrofitting Manager with inputs from WP3

3.2.1 On- offsite tool

Construction process is industrialized by identifying the work to be done onsite and off-site, while Robots and Cobots (e.g. Exo-Skeletons) are used for off-site production and on-site assembly of prefabricated parts.

Progress achieved through RINNO
The product has been developed by BOUYGUES internally by its own R&D program and with the support of EU projects (e.g. Bots2ReC). It is utilized in construction applications (e.g. for pouring prefab slabs). During RINNO, the currently limited robot has been used to implement exterior insulation at the French demo site. Cobots has been adapted to facilitate the utilization of the robots and optimize their operation, leading to a complete construction assistance system.

KPIs

- 20% savings on the cost of construction (due to the utilization of Robots/Cobots and 3D printing)
- Payback period: <3 for 3D-printing, <1 for the rest of the technologies
- Reduction 5% of maintenance and design project costs (from Robots/Cobots
- use)
- Reduction of cost overruns: up to 12.5 for 3D-printing, 10% for the use of robots/cobots,
- 10%-20% savings on material cost (due to the utilization of Robots/Cobots and 3D printing)
- Purchase cost reduction: up to 20%. 5% reduction of delivery costs due to ELOGISTICS.

- Reduction of thermal bridges
- Increase of airtightness
- Reducing repetitive tasks
- Increase of safety factor and reduction of human error

Comments:
Despite the need to remove the foam, the solution is a success. The reduced transport required, showed its advantage, the fast installation also proved its interest and the render of the foam once dried was exactly as planned. In addition, the architect and building owner that were present at the demonstration were additionally interested by the fact that the insulation was achieved by a thinner material thus eating up less space on the peripheric of the building.

Advantages	Barrier
Low Carbone	ATEx in France
Massive transportation reduction	Acceptance by Workers
Waste generation reduction	New elevator and mobile platform adapted for robot.
Works on various support	New method statement to create
Custom thickness	Health and safety procedure to be adapted
Sustainable	Maintenance and specific supervision.
Fast to apply and to install	
Reduce the risk for operators	
Global Costs in a near future	
Noise reduction	

Figure 5 Advantages and barriers for robots/cobots

3.2.2 E-LOGISTICS platform

In the E-LOGISTICS platform, the construction site data are automatically collected and analysed by algorithms to enable site managers' quick decisions with lesser risks, so logistics are better handled, towards on-time delivery, diminishing costs and saving space. Innovative Elements: QR (Quick Response) code, RFID (Radio Frequency Identification) and IoT sensors to track the delivery and installation of materials such as prefabricated façades, windows and others. In parallel, junior researchers with digital oriented background are trained on topics applied to the civil engineering sector.

Progress achieved through RINNO
The E-LOGISTICS platform is developed under the umbrella of "Construction 4.0" University Chair (established by Centrale Lille University and Bouygues Construction) and QR code, RFID and IoT sensors have been demonstrated so far only on part of material delivery. Through RINNO, the whole supply chain during renovation (on-field testing under actual installation environment) has been equipped with a view to reaching market needs.

This tool helps bring the right material to the right place at the right time. It aims to also help reduce disruption to occupied apartments under renovation by reducing the movement in and out of an apartment.

KPIs
- 5 % savings on the cost of construction
- Purchase cost reductions
- Time reduction on-site

Comments
It is difficult to evaluate if the KPIs are achieved because the training couldn't be done. However, every progress achieved through the last months of RINNO were done to simplify the user interface and to improve the usability.

3.2.3 COCKPIT platform

COCKPIT platform is a central control system that pilots the fully automated processes, regulates the workflow and logistics and pilots the robots, via a “data acquisition platform” supervising and monitoring in real time the construction process. The COCKPIT platform has a dashboard that compiles data from different sources or actions during construction activities. By the co-relating, the data site teams can have a quick overview of how the site is progressing and take corrective actions if it is not progressing as planned. Early alerts give possibility of mitigation plans to reduce the time and material loss. Reduced time for construction team to complete all reports.

Progress achieved through RINNO
BOUYGUES has deployed and tested the COCKPIT platform, a number of technological advancements and solutions in use-cases under a central control system (“Construction 4.0” framework), facilitating the automated supervision and monitoring of the construction process. During RINNO, these multi use-cases was to be merged in a unique drone and software solution. This is only partly succeeded. The Cockpit tool for new construction existed is in its beta version and is under testing on sites. The need for Cockpit was identified on construction sites, not being able to have a global coordinated vision of the construction progress.

KPIs
- Process monitoring
- Forecasting
- Reduction of cost (<5%).
- Reduction of time

Comments
The Cockpit developed will help site operatives run a smooth renovation process. This was the intention in RINNO, but it has not been fully achieved. Once finished, the Cockpit will be adopted to an open-source tool to make it available for the benefit of all. Like E-logistic It is difficult to evaluate if the KPIs are achieved because the training couldn’t be done. However, the KPIs process monitoring and forecasting were achieved during development.

3.2.4 AR Training Suite

The AR Training Suite is especially useful for new technology providers to visually explain how the product should be installed. This is also helpful for new site workers to learn when they come on to a site on how to install a product. During design stage, managers and architects can simulate the final appearance of the buildings using their 3D models. Thus, they can estimate and adapt the final design. Experts can assist novice workers using remote collaboration.

Progress achieved through RINNO
The product is developed and demonstrated in a H2020 project (SatisFactory), while in RINNO the following improvements has taken place: a) extension of the tool’s functionalities in un-managed environments such as the renovation sites, b) support both marker-based and markerless operation, and c) demonstration in outdoor real-life environments of the upgraded toolkit.

KPIs
- time savings for renovation scenario creation with and without AR.
- completion time of tasks for workers using the remote collaboration functionality, and users that do not use it.

Comments
New technology takes more time and costs more money in the starting phase. The gains are still to come. Results and comments from the trainings at the demo sites can be found in D6.5 Trainings.

3.3 RINNO building lifecycle renovation manager (WP5)

The third set of tools is the Building Lifecycle Renovation Manager, consisting of a performance dashboard and a platform for social collaboration, community and support.

These tools also get inputs from WP3 tools, and are supplied with the social collaboration, community and support platform.

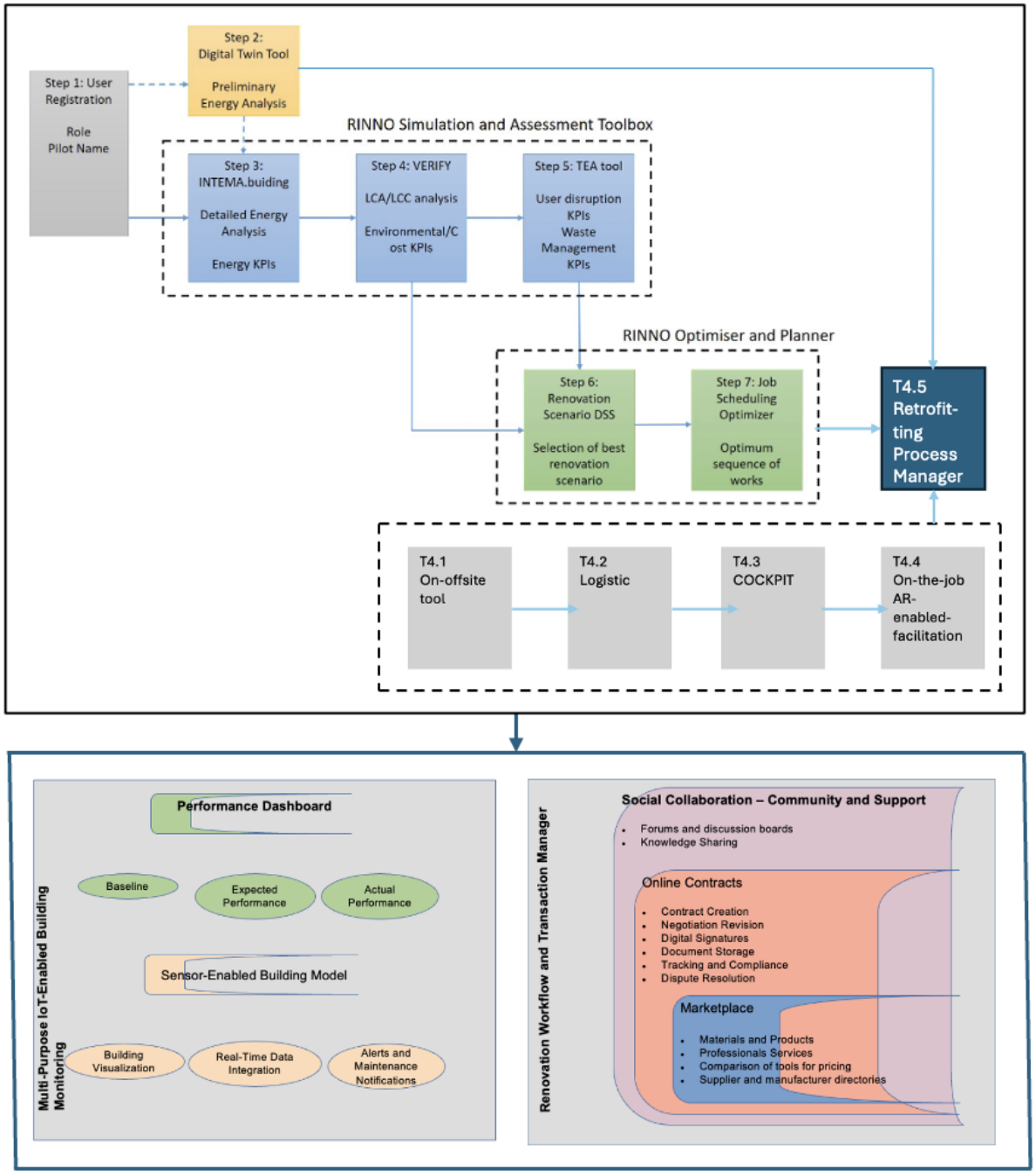


Figure 6 Interrelation between the IT-tools in the RINNO Renovation Manager

3.3.1 Building Monitoring System

BMS can receive information from any kind of devices (e.g. energy, environmental meters) under any kind of protocol (e.g. TCP/IP, Bluetooth, ZigBee, Z-Wave). Functionalities, such as e.g. short-term energy consumption predictions, data correlations, comparisons, reports, are supported. It is an integrated tool where all renovation process information can be visualized through personalized dashboards. It supports any kind of information, such as e.g. energy consumption-generation, water, gas, occupancy, which can be correlated and provide a uniform visualization. It can be enhanced with data and visual analytics tools assisting the user to extract useful and meaningful conclusions not only about the renovation process, but also about the operation of the building.

We use the performance dashboard of the Building Monitoring System where we have calculated the baseline energy consumption. The theoretical consumption is calculated from WP3 tools thus, notifications will inform tenants on how to reach this theoretical consumption which is 20% lower than the baseline.

Progress achieved through RINNO
The product is developed and demonstrated in a FP7 project (INERTIA), extended in a H2020 project (GreenSoul), while in RINNO it has been further enriched and demonstrated in real-life environments, including the following improvements:

KPIs
- connectivity with more sensors
- enhancement with more sophisticated data and visual analytics techniques
- full monitoring and control during building operation
- new visualizations according to user needs
- reduction of cost in electricity
- >5 years payback time

Comments
A monitoring system doesn't guarantee short payback by itself, but it enables smart selection of renovation measures (phased, prioritized), reduced performance gap (savings actually realized) and it can capture of secondary benefits (maintenance, comfort, ESG). Therefore, it contributes to the achievement of a short-payback plan.

3.3.2 Tool for IoT Management

IoT Management is a system/tool that facilitates sensor collection, processing and actuation by (a) consolidation of system input-output data, containing commands not only to individual devices but to other systems and services too, and (b) a central service interconnecting these data, via a web interface allowing even the interconnection of non-homogeneous systems. The controlling system of IoT Management informs tenants on how to optimize technology usage. Moreover, it controls, where possible, the functionality of some technologies.

Progress achieved through RINNO
IoT Management has been developed and demonstrated in a Greek pilot building in a self-titled National R&D project, while within RINNO it has been further demonstrated in the renovation sector, expanding its capabilities including a) further user interface development for better navigation, more detailed asset data access and tailoring to occupants, b) advanced blockchain technologies
introduction to secure data exchange, c) improved simulation techniques, d) better business analysis of data gathered and processed, and e) enhanced compliance to international standards.

KPIs
- Cost reductions
- Decrease in energy consumption and reduction of cost of electricity

Comments
Prediction of cost savings for the coming years has been calculated but it is not possible to verify that the payback period is 2 years, as the results show.

3.3.3 Social Collaboration – Knowledge Platform

CERTH/ITI has developed a social collaborative and knowledge sharing platform for providing user assistance during the renovation stages. It can be utilized for sharing information, knowledge and experiences among workers, managers, engineers and buildings owners. It supports users in exchanging and sharing information on-site and during the renovation activities.

The tool can be utilized as the main platform of the RINNO Operational Interface, where the users (building owners, AEC) are able to communicate and react among each other. Also, users can overview the overall renovation project flow and monitor the buildings operations. Finally, in combination with the AR/VR tool, the users can assist the workers (especially the novice ones) on the site ("on-the-job" assistance).

Progress achieved through RINNO
The product is developed and demonstrated in a H2020 project (SatisFactory). In RINNO, it is being utilized as the integrating platform for the RINNO framework, assisting real time interaction and exchange of information. The RINNO's Social Collaboration Platform has been available in real-life environments at the demo sites in RINNO during the whole renovation process and it has been enhanced with new functionalities.

KPIs

- Platform being utilized as the integrating platform for the RINNO framework
- Remote virtual assistance can be offered to workers onsite

Comments
No comments.

4 SURVEY ON THE IMPLEMENTATION OF THE IT-TOOLS

An evaluation of the tools has been conducted together with the training sessions – on user friendliness and if results are easily understandable. This is reported in D6.5 Training of Stakeholders.

Below is the result of a short survey with participation of 25 professionals, who were all involved in the implementation of the renovation projects at the demo sites. They have participated in trainings, have been introduced to the tools, but they have not necessarily tried to use them concretely.

The answers are distributed as follows:

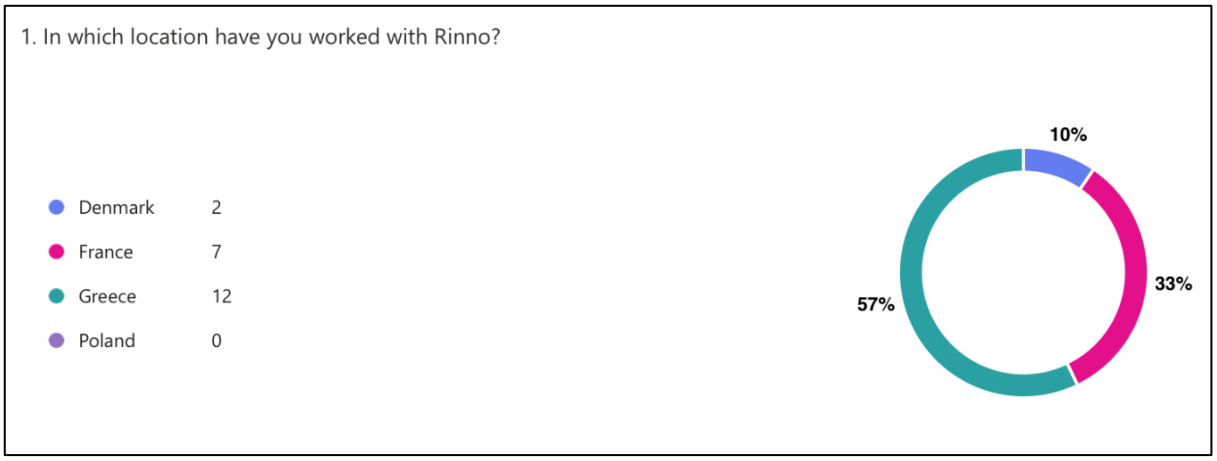


Figure 7 Overview of the participating countries in the survey

There are no answers from the Polish demo site, as they have not started the renovation yet.

The answers come from the following professionals:

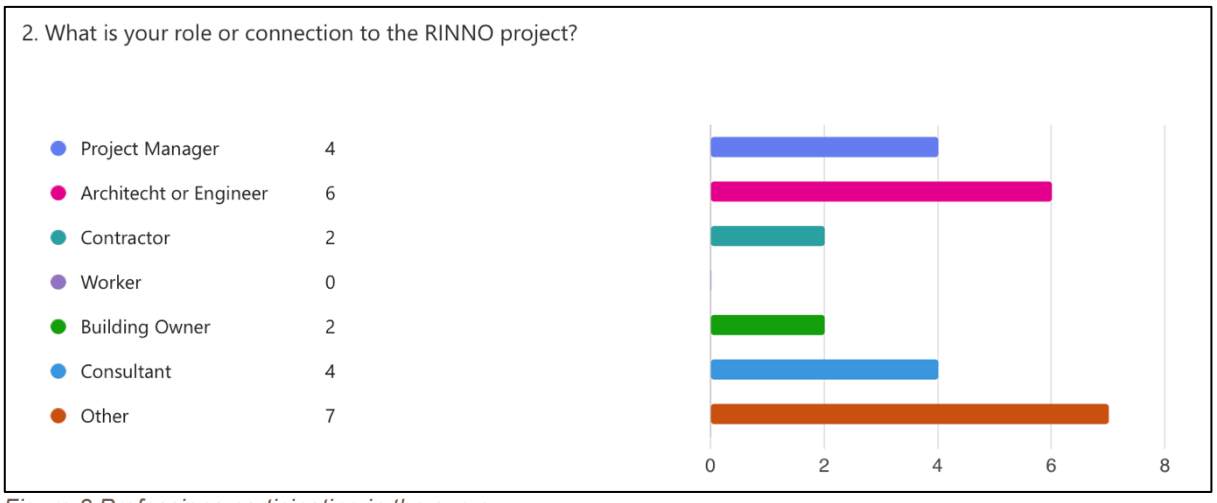


Figure 8 Professions participating in the survey

The professionals have been asked three questions on their experiences concerning a reduction of the time needed for the renovation. Was it due to:

a) the scenarios from WP3,
b) the design (design of the renovation)

c) the videos from the A/R tool. The results of the survey show the following:

Do you experience time saving:

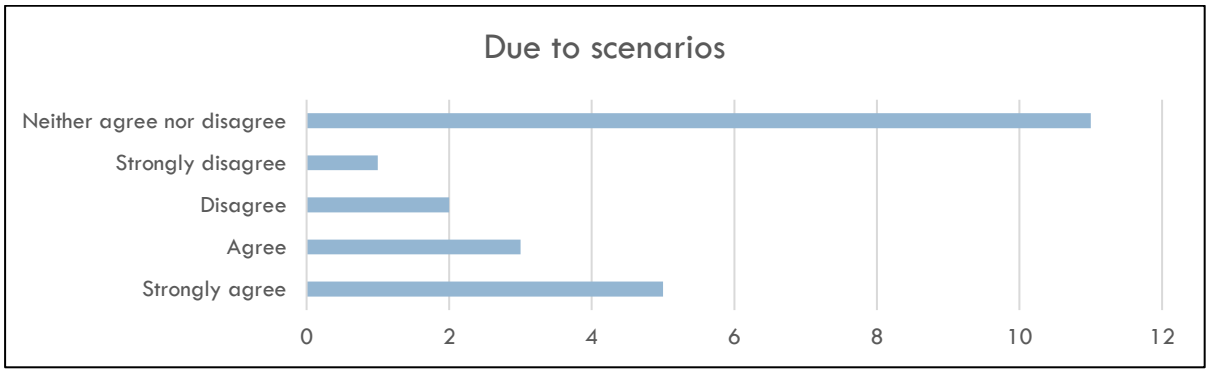


Figure 9 Time savings due to scenarios

Three of the respondents disagree and seven agreed or strongly agreed. 11 answered neither nor. It is not possible to conclude, but of the answers on agree or disagree, the positive answers were in overweight.

Do you experience time saving:

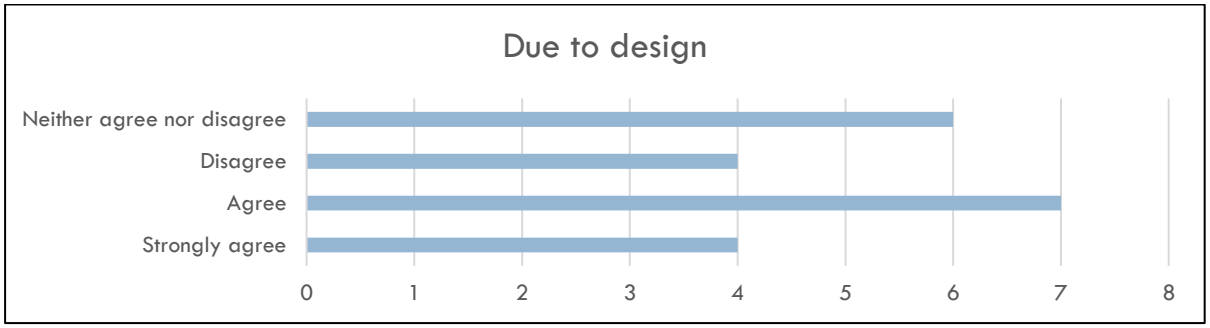


Figure 10 Time savings due to design

Four of the respondents disagree and eleven agreed or strongly agreed. Six answered neither nor. So, the overall impression is that the responders either experience or expect to experience time savings due to inputs from the IT-tools concerning the design of the project.

Do you experience time saving:

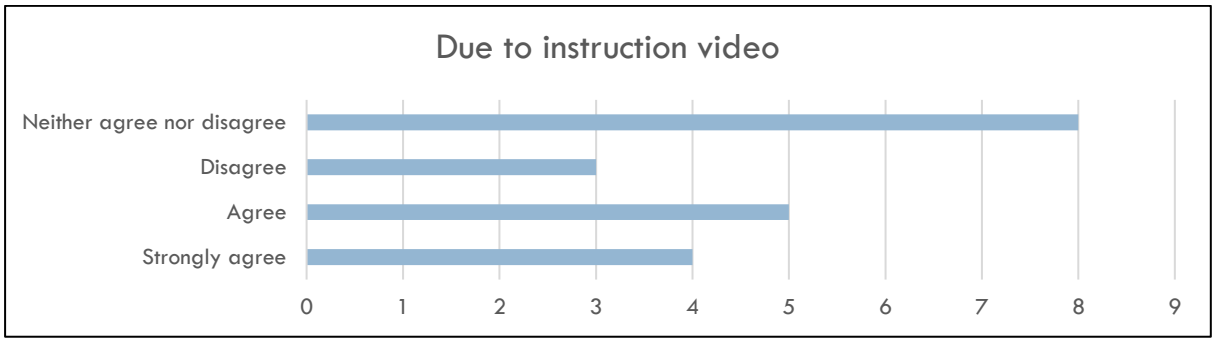


Figure 11 Time savings due to instruction videos

Three of the respondents disagree and nine agreed or strongly agreed. Eight answered neither nor. So, instruction videos are a tool to be used and developed at renovation sites.

In an overview, it looks as follows:

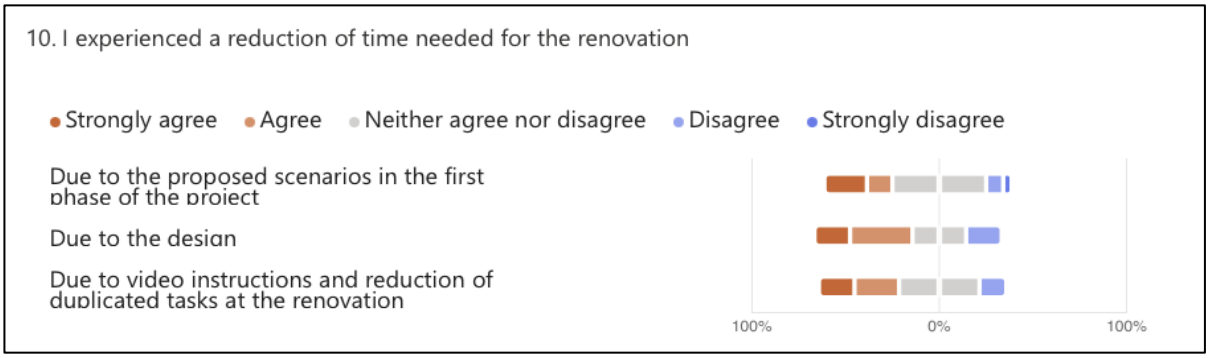


Figure 12 Overview of experiences with time savings

In more details, the responses from France, Greece and Denmark were distributed as follows:

Greece

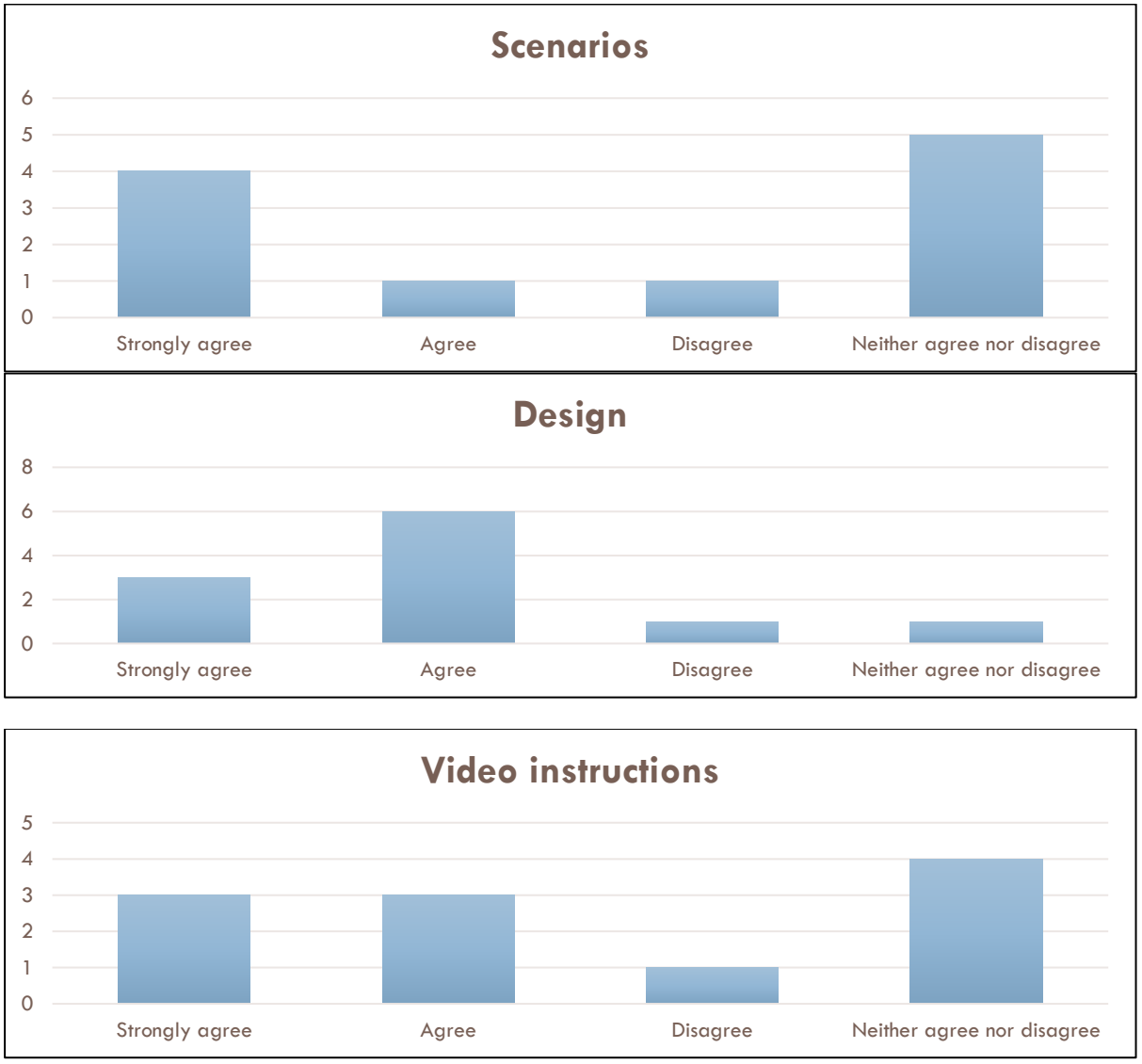
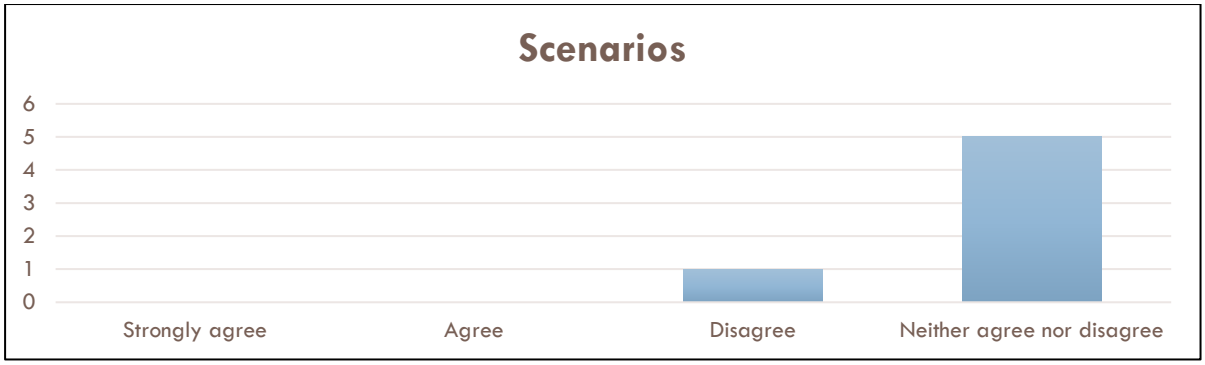
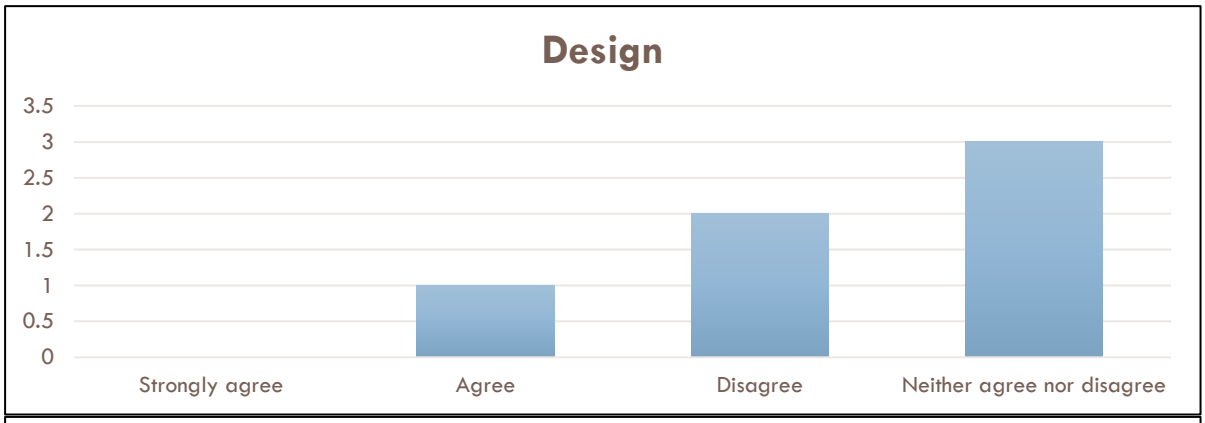


Figure 13 Greece – reduction of time experienced due to scenarios, design and videos

France





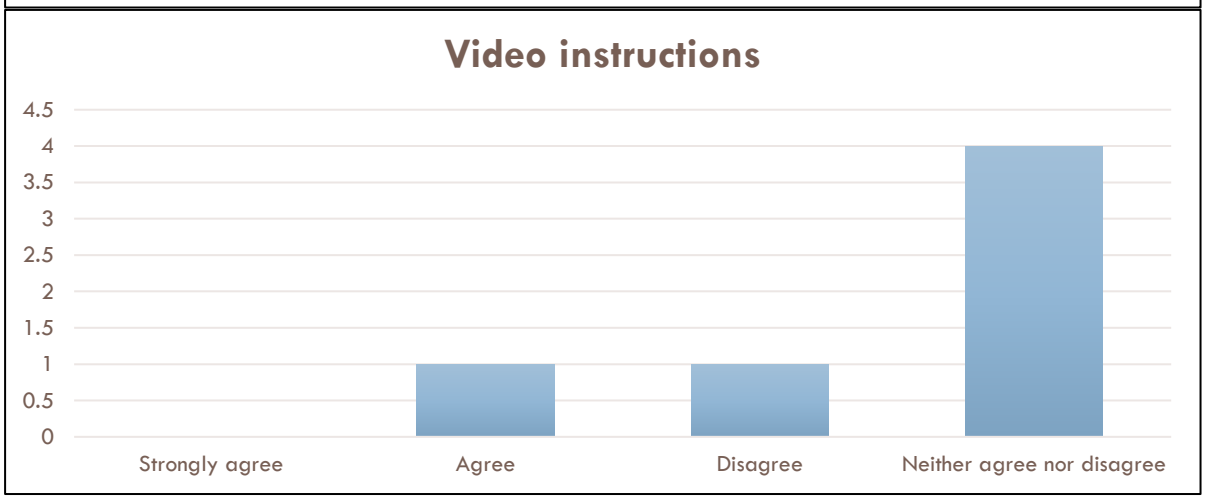
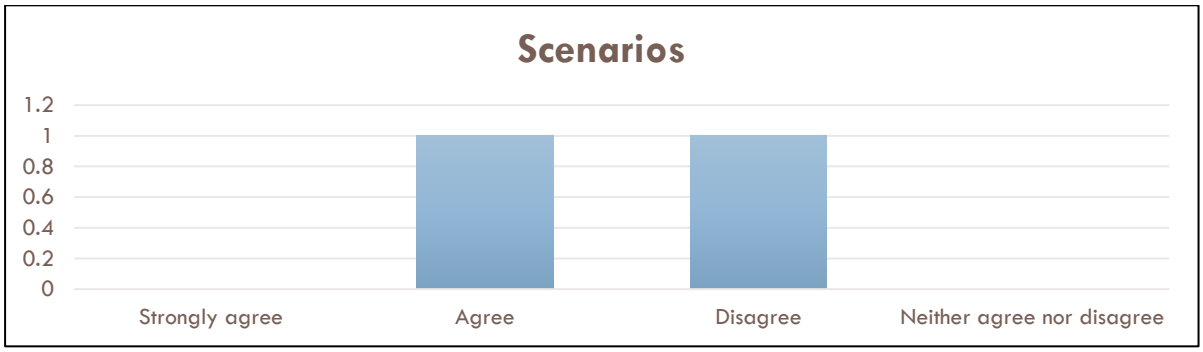


Figure 14– France - reduction of time experienced due to scenarios, design and videos

Denmark



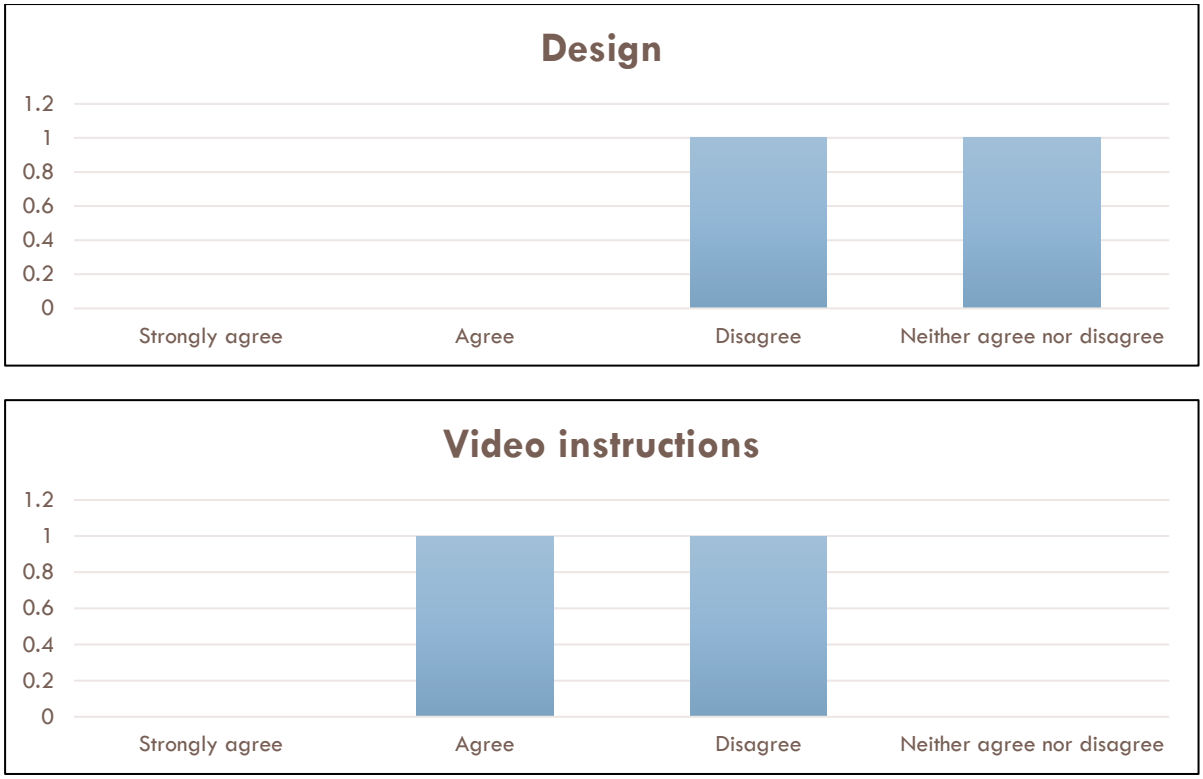


Figure 15 Denmark - – reduction of time experienced due to scenarios, design and video instructions

Overall, the Greek respondents were most satisfied, French and Danish rather critical. This might be due to difficult communication with the tenants at these two demo sites, and difficulties in the monitoring.

In France “only a little time was saved by the help of RINNO tools because not all were ready at the time of our work; The videos were able to facilitate the installations but unfortunately, since they were new products, the time savings could not be demonstrated on our demo. It would have been interesting to use the same companies to apply the same technologies on different demo cases, to see the improvement in time savings as we go along.”

5 EVALUATION OF THE IMPLEMENTATION OF THE RINNO TECHNOLOGIES

This chapter covers the evaluation of the implementation of the RINNO technologies at the demo sites. There are eight technologies which together represent the RINNO RENOVATION REPOSITORY.

The eight technologies are:

1) K-FLEX Bio-based double-layer panels
2) K-BOX bio-based insulating system (pipes and valves)
3) Isocell Cellulose Insulation
4) InVentilate MicroVent Ventilation
5) Zappa PV-Roof and Façade solutions
6) Thermochromic Glass
7) Building Integrated PV Glass
8) De-centralized DHW solution (PINK)

The technologies are categorized as follows:

- **The modular plug&play solutions** –
  K-FLEX Bio-based double-layer panels, K-BOX bio-based insulating system (pipes and valves), Isocell Cellulose Insulation, Thermochromic glass and InVentilate micro ventilation system
- **The RES harvesting solutions –**
  GREENSTRUCT Building Integrated PV Glass
- **The storage solutions** –
  PINK De-centralized DHW solution
- **The multi-functional hybrid retrofitting solutions** –
  Zappa PV-Roof and Façade solutions

Technology Readyness Level
The technologies are either ready-to-be demonstrated in real environment (TRL 7-8), or ready-to-enter the market (TRL 9).

RINNO Renovation Repository	TRL Levels
PRODUCT INNOVATIONS	
Bio-based double layer panels (K-FLEX)	**TRL7 -> TRL9**
Bio-based pipes and sheets (K-FLEX)	**TRL7 -> TRL9**
Isocell Cellulose Insulation (EKOLAB)	**TRL8 -> TRL9**
Thermochromic glass (GREENSTRUCT)	**TRL8 -> TRL9**
Climate Cover PV -Roof and -Facade solutions (EKOLAB)	**TRL8 -> TRL9**
MicroVent sustainable Ventilation system (EKOLAB)	**TRL8 -> TRL9**
K-BOX bio-based insulating system for parts of energy systems (K-FLEX)	**TRL7 -> TRL9**
Building integrated photovoltaic glass (GREENSTRUCT)	**TRL8 -> TRL9**
De-centralized domestic hot water preparation (PINK)	**TRL7 -> TRL9**

Figure 16 TRL as defined in the Grant Agreement

The technologies were implemented and tested at the four demo sites:

France	• Inventilate Double Flow Micro Ventilation Box in 8 dwellings • Insulation pipes KFLEX in all the building • Insulation valves KFLEX (Kbox) in all the building
Greece	• Bio-based double layer panels (K-FLEX) • Thermochromic glass (GREENSTRUCT) • Building integrated photovoltaic panels (GREENSTRUCT)
Poland	• Bio-based double layer panels (K-FLEX) • Isocell Cellulose Insulation (EKOLAB) • Zappa PV Facade solutions (EKOLAB)
Denmark	• PINK - De-centralized DHW solution • Zappa PV Facade solutions (EKOLAB) • InVentilate - Double Flow Micro-Ventilation • K-BOX - bio-based insulating system (pipes and valves) • Isocell Cellulose Insulation (EKOLAB)

Figure 17 Implementation of technologies at the demo sites

In the following, the technologies are shortly presented, the targeted KPIs are listed and the progress achieved in the RINNO project is described incl the achieved TRL. Comments and user satisfaction are described in chapter 9.

5.1 The modular plug&play solutions

5.1.1 Bio-based double-layer panels

Multi-layered panel with bio-based (25-50%) polyurethane and compact rubber for insulating panels.

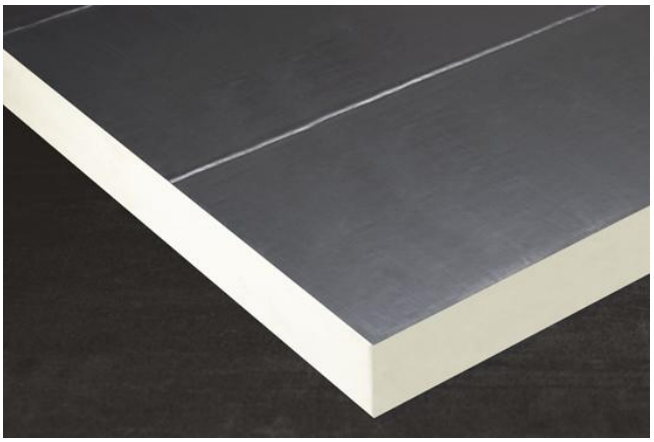


Figure 18 Biobased double-layer panel

KPIs:

- extremely robust
- shock-resistant
- reduces application time
- easy to maintain.

Progress achieved through RINNO
The product is certified and CE marked according to EN 13165:2012+A2:2016 Thermal insulation products for buildings - Factory made rigid polyurethane foam (PU) products – Specification
Product is under inspection of Notified certification body No. 0751.

The product has been in the industrial trial phase and continuous production is now running smoothly and efficiently. During RINNO an increase of bio-based portion has been examined.

K-FLEX biobased double-layer panels have been implemented at the Greek pilot project and is planned to be implemented at the Polish pilot project.

K-FLEX has been developed from TRL 7 to TRL9.

5.1.2 K-BOX bio-based insulating system

K-BOX is a preformed, removable, reusable insulation system, designed for components with complex shape and geometry. It consists of a FEF (flexible elastomeric foam) insulation material mechanically preformed allowing tailor made solutions produced directly from CAD file, to fit exactly on multiple types of line components and is cladded by protection foil. K-BOX can be applied to various secondary components, such as insulating the pipes of energy systems

Figure 19 K-Box biobased insulation system

The product is certified and CE marked according to EN 14304:2009+A1:2013 Thermal insulation products for building equipment and industrial installations - Factory made flexible elastomeric foam (FEF) products – Specification. The product is under inspection of Notified certification body No. 0751.

KPIs

- Time savings during equipment maintenance.
- Easy and quick to use.
- Quality finish.
- Made in the EU.

Progress Achieved through RINNO

K-BOX has passed the industrial trial phase and the last parameters to make continuous production running smoothly and efficiently have been achieved. In RINNO it it has been realized with an innovative bio-based EPDM (target: 50-60%), which has been applied and demonstrated at the demo sites. The installation time for secondary, smaller components (e.g. valves) has been reduced, contributing to the marketability of more attractive and environmentally friendlier relevant products.

K-BOX'es have been implemented at the French and Danish demo sites.

K-BOX has been developed from TRL 7 to TRL9.

5.1.3 Isocell Cellulose Insulation

Isocell Cellulose Insulation is a 90% bio-based material for insulating roofs, walls or ceilings, made of newspapers surplus upcycling. Its high thermal insulation and capacity, airflow resistivity, fit accuracy and settling resistance, minimize heat loss and improve acoustic characteristics and indoor climate.

Figure 20 Isocell Cellulose insulation

KPIs:

- non-toxic
- contains no harmful substances or additives
- is pleasantly soft and warm to the touch
- does not irritate or damage the skin

Progress achieved through RINNO
Capitalizing on the currently extreme versatility and ability of this complete product to be used almost everywhere, the challenge in RINNO has been its optimal exploitation in building renovation projects, both on-site and with regards to prefab-elements, with its real-life demonstration bringing it fully to market. The product is now certified and CE MARKED according to EAD 040138-00-1201, 11.2015 In-situ formed loose fill thermal and/or acoustic insulation products made of vegetable fibres.

The product is under inspection of Notified certification body No. 0658.

Isocell insulation has been implemented at the Danish demo sites and is to be implemented at the Polish.

Isocell has been developed from TRL 8 to TRL9.

5.1.4 Thermochromic Glass

Thermochromic glass is an emerging technology in window design. This innovative, smart material changes tint automatically, using heat from the sun to darken or lighten the tint of the glass, reducing glare and increasing energy efficiency inside the building. Primarily in use in commercial glass storefronts, office buildings, and institutional constructions at present, thermochromic glass is also increasingly finding its way into residential construction, making for smarter, more comfortable, and energy efficient homes.

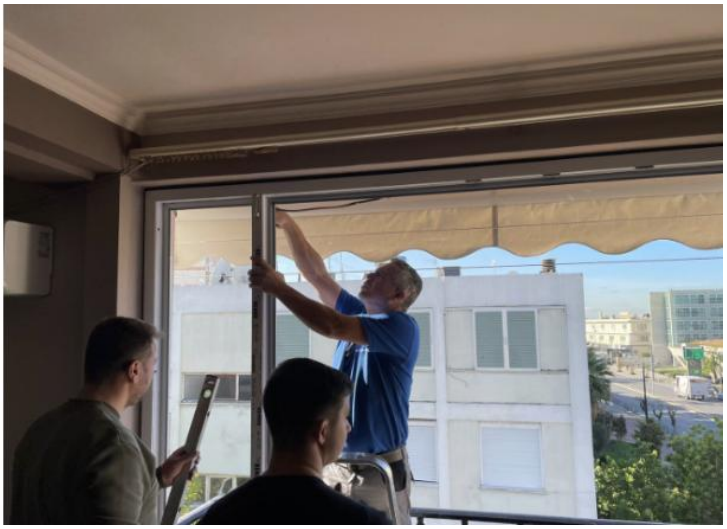



Figure 21 Thermocromic glass

KPIs (USPs) of the solutions

- Decrease in energy consumption – up to 35%
- Payback period for tenants – less than 2 years
- Costs savings in design – up to 15%
- Maintenance - cost reduction – up to 20%
- Thermal performance U value – <1.1W/m^2.K.
- creates a self-regulated building in terms of energy allowance and rejection
- easy mounting (same as conventional glasses) and no need for maintenance
- made of 100% recyclable materials
- no need for blinds.

Progress achieved through RINNO

Thermochromic glass systems have already been successfully applied in large (mostly tertiary) buildings. During RINNO, a reference point for use in residential retrofit projects has been implemented through real-life demonstration bringing a more attractive, residential-users oriented product to market.

The thermocromic glass has been implemented at the Greek pilot site.

Thermocromic glass has been developed from TRL 8 to TRL9.

5.1.5 InVentilate Microvent Ventilation

“MicroVent” is a facade integrated ventilation system with the lowest power consumption (300 J/m3) in the market and an 85-92% heat recovery. It is demand-controlled with variable air volume (VAV) based on CO2, temperature and humidity, and can be combined with window replacement.

KPIs:

- Energy efficiency: 300 J/m3
- Capacity: 30-130 %
- Noise level: 30 dB (A)
- Nominal airflow MV7 per set: 105 m^3/h
- Operating temperature: 0 to 45˚ C
- TDS – YES
- EPD – NO

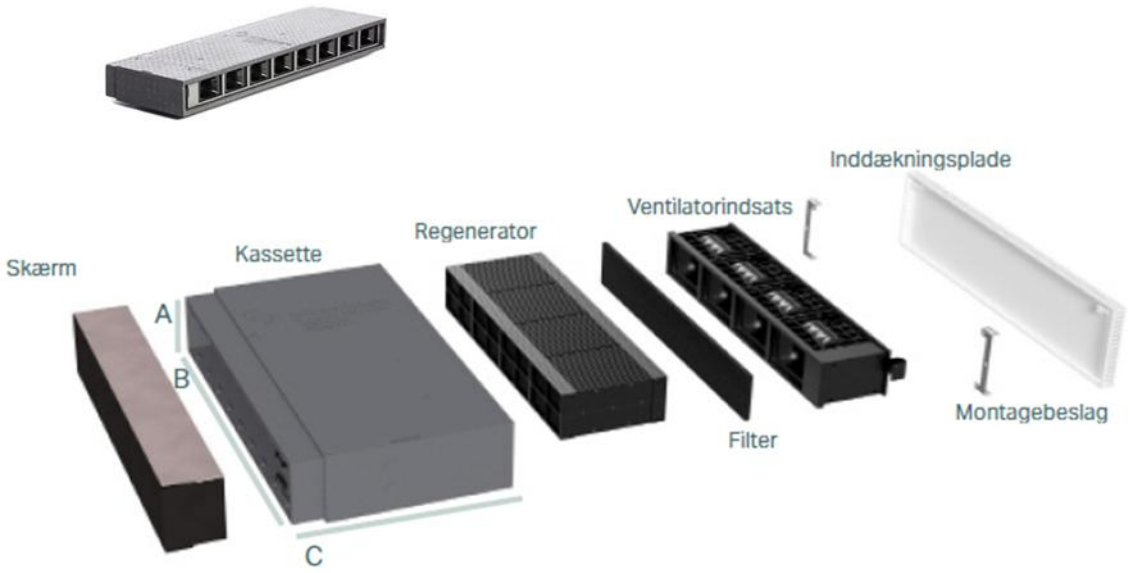


Figure 22 InVentilate – all elements (screen, cassette, regenerator, ventilator, cover)

Progress achieved through RINNO

In RINNO, the product has been upgraded by offering
a) wireless communication and control development,
b) new BUS-system in place of LON,
c) optional filters,
d) noise reduction,
e) possible exploitation of wind pressure towards a compact hybrid ventilation solution,
f) optimizing installation procedures,

The product is manufactured in accordance with Council Directive 2006/42/EC - Machinery Directive - nationalised with At Order no. 612 of 25 June 2008, Low Voltage Directive 73/23/EEC and EMC Directive 2004/108/EC. It is not covered by EPD. The air handling units follow the standards: EN 13141-7 / EN 13141-8.

InVentilate units have been installed at the French and Danish demo site.

InVentilate has been developed from TRL 8 to TRL9.

5.2 The RES harvesting solutions

5.2.1 Building Integrated PV Glass

BIPV Glass, available from GREENSTRUCT, is an integrated structural-insulation-energy production element that can be used in different applications such as roofs, facades and canopies. BIPV Glass is installed the same way as conventional glasses, but at the same time it generates renewable energy (solar), thus significantly reducing the time and space needs, compared to the installation of typical glass frames and PV systems separately. PV glass can be supported using a variety of structural systems, including point-supported systems, U channels and skylight-like structures.

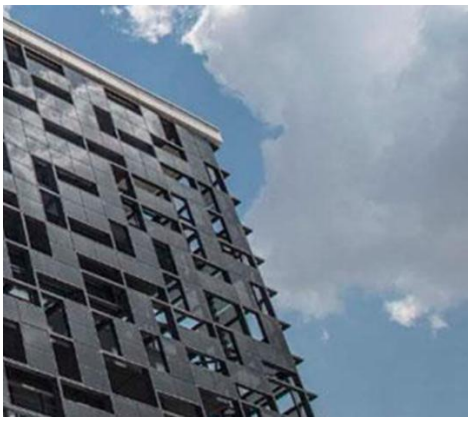


Figure 23 Building integrated PV glass (GREENSTRUCT)

KPIs:

- Reduction of cost of electricity – up to 60%:
- Payback period for tenants – less than 8 years:
- Electric energy harvesting – 140Wp/m2:
- Thermal performance U value – less than 1.2W/m2.K.:
- Cost savings in design – up to 30%:
- Reduction in construction cost – up to 30%:
- Time savings during design stage – up to 20%
- Time reduction on-site owed to being prefabricated – up to 50%
- Creates a self-regulated building in terms of energy allowance and rejection
- No need for maintenance
- Made of 100% recyclable materials
- No need for blinds.

Progress achieved through RINNO

Thermochromic glass systems have already been successfully applied in large (mostly tertiary) buildings. During RINNO, a reference point for use in residential retrofit projects has been implemented through real-life demonstration bringing a more attractive, residential-users oriented product to market.

Building integrated PV glass has been implemented at the Greek demo site.

Building Integrated PV Glass has been developed from TRL 8 to TRL9.

5.3 The storage solutions

5.3.1 De-centralized DHW solution (PINK)

The innovative system of the wall mounted storage tank offers numerous possibilities of integration into a dwelling. Except the maintenance opening, which gives access for maintenance works, the tank can be completely integrated into the wall shoring, clad with design elements, or integrated into the building in different variants

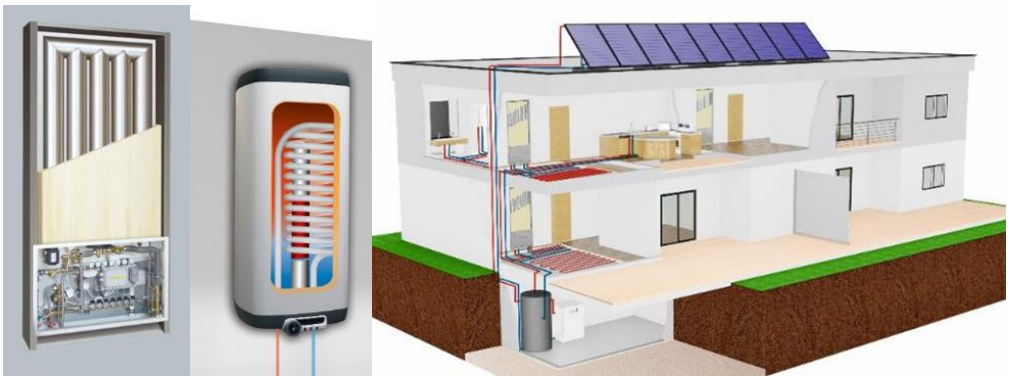


Figure 24 Decentralized DHW solution (PINK)

KPIs

- Sustainable
- Efficient
- Cost-effective
- Utilizes solar power to cover up to 70% of the energy demand for hot water production
- Minimal maintenance
- High operational reliability
- Low investment costs

Progress achieved through RINNO

The product has already been installed and tested in real-life environments in Austria and meets its specifications. During RINNO the inclusion of bio-based materials has been examined in collaboration with K-FLEX and EKOLAB, prior to its demonstration in Denmark. But due to delay in appointing the demo site to demonstrate PINK, this has not been implemented.

PINK intelligent water heater has been installed at the Danish pilot site.

PINK has been developed from TRL 7 to TRL8.

5.4 The multi-functional hybrid retrofitting solutions

5.4.1 Zappa PV-Roof and Façade solutions

Zappa and Koncept Roof is an envelope solution particularly suitable for the retrofit of both the roof and façade of buildings. The system may be finished with either a natural slate plate or BIPV modules, which are well-integrated, taking into consideration the aesthetical appeal of the finished solution. The Zappa and Koncept Roof system is lightweight and offers benefits of quick and cost-effective installation. Natural slate is a durable material with unusually good qualities when it comes to all kinds of weather, winds, fires etc. It requires no maintenance and has an expected minimum lifespan of + 80 years.

Figure 25 the Zappa active façade system with PV

KPIs:

- Time to installation: Given that a typical residential solar panel is around 1.7 m² in area, and a standard residential system (e.g., 6-8 kWp) often consists of 15-25 panels (which would be roughly 25-40 m²), the physical installation phase for a typical residential roof (excluding permitting and procurement) might range from 1 to 2 days.
- Durability guarantee: More than 25 years
- Efficiency after 25 years: Not less than 80%
- CO2 footprint during production: Studies estimate the carbon footprint of manufacturing to range from 40 to 100 gCO2/kWh.
- No aesthetics adverse caps sticking out of the roof/façade
- lightweight system easy to integrate into most existing designs, providing an architectural BIPV solution and an excellent retrofit option in traditional, historic and listed property
- PV modules replace ordinary roof materials instead of add-on PV solutions.

Progress achieved through RINNO:
RINNO has focused on reducing costs in assembly systems and localizing of better price/performance on solar cells. The demonstration on most building geometries has brought it fully to the market.

The ZAPPA façade system has been implemented at the Danish pilot site and is planned to be installed at the Polish pilot site after the project end if financialy possible.

ZAPPA Façade system has been developed from TRL 8 to TRL9.

6 SURVEY ON THE IMPLEMENTATION OF THE RINNO TECHNOLOGIES

6.1 Questionnaire for professionals

In a survey, the 25 professionals (see description of the participating professionals in Chapter 4, p.31) were asked about their satisfaction with the technologies installed at the demo sites. The answers concern one technology at a time.

6.1.1 K-FLEX

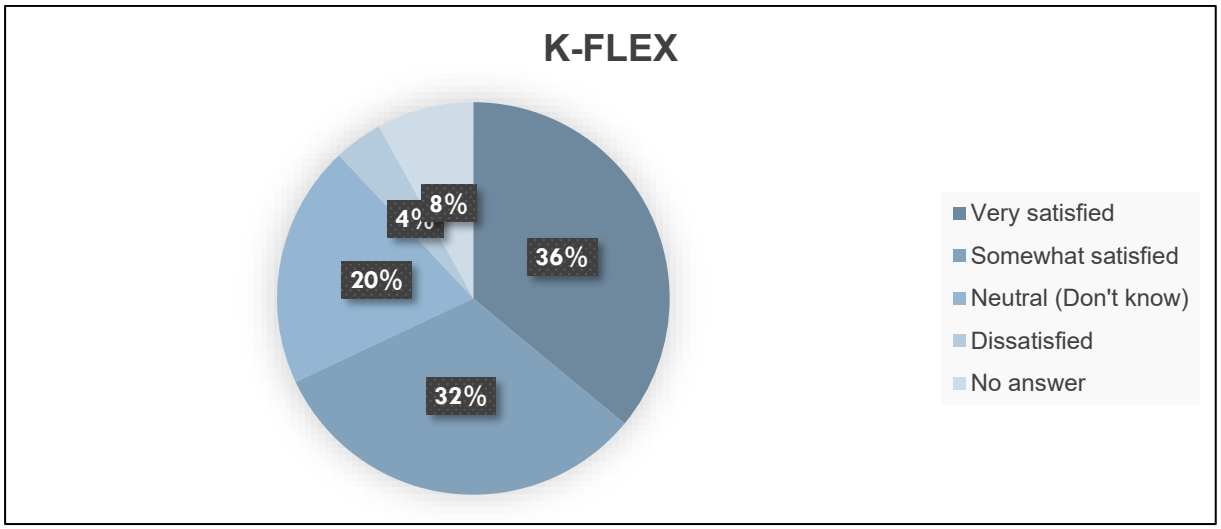


Figure 26 Satisfaction with K-FLEX

Comments

- The K-Flex insulation is challenging to work with because it produces a significant amount of dust and particles, which are both unhealthy and distracting (project manager, Greece).
- The insulation K-Flex material is difficult to apply (Architect / engineer, Greece)
- The insulation K-Flex material is difficult to apply (Architect / engineer, France)

Despite the comments, it must be noticed that the satisfaction (very satisfied and somewhat satisfied) is convincingly high – 68 %. And the product is important in the RINNO Technology Repository both as a modular plug&play building solution and a biobased insulation solution.

6.1.2 ISOCELL

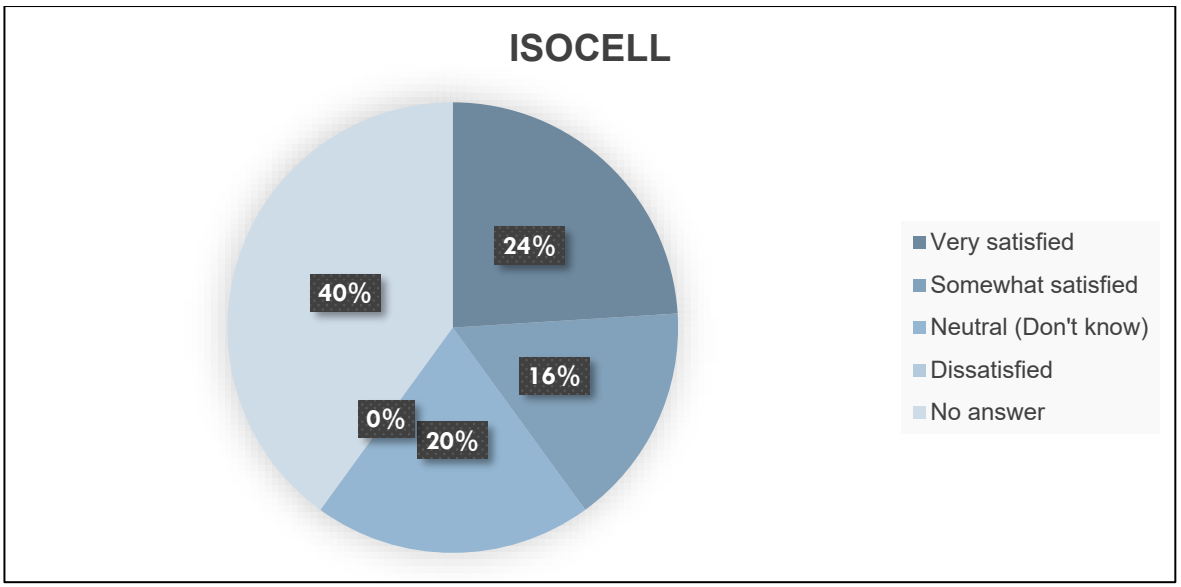


Figure 27 Satisfaction with Isocell

Comments
No comments. The satisfaction (very satisfied and somewhat satisfied) is 40 %. 60 % are neutral or have no answer. There are no dissatisfied respondents. Isocell is being used in Poland and Denmark, and the Polish evaluation has not been completed.

6.1.3 INVENTILATE

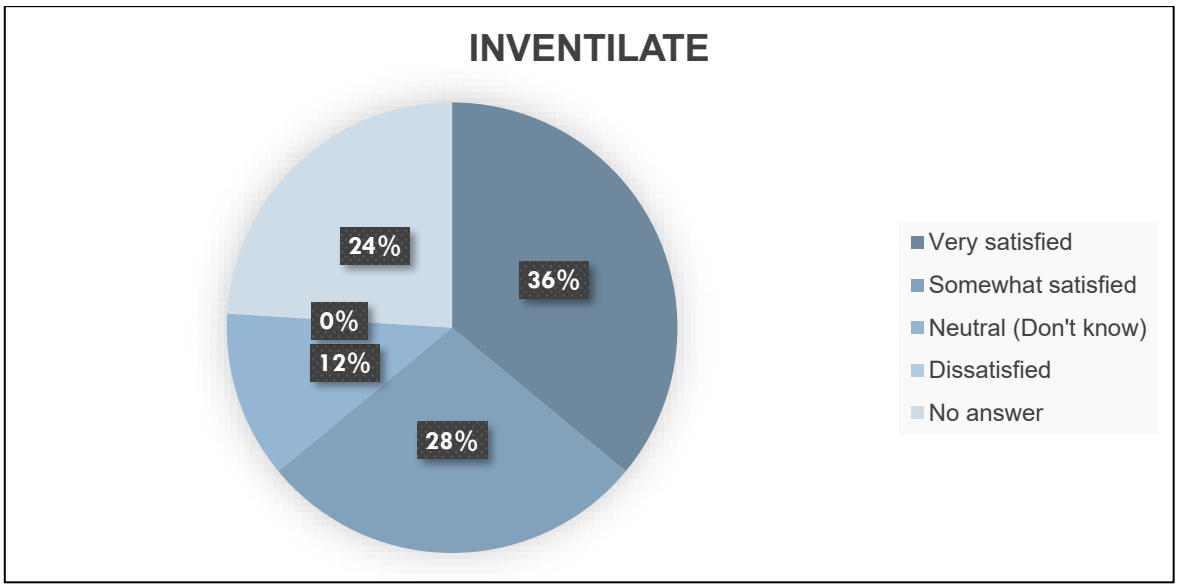


Figure 28 Satisfaction with InVentilate

Comments
No comments. The satisfaction (very satisfied and somewhat satisfied) is 64 %. Neutral and no answer covers 36 %. The micro ventilation system is new compared to the ordinary ventilation systems, much more flexible and in the group of modular plug&play building envelope solutions.

6.1.4 ZAPPA FAÇADE

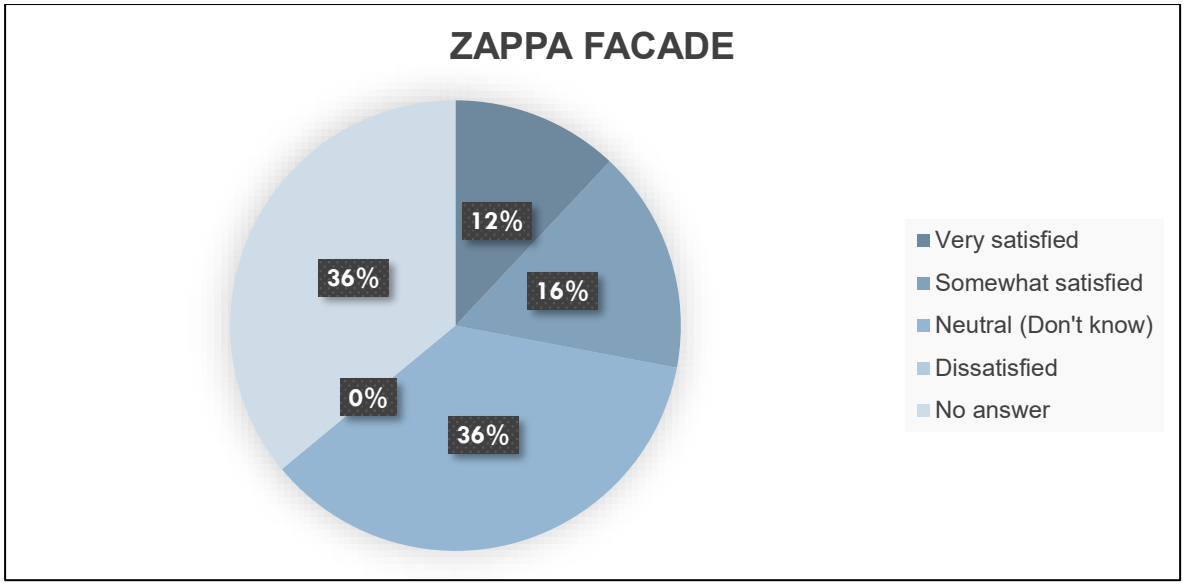


Figure 29 Satisfaction with ZAPPA

Comments
No comments. The satisfaction (very satisfied and somewhat satisfied) is rather low 28 %, but 72 % are neutral or has given no answer. The system is planned installed in Poland, but no results yet. It is one of the multi-functional hybrid retrofitting solutions.

6.1.5 PINK – WATER HEATER

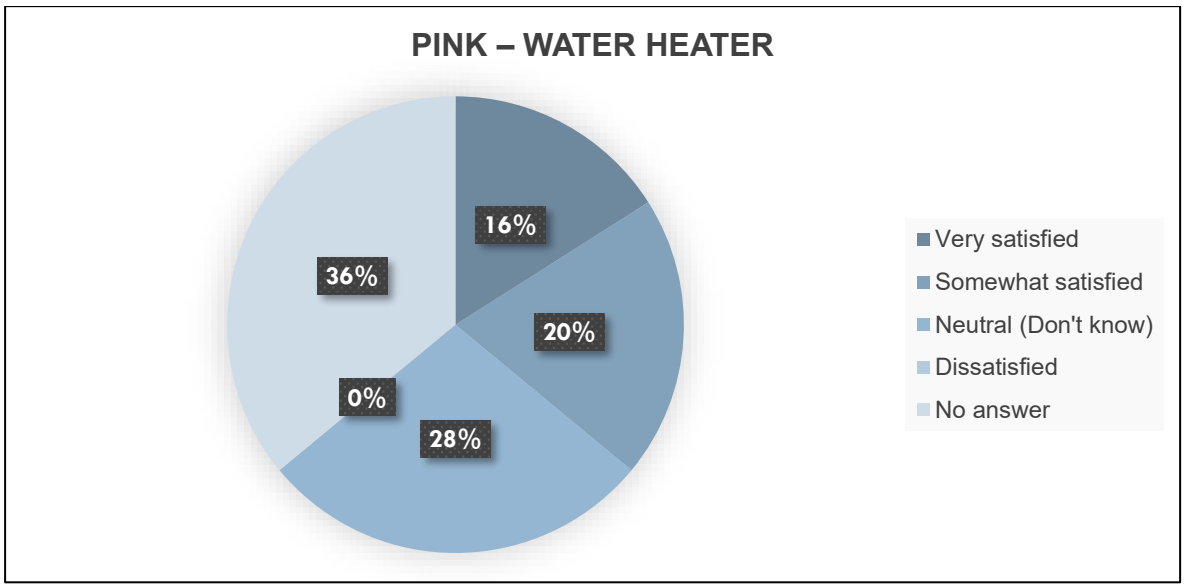


Figure 30 Satisfaction with PINK water heater

Comments
No comments. The satisfaction (very satisfied and somewhat satisfied) is rather low – 36 %, but 64 % are neutral or has given no answer. The PINK water heaters are under installation at the Danish demo site. It is a storage solution to be combined with the PV panels at the façade (ZAPPA).

6.1.6 GREENSTRUCT PV

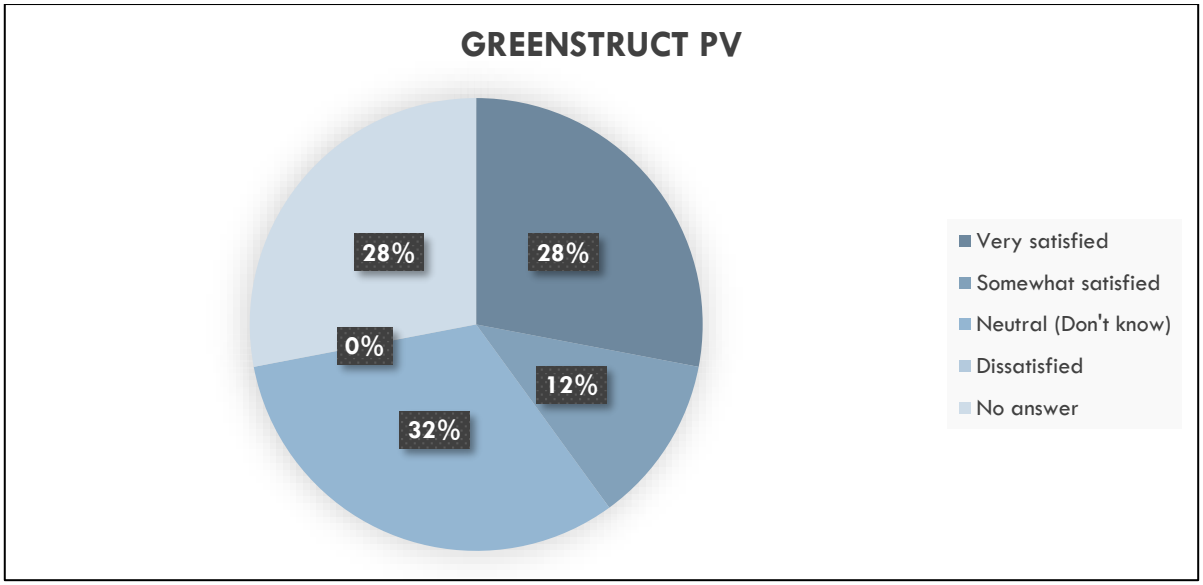


Figure 31 Satisfaction with GREENSTRUCT PV glass

Comments

- The PV system is not sufficient to meet the energy needs of the house.

The satisfaction (very satisfied and somewhat satisfied) is 40 %, but 60 % are neutral or has given no answer. No one was dissatisfied. Greenstruct PV is a RES harvesting solution.

6.1.7 GREENSTRUCT SHADINGS

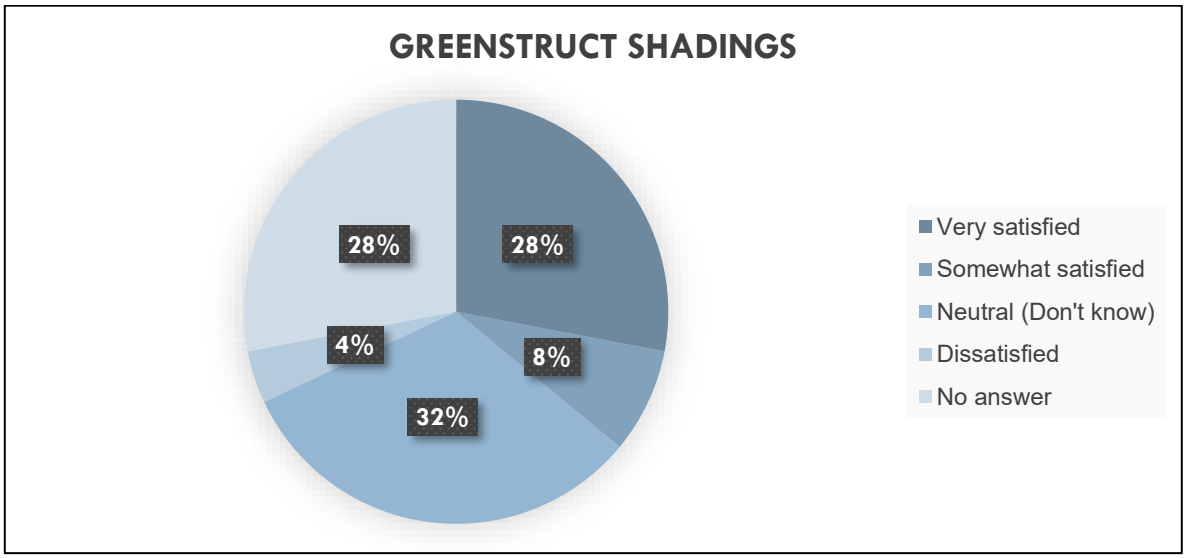


Figure 32 Satisfaction with GREENSTRUCT shading

Comments

- The GREENSTRUCT windows with shadings had no significant results.

The satisfaction (very satisfied and somewhat satisfied) is 36 %, 4 % are dissatisfied and 60 % are neutral or has given no answer. Dissatisfaction is mainly due to problems with some broken glass a.o.

6.1.8 Overview of the qualitative evaluation by the professionals

Overview of the qualitative evaluation by the professionals on the satisfaction with the technologies.

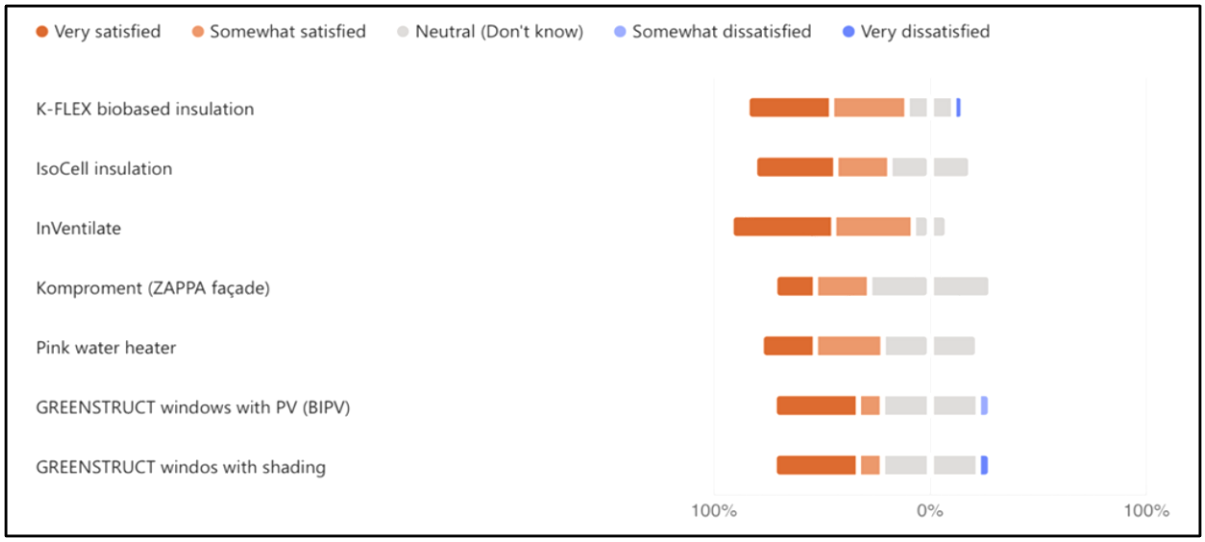


Figure 33 Overview of the qualitative evaluation by the professionals

The general satisfaction (orange colors) is dominant, which is a good basis for taking the next step with the RINNO Technology Repository. The results are a recommendation of the different technologies as a part of a smart renovation and preparation for a more intelligent renovation.

The professionals were also asked for their overall satisfaction with the project outcome.

Figure 34 Overall satisfaction with the project outcome

92 % said that they strongly agreed or agreed to be satisfied with the outcome of the renovation project.

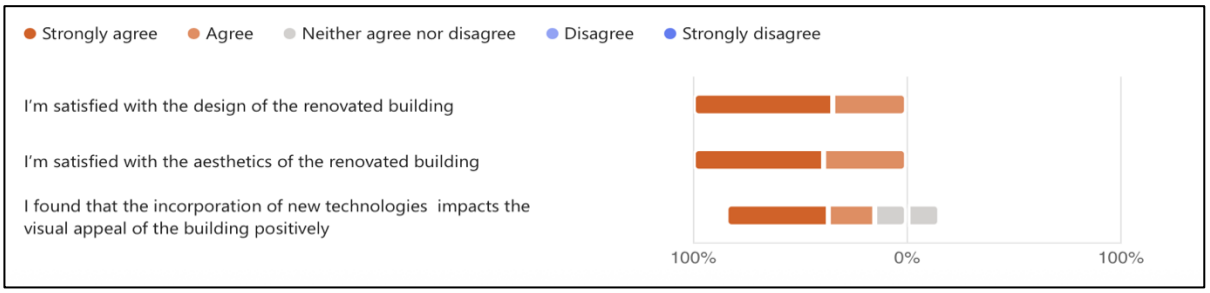


Figure 35 Satisfaction with design, aestetics and new technologies

65 % strongly agree of being satisfied with the design of the renovated building.
61% strongly agree of being satisfied with the aesthetics of the building and 48 % strongly agrees that the incorporation of the new technologies impacts the visual appeal of the building positively. The last question is somewhat difficult to answer, as many of the technologies (K-FLEX, PINK, ISOCELL) do not influence the aesthetics of the building and others only to a limited degree (InVentilate, Greenstruct). But it is satisfactory for recommending the solutions as part of a smart renovation.

6.2 Questionnaire for tenants

The tenants were also asked about their opinion of the new technologies (after the renovation). Concretely, they were asked about their satisfaction with the technologies. The answers were as follows:

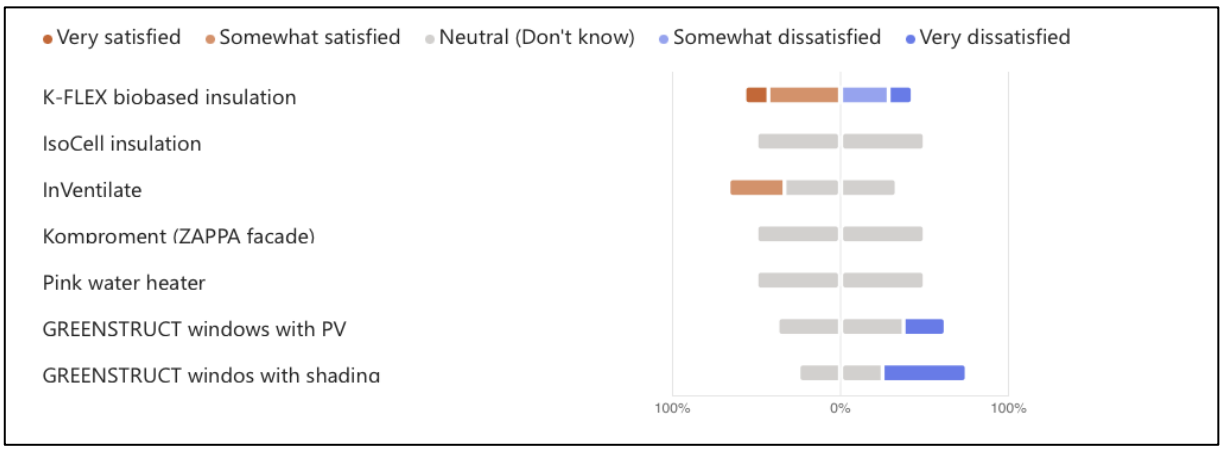


Figure 36 Tenants satisfaction with the new technologies

It is obvious that it is difficult for the tenants to have an opinion on the technologies. Anyway, they have added comments on the renovation as follows:

- Difficult to apply and long installment process. Not special difference with thermochromic windows.
- The K-FLEX insulation made a lot of dust that stuck to the windows and balcony, so we had to clean them regularly, and the workers needed several months to finish the facade. The PV is not installed yet. had no different effect than typical triple glazing.
- K-FLEX took a long time to be finalized. But the result seems good. We are waiting for the BIPVs. We use the new air-condition unit for short periods in winter and summer
- The K-FLEX insulation produced a lot of dust that covered everything and entered the house. The PV system has not been installed yet.

The tenants were also asked, which improvements or changes they would recommend for future building renovation projects with new technologies:

- More organization to synchronize the various phases of the renovation more smoothly, ensuring the process is finished in time (anonymous)
- Smaller scale and actual impact. The BIPVs power (GREENSTRUCT) is very small (anonymous)
- Effective insulation (K-FLEX), but too long installation process (anonymous)
- Reduction of the time required for on-site work (anonymous)
- Better organization, find solutions for underfunding, easier way to trach the renovation (anonymous)
- We did not receive important feedback from the meters even if the situation is better inside
- Shorter timeframe to complete the entire renovation (Greece)
- A change in regulations would be useful to be able to implement more new technologies (France)

The questionnaire also contained questions on e.g. the indoor climate and on the general satisfaction. The results are presented in chapter 9.

7 EVALUATION OF THE PROJECT IMPACTS

The quantitative impacts of the implementation of the RINNO IT tools and technologies at the four demo sites are evaluated in relation to the KPIs set up in the Grant Agreement.

Not all the KPIs can be documented as unforeseen events have delayed some of the processes during the implementation of the project. One important challenge, already mentioned in the Grant Agreement, was the difficulties in synchronizing the development of the IT tools to fit into the renovation process at the demo sites. Also, technical challenges with the implementation of the RINNO technologies have influenced the results.

In the following, we have gathered the available documentation for the 7 impacts and 27 KPIs for the four pilots:

Impact 1: Primary Energy Savings (PES) triggered by the project (in gwh/year)
• KPI 1.1: PES triggered by the project during its implementation: 0.98 GWh/year
• KPI 1.2: PES triggered by the project after entering markets – full development: >157,6 GWh/year
• KPI 1.3: Reduction of cost of electricity: >30%
Impact 2: Investments in sustainable energy triggered by the project (in M€)
• KPI 2.1: Annual turnover due to RINNO implementation: >38 million Euro/year
• KPI 2.2: Payback period: <4 years on average
Impact 3: High-energy performance in the renovated buildings
• KPI 3.1: Energy efficiency/decrease in energy consumption: >65%
• KPI 3.2: Electric energy harvesting of RINNO technologies: >125 Wp/m2
• KPI 3.3: Thermal performance of RINNO technologies (U-value in W/m2.K): <0.4 W/m2.K for novel insulation, <1.2 W/m2.K for novel glass systems.
• KPI 3.4: RES penetration on a building level: >30%.
Impact 4: Measurable cost reduction compared with a typical renovation (i.e., a renovation that meets current minimum requirements of existing building regulations) or major energy performance improvement at comparable cost)
• KPI 4.1: Cost reduction in comparison with typical renovation during design: >15%
• KPI 4.2: Cost reduction in comparison with typical renovation during construction/installation: >20%
• KPI 4.3: Maintenance costs reduction: >25%
• KPI 4.4: Total cost reduction in comparison with typical renovation: >30%
• KPI 4.5: Durability guarantee: >25 years
Impact 5: Reduction of time needed on site for renovation works by 20% compared to current national
• KPI 5.1: Reduction of time needed for designing renovation works: >15%
• KPI 5.2: Reduction of time needed on-site for renovation works: >40%
• KPI 5.3: Reduction of duplicated tasks due to streamlined-integrated process: >25%
Impact 6: Demonstration of the effectiveness and replicability of the proposed solutions to lead to an increased rate of renovation for defined building typologies in several districts/cities/regions
• KPI 6.1: User acceptance: >90%
• KPI 6.2: Number of residents beneficiated during the project: 128
• KPI 6.3: Total floor area to be deep renovated during the Project: 3,386 m2

Impact 7: Reduction of the greenhouse gases emissions (in tco2-eq/year) and/or air pollutants (in kg/year) triggered by the project (
• KPI 7.1: Reduction of GHG emissions: 40,400 t CO2-eq/year
• KPI 7.2: Reduced Embodied Energy of RINNO technologies vs Typical ones: >20%
• KPI 7.3: Utilization of bio-based materials: 10-90% depending on applicable technology
• KP! 7.4: Time outside indoor quality range
• KPI 7.5: Time outside thermal comfort range

Figure 37 Overview of impacts

7.1 Impact 1: Primary Energy Savings (PES) triggered by the project (in GWh/year)

KPI 1.1: Primary energy savings (PES) triggered by the project during its implementation

The monitored energy use for the four demo sites shows the energy use for heating, cooling, hot water, electricity and other consumption and the total average and can be summarized as follows:

France	Baseline (from Proposal) kWh/m2	Reduction calculated (from Proposal) %	Reduction calculated (by INTEMA) %	Monitoring 2024-2025 kWh/m2	Actual reduction 2025 (%)
Energy Consumption	321 kWh/m2/y	104 kWh/m2/y =68%	67%	97,26 kWh/m2/y	70%
Heating Consumption	205 kWh/m2/y	65kWh/m^2/y =68% =	80%	42 kWh/m2/y	86 %
DHW Consumption	117 kWh/m2/y	34 kWh/m^2/y =71%	71%		
Other Consumption	12 kWh/m2/y	NA	NA	NA	NA

Figure 38 Monitored energy use - France

Greece	Baseline (from Proposal) kWh/m2	Reduction calculated (from Proposal) %	Reduction calculated (by INTEMA) %	Monitoring 2024-2025 kWh/m2	Actual reduction 2025 (%)
Energy Consumption	250 kWh/m2/y	45 kWh/m^2/y =82%	85/100%*	87,65 kWh/m^2/y	65%
Heating Consumption	100 kWh/m2/y	5kWh/m^2/y =93%	96%	2,4 kWh/m2/y=	98%
DHW Consumption	30 kWh/m2/y	10kWh/m^2/y =67%	80%	1,3 kWh/m2/y=	96%
Cooling Demand	70 kWh/m2/y	10kWh/m^2/y =75	94%	5,9 kWh/m2/y=	92%
Other Consumption	50 kWh/m2/y	20kWh/m^2/y =60%	NA	21,2 kWh/m2/y=	64%

** Including also the electricity produced from the GREENSTRUCT PV glass*

Figure 39 Monitored energy use – Greece

Poland	Baseline (from Proposal) kWh/m2	Reduction calculated (from Proposal) %	Reduction calculated (by INTEMA) %	Monitoring 2024-2025 kWh/m2	Actual reduction 2025 (%)
Energy Consumption	300 kWh/m2/y	63kWh/m2/y =79%	80%	TBD	TBD
Heating Consumption	250 kWh/m2/y	40kWh/m^2/y =84%	84%	TBD	TBD

DHW Consumption	50 kWh/m2/y	23kWh/m²/y =54%	47%	TBD	TBD
Other Consumption	10 kWh/m2/y	=5kWh/m²/y =50%	88%	TBD	TBD

Figure 40 Monitored energy use - Poland

Denmark	Baseline (from Proposal) kWh/m2	Reduction calculated (from Proposal) %	Reduction calculated (by INTEMA) %	Monitoring after renovation 2025 *) kWh/m2	Actual reduction 2025 (%)
Energy Consumption	159 kWh/m²/y	108 kWh/m²/y =32%	22%	106,81 kWh/m²/y	33%
Heating Consumption	97 kWh/m²/y	66 kWh/m²/y =32%	21%	73.93 kWh/m²/y	24%
DHW Consumption	29 kWh/m²/y	26 kWh/m²/y =10%	21%	32.88 kWh/m²/y	-10%
Other Consumption	34 kWh/m²/y	17 kWh/m²/y =50%	27%	11.53 kWh/m²/y	66% (common areas)

**Partially calculated and not including the electricity produced from the PV system (Komproment)*

Figure 41 Monitored energy use – Denmark

KPI 1.2: PES after entering the market – full development

Best Case Scenario (BCS)					
Parameter / Country	**France**	**Greece**	**Denmark**	**Poland**	**TOTAL**
Building Avg. [kWh/y]	188.450,73	91.574,57	123.075,17	86.750,02	**489.850,49**
Floor area Avg. [kWh/m2/y]	62,96	122,39	156,40	294,12	**635,88**
TOTAL demo region [GWh/y]	431,18	388,73	114,95	301,63	**1.236,49**
% of contribution to the target	35%	31%	9%	24%	**100%**

Figure 42 Primary energy savings under the Best Case Scenario

Worst Case Scenario (WCS)					
Demo region country	**France**	**Greece**	**Denmark**	**Poland**	**TOTAL**
Building Avg. [kWh/y]	33.316,80	30.219,61	1.846,13	51.182,51	116.565,05
Floor area Avg. [kWh/m2/y]	11,13	40,39	2,35	173,53	227,40
TOTAL demo region [GWh/y]	76,23	128,28	1,72	177,96	384,20
% of contribution to the target	20%	33%	0,4%	46%	100%

Figure 43 Primary energy savings under the Worst Case Scenario

Even under the most conservative assumptions, the Worst Case Scenarios are highly positive. It yields a total energy saving of 391 GWh/year, exceeding the target by 227 GWh/year (+144%) (see D6.8, 2.1 Primary Energy Savings).

KPI 1.3: Reduction of use/cost of electricity: >30%

It is difficult to get the results concerning the electricity use, as it is individualized in most cases. We have the electricity use for the French and the Greek demo. The electricity use in the Danish pilot site is for common areas only.

KPI 1.3 Reduction of use of electricity	Electricity use – baseline 2023-24 kWh/m2/y	Electricity use 2024-25 kWh/m2/y	Reduction %
French demo (common areas)	8 kWh/m^2/y	4 kWh/m^2/y	50 %
Greek demo	225,45 kWh/m^2/y	41,52 kWh/m^2/y	82%
Polish demo	NA	NA	NA
Danish demo (common areas)	34 kWh/m^2/y	11,53 kWh/m^2/y	66 %

Figure 44 Use of electricity at the demo sites

Conclusion to Impact 1

• KPI 1.1: PES triggered by the project during its implementation: 0.98 GWh/year	193,921.53 kWh/year (only three of four demo sites and only renovated m^2)
• KPI 1.2: PES triggered by the project after entering markets – full development: >157,6 GWh/year	391 GWh/year, exceeding the target by 227 GWh/year (+144%)
• KPI 1.3: Reduction of cost of electricity: >30%	NA

7.2 Impact 2: Investments in sustainable energy triggered by the project

KPI 2.1 RES investment & KPI 2.2 Payback time	Investment – planned €	Investment – Actual €	Payback time years
French demo	20.000 €	24.234 €	17 years
Greek demo	NA	1.180 €	NA
Polish demo	NA	7.880 €	NA
Danish demo	22.707 €	29,127.50 €	10 years
Total	**42.707 €**	**62.421,50 €**	

Figure 45 RES investments & payback time

Conclusion to Impact 2

• KPI 2.1: Annual turnover due to RINNO implementation: >38 million Euro/year	It has not been possible to verify this figure based on the impact at the four demo sites.
• KPI 2.2: Payback period: <4 years on average	Payback time - as far as informed - is between10 and 17 years

7.3 Impact 3: High-energy performance in the renovated buildings

KPI 3.1: Energy efficiency/decrease in energy consumption

Decrease in energy consumption (figures from KPI 1.1) shows the following result:

Energy efficiency / decrease in energy consumption	Baseline kWh/m2/y	Effective reduction - to kWh/m2/y	Reduction from Proposal %	Effective reduction %
French demo	321	223,74	68%	69%
Greek demo	250	162,35	82%	65%
Polish demo	300	NA	79%	NA
Danish demo	159	52,19	32%	33%

Figure 46 Decrease in energy consumption

KPI 3.2: Electric energy harvesting

Based on the description in the GA, the figure > 125 W_p/m^2 by electric energy harvesting of RINNO technologies applies only to the Zappa PV system and refers to the PV panel used by Komproment. The PV panel appears to meet this target. Anyway, it is important to emphasize that all four demo sites have implemented or planned to implement RES and if the same level is reached in all renovations, the target will easily be reached.

KPI 3.3 Thermal performance of the RINNO technologies

The U-value of the walls in the demo buildings in the renovation scenarios were examined (where novel insulation is considered) and reported in D6.2. They range between approximately 0.15 and 0.30 W/m^2K and this has not changed during renovation.

KPI 3.4 RES based production

Supplementary to the IMPACT on energy use, the weighted average RES penetration (in primary energy terms) in the four demo buildings that was estimated in the energy analysis was approximately 48% (9% in the French demo, 123% in the Greek demo, 40% in the Polish demo and 18% in the Danish demo).

KPI 3.4 RES-based Production	Before monitored	After - monitored
French demo	0%	9% (installed)
Greek demo	0%	123% (planned)
Polish demo	0%	40% (planned)
Danish demo	0%	18% (planned)
Average	**0%**	**48%**

Figure 47 RES-based production at the four demo sites

Conclusion to Impact 3

• KPI 3.1: Energy efficiency/decrease in energy consumption: >65%	From 33% (DK) – 69% (F) Polish demo is missing. But if they reach target, average decrease is: 62%
• KPI 3.2: Electric energy harvesting of RINNO technologies: >125 Wp/m2	ZAPPA: 184,1 Wp/m2
• KPI 3.3: Thermal performance of RINNO technologies (U-value in W/m2.K): <0.4 W/m2.K for novel insulation, <1.2 W/m2.K for novel glass systems	Isocell: 0,037 W/(mK) K-BOX: 0,036 W/(mK) K-FLEX panels: 0,023 W/(mK) GREENSTRUCT PV: 1.2W/m2K. GREENSTRUCT Thermo: 1.1 W/m2K.
• KPI 3.4: RES penetration on a building level: >30%.	48% - target met.

7.4 Impact 4: Measurable cost reduction

KPI 4.1: Cost reduction in comparison with typical renovation during design (i.e., a renovation that meets current minimum requirements of existing building regulations) or major energy performance improvement at comparable cost

The scenarios were inspirational and supported the decision process for the building owners and consultants at all four demo sites concerning the technologies to be implemented.

KPI 4.2: Cost reduction in comparison with typical renovation during construction / installation

The AR tool was demonstrated for all demo sites, and the overall feedback was positive. Purpose of the AR tool is to increase the efficiency of the work at the construction / renovation site. 77,3% of the respondents in the first testing (Dublin – May 2023) found that the AR tool was helpful in the learning process. The AR tool is meant to be user friendly and easy to access. Therefore, it is important that the users are confident in using the tool after the presentation. 72,7% expresses this confidence.

The robots/cobots were used at the French demo site for insulation. At this point, it is not possible to evaluate the eventual time reduction during construction, but it is for sure obtainable.

KPI 4.3: Maintenance costs reduction

This KPI cannot be estimated by the demo leaders during the time of the RINNO project. An estimate has been provided by the technology providers according to product specifications on maintenance compared to conventional technologies:

K-BOX - maintenance cost reduction is more than 80%.
PINK - maintenance cost reduction is 30-50%.
GREENSTRUCT - maintenance cost reduction is 20%.
For other solutions – according to K-FLEX - it will be the same as for a standard product.

KPI 4.4: Total cost reduction in comparison with typical renovation

None of the four demo sites have experienced a reduction in renovation costs. It is a well-known fact that using new technologies take more time and cost more money than “business as usual”, which is also what has been experienced in RINNO.

The French demo site describes it as follows as follows:

“This experience tells us that the intervention has not reduced the costs of renovation, but it has shown good results for reducing the rent charges for our tenants. The goal is achieved for us. We tried to adjust the rent levels to achieve a better return on investment, but we already knew before renovating the building that the cost of the work for such a small project could never be fully recovered”.

The Greek pilot site has the following comment:

“In comparison with typical renovation, the energy consumption is less, but with the rise of the energy prices and the parameter of "energy poverty" (the owners did not consume enough to have the internal conditions that they have now), the total energy bills are not significantly different according to an energy bill analysis at one of the 7 occupied apartments”.

KPI 4.4 Cost reductions in total	Actual	Comparison with typical	Difference in %
French demo	114,970 € with taxes / housing	85,000 € with taxes / housing	+35 %
Greek demo	NA	NA	We cannot estimate the actual investment due to the semi-sponsorship state of the project
Polish demo	235,000 €	353,000 €	After four tenders the price was +50% over budget and financing
Danish demo	1,282,937 € without taxes	500,000 € without taxes	+157%

Figure 48 Total cost reduction in comparison with typical renovation

KPI 4.5: Durability guarantee

We only have the durability guarantee for Komproment, which is 25 years.

Conclusion to Impact 4

• KPI 4.1: Cost reduction in comparison with typical renovation during design: >15%	Due to the innovations implemented at the demo sites, the costs have been higher than normal.
• KPI 4.2: Cost reduction in comparison with typical renovation during construction / installation: >20%	The full deployment of the IT technologies has not been achieved and evt. cost reduction cannot be monitored.
• KPI 4.3: Maintenance costs reduction: >25%	The technology providers states maintenance costs reduction of PINK: -30-50% GREENSTRUCT shading: -20%
• KPI 4.4: Total cost reduction in comparison with typical renovation: >30%	Due to the innovative technologies, more more time and more money have been necessary in the starting phase.
• KPI 4.5: Durability guarantee: >25 years	Komproment: 25 years.

7.5 Impact 5: Reduction of time needed on site for renovation works

KPI 5.1: Reduction of time needed for designing renovation works

This KPI will not be able to be estimated by the demo leaders during the implementation of the RINNO project. Integrating the RINNO tools has taken extra time, because of the time needed for the learning process and often double work, because both old tools and RINNO tools are used for the designing of the renovation.

KPI 5.2: Reduction of time needed on-site for renovation works

This KPI should be determined by the demo leaders after the demonstration of the RINNO framework solution at the four demo sites. But as the WP4 tools for on-site support of the renovation process have been delayed, it is not possible. Anyway, when implemented, using a robot will reduce thermal bridges, increase airtightness while reducing the repetitive tasks that would otherwise be done by a site worker.

Also time loss due to material unavailability will be avoided through warehouse management. Time to prepare the material quantities required will be reduced. The RINNO tool E-Logistic helps bring the right material to the right place at the right time. It aims to also help reduce disruption to occupied apartments under renovation by reducing the movement in and out of an apartment.

KPI 5.3: Reduction of duplicated tasks due to streamlined-integrated process

This KPI cannot be determined by the demo leaders after the demonstration of the RINNO framework solution on the four demo sites for the same reasons as mentioned above.

Conclusion to Impact 5

• KPI 5.1: Reduction of time needed for designing renovation works: >15%	The full deployment of the IT technologies has not been achieved and evt. reduction of time needed for designing renovation works cannot be monitored.
• KPI 5.2: Reduction of time needed on-site for renovation works: >40%	The full deployment of the IT technologies has not been achieved and the time needed on-site for renovation works cannot be monitored.
• KPI 5.3: Reduction of duplicated tasks due to streamlined-integrated process: >25%	The full deployment of the IT technologies has not been achieved and duplicated tasks cannot be monitored.

7.6 Impact 6: Demonstration of the effectiveness and replicability

Impact 6 focus on demonstration of the effectiveness and replicability of the proposed solutions to lead to an increased rate of renovation for defined building typologies in several districts/cities/regions

KPI 6.1 User acceptance

A questionnaire has been distributed to the users (professionals, tenants, owners etc.) before and after the renovation to determine the user acceptance of the RINNO solution.

This will be described in Chapter 9, User Acceptance.

The total number of residents and the total renovated floor area can be seen below.

KPI 6.2: Number of residents benefited during the project
Greek Demo: 8 flats – 14 residents
Danish Demo: 12 flats – 12 residents
French Demo: 8 flats – 9 residents - total in the building: 29 flats and 32 residents
Polish Demo: 5 flats– 12 residents

KPI6.3 Total floor area to be deep renovated during the Project
Greek Demo: 560m^2 (treated floor area of the multifamily building)
Danish Demo: 739m^2
French Demo: 288 m2 for 8 flats
Polish Demo: 258 m^2

Figure 49 Residents and m2 at the four demo sites

7.7 Impact 7: Reduction of the greenhouse gases emissions

KPI 7.1 Reduction of GHG emissions
This KPI refers to reduction of GHG emissions after the full roll out of the project (after RINNO solutions enter the market). Therefore, it cannot be quantified during RINNO. Therefore, the reductions have been estimated during T6.5. See more details in Deliverable 6.8.

The target value for this indicator is 39,206 tCO_2-eq/year

KPI 7.1 GHG reduction
Greek Demo: 28.458 tCO_2-eq/year
Danish Demo: 383 tCO_2-eq/year
French Demo: 9.621 tCO_2-eq/year
Polish Demo: 85.524 tCO_2-eq/year

Figure 50 GHG reduction

KPI 7.2 Technology providers estimate for their technologies reduced embodied energy of > 20%

KPI 7.2 technologies reduced embodied energy
Greek Demo: NA
Danish Demo: NA
French Demo: NA
Polish Demo: NA

Figure 51 Reduced embodied energy

KPI 7.3 Technology providers estimate use of biobased materials for their technologies to be: 10-90% depending on applicable technology

KPI 7.3 Biobased materials
Greek Demo: 28% of biobased material in Thermal insulation
Danish Demo: 45 % of biobased material in Thermal insulation
French Demo: 45 % of biobased material in Thermal insulation
Polish Demo: NA

Figure 52 Biobased material in thermal insulation

KPI 7.4 From S-LCA tool using monitored data: Time outside indoor quality range

KPI 7.4 Time outside indoor quality range
Greek Demo: 35.69%
Danish Demo: 53.20%
French Demo: 80.50%
Polish Demo: 70.99%

Figure 53 Time outside indoor quality range

KPI 7.5 From S-LCA tool using monitored data: Time outside thermal comfort range

KPI 7.5 Time outside thermal comfort range
Greek Demo: 35.69%
Danish Demo: 56.49%
French Demo: 37.10%
Polish Demo: 35.69%

Figure 54 Time outside thermal comfort range

Conclusion to Impact 7

• KPI 7.1: Reduction of GHG emissions: 40,400 t CO2-eq/year	123,986 tCO_2-eq/year

• KPI 7.2: Reduced Embodied Energy of RINNO technologies vs Typical ones: >20%	NA
• KPI 7.3: Utilization of bio-based materials: 10-90% depending on applicable technology	In insulation – Greece: 28 %, France and Denmark 45 %. Poland has not implemented the project yet.
• KP! 7.4: Time outside indoor quality range	See above –no KPI in the GA
• KPI 7.5: Time outside thermal comfort range	See above –no KPI in the GA

8 SURVEY ON THE PROJECT IMPACT

The survey on the project impact is part of the qualitative evaluation of user satisfaction, which will be described in the following.

Here we shall only mention that the general satisfaction among tenants and building owners – although a limited number of persons has answered yet (7) – is overwhelmingly positive:

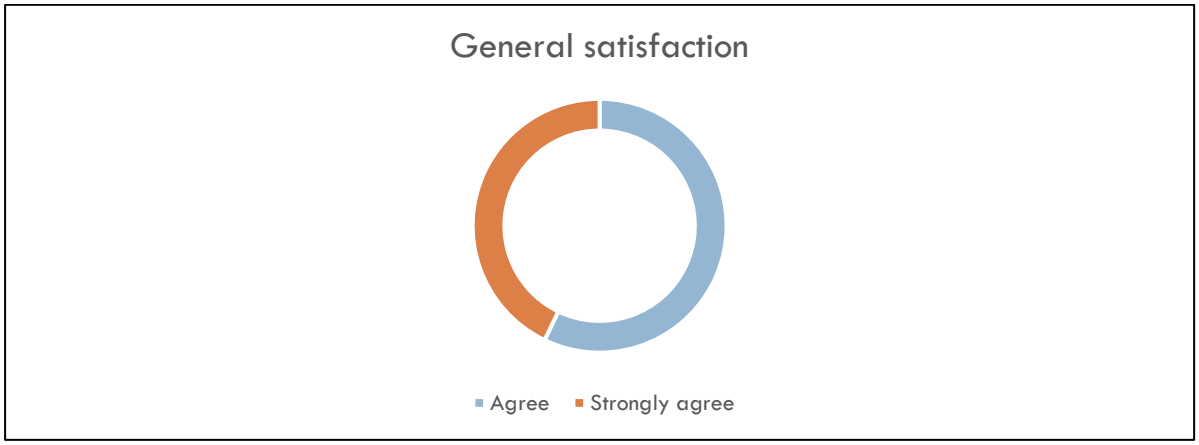


Figure 55 General satisfaction among tenants and building owners

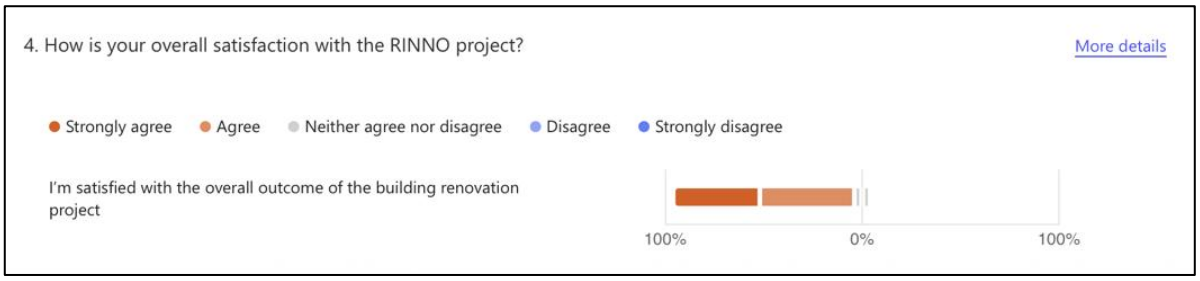
For further details - see 9 Evaluation of user satisfaction.

9 EVALUATION OF USER SATISFACTION

9.1 Questionnaire for professionals

The 25 professional stakeholders from three of the four demo sites answered the Microsoft Forms questionnaire on user satisfaction (see description of the participating professionals in chapter 4, p.31).

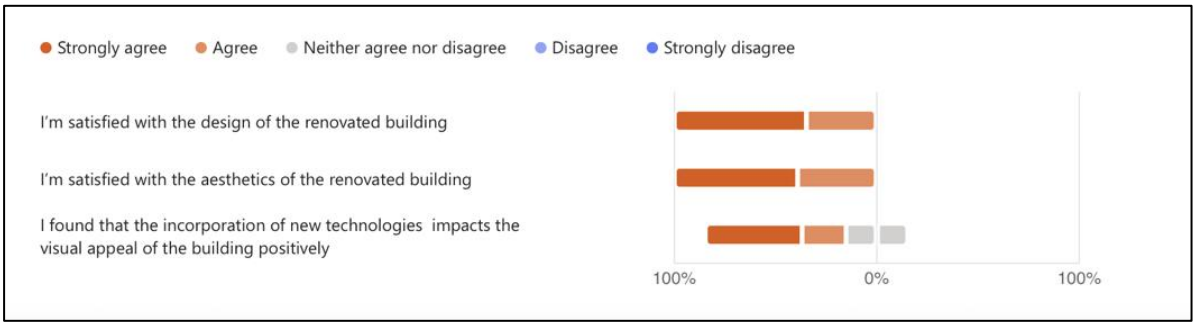
Asked, how is your overall satisfaction with the RINNO project, almost 100 % were positive.



Comment:

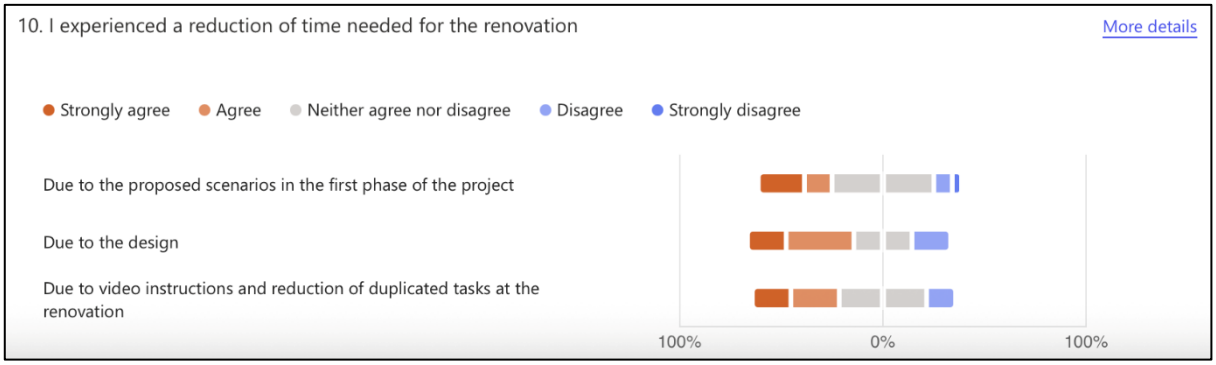
- The work was done very well and the impact for the residents was significant (anonymous).

Next question, related to the first one was, if they were satisfied with the design, aesthetics and incorporation of new technologies. Still very positive feedback.



The respondents were also asked for comments here:

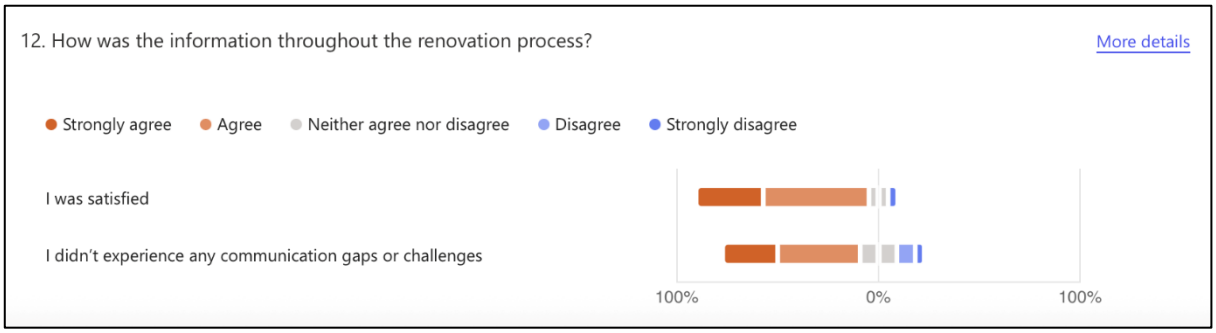
- The BIPV technology appears outdated regarding the potential installed power. The insulation K-Flex material is difficult to apply
- The technical systems are not visible



Comment:

- The project schedule did not notably affect the time required for the renovation.

The last question was about the communication within the project, where a few respondents had comments.



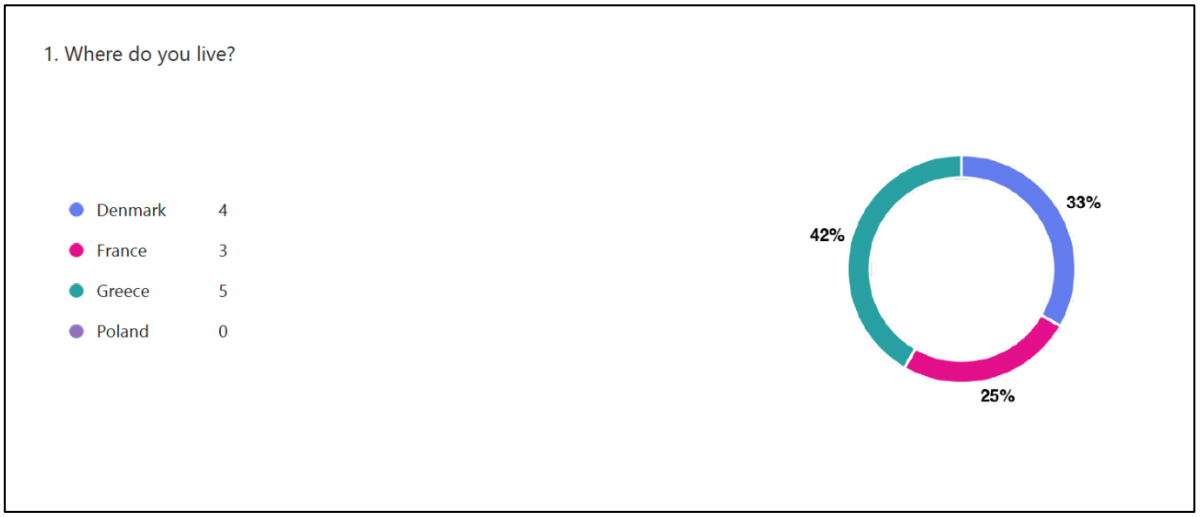
Comments:

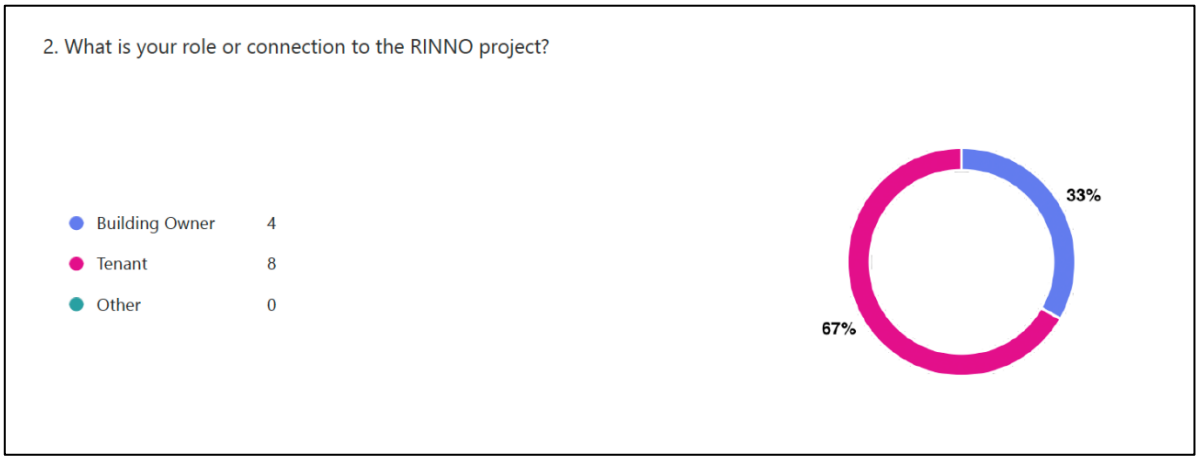
- It was difficult to communicate with all the partners and technology providers
- As a project manager, I would have appreciated better integration of the ins and outs of the RINNO project from the design stage. Perhaps training at the beginning of the design process would have been useful (France).

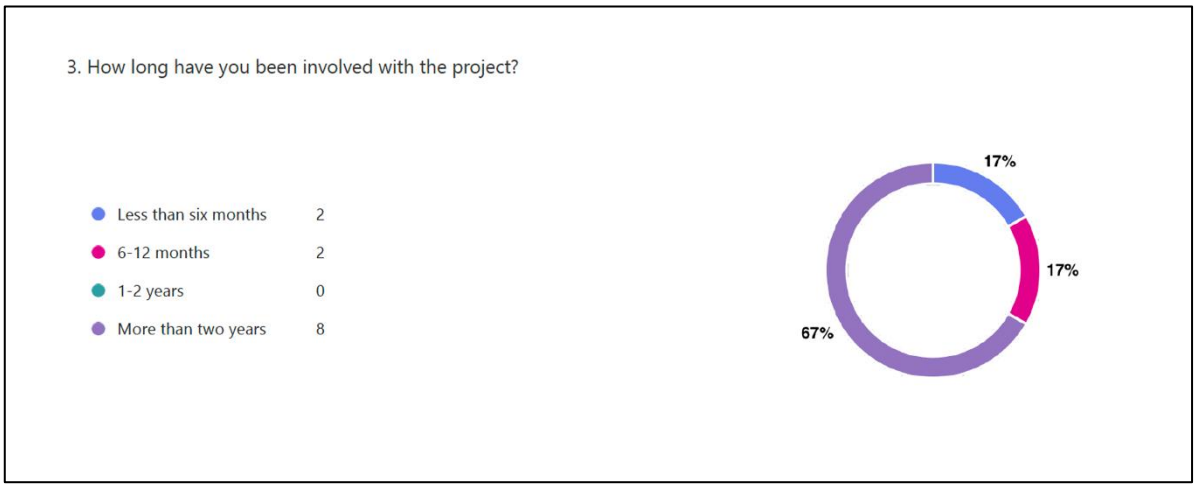
9.2 Questionnaire for tenants – before and after renovation

Before the renovation
The survey has no answers from the Polish demo site, as the project is still under development.

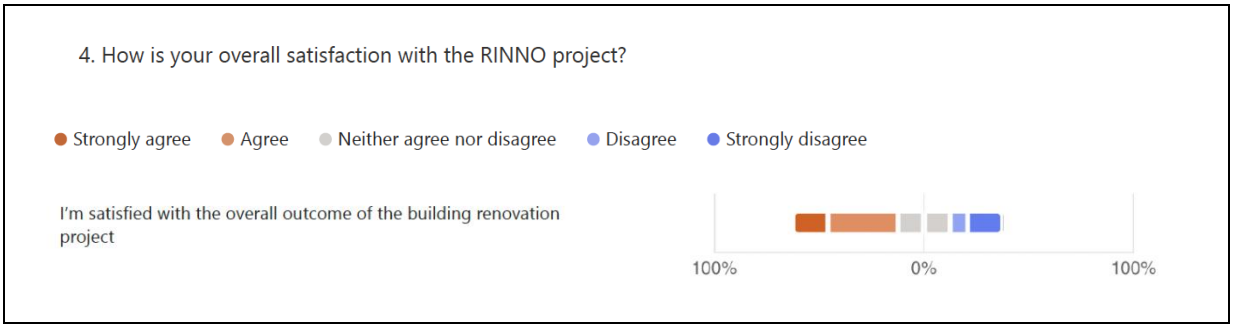
The following graphs show the nationality and role of the respondents. There were 12 respondents to the survey.







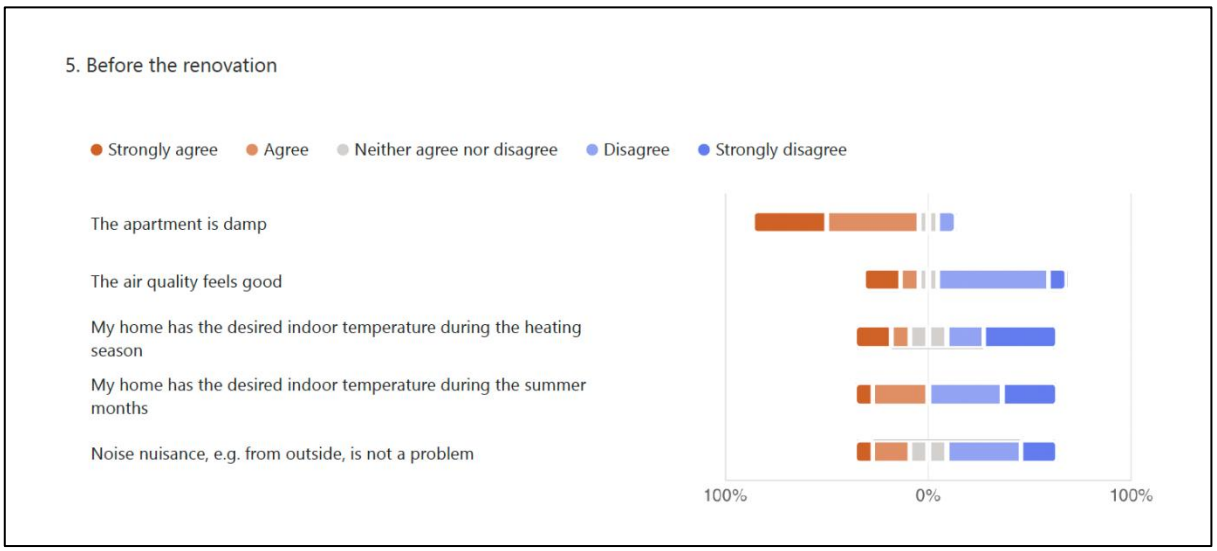
The respondents were then asked about their overall satisfaction with the building before renovation.



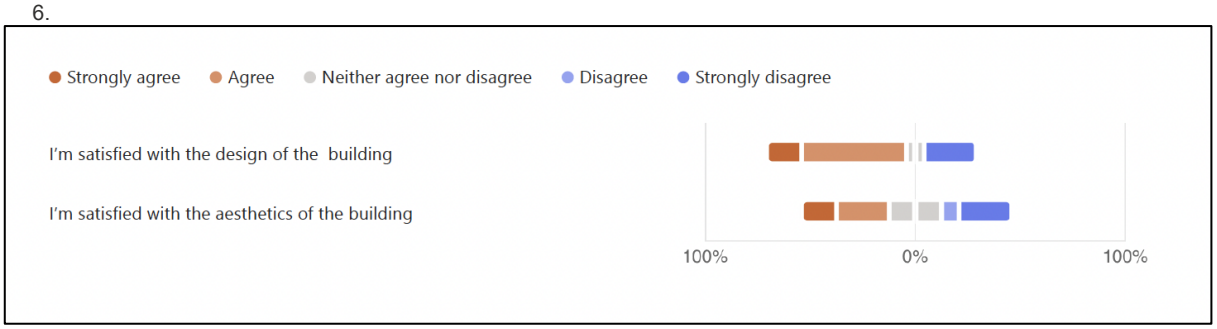
Comments:

- The BIPVs not installed yet, insulation not bad (anonymous)
- Not everything completed, cannot judge yet Insulation was well installed, but took too much time (anonymous)
- The interior conditions of the apartment have drastically improved. We didn't use any heating system this winter, yet the house remained warm. The air quality has significantly improved, and the house doesn't smell, even when we smoke inside. Noise levels have also been greatly reduced, even though we live on a major avenue. We are looking forward to seeing how the conditions will be during the summer (Greece)

Next question is about satisfaction before and after renovation. Only the Greek and French demo sites – having finished the renovation – have answered this part of the questionnaire.



6.



The graphs talk a clear language – the satisfaction with the renovation has improved significantly.

Comments from the tenants after the renovation:

Please comment if you disapprove of the design or aesthetics.

- The design of the building is fine, but the building before was dirty
- Not enough money to take care of the aesthetics
- As a tenant, we have not had much say in the renovation and the changes that have been chosen.
- • It is not finished at all, and the new solar cells and circulation system have not been installed. Errors and deficiencies are in the queue
- The installations are constantly broken down: this winter countless days without heating or hot water; the light from the bicycle room illuminates the accommodations significantly in the evening; the tenants treated like s**t during the renovation and then no way to get repairs... all the door handles of the accommodations were faulty, they were changed thanks to the visit of the Mayor of Lille (slashdot days before her visit: major cleaning etc. proof that LMH (building owner) only acts in its own interest not those of the tenants)... and many other things to say

What improvements or changes would you recommend for future building renovation projects with new technologies?

- To be better planned before the implementation. The communication was good with the engineers, but we experienced important delays, and the new technologies were difficult to adjust to the program
- Better planning and organisation
- The duration of the renovation should be reduced.
- Better organization and better support after the installation, because problems can come up

- It would be useful for regulations to evolve so that more innovative solutions can be applied to our buildings to be renovated.
- Have materials and approvals ready before starting of the renovation
- Rehouse tenants during renovations or grant a rent deduction for those who stay and respect: warn when someone is going to hit their window with a jackhammer at 8am (the worker wears hearing protection, not us). And as a new technology I recommend doing a project designed so that people, made of bones, flesh with five senses, can LIVE there without DISCOMFORT.

Do you have any additional comments or suggestions

- Construction delays left tenants with two space heaters throughout the winter of the renovation, and the electricity bill with them: a DISGRACE

10 CONCLUSIONS

RINNO has advanced the development and demonstration of a full suite of IT tools and innovative renovation technologies to accelerate deep energy renovation in Europe, aiming for a long-term renovation rate of 3.5% annually compared to the current ~1%. All planned tools and technologies have been developed, and most have been tested at the four demo sites in France, Greece, Denmark, and Poland. However, integration into actual renovation processes was limited by delays, timing mismatches, and financial challenges at the demo sites.

The technologies progressed by 1–3 TRL levels, with installations including modular building envelope solutions, RES harvesting and storage, and hybrid retrofitting systems. Performance monitoring showed significant energy savings (up to 100% in Greece) and high user acceptance (>90%). However, cost reductions and time savings could not be fully demonstrated within the project timeframe.

While RINNO did not fully achieve its ultimate goal—developing, validating, and demonstrating an operational augmented-intelligence interface with an occupant-centred approach for the entire renovation lifecycle — the project took a significant step forward, aided by the granted extension. Most importantly, the IT tools and technologies to streamline renovation processes are now available and functional. The key gap remains full-scale integration into real renovation workflows, which was hindered by the slower-than-planned development of IT tools, delays in deep renovation works at demo sites, language barriers, skepticism, and the communication between users and producers. Actually, more funding would be needed to ensure a better communication and motivation from users. The deal was not attractive enough compared to the risk they felt they would take.

A follow-up project—RINNO II—would be essential to validate the integrated approach under realistic renovation timelines and to fully demonstrate its potential impact on Europe’s renovation rate.

RINNO IT-tools
The RINNO Suite was completed with tools to support the whole process from planning and design to implementation and management. And the IT tools have been interconnected so that uploading of information from the renovation projects is one process, and data can be used in the next tool in line, which will save time compared to using different IT tools, where you need to upload data every time you start on a new part of the process.

For the different tools, RINNO has the following conclusions:

INTEMA - price is lower than other commercial software.

VERIFY - there are presently no competitors in this field; VERIFY is the only tool that provides this service.

TEA TOOL - is a new tool on the market, and the outcomes can be used for project files and documentations.

JSO - to the best of our knowledge there is no competition in this field since no other commercial tool is addressing this need in the market.

Social LCA - this tool introduces a new functionality and could pave the way for social assessment in traditional sectors that still don’t take it into account, such as architecture and engineering.

E-Cockpit - will help site operatives run a smooth renovation operation. This was the intention in RINNO, but it has not been fully achieved.

AR-TOOL – is useful for new technology providers to visually explain how the product should be installed. The Augmented Reality tool and the videos concerning the installation of the technology tool has been tested at three of four demo sites and was found useful.

Building Monitoring System (BEM) - has improved the connectivity with more sensors, enhanced the system with more sophisticated data and visual analytics techniques and full monitoring and control during building operation.

IoT - within RINNO it has been further demonstrated in the renovation sector, expanding its capabilities including: a) further user interface development for better navigation, more detailed asset data access and tailoring to occupants, b) advanced blockchain technologies introduction to secure data exchange, c) improved simulation techniques, d) better business analysis of data gathered and processed, and e) enhanced compliance to international standards.

Knowledge Platform - the target, the platform being utilized as the integrating platform for the RINNO framework will need refinement after the Transaction Workflow has been tested at demo sites (new project).

As the experiences with the use of the tools in practical renovation projects are limited, the results from the qualitative evaluation are of limited value. But in Greece, there was an overweight of positive responses, while in France and Denmark, the respondents were more reluctant.

Innovative technologies
Concerning the technologies, all the technologies have been installed physically at least at one of the four pilot sites. Not all have been installed twice at two different demo sites as planned, but RINNO now has experience with the installation and the operation process for all the technologies, which is canalized to the technology providers.

Results from the French demo site
LMH (building owner) has tested the robots from BOUYGUES on the façade with printing of façade insulation and are satisfied with the experience.

Unfortunately, due to the French regulations in force, it was not possible to leave the projected insulation of polyurethane type on the facade of this collective building. Indeed, although we attempted to obtain a derogation through an experimental technical opinion, this could not be obtained within the construction site preparation deadlines constrained by the overall deadline of the RINNO project. Thus, the building made it possible to test the proper functioning of the robot, which was largely demonstrated during the test, but LMH was obliged to remove the insulation applied for replacement with an insulation that complies with the current standards.

LMH has also installed the bio-based pipes and sheets (300 m) and K-BOX bio-based insulation installations (30 units), which has worked fine. Finally,16 units of the InVentilate micro ventilation system have been installed in 8 flats.

LMH has faced challenges with tenants who have disconnected measuring equipment or caused issues such as thefts of data transmission facilities installed in common areas within technical ducts. These problems have resulted in the need to purchase three sets of replacement equipment since the initial installation. Despite efforts to inform tenants about the purpose of these facilities, some continue to lose or disconnect the equipment. Consequently, LMH has recently agreed with the rental agency and its provider to cease reinstalling equipment in the flats of non-cooperative tenants. As a result, only five dwellings remain equipped out of the original eight which influences the survey of the functioning of the building and the building management. Moreover, numerous cuts in the data reporting to our collection platform or to that of ITI have occurred, sometimes for several weeks without our provider managing to solve the problem. The combination of problems related to the tenants' misunderstanding, repeated vandalism and problems with the connection of equipment with data collection platforms has led to a very questionable quality that is difficult to exploit. LMH is aware of this issue, LMH works to capitalize on this experience and is determinated to seek and implement solutions so that future monitoring of its renovations does not pose the same difficulties.

Results from the Greek demo site
The Greek demo site renovation project is co-funded by companies, which sponsor the building's renovation with innovative materials and systems according to the requirements of the Hellenic Passive House Institute through an international crowdfunding campaign, which did not have the expected results. During the various construction phases, the project has also functioned as an educational, informative and social innovation support hub for all stakeholders.

The crowdfunding and the sponsorships have taken extra time and effort and contributed to the delay of the project. But it makes the project exceptional as a successful social experiment. The interventions have resulted in significant improvements in the interior conditions that most of the building occupants already appreciate even if the scaffolding is still there partially.

By the implementation of bio-based double layer panels (K-FLEX) of 750 m2 and 80 mm thickness there have been no problems.

By the implementation of the GREENSTRUCT PV on the gable of the demo building (12,24 m2), there was a challenge with the construction and the capability of the gable to carrying the weight of the PV. This was not handled in the Grant Agreement and not financed. A static analysis was performed, and a metallic structure is installed in the building to support the BIPVs. Furthermore, there was a problem with one broken window with thermochromic glass (34.6 m2) at delivery. Both problems are in the process of being resolved but face delays because the windows were sponsored.

As in the French project, there has also been challenges with the installation of the monitoring system and the management. HPHI had to collect all the installed data loggers (installed in the apartments from MEAZON in July 2021) to access the data before the renovation. The export of the data stored in them was realized. Multiple visits were made, and monitoring of four apartments was completed. Extra devices were installed to ensure the monitoring of internal thermal comfort (temperature, relative humidity, CO2 concentration).

Results from the Polish demo site
Although the renovation has not started yet, there are also experiences from the Polish demo site to be included in the conclusion.

In previous plans for the tender, the PV installation was supposed to be announced as "project and install". This means that the contractor prepares the documentation and installs the PV on the roof and on the façade (ZAPPA). Therefore, the details in the project regarding the installation were not prepared. As per information from BGK (Bank Gospodarstwa Krajowego from where a part of the funding will be obtained), the project of PV installation including permit from the fire department had to be prepared before signing the agreement with the contractor. The permission from the fire department took longer than expected, and the tender has been delayed.

The results of not only one tender, but four tenders are unfortunately far beyond budget, and the renovation must be postponed till after the end of the RINNO project. Nevertheless, the owner of the building – Commune Jablonna, is still planning to perform the renovation according to the guidelines provided by the RINNO project in order to achieve the energy results indicated in scenario for polish demo site. Commune Jablonna is open to use the RINNO tools even after the project ends.

Results from the Danish demo site
Although FOB is a social housing company and must be very much aware of the social effects of renovation costs, the Danish demo site leader agreed to install five of the eight innovative technologies: ZAPPA, InVentilate, K-FLEX, IsoCell and PINK. This means that the Danish demo site demonstrates the RES harvesting solutions, the storage solutions as well as the multi-functional hybrid retrofitting solutions. ZAPPA (PV), InVentilate and PINK are both communicating with the Internet (IoT).

Unexpectedly, the municipalities in Slagelse rejected the use of ZAPPA slate at the gable of the Danish demo site due to a local plan stating which façade materials could be used in the area, and this did not

include slate, no matter which color. The project had to be changed, and the new result adds only the ZAPPA PV panels. The discussions with the municipalities delayed the finalization of the renovation design.

Another big challenge was that the tenants at first rejected the project (in a tenants' democracy vote). FOB succeeded in convincing the tenants by changing the bathroom renovation to a kitchen renovation. The hot water tank from PINK has then been built into the kitchen instead of the bathroom as previously decided, which also caused delay in the planning and design of the project.

The PINK water heater is a smart device, connected to the Internet and uses the surplus electricity from the PV panels to heat the water, but it is also connected to the district heating to supplement the heating of hot water if necessary. Use of hot water and electricity can be followed on-line.

After installation, the water tanks started leaking – 8 of 12 tanks. The solving of the problem, which supposedly is due to differences in Danish and Austrian water quality, is ongoing.

Microventilation is a ventilation solution with minimal intervention in existing m2 and minimal inconvenience in connection with installation due to the simple and quick installation. The units can, for instance, be installed in conjunction with a facade renovation — particularly when additional insulation and/or window replacements are already planned and scaffolding is required. This allows for significant cost savings. The solution implemented at the Danish demo site was developed to provide an energy-efficient ventilation system with heat recovery. The latest version of InVentilate's microventilation units has been installed to test their compatibility with a simple extraction setup from the bathroom and kitchen hood.

The overall efficiency of the InVentilate system, in combination with the extraction system, heat recovery performance in practice, user experiences related to thermal comfort, noise levels, and demand control, has been rated positively according to the professional questionnaire. InVentilate received the highest overall score. Tenants also responded positively, although the number of tenant responses to the survey was very limited.
K-FLEX and ISOCELL were installed successfully without any challenges.

As with the other demo sites, metering has been crucial to the success of the Danish demo site. Early in the project, the decision was made to install ICMeters – indoor climate meters – but concerns among tenants about being monitored led to delays. In the later stages of the project, additional intelligent meters were integrated, allowing communication with the PV system, ventilation, and water heaters. This transformation turned the building into a smart system, where multiple parameters can now be monitored and managed – including heating, hot and cold water, electricity, PV production, and indoor humidity and temperature via the ICMeter. This will be described at a later stage (see below).

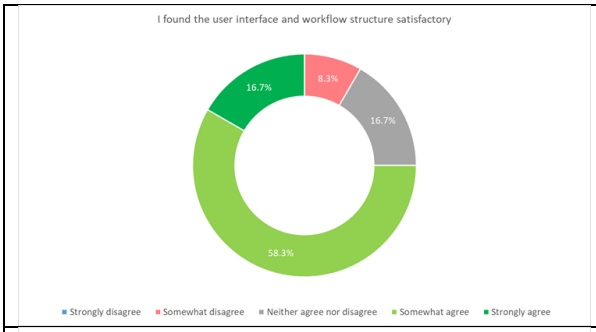
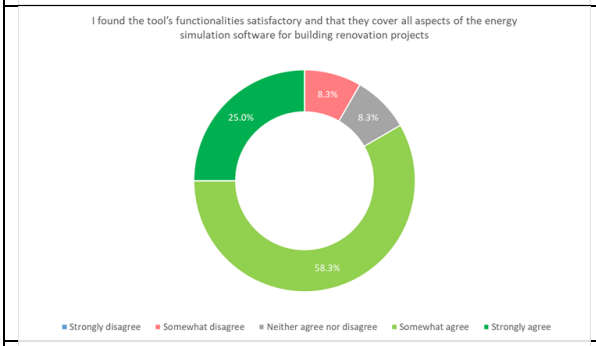
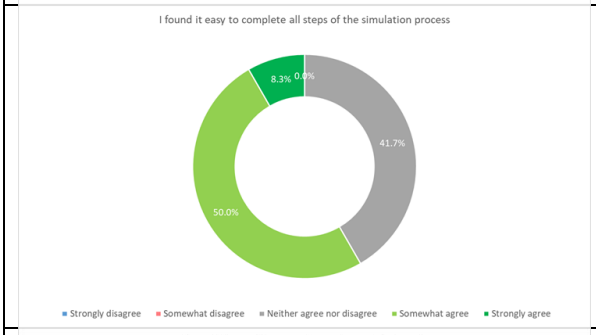
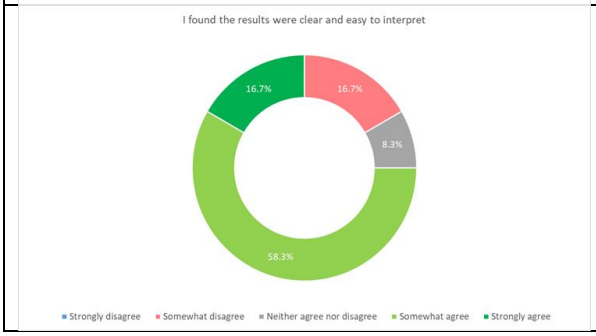
Several other parameters also show good results, which will be investigated and documented by the Aalborg University / Danish Building Research Institute after the end of the RINNO project (2025-26). The assessment will focus on innovative potential, environmental and climate benefits, project-specific competencies of the applicant, cost-effectiveness and self-financing, as well as the project's application and dissemination possibilities in the sector and its scaling potential.

Appendix I

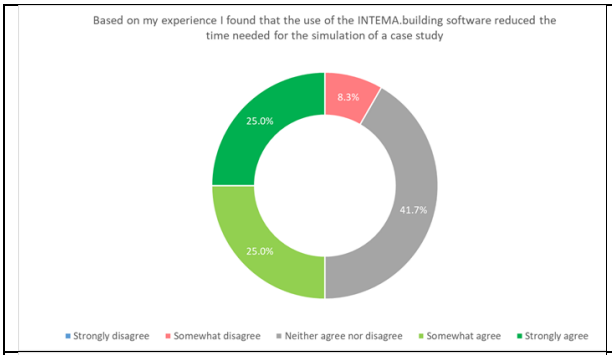
ANNEX 1 SURVEY ON THE RINNO PLANNING TOOLS (WP3)

INTEMA

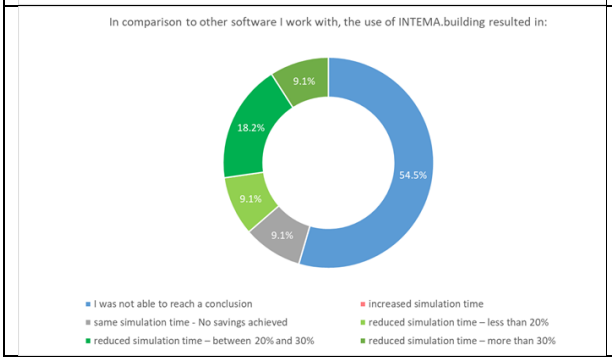
User friendliness

	• 75% positive feedback on user interface and workflow
	• >83% positive feedback on the tool's functionalities and suitability for building renovation
	• 58.3% positive feedback on ease of use • 41.7% neutral as they did not test the tool
	• 75% positive feedback on results interpretation

Time savings



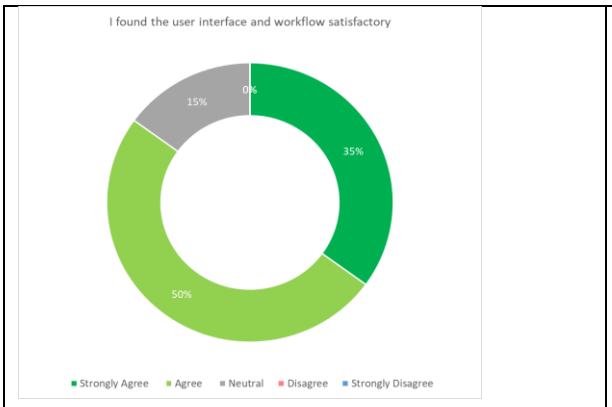
- 50% positive feedback on time savings
- 41.7% neutral as they did not test the tool

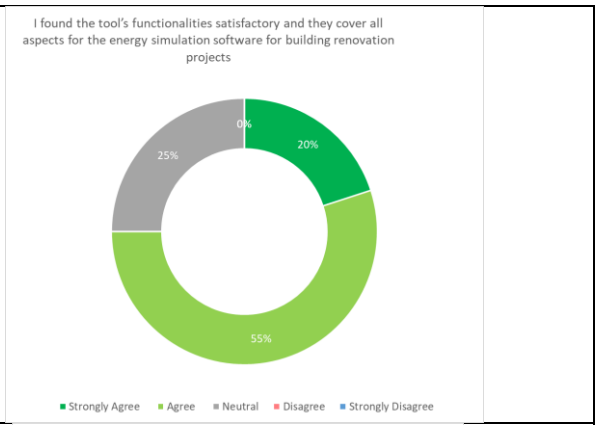


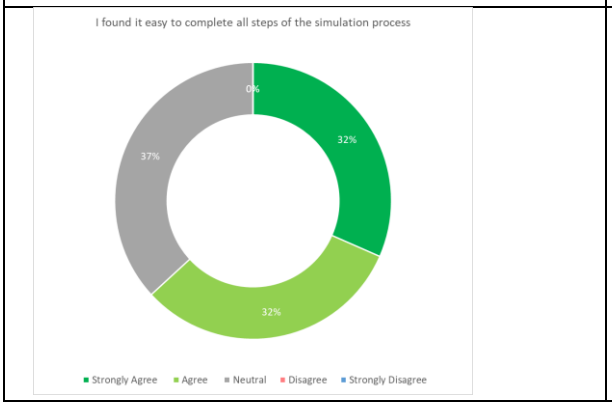
- 36.4% consider time savings
- 27.3% considered that the use of the tool would result in >20% reduced simulation time
- 54.5% was not able to reach conclusion

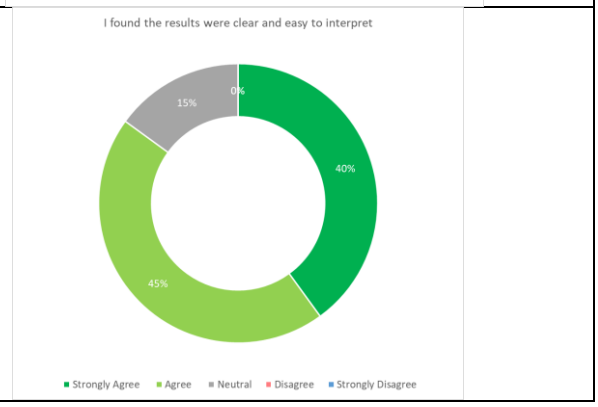
Feedback from demonstrating the INTEMA.building to NTUA students
Results are presented in the following graphs:

User friendliness

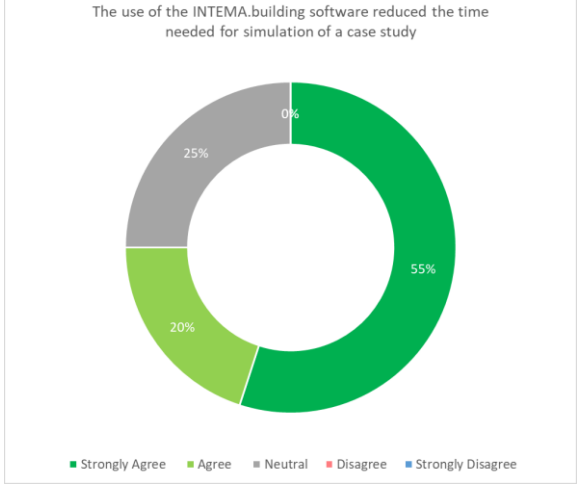


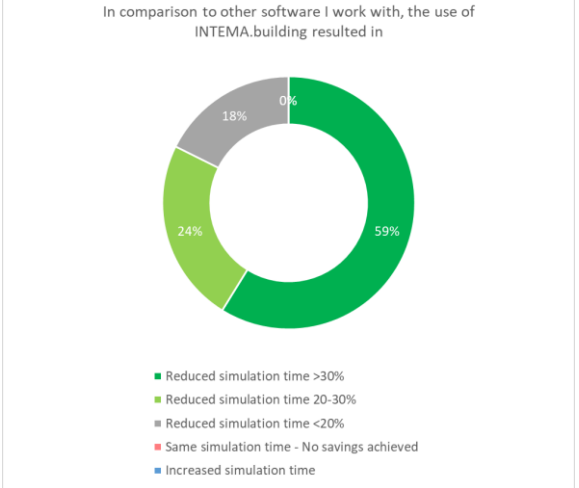




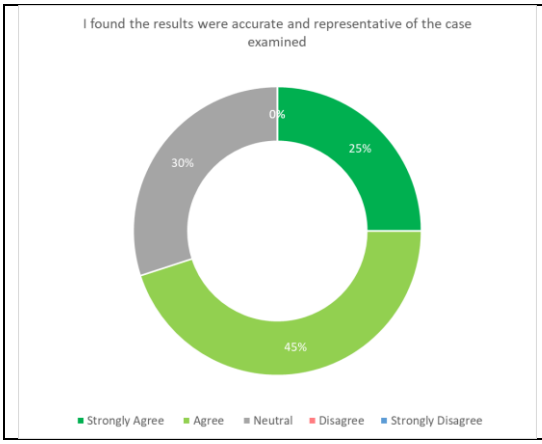


Time savings



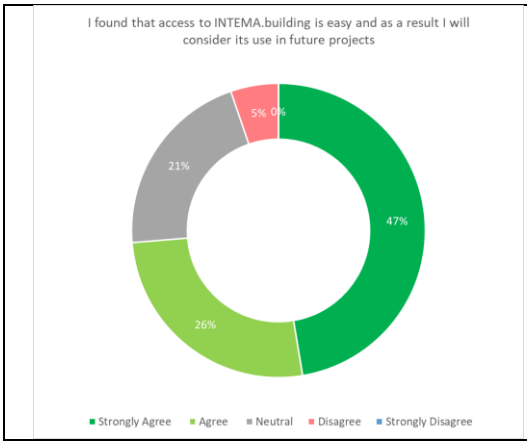


Accuracy



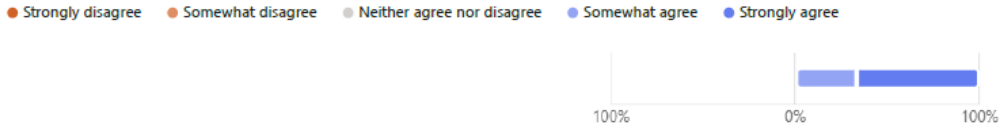
- 70% of the respondents considered the results accurate and reporesentative of the case examined
- 30% neutral

Ease of access

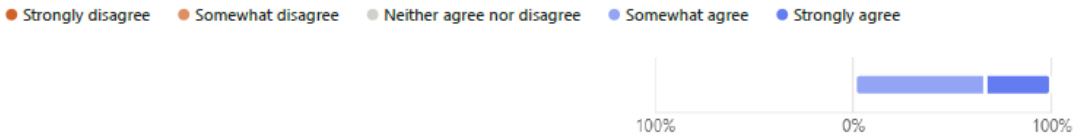


- 76% of the respondents considered that the tool is easily accessible and they would consider it for future projects
- 21% neutral

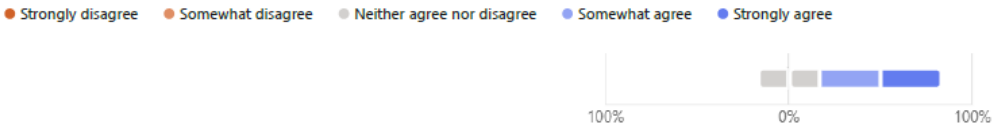
8. I found the INTEMA.building tool user friendly



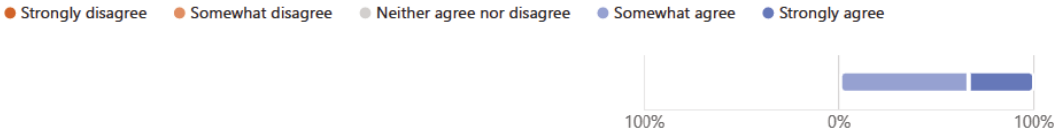
9. I found the INTEMA.building user interface and workflow structure satisfactory



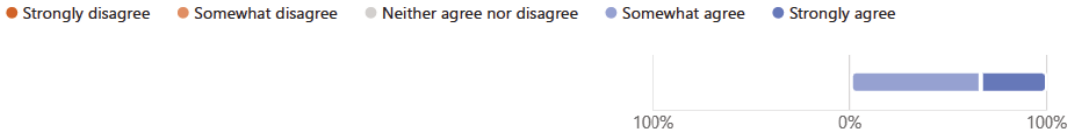
10. I found the INTEMA.building functionalities satisfactory and that they cover all aspects of the energy simulation software for building renovation projects



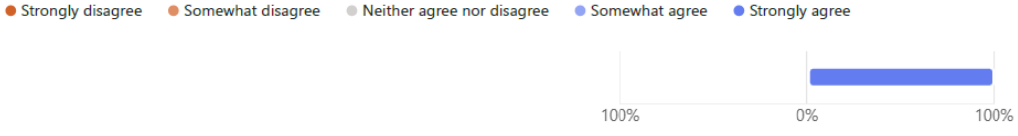
11. I found it easy to complete all steps of the INTEMA.building simulation process



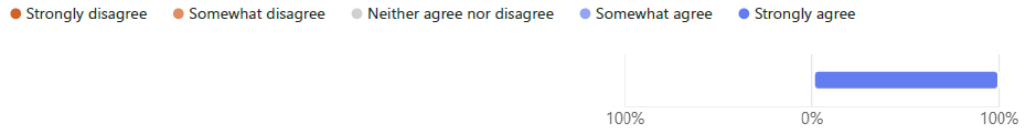
12. I found the INTEMA.building results were clear and easy to interpret



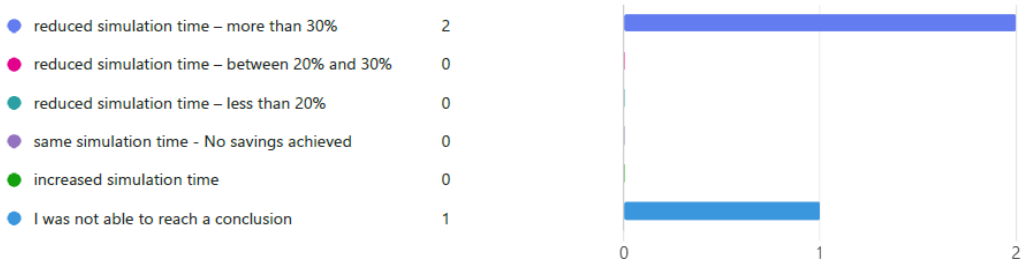
14. Based on my experience I found that the use of the INTEMA.building software reduced the time needed for the simulation of a case study



14. Based on my experience I found that the use of the INTEMA.building software reduced the time needed for the simulation of a case stud y

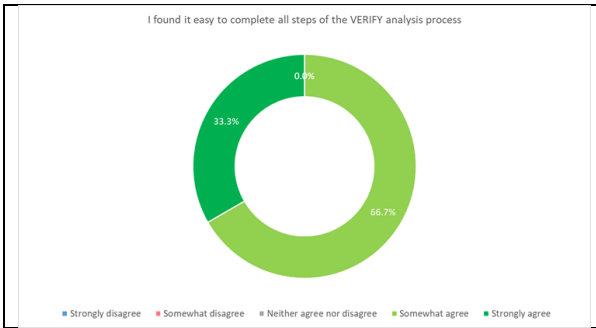


15. In comparison to other software I work with, the use of INTEMA.building resulted in:

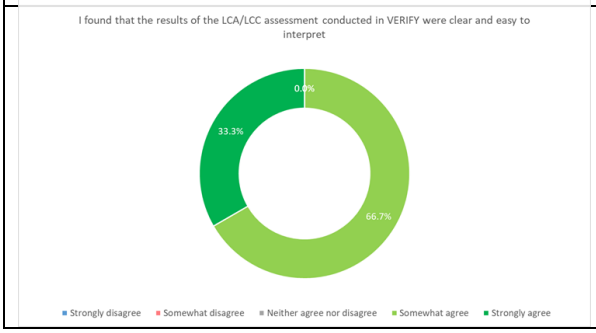


VERIFY (LCA/LCC toolkit)

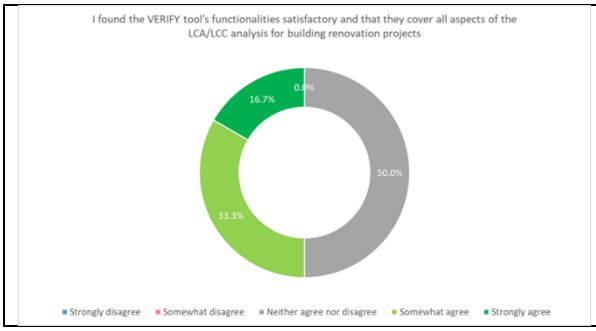
User friendliness



- 100% positive feedback on ease of use

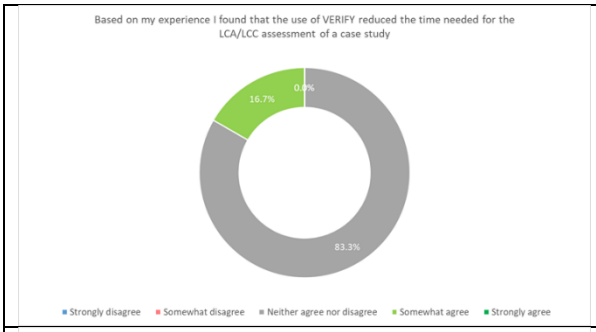


- 100% positive feedback on results interpretation

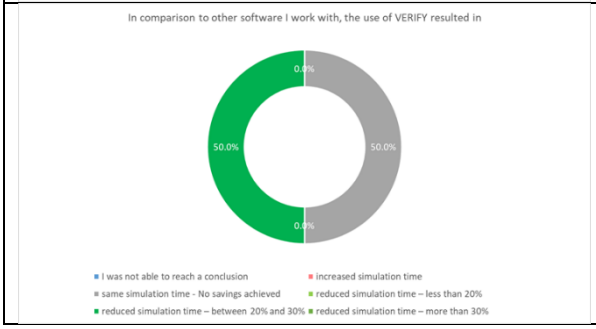


- 50% positive feedback on tool's functionalities
- 50% was not able to reach conclusion

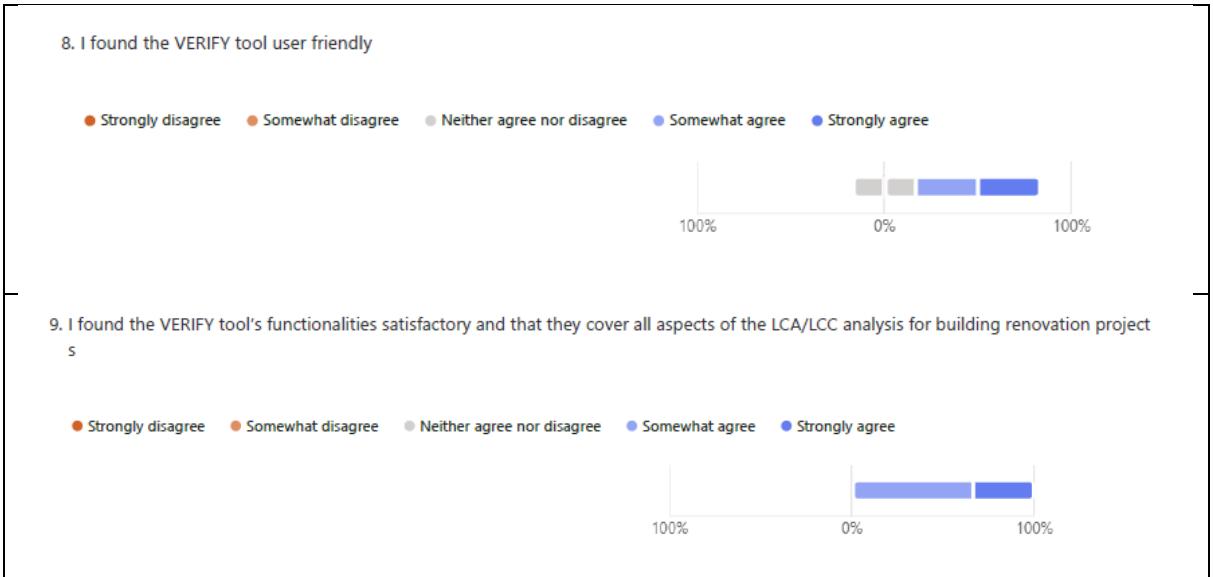
Time savings



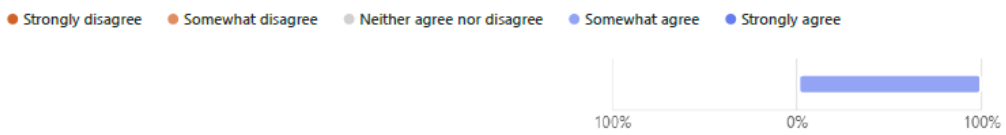
- 83.3% of respondents could not reach a decision on perceived time savings



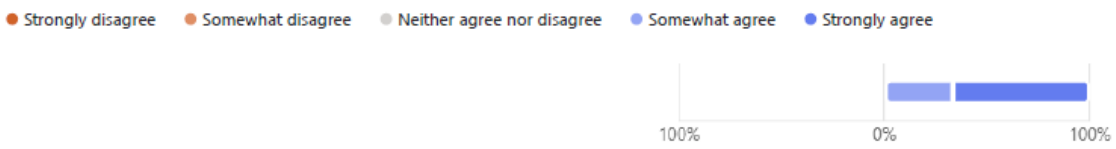
- 50% estimate reduced simulation time
- Not representative as it is based on just 2 responses



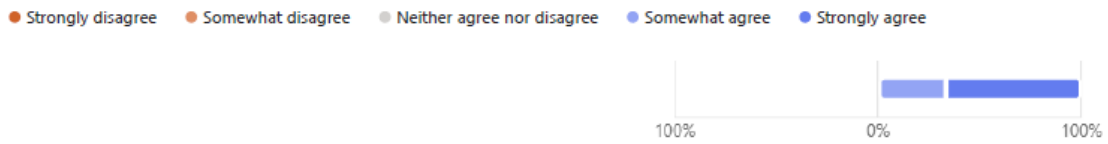
10. I found it easy to complete all steps of the VERIFY analysis process



11. I found that the results of the LCA/LCC assessment conducted in VERIFY were clear and easy to interpret

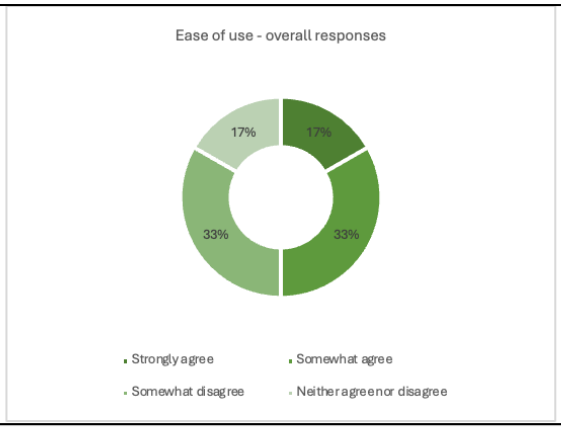
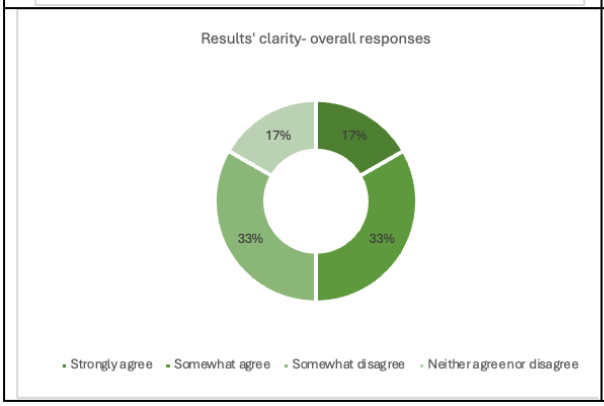


12. Based on my experience I found that the use of VERIFY reduced the time needed for the LCA/LCC assessment of a case study



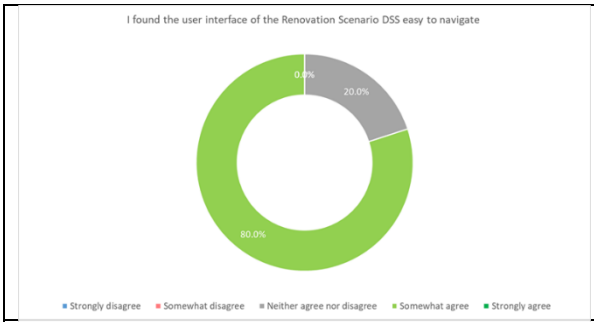
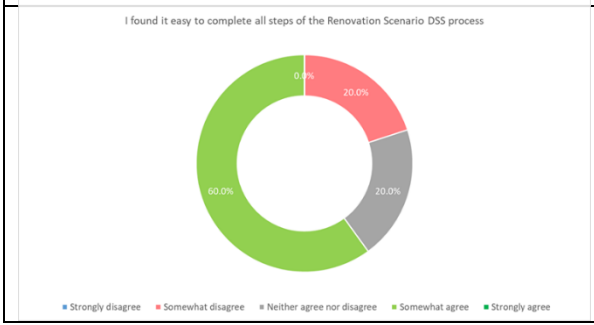
13. In comparison to other software I work with, the use of VERIFY resulted in

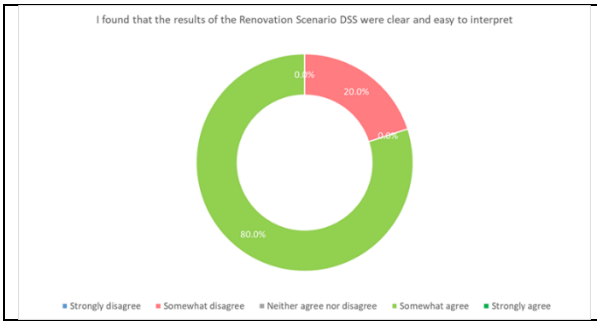
reduced time for the analysis – more than 30%	0
reduced time for the analysis – between 20% and 30%	0
reduced time for the analysis – less than 20%	0
same time for the analysis - No savings achieved	0
increased time for the analysis	0

	• 50% positive feedback • 33.3% negative feedback • 16.7% neutral feedback
	• 50% positive feedback • 33.3% neutral feedback • 16.7% negative feedback

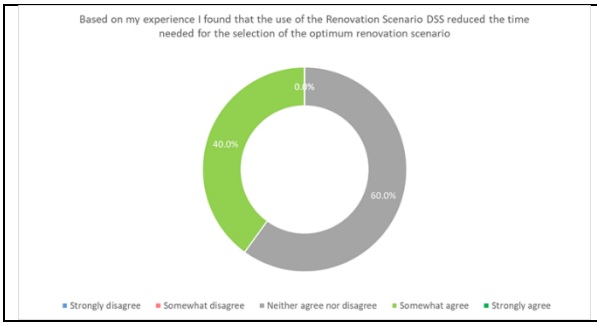
RENOVATION SCENARIO DSS

User friendliness

	• 80% positive feedback on navigating through the software
	• 60% positive feedback on ease of completing the process

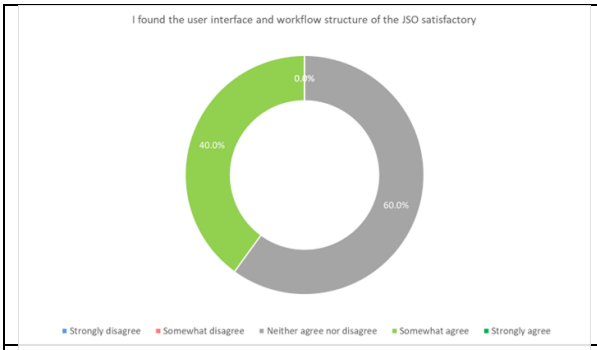
	• 80% positive feedback on results interpretation

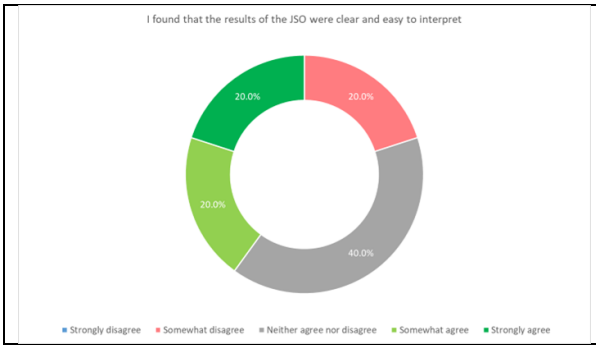
Time savings

	• 40% believe that the DSS contributes to time savings in decision making • 60% neutral

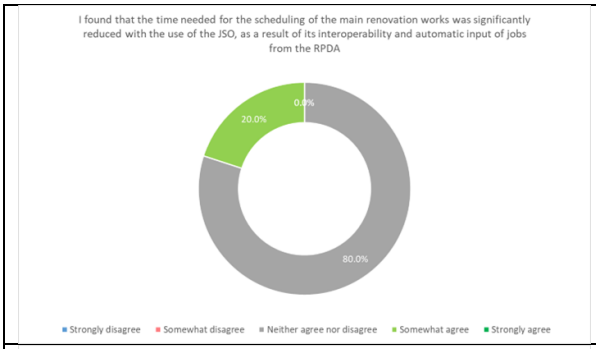
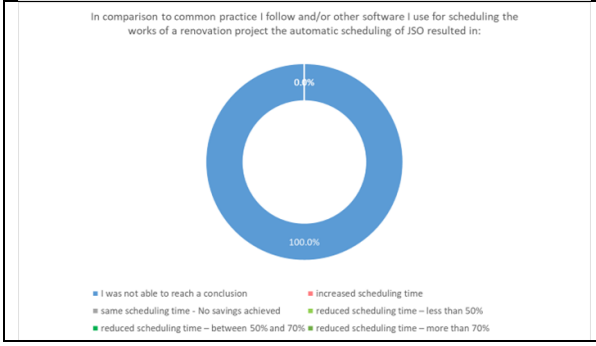
JOB SCHEDULING OPTIMIZER

User friendliness

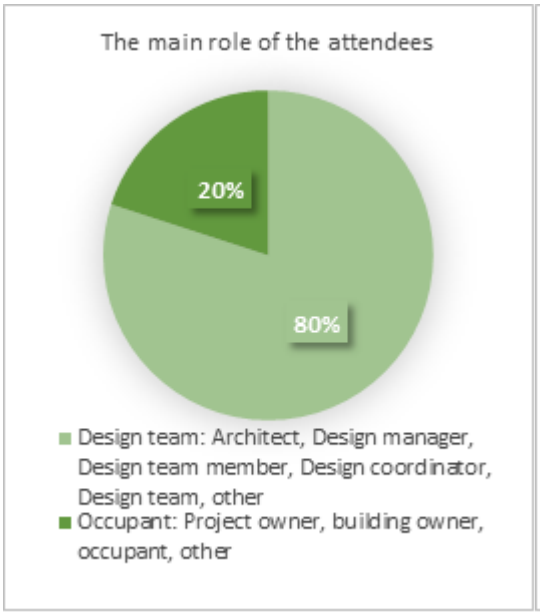
	•40% positive feedback on user interface and workflow •60% neutral
	•40% positive feedback on ease of use •60% neutral

	•40% positive feedback on results interpretation •40% neutral

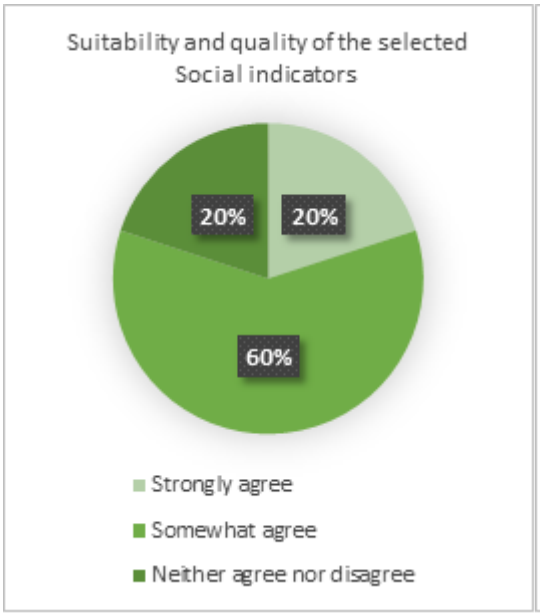
Time savings

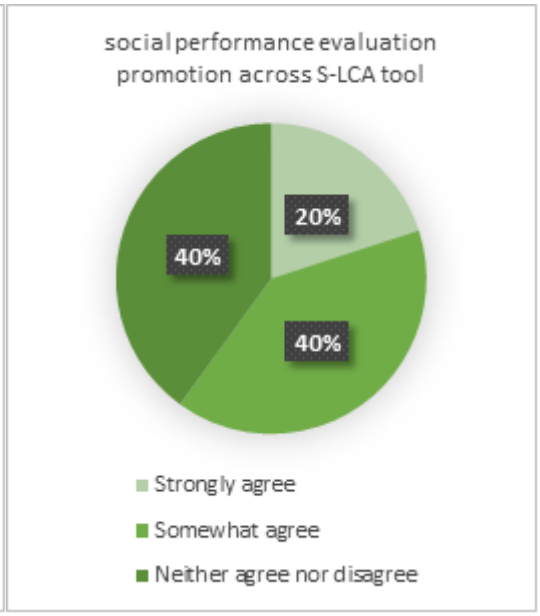
	•80% neutral on perceived time savings
	•100% could not reach a conclusion on the time savings that may be achieved

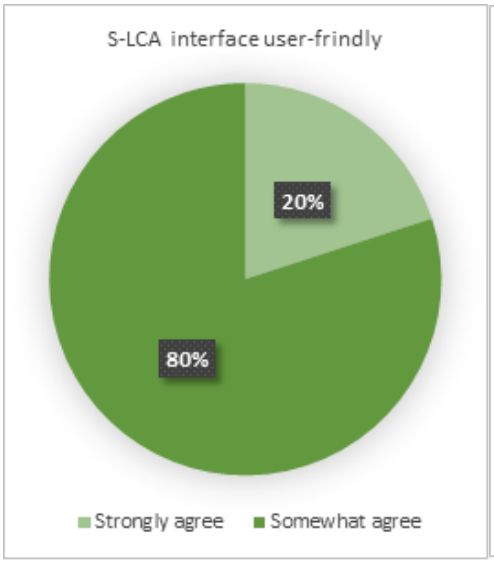
SOCIAL LCA TOOL

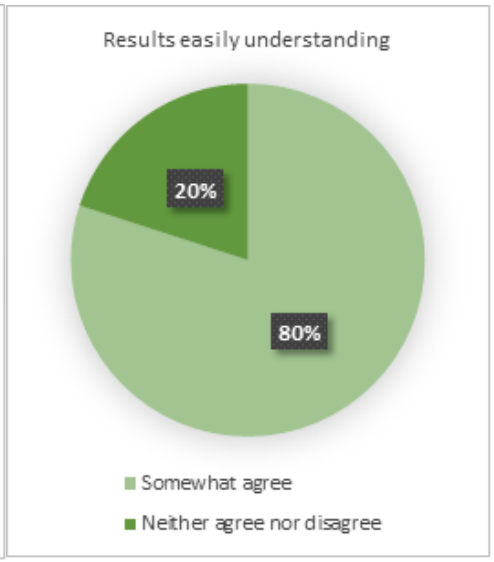

The main role of the attendees
20%
80%
Design team: Architect, Design manager, Design team member, Design coordinator, Design team, other
Occupant: Project owner, building owner, occupant, other


Previous experience using S-LCA assessment software
100%
No experience


Suitability and quality of the selected Social indicators
20%
20%
60%
Strongly agree
Somewhat agree
Neither agree nor disagree


social performance evaluation promotion across S-LCA tool
20%
40%
40%
Strongly agree
Somewhat agree
Neither agree nor disagree


S-LCA interface user-frindly
20%
80%
Strongly agree
Somewhat agree


Results easily understanding
20%
80%
Somewhat agree
Neither agree nor disagree

ABOUT RINNO

RINNO is a four-year EU-funded research project that aspires to deliver greener, bio-based, less energy- intensive from a life cycle perspective and easily applicable building renovation elements and energy systems that will reduce the time and cost required for deep energy renovation, while improving the building energy performance. Its ultimate goal is to develop, validate and demonstrate an operational interface with augmented intelligence and an occupant-centered approach that will streamline and facilitate the whole lifecycle of building renovation.

For more information, please visit **https://rinno-h2020.eu/**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 892071