# Deep REnovation roadmaps to decrease households VulnERability to Energy poveRty

## Project No. 101076277

## Deliverable 2.2 - REVERTER Knowledge database and Atlas

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| Due date: | **31/10/2024** |
| Dissemination level: | **PU - Public** |
| Lead beneficiary: | **NTUA** |
| Contributing beneficiaries: | **All** |

*This deliverable is not yet officially approved by CINEA*

Co-funded by the European Union

# About this document

This deliverable provides the global methodology for the pilots and the monitoring and evaluation (M&E) strategy.

| Status of deliverable | By | Date |
|---|---|---|
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**Disclaimer**



**Acknowledgement**

This document is a deliverable of the REVERTER project. This project has received funding from the European Union's LIFE programme under grant agreement No 101076277.

# Executive summary

This document summarises the concept, structure and content of the REVERTER Knowledge Database and Atlas, which were developed in the context of T2.5. In addition, the document provides information about REVERTERUp!, the online tool mentioned in T5.2. The latter is described in this deliverable because NTUA developed it in parallel with the REVERTER Knowledge Database and Atlas and because it is not described in another deliverable.

The REVERTER Knowledge Database has been created to serve as a central information access point for energy poverty definitions, drivers and indicators, financial, environmental and other information for alternative deep renovation measures, existing EP and building renovation policies, initiatives, strategies, targets, etc., energy poverty and deep renovation roadmaps and policies and innovative financing instruments, as well as the main barriers and benefits related to deep renovation at the four REVERTER pilots and beyond.

The REVERTER Atlas is an online map and (non-searchable) database offering critical information for the four REVERTER pilots. Specifically, the REVERTER Atlas provides, at a glance, data on the main characteristics of the four project pilots, e.g. area description, population and housing characteristics, climate conditions and energy poverty status calculated by primary and secondary data with several indicators. Moreover, it presents the main impacts expected to be triggered by the project based on the REVERTER's KPIs, e.g. primary and final energy savings, reduction of greenhouse gas emissions, number of buildings renovated, number of roadmaps created, number of energy-poor consumers impacted, households approached through home visits, social engagement events and media campaigns, etc.

The REVERTERUp! is an online energy consumption and savings calculator addressed to households. It differs from similar tools because it requires minimum input from the user to estimate the initial energy consumption, the annual monetary benefits for several pre-defined energy retrofit combinations, the investment cost, etc. Although the simplicity comes at the cost of accuracy because the calculations are based on an "average" house, the app – by requiring minimum effort, time and technical knowledge – provides useful information for the target groups of REVERTER.

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# Glossary

| Abbreviation / acronym | Description |
|---|---|
| LTRS | Long-Term Renovation Strategies |
| EP | Energy Poverty |
| OSS | One-stop shop |
| EPAH | Energy Poverty Advisory Hub |

# 1 Concept and design of the REVERTER Knowledge Database

## 1.1 The Knowledge Database concept

The REVERTER Knowledge Database has been created to serve as a central information access point for energy poverty definitions, drivers and indicators; financial, environmental and other information for alternative deep renovation measures; existing EP and building renovation policies, initiatives, strategies, targets, etc.; energy poverty and deep renovation roadmaps and policies and innovative financing instruments; and main barriers and benefits related to deep renovation at the four REVERTER pilots and beyond.

The database was basically fed by the results of the other WP2 tasks, i.e. T2.1 to T2.4. and is addressed mainly to scholars, practitioners and policymakers working at the interface of energy poverty and energy saving through deep renovation of houses. The design, structure and content of the database took into consideration these findings to provide the target audiences with a better user experience, wider information, easier access to specific information and less confusing navigation. During the project, NTUA will monitor the performance of the database to optimise and improve its services.

So far, the database contains about 700 records from more than 290 unique items (e.g. scientific papers, policy documents, etc.). The records are in English, although some of the original documents are available in other EU languages and are accessible through the domain name: [http://dbase.reverterhub.eu/](http://dbase.reverterhub.eu/) (Fig. 1).

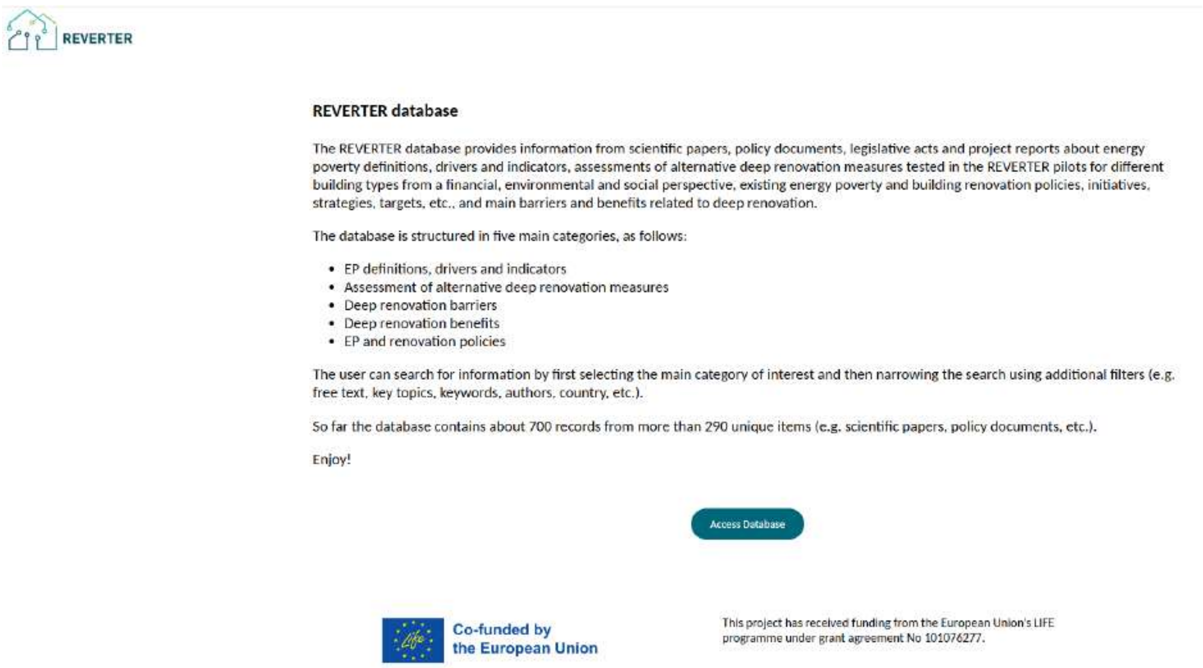



*Figure 1. REVERTER Knowledge Database – Welcome screen*

## 1.2 Structure and content

The database is structured in five main categories, as follows:

- EP definitions, drivers and indicators
- Assessment of alternative deep renovation measures
- Deep renovation barriers
- Deep renovation benefits
- EP and renovation policies

The user can search for information by first selecting the main category of interest and then narrowing the search using additional filters (e.g. free text, key topics, keywords, authors, country, etc.), as shown in Fig. 2.

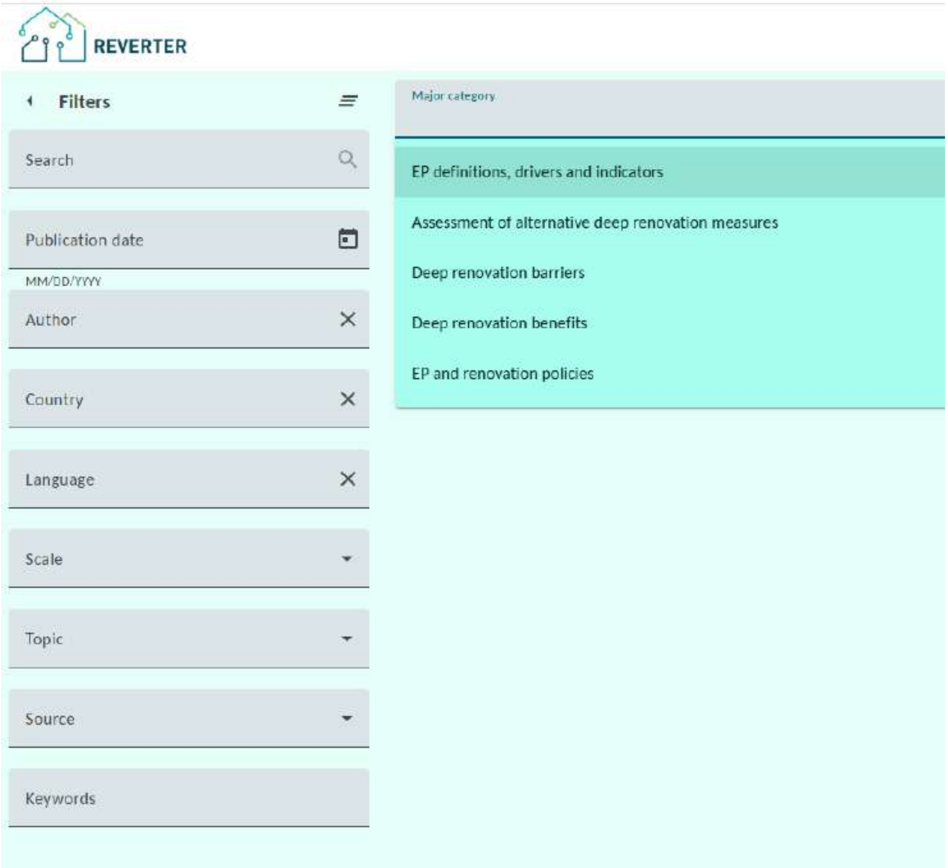



*Figure 2. REVERTER Knowledge Database – Main screen*

The structure and the basic characteristics of the database at the moment of launch are, as follows:

- **EP definitions, drivers and indicators –** 184 records from 184 source documents (mainly research papers-43%), including the Long-Term Renovation Strategies (LTRS) of 10 EU Member States.
- **Assessment of alternative deep renovation measures –** 28 records from 1 source document, i.e. REVERTER's deliverable "D2.1 State-of-the-art review and assessment report", which presents the results of the assessment of alternative deep renovation measures conducted at the four REVERTER pilots.
- **Deep renovation barriers -** 329 records from 23 source documents (mainly peer-reviewed journals – 54%, reports-23% and project results 11%).
- **Deep renovation benefits -** 98 records from 18 source documents (mainly peer-reviewed journals – 40%, project results 31% and other reports-14%).
- **EP and renovation policies –** 68 records from identified policies spanning across the following countries: Bulgaria, Greece, Latvia, Portugal, Spain, the UK, France, Denmark, Poland, Ireland, Austria, and Italy.

The database records contain some common fields (e.g. Title, Full bibliographical reference, Abstract, Publication date, URL, Source type, etc.) and some unique fields that depend on the main category (for instance, the "Deep renovation benefits" include 17 unique fields, e.g. General category of benefits, Subcategory of benefits, Specific benefits, Beneficiary, Valuation subject, Method used, Payment Vehicle, Type of data, Target population, Sample size, etc.).

# 2 Concept and design of the REVERTER Atlas

## 2.1 The REVERTER Atlas concept

When the proposal for the REVERTER project was being drafted, the Energy Poverty Advisory Hub (EPAH) was under development and the EPAH Atlas was not released. Therefore, the submitted proposal (and later the Grant Agreement) foresaw the creation of an interactive map, i.e. the “European EP Atlas”, providing information on energy poverty in the EU with the aim of complementing the EPAH.

After the release of the EPAH Atlas, REVERTER was asked to contact the EPAH and discuss the scope and contents of the REVERTER "European EP Atlas" to prevent duplication of work. REVERTER team members had a meeting on Monday, January 22, 2024, with EPAH representatives. After that meeting, it was mutually agreed (a) to rename the REVERTER's "European EP Atlas" to make sure that there will be no confusion with the EPAH Atlas to simply “REVERTER Atlas” and (b) to focus on KPIs and EP indicators of the REVERTER pilots.

Hence, the ‘new’ REVERTER Atlas is an online map and (non-searchable) database providing critical information for the four REVERTER pilots. Specifically, the REVERTER Atlas provides, at a glance, data on the main characteristics of the four pilots, e.g. area description, population and housing characteristics, climate conditions and energy poverty status calculated by primary and secondary data with several indicators. Moreover, it presents the main impacts expected to be triggered by the project based on the REVERTER’s KPIs, e.g. primary and final energy savings, reduction of greenhouse gas emissions, number of buildings renovated, number of roadmaps created, number of energy-poor consumers impacted, households approached through home visits, social engagement events and media campaigns, etc.

The information is in English, and the Atlas is accessible through the domain name: http://atlas.reverterhub.eu/ (Fig. 3).

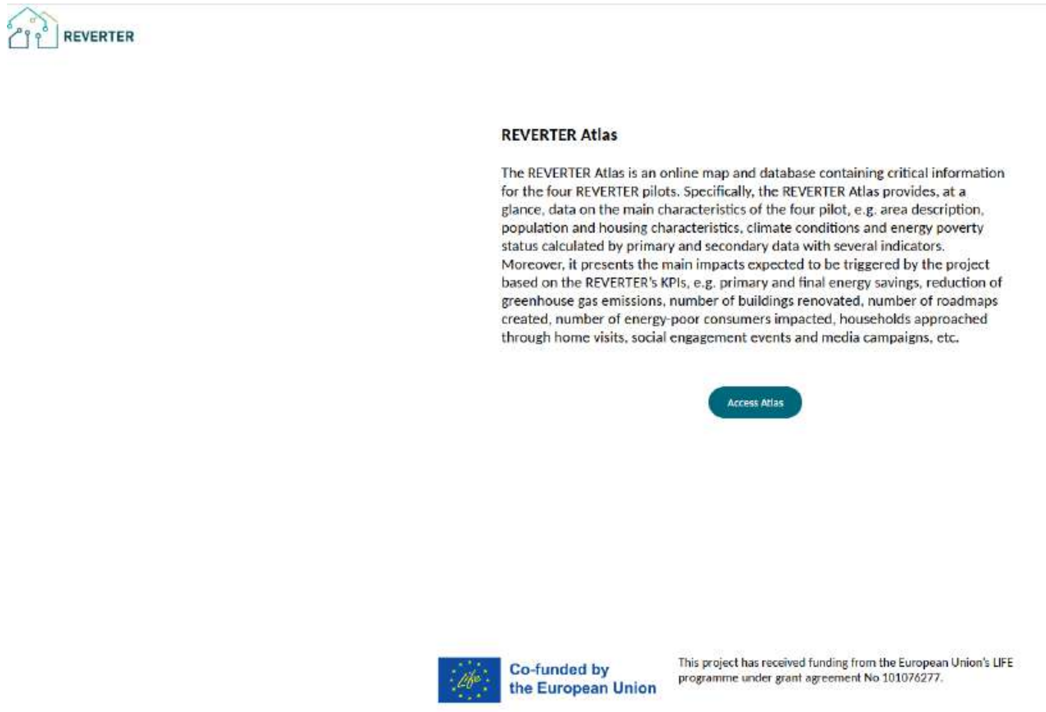



*Figure 3. REVERTER Atlas – Welcome screen*

## 2.2 Structure and content

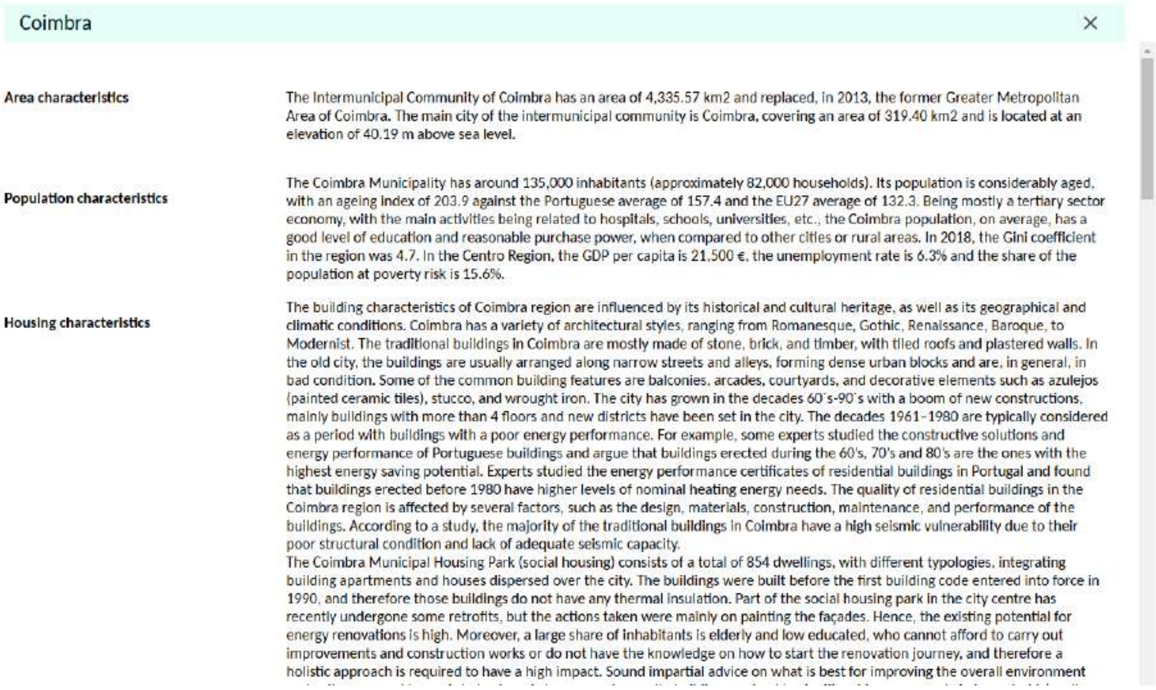
The REVERTER Atlas is an interactive map depicting the four REVERTER pilots (Fig. 4):

- Brezovo, Bulgaria
- Athens Urban Area, Greece
- Riga, Latvia
- Coimbra, Portugal

The user will find a summary of the area characteristics by clicking on the pilots' pins, as shown in Fig. 5, and will retreive for more specific information (KPIs, energy poverty levels, etc.), by clicking on "More" (Fig. 6).


*Figure 4. REVERTER Atlas – Main screen*


*Figure 5. REVERTER Atlas – Summary information about the area characteristics of the Coimbra pilot*


Coimbra

**Area characteristics**

The Intermunicipal Community of Coimbra has an area of 4,335.57 km2 and replaced, in 2013, the former Greater Metropolitan Area of Coimbra. The main city of the intermunicipal community is Coimbra, covering an area of 319.40 km2 and is located at an elevation of 40.19 m above sea level.

**Population characteristics**

The Coimbra Municipality has around 135,000 inhabitants (approximately 82,000 households). Its population is considerably aged, with an ageing index of 203.9 against the Portuguese average of 157.4 and the EU27 average of 132.3. Being mostly a tertiary sector economy, with the main activities being related to hospitals, schools, universities, etc., the Coimbra population, on average, has a good level of education and reasonable purchase power, when compared to other cities or rural areas. In 2018, the Gini coefficient in the region was 4.7. In the Centro Region, the GDP per capita is 21,500 €, the unemployment rate is 6.3% and the share of the population at poverty risk is 15.6%.

**Housing characteristics**

The building characteristics of Coimbra region are influenced by its historical and cultural heritage, as well as its geographical and climatic conditions. Coimbra has a variety of architectural styles, ranging from Romanesque, Gothic, Renaissance, Baroque, to Modernist. The traditional buildings in Coimbra are mostly made of stone, brick, and timber, with tiled roofs and plastered walls. In the old city, the buildings are usually arranged along narrow streets and alleys, forming dense urban blocks and are, in general, in bad condition. Some of the common building features are balconies, arcades, courtyards, and decorative elements such as azulejos (painted ceramic tiles), stucco, and wrought iron. The city has grown in the decades 60´s-90´s with a boom of new constructions, mainly buildings with more than 4 floors and new districts have been set in the city. The decades 1961-1980 are typically considered as a period with buildings with a poor energy performance. For example, some experts studied the constructive solutions and energy performance of Portuguese buildings and argue that buildings erected during the 60's, 70's and 80's are the ones with the highest energy saving potential. Experts studied the energy performance certificates of residential buildings in Portugal and found that buildings erected before 1980 have higher levels of nominal heating energy needs. The quality of residential buildings in the Coimbra region is affected by several factors, such as the design, materials, construction, maintenance, and performance of the buildings. According to a study, the majority of the traditional buildings in Coimbra have a high seismic vulnerability due to their poor structural condition and lack of adequate seismic capacity.
The Coimbra Municipal Housing Park (social housing) consists of a total of 854 dwellings, with different typologies, integrating building apartments and houses dispersed over the city. The buildings were built before the first building code entered into force in 1990, and therefore those buildings do not have any thermal insulation. Part of the social housing park in the city centre has recently undergone some retrofits, but the actions taken were mainly on painting the façades. Hence, the existing potential for energy renovations is high. Moreover, a large share of inhabitants is elderly and low educated, who cannot afford to carry out improvements and construction works or do not have the knowledge on how to start the renovation journey, and therefore a holistic approach is required to have a high impact. Sound impartial advice on what is best for improving the overall environment

*Figure 6. REVERTER Atlas – Detailed information about the Coimbra pilot*

The detailed information includes the following fields:

- Area characteristics
- Population characteristics
- Housing characteristics
- Climate conditions
- Energy poverty status
- Impacts expected to be triggered by the project till the end of the project and 5 years beyond
  - Primary Energy Savings in GWh/year
  - Final Energy Savings in GWh/year
  - Renewable Energy generation in GWh/year
  - Reduction of greenhouse gas emissions in tCO2eq/year
  - Investments in sustainable energy in €
  - Number of buildings renovated
  - Demonstration of the effectiveness and replicability of the proposed solutions among energy-poor households
  - Number of roadmaps created
  - Number of energy-poor consumers impacted
  - Number of people enjoying multiple benefits, such as improved mental and physical health, etc.
  - Number of people helped to improve their quality of life:

- Number of people helped to adapt their energy use behaviour
- Households approached through home visits
- Households approached through social engagement events
- Households approached through media campaigns

During the project, this information will be updated following the pilot implementation achievements.

# 3 Concept and design of the REVERTERUp!

## 3.1 The REVERTERUp! concept

The REVERTERUp! is actually an online tool mentioned in T5.2. However, it is described in this deliverable because NTUA developed it in parallel with the REVERTER Knowledge Database and Atlas.

The REVERTERUp! is addressed to households. Although similar tools are available (for example, in Greece, the Regulatory Authority for Energy, Waste and Water – RAAEY has developed a tool entitled "Odigos Exoikonomisis Energeias[1]"), REVERTERUp! differs because it requires minimum input from the user to estimate the initial energy consumption, the annual monetary benefits for twelve pre-defined energy retrofit combinations, the investment cost, etc. This simplicity comes at the cost of accuracy because the calculations are based on an "average" house. On the other hand, the app requires minimum effort, time and technical knowledge (e.g. the construction materials of the external walls, the type of window frames, etc.). The latter is important, especially for the target groups of REVERTER.

The app was initially developed and tested for the Greek pilot, i.e. the Athens Urban Area, in English. The main input and the calculation sheet were then shared with the partners of the other three pilot areas, i.e. Brezovo, Coimbra and Riga, who suggested specific modifications so as to adapt the tool to the local conditions.

The four final versions were translated into the national languages. The app is accessible through the REVERTER Hub (http://app.reverterhub.eu/), as shown in Fig. 7, or directly through the four local OSS:

http://app.reverterhub.eu?location=Athens

http://app.reverterhub.eu?location=Brezovo

http://app.reverterhub.eu?location=Coimbra

http://app.reverterhub.eu?location=Riga

[1] The tool is available at: https://www.buildingenergysaving.gr/

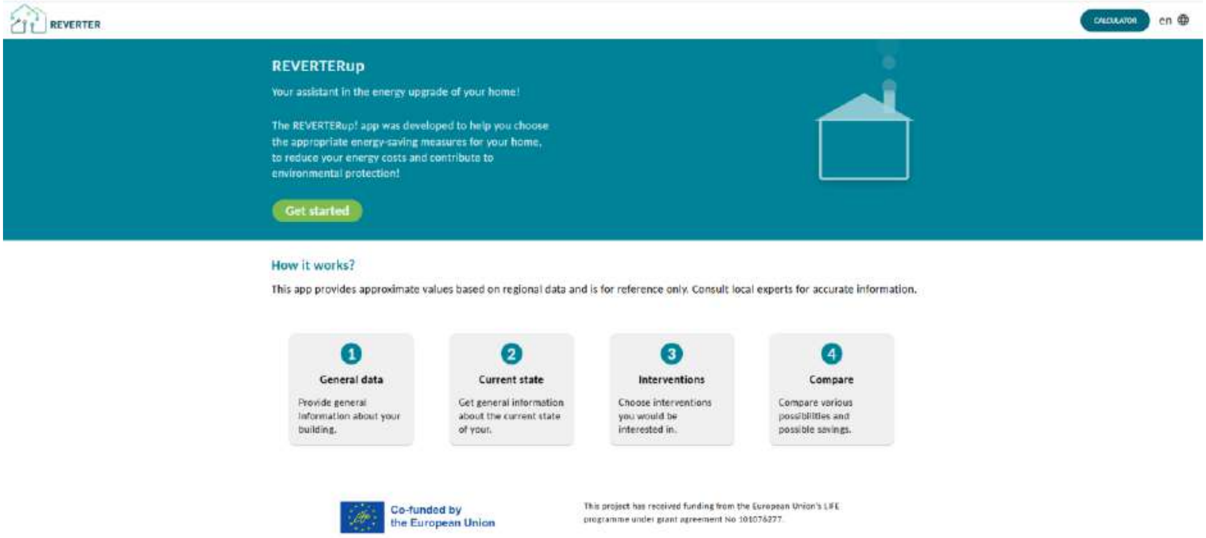



*Figure 7. REVERTERUp! – Main screen of the English version at http://app.reverterhub.eu/*

## 3.2 Structure and content

The REVERTERUp! consists of four tabs, as shown in Fig. 7, namely “General data”, “Current state”, “Interventions” and “Compare”.

The first tab (Fig. 8) is an input sheet requiring basic information about the characteristics of the house and the heating and cooling systems used.

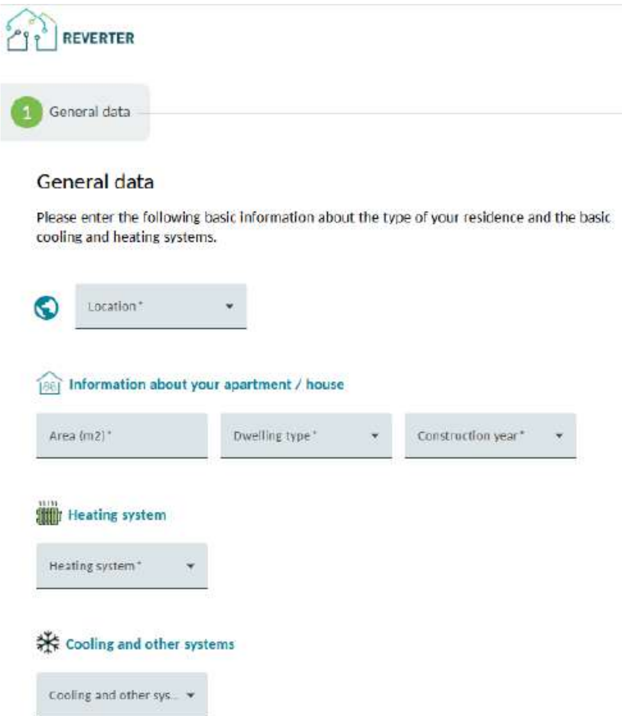



*Figure 8. REVERTERUp! – The “General data” tab*

The second tab (Fig. 9) shows the results of the analysis for the current state of the house, which includes information about the annual energy consumption (in kWh) for heating, cooling, lighting, etc., the annual cost of thermal energy and electricity (in EUR), the primary energy and the annual energy-related $CO_2$ emissions (in kg).

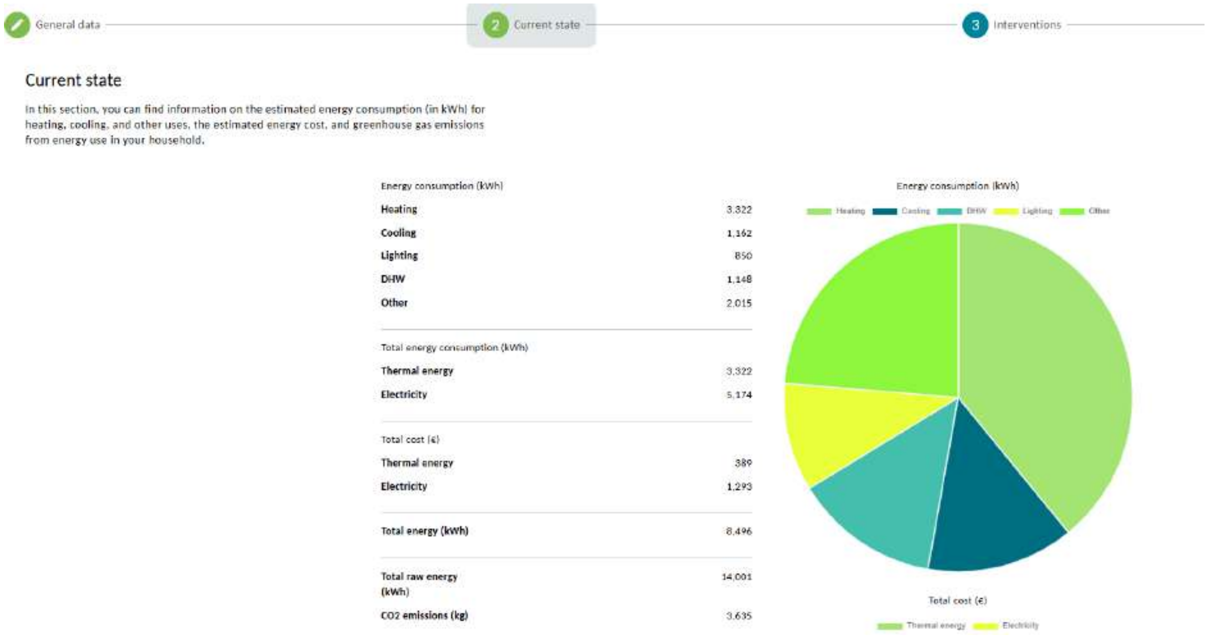



*Figure 9. REVERTERUp! – The "Current state" tab*

In the "Interventions" tab (Fig. 10), the user is provided with 12 predefined energy interventions, namely:

1. Frames replacement with more energy-efficient ones
2. Thermal Insulation
3. Solar System
4. Heat Pump
5. Geothermal Heat Pump
6. Photovoltaic System
7. Building's Shell Interventions (thermal insulation and frames replacement)
8. Building's Shell Interventions & Solar System
9. Building's Shell Interventions & Solar System & Heat Pump
10. Building's Shell Interventions & Solar System & Geothermal Heat Pump
11. Building's Shell Interventions & Solar System & Heat Pump & Photovoltaic System

12. Building's Shell Interventions & Solar System & Geothermal Heat Pump & Photovoltaic System


*Figure 10. REVERTERUp! – The "Interventions" tab*

The user can select any energy intervention she/he wishes to examine. For each intervention, the following detailed information is presented (see for example Fig. 11):

- The energy savings (in kWh) for heating, cooling, and other uses annually
- The investment cost of each intervention (in €)
- The annual reduction in greenhouse gas emissions (in kg $CO_2$)
- The annual reduction in energy costs (in €)
- The payback period of the investment (in years)

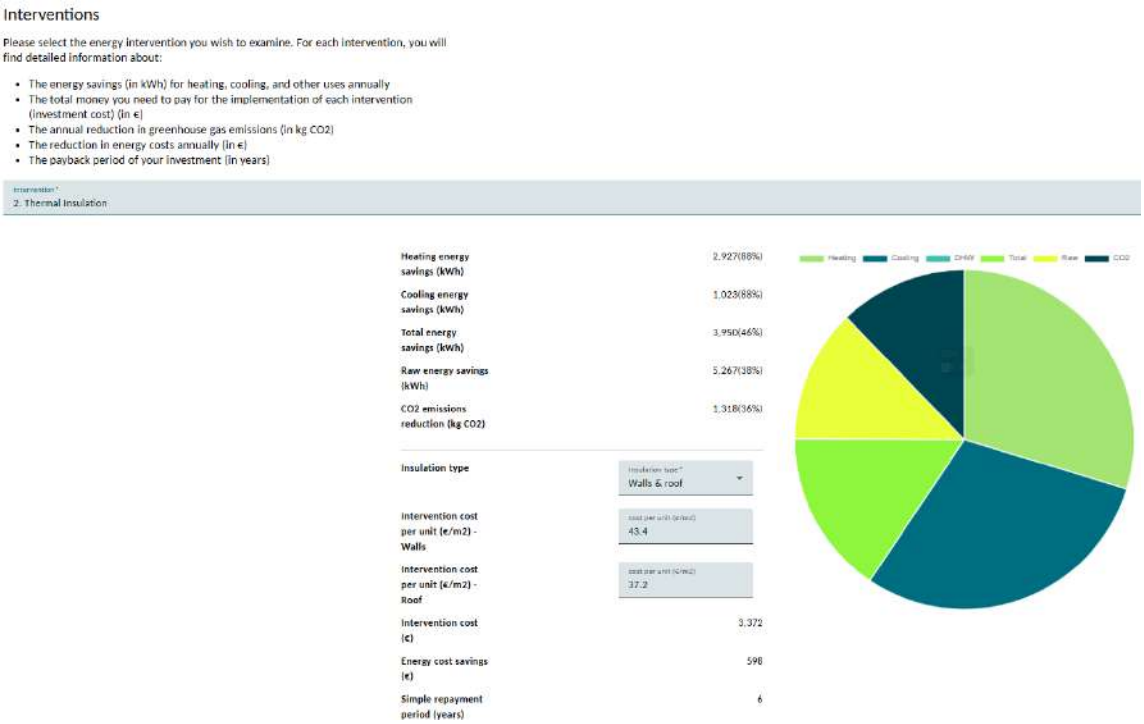



*Figure 11. REVERTERUp! – The "interventions" tab – Illustrative results for thermal insulation*

The calculations are based on predefined unit values. Nevertheless, the app offers the user the ability to modify some unit costs, as shown in Fig. 11.

Finally, the last tab, "Compare", allows the user to quickly compare all proposed alternative interventions through easy-to-understand charts. The comparisons are limited to the following information:

- Investment cost (in €)
- Annual energy cost savings (in €)
- Payback period (in years)
- Cost per saved kWh (in kWh/€)
- Annual greenhouse gas emissions reduction (in kg $CO_2$)

An illustrative example of this tab is presented in Fig, 12.

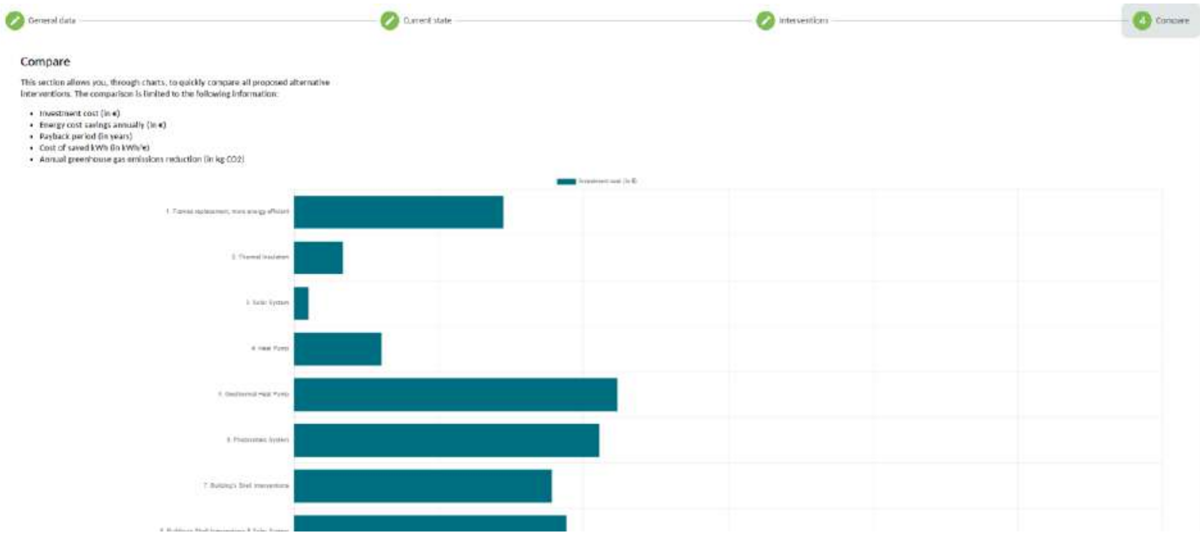



*Figure 12. REVERTERUp! – The “Compare” tab – Illustrative example for the investment cost*

# 4 Development process and technical specifications

The three applications were developed using an iterative and modular development methodology, which included the following key stages:

1. Requirement Analysis: Requirements were discussed among the partners to define the functionality and technical needs of each application. The key features of the three applications are, as follows:
   - REVERTER Knowledge database: Multi-criteria search functionality, including filters for authors, keywords, language, regions and more. Optimized queries ensured minimal latency for large datasets. Ability to accommodate future data growth, with a fine-tuned architecture designed for horizontal scalability and the addition of more structured datasets over time.
   - REVERTER Atlas: Interactive maps with zoom, pan, and detailed pop-ups showing project pilot information. The application also supports dynamic loading of geospatial data layers to optimise performance.
   - REVERTERUp!: Ii includes dynamic data visualization based on user input, implementation of standard energy variables, and rigorous input validation mechanisms. The application handles a large number of calculations performed on-the-fly, and processes several combinations and cases to provide tailored results.
2. Architecture Design: The architecture for each application was planned based on the Single Page Application (SPA) model using Angular. This approach was chosen for its ability to deliver dynamic and responsive user experiences.
3. Frontend Development: Angular was employed as the primary framework for all three applications due to its component-based structure, which facilitates modular and reusable code and Angular Material was used to ensure a cohesive, responsive, and visually appealing user interface. For visualizations in the REVERTERUp!, Chart.js was integrated to produce dynamic graphs and charts.
4. Backend Development: The backend services for the database and mapping applications were developed with a combination of PostgreSQL and Strapi. PostgreSQL, a powerful relational database management system, was selected for its reliability and performance in handling complex queries and large datasets. Strapi, a Node.js-based headless CMS, provided a flexible API-driven backend to support the database's functionality. Custom API endpoints were developed to enable seamless communication between the frontend and backend.
5. Geospatial Integration: For the REVERTER Atlas, OpenLayers, a high-performance library for displaying map data in web browsers, was utilised to handle geospatial data. GeoJSON formatted files were used to store and manage geographical features. Interactive map layers were configured to display project pilot locations and features like panning, zooming, and pop-ups were implemented to enhance user interactivity.

6. Testing and Validation: Unit testing was conducted using Jasmine and Karma for frontend components, while backend APIs were tested using Postman. Automated test scripts were also developed to validate input handling, data processing, and API responses. Finally, cross-browser tests were conducted to ensure compatibility with major web browsers.

# 5 Monitoring, improvements and updates

## 5.1 Monitoring

Monitoring and improvement of the REVERTER Knowledge Database and Atlas will involve a systematic approach to ensure performance, security, and user satisfaction. For the Knowledge Database, consistent performance monitoring includes tracking query efficiency, resource utilisation, and reviewing error logs. It is equally important to maintain data integrity by scheduling validation routines and ensuring that backups are regularly tested for reliability. To guarantee uptime, automated health checks and alert systems are in place to promptly address issues such as downtime or threshold breaches. For the REVERTER Atlas, also performance metrics like response times will be used to monitor its functionality.

The REVERTRUp!'s performance will be closely monitored to track crashes and optimise load times. Gathering user feedback during social engagement events and home and OSS visits will also prove helpful for improvement.

## 5.2 Improvements and updates

Improving these systems demands strategic approaches tailored to each component. For instance, optimising database queries, automating backups, and scaling resources are effective strategies for the Knowledge Database. For the Atlas, data updates when needed will boost efficiency and satisfaction. Enhancing the REVERTERUp! performance involves updating the unit costs (e.g. the unit cost of fuels and energy retrofit measures) and refining features based on user needs.

Continuous improvement follows a structured workflow: data collection, trend analysis, task prioritisation, implementation of updates, and post-implementation evaluation. This iterative process ensures the Knowledge Database, the Atlas and the REVERTERTUp! consistently meet high performance and user satisfaction standards.

Major changes will be made only after careful work on the concept in close collaboration with responsible partners for each project pilot. For example, it will be interesting to discuss feedback from users and observe similarities and differences in the application of the tools in the four different project pilots before designing and implementing major changes.