iBRoad2EPC

Integrating Building Renovation Passports
into Energy Performance Certification schemes
for a decarbonised building stock

iBRoad2EPC in depth

Technical report on the definition of the proposed concept, content and methodology

ifeu – Institute for Energy and Environmental Research

July 2023

www.ibroad2epc.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 101033781

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Published in February 2023 by iBRoad2EPC. Updated July 2023.

All of iBRoad2EPC's reports, analysis and evidence can be accessed from ibroad2epc.eu

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EXECUTIVE SUMMARY

This report presents the concrete concept and methodology for the technical implementation of iBRoad2EPC. It is based on the conceptualisation report which derived the key principles and features of iBRoad2EPC from market analyses conducted in six countries (Bulgaria, Greece, Poland, Portugal, Romania and Spain).

iBRoad2EPC is intended to integrate Building Renovation Passport (BRP) elements into existing EPC schemes. The intended added value of iBRoad2EPC for building owners is the starting point of the further development:

Added value of iBRoad2EPC

- Improvement of the renovation recommendations in EPCs with BRP elements that are aligned with the national climate targets for the building sector
- Outline of an individual long-term renovation strategy considering
    - Step-by-step renovations that gradually lead to a consistent deep renovation
    - Avoidance of mistakes through early preparation of later renovation measures
    - Alignment with overarching national building targets
    - Announcing future requirements and obligations (e.g. ban of fossil fuels, minimum energy performance standards) in order to prepare the building and fulfil all legal requirements
- Obligatory on-site visit by trained expert enhances quality
- Additional indicators (e. g. IEQ, SRI) can be included

The intended added value is the basis to derive the concrete key features of iBRoad2EPC. **The basic questions that each iBRoad2EPC answers are**

- What?
  technical description of renovation measures to carry out in an individual building
- When?
  Likely time span to implement the measures
- How?
  technical specifications of the measures to align them with the national targets for the building sector
- What to beware of?
  legal obligation that the building foreseeably will have to fulfil
- What to pay attention to?
  Notes to prepare for later steps in order to avoid lock-in situations and achieve deep renovation standard

Modular Approach

These questions can be answered in different information depths causing different effort. The depth of information in iBRoad2EPC can be adapted to the implementing countries´ requirements. It depends on how iBRoad2EPC is to be positioned in the countries' energy consulting market. If iBRoad2EPC is to be a complement to every EPC issued in a country, it must have a low additional cost. In this case iBRoad2EPC is closely related to the EPC. If a country chooses to introduce iBRoad2EPC independently from EPCs as an energy consultancy that building owners order voluntarily, the effort required to produce it can be higher. In this case iBRoad2EPC functions like a BRP.

The design of iBRoad2EPC allows Member States to decide freely where exactly they want to place it between EPC and BRP. Many individual solutions can be realised along the band width. To this end, iBRoad2EPC follows a semi-flexible approach, in which a unified Basic Module can be complemented flexibly with additional modules. The unified core features include the output of indispensable

technical information for building owners and, in addition, a unifying methodology and layout as well as a uniform software infrastructure to issue the iBRoad2EPC. The minimum content is derived from the main questions the iBRoad2EPC has to answer as shown above. The additional modules provide extra information on energy demand, investment cost, smart readiness (SRI) and indoor environmental quality (IEQ).

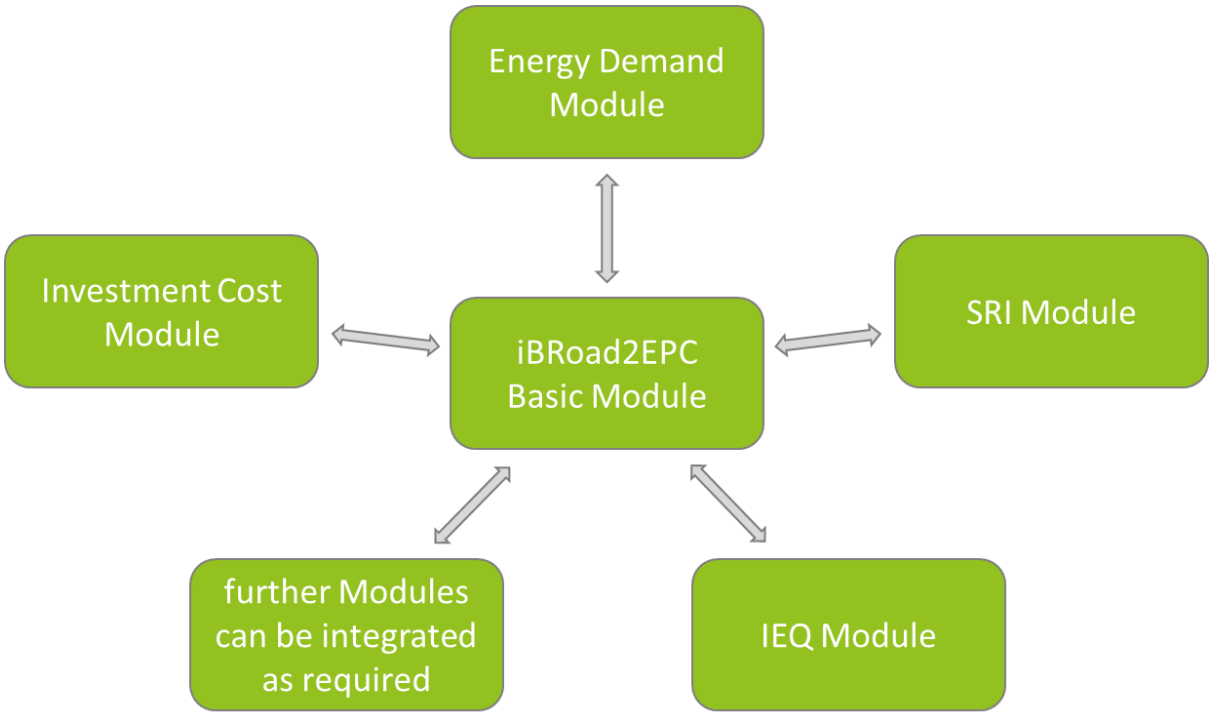


Figure 1: semi-flexible modular concept of iBRoad2EPC

Basic Module

The five questions that the Basic Module answers are processed in a standardised procedure. The issuers determine **which renovation measures are carried out when and in what order**. These decisions require the expertise of a specialist and an on-site visit. They are not made automatically because they form the basis for the individual renovation strategy of the building. This increases the added value for the building owners considerably, because the peculiarities of a building are taken into account.

The question **how** the measures should be implemented and which specific requirements they have to fulfil is answered automatically. All measures are aligned with the national GHG targets for the building sector by default. This avoids recommending inadequate renovations that lead to a lock-in situation. If required, issuers may edit the specifications to adapt to individual circumstances.

The question **what to beware of** refers to obligations the building will have to fulfil foreseeably in the future. The obligations result from the national legislation, e. g. the national implementation of minimum energy performance standards (MEPS) as foreseen in the current draft of the next Energy Performance of Buildings Directive (EPBD). Thus, building owners receive a clear overview which standards their buildings will have to fulfil when and how they can be met.

The question **what to pay attention to** is also answered automatically. iBRoad2EPC provides notes and tips that link the various renovation steps and support achieving a deep renovation. In particular, the notes indicate how later renovation measures should be prepared in earlier steps to achieve high quality component connections.

Graphical Design

The aim of the iBRoad2EPC graphic design is to be attractive, to make the iBRoad2EPC a recognisable brand, to allow the iBRoad Roadmap and Logbook to adopt the design, thus creating a product family (which is not part of the project), to work both online and in print, to display various numbers of modules flexibly, and to present the technical content in a way that is easy to understand.

The graphical design consists of an overview page and additional detail pages. A system of tabs helps to navigate through the various modules.

iBRoad2EPC Assistant Tool

The iBRoad2EPC is created with an online tool called iBRoad2EPC Assistant. The main objectives of this tool are

- create the iBRoad2EPC in a uniform design,
- output the iBRoad2EPC in an online version
- create a printable page that can be attached to the EPC and leads to the iBRoad2EPC,
- provide clear and intuitive user guidance to the issuers,
- facilitate issuers in assigning renovation measures at specific points in time,
- output automatic selection of prefabricated content,
- allow easy overwriting of all default content,
- provide easy expandability with additional modules,
- demonstrate that the iBRoad2EPC API contains all endpoints needed to create the iBRoad2EPC from client software.

The iBRoad2EPC Assistant is a backend tool that compiles and transmits data for a specific building on request. The request can be submitted from different platforms or frontends. This allows the iBRoad2EPC Assistant to be connected to various existing tools in the Member States, such as EPC software or energy performance registers. In addition, a standardised frontend for the Assistant is delivered to enable data entry independently from external software.

The iBRoad2EPC Assistant uses a multi-faceted application programming interface (API) as an interface. The data is stored in relational databases. In order to connect the API to a frontend, user interface or software, this must allow the input of the required input data. Depending on the type of frontend, various required data may already be available. For example, in an EPC software, the information about the efficiency class of a building is generally available. Data that is not already available in the frontend, however, must be entered via an input mask. This input mask must be integrated into the software products by software producers in the respective implementing countries. In this way, issuers can create the iBRoad2EPC directly from one application without having to change to the iBRoad2EPC Assistant. In case local software providers do not make or have not yet made these changes to their products, a standardised front-end is provided. It is the default input mask for the Assistant tool to issue the iBRoad2EPC. It guarantees that all required input data to process the Assistant tool can be entered.

The printable page allows handing out a hard copy with a link to iBRoad2EPC together with a paper version of the EPC. In this case, iBRoad2EPC works like an annex to the EPC. The online output of iBRoad2EPC offers intuitive user guidance, links to external information, such as authorities or funding schemes and context-sensitive help.

Embedding iBRoad2EPC into existing Instruments

iBRoad2EPC can fit into the existing "ecosystem" of building and energy related instruments such as EPC software, building databases, funding, renovation obligations and occasions that trigger the issuance of EPCs in the respective implementing countries. It can be implemented as the only tool of the iBRoad tool family or together with the iBRoad Renovation Roadmap and the iBRoad Logbook.

iBRoad2EPC may than serve as a “light version” of the iBRoad Renovation Roadmap and raise the customers´ interest. Building owners who want more specific information can order a detailed iBRoad Renovation Roadmap. There they can easily orientate themselves because they already know the general layout from iBRoad2EPC.

The iBRoad2EPC can be stored and displayed as a document in the iBRoad Logbook. Building owners can enter concretely implemented renovation measures in the Logbook and thus document their renovation progress. They can align planned renovation measures with the iBRoad2EPC and check after completion whether the building is still on the target path. This provides the Logbook with additional information about the future planned energy status of the buildings. In this way, the future development of the building stock can be modelled using the Logbook data. As this modelling is based on the concrete renovation strategies of individual buildings, it is well suited as a bottom-up cross-check of overarching renovation strategies such as the Long Term Renovation Strategies (LTRS) or National Building Renovation Plans (NBRP), which have a top-down perspective. An interface to a logbook is not part of the current project.

iBRoad2EPC is designed in a way that it can also be coupled with an existing national EPC database or a digital building logbook. The concrete way of data transfer between iBRoad2EPC and the EPC database has to be adapted in each implementing country to the respective objectives, the existing data exchange formats and the existing organisation of data transfer between EPC software and EPC database. Manual, assisted or fully automated data exchange is possible.

Another possible conceptual idea is to combine iBRoad2EPC data with spatially resolved data, such as geoinformation systems. This could support municipal heat planning. It can provide the present and future heat demand for individual buildings, neighbourhoods, and settlements. Thus, it can allow predicting the economic viability of planned district heating or the development of electric load through heat pumps. Other tools that make use of the spatial resolution of the heat demand may be developed if required. This function is a possible further development of iBRoad2EPC and is listed to show the many possible combinations with other instruments. However, it is not part of the work in this project.

The options for embedding iBRoad2EPC into existing policy instruments were considered during the development of iBRoad2EPC in order to create a tool that can be widely adapted and flexibly used.

INTRODUCTION

The building sector accounts for approximately 40 % of total energy consumption and 36 % of CO2 emissions in the European Union. Currently, almost 75 % of the European building stock is not energy efficient, while the building renovation rate is very low[1].

Deep building renovation has the potential to lead to significant energy savings and lower CO2 emissions and contribute to the energy and climate objectives at national and European level.

The iBRoad2EPC project is intended to contribute to raising this potential. To this end, it aims to spread the idea of long-term renovation strategies (BRP) widely, and to provide building owners with pragmatic assistance.

The iBRoad2EPC project

The iBRoad2EPC project funded by the Horizon 2020 European programme represents the next step in energy performance assessment schemes and certification practices, promoting and showcasing the integration of Building Renovation Passport elements into EPC schemes. Building on the results of the iBRoad project (2017-2020) which developed, tested and delivered a model for the Building Renovation Passport supporting single-family homeowners with personalised advice to facilitate stepwise deep renovation, iBRoad2EPC aims to bridge the Building Renovation Passport with the EPC, and expand, improve and broaden their format and joint scope to consider additional features and become applicable also to multi-family and public buildings. The aim is to improve reliability, usefulness and effectiveness, thereby establishing the next generation of EPCs that will support Europe's decarbonisation ambitions while improving conditions for building occupants. This is done by clustering the project's activities around four main pillars:

(1) assess the needs, potential and practicability of merging the EPC with the Building Renovation Passport;
(2) adapt the iBRoad concept to become part of EPCs;
(3) test and evaluate the applicability of iBRoad2EPC in six countries (Bulgaria, Greece, Poland, Portugal, Romania and Spain), including training for issuers and EPC issuers and
(4) facilitate the adoption and exploitation of the iBRoad2EPC model across Europe.

Implementing authorities in the six countries are directly involved in the process of conceptualisation, development and testing of iBRoad2EPC to become an integral part of existing relevant schemes. Targeted communication, dissemination and exploitation activities at national and European level support further acceptance and uptake. The project leverages existing knowledge from other projects to expand EPC features and contributes back policy proposals as well as training and capacity building modules.

Objectives of this report

This report presents the concrete concept and methodology for the technical implementation of iBRoad2EPC. The report builds the basis for the software implementation of the iBRoad2EPC Assistant tool, the API interface, and the output forms.

The report is based on the report "Conceptualising iBRoad2EPC: can EPCs be upgraded to include Building Renovation Passport elements?" and other studies performed in the context of iBRoad2EPC which provide the basic fundamental information that goes into the development, e.g.: "Summary

[1] EU annual average renovation rate is confirmed at 1%, with deep renovations accounting for only 0.2-0.3% of the renovated floor area (European Commission, 2019).

Analysis of national Long-term Strategies", "Experience from other Projects related to Links between EPCs and the BRP", "Report on the Adaptation to multi-family and public Buildings".

The software implementation started in parallel to and is based on this report. As it is still ongoing while this report is being finished minor discrepancies may occur in the final versions of the software tools.

This report builds the basis for the adaptation of iBRoad2EPC to the specific requirements in the pilot countries Bulgaria, Greece, Poland, Portugal, Romania and Spain. Therefore, concrete solutions in this report will be discussed in the National Advisory Committees (NACs) in the respective countries. This process will prepare the field test and the roll-out of iBRoad2EPC in these countries. The training tool kit for the field test will build on this report as well as the stakeholder communication and the advisory package for public authorities.

This report is structured as follows: Chapter "Key Features of iBRoad2EPC" defines the key features and concrete added value of iBRoad2EPC from the customers´ perspective. Chapter "Strategic approach" describes the modular approach of iBRoad2EPC and how it enables to adapt to specific country requirements. Chapter "iBRoad2EPC Basic Module" introduces the Basic Module of iBRoad2EPC, how it works and what it comprises. The graphical design of iBRaod2EPC is shown in chapter "Graphical design of iBRoad2EPC". Chapter "Additional Modules" describes the additional Modules that iBRoad2EPC can be extended with. Chapter "Issuing an iBRoad2EPC with an Assistant Tool" shows the Assistance tool to issue the iBRoad2EPC and how it can be linked to country specific software tools. The various ways to embed iBRoad2EPC into the existing ecosystem of building related instruments in individual countries are described in chapter "Embedding iBRoad2EPC into existing Instruments".

Methodology

- Clarification of key features that iBRoad2EPC needs to provide
- Definition of the main added value that iBRoad2EPC provides
- Anticipation of different use cases
- Determination of a modular approach
- Elaboration of the various modules
- Elaboration of the graphical design of the output forms
- Determination of the functionalities of the iBRoad2EPC Assistant tool
- Outlining the possibilities of embedding iBRoad2EPC in existing instruments

KEY FEATURES OF IBROAD2EPC

The conceptualisation of iBRoad2EPC is described in the report "Conceptualising iBRoad2EPC: can EPCs be upgraded to include Building Renovation Passport elements?". It derives the key principles and features of iBRoad2EPC from market analyses conducted in six countries (Bulgaria, Greece, Poland, Portugal, Romania and Spain). It summarises the key features as follows:

iBRoad2EPC should serve as a link between existing EPCs and future building renovation passports. It is intended to integrate Building Renovation Passport (BRP) elements into existing EPC schemes by adapting the building renovation passport concept to fit existing EPC certification regimes and to improve the list of recommendations. The latter will also imply that EPCs will need to evolve and iBRoad2EPC is a beacon that highlights what needs to be reformed to capture high quality and trusted information that is able to support building owners make the steps needed to get to zero emissions buildings.

iBRoad2EPC will improve the quality, reliability, data gathering and storage approaches and EPC recommendations in a number of ways. The reliability of the recommendations is improved enabling a staged or one step renovation approach to a future-proof state.

The aim of iBRoad2EPC is to bring existing EPCs closer to a decarbonisation roadmap and introduce a focus on the long-term objective of decarbonisation by:

- including improvement measures in a specific sequence to avoid lock-in effects
- ensuring that every measure implemented is part of a comprehensive renovation strategy
- complying with future regulatory and financial requirements, e.g. mandatory Minimum Energy Performance Standards (MEPS), mortgage portfolio standards or the EU taxonomy regulation
- presenting the recommendations in a way that can easily be understood by the end-user and consider the user's needs.

The specific way in which iBRoad2EPC will be designed in individual Member States may vary depending on the specific requirements. The implementation of iBRoad2EPC with a modular approach allows maximum flexibility and customisability. Thus, iBRoad2EPC can appear as an annex to the EPC as well as a stand-alone consulting product. The basic content, the general design and the key features, however, make the brand core of iBRoad2EPC and remain the same regardless of the flexible adjustments.

iBRoad2EPC is intended to provide the basic information of a BRP, but require only a small amount of effort to create. To this end, it should be generated largely automatically from as few data entries as possible. Complex calculations, which cause a large part of the effort for the BRP, are only foreseen as an option. Despite extensive automation, care must be taken to provide advice that is as individual as possible. The indispensable content is shown and explained in Figure 2.

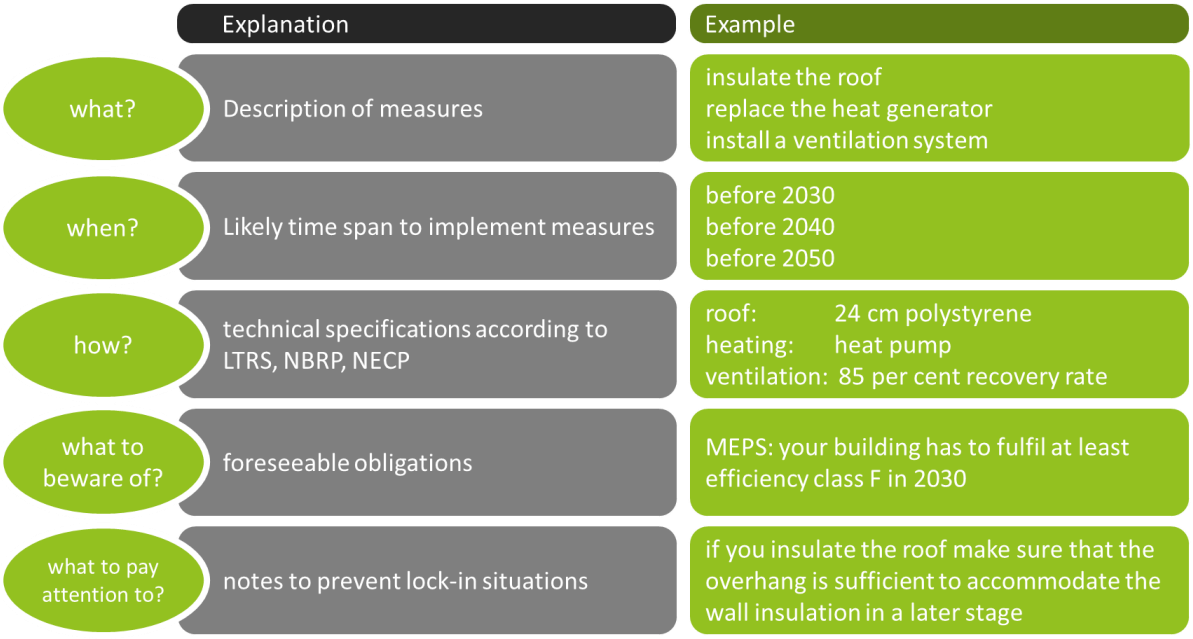


Figure 2: guiding questions to be answered by the Basic Module and examples for respective content

In case of stepwise renovations this information has to be provided for each renovation step. The functionality of the module that provides this basic information is described in detail in chapter "iBRoad2EPC Basic Module". Additional information can be included in the iBRoad2EPC depending on individual country requirements, such as investment cost, funding, and energy demand (see chapter "Additional Modules" for further information).

Added value of iBRoad2EPC

- Improvement of the renovation recommendations in EPCs with BRP elements.
- Outline of an individual long-term renovation strategy considering
  - step-by-step renovations that gradually lead to a meaningful whole,
  - avoidance of mistakes through early preparation of later renovation measures,
  - alignment with overarching national building targets,
  - future requirements and obligations (e.g. ban of fossil fuels, minimum energy performance standards) in order to prepare the building and fulfil all legal requirements

STRATEGIC APPROACH

The objectives of iBRoad2EPC were derived from different perspectives:

1. Looking at the various existing EPCs in the six implementing countries, it is clear that recommendations are being made, but sometimes at an unsatisfactory level of quality (see report "Summary Analysis of national Long-term Strategies"). Often, they do not include concrete technical renovation recommendations, are selected automatically, describe only few measures with insufficient information, and have no strict relation to the national strategies for the building stock. To overcome this, Building Renovation Passports (BRP) would be the appropriate tool. They comprise a renovation strategy for individual buildings taking into account the specific potential and restrictions as well as the targets for the building sector.
2. BRPs are designed as a complete plan including all measures, in a feasible sequence, with the required renovation depth to reach a target state. To this end, BRPs cause high processing effort that is not compatible with the large number of EPCs issued annually.

iBRoad2EPC aims to bridge this gap between EPCs and BRPs, taking the core information on target-oriented renovations, providing it at an adjusted information depth at affordable cost. This chapter shows the underlying approach to design the iBRoad2EPC to combine the benefits of EPC and BRP and to meet the requirements of the various groups involved. To this end, the required depth of information is first examined, which in turn is closely linked to the required processing effort. Then it is shown how iBRoad2EPC can be adapted to the different requirements in implementing countries. Finally, the requirements of the individual target groups are listed so that iBRoad2EPC can be tailored to them.

Adjusting Information Depth against Effort to issue iBRoad2EPC

The iBRoad2EPC is designed to bridge the gap between the EPC and the BRP. Where exactly it fits in between these two tools has a decisive influence on its design. The EPC is designed to be issued with rather little effort and in large numbers, as the aim is to achieve a high degree of dissemination. It provides a comparison between buildings based on few key indicators, usually final energy demand. It reaches million units across the EU annually. House owners do not have an intrinsic interest in EPCs but are obliged to have one when entering certain occasions. The triggering points for issuing EPCs are defined in national legislation. EPCs stand on the left-hand side in Figure 3.

The BRP marks the other end of the scale (right hand side in Figure 3). They are requested actively and voluntarily by building owners. The trigger is usually a concrete upcoming renovation project. The owners need detailed planning support. They are willing to pay a certain fee for it. BRPs are often supported by government subsidies. The market range of BRPs reaches only up to thousands or ten thousands per year.

Placing iBRoad2EPC between EPC and BRP

The design of iBRoad2EPC allows Member States to decide where exactly they want to place it between EPC and BRP. Many individual solutions can be realised along the band width. However, the relationship between issuance effort and market penetration can only be broken down to a limited extent. The decision as to whether the iBRoad2EPC should be mandatory or voluntary for homeowners must be made at an early stage of the implementation of the iBRoad2EPC. The possible positioning between EPC and BRP depends on this decision. The consequences of this decision are shown in the following three cases.

Case 1 - iBRoad2EPC as mandatory part of the EPC
If the iBRoad2EPC would be designed as an obligatory extension of the EPC, this would mean that building owners would by default and in all cases receive additional information. However, they would foreseeably have to bear the extra cost. Thus, the additional information of the iBRoad2EPC would have to provide a high added value for the owners to accept. Accordingly, the effort to create the iBRoad2EPC would have to be low and only marginally exceed the effort required to create the EPC. Furthermore, this would mean that the occasions to issue an EPC would apply also for the iBRoad2EPC (e.g., purchase or rental) and thus the number of buildings that would receive more detailed renovation advise would range in a few millions across the EU annually, thereby substantially, even though occasionally, increasing the number and depth of renovations performed each year. The issuing effort however would have to be kept in mind so as not to exceed the market capacity of the EPC issuers. This case represents the left end of the scale in Figure 3.

Case 2 - iBRoad2EPC as a voluntary BRP
If the iBRoad2EPC was designed as a specific kind of a BRP that building owners order voluntarily there would be less restrictions concerning effort and cost. Building owners would decide if they were willing to pay for the added value. An additional funding scheme could support the market. Yet, this approach would reach less but more aware, interested and possibly ready to act building owners. This case can be set to any point along the bandwith in Figure 3. The further it extends to the right (closer to a full BRP) the more content, effort and cost – e.g., with the support of additional funding schemes. The positioning depends mainly on how well it fits into the existing ecosystem of instruments.

Case 3 - full BRP
This case represents the right end of the scale in Figure 3. A full BRP usually requires comprehensive calculations causing high effort and costs. In many cases, BRPs are subject to funding programmes to make them economically attractive for building owners. They often only reach motivated and interested building owners. Their market penetration is limited by demand, the number of consultants and the processing time required.

The concept for the iBRoad2EPC is to be able to carry out both cases to meet the requirements in the respective Member States.

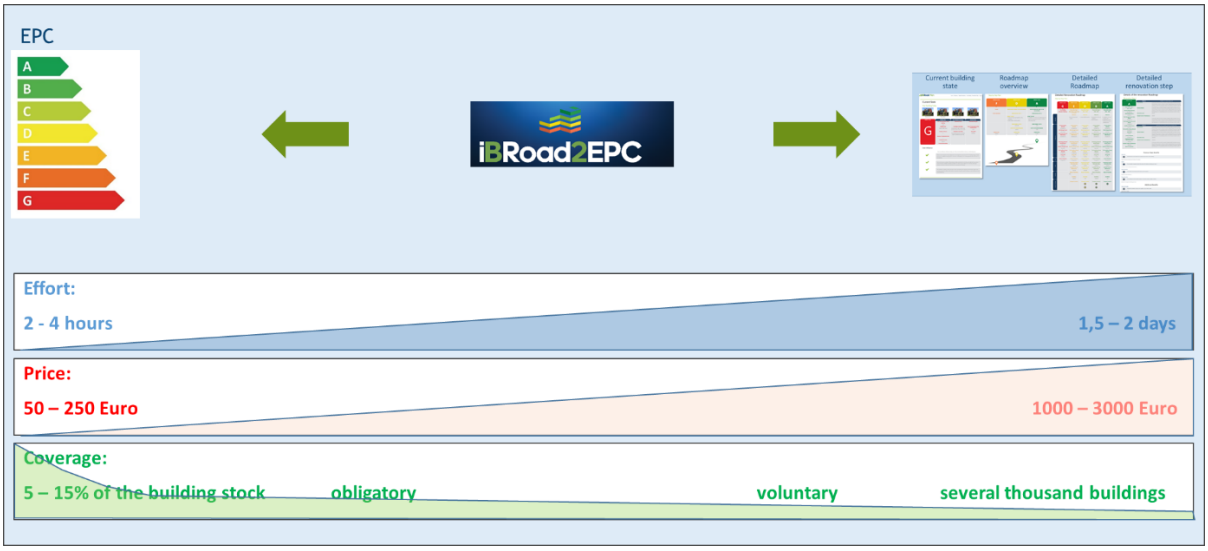


Figure 3: strategic placement of iBRoad2EPC in relation to the existing EPC and the Building Renovation Passport (BRP) with consequences for effort and cost to issue and market penetration

Semi-flexible unified Method

As already shown in the report "Conceptualising iBRoad2EPC", the initial conditions and requirements for the iBRoad2EPC vary considerably between the pilot countries due to differences in the market conditions of the EPCs across the MS. This is partly due to the policy framework of building energy instruments already established and partly due to the strategies already developed in the Member States before the start of this project. The iBRoad2EPC concept must therefore be able to adapt to these specific requirements. However, this does not mean that completely independent iBRoad2EPC solutions should be developed for each Member State. Instead, a semi-flexible approach is taken, in which a unified core can be complemented with flexible parts. The first step is to determine which features of iBRoad2EPC should be part of the unified core.

Unified Core Features

The unified core features include the output of indispensable technical information for building owners and, in addition, a unifying methodology and layout as well as a uniform software infrastructure. The indispensable technical information for building owners that have to be included in every iBRoad2EPC can be derived from the main questions the iBRoad2EPC has to answer. They represent the fundamental different content that distinguishes a BRP from other energy audits (see Figure 4).

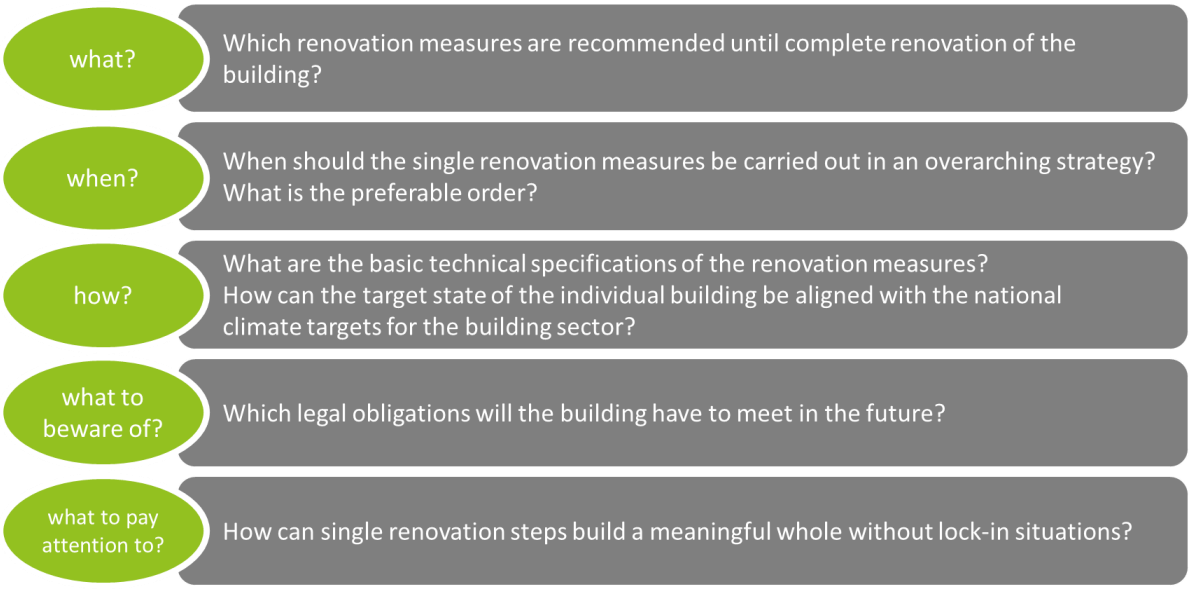


Figure 4: Indispensable technical information for building owners that have to be included in every iBRoad2EPC

In addition to the technical recommendations, the unified core features also include the layout and design of the iBRoad2EPC output form. This introduces a trademark that will be recognised in all implementing countries (see chapters "Brand design").

The software tool used by the issuers to create the iBRoad2EPC is also part of the unified core features. The basic functions of the tool, the look and feel, the user experience and navigation are defined along with the unified core features. The flexible extension modules, which can be added individually on request, will follow these specifications (please see chapter "Additional Modules" on the iBRoad2EPC Assistant).

The unified core features are bundled in the so-called Basic Module (see chapter "iBRoad2EPC Basic Module").

Flexible Elements

In addition to the Basic Module (unified core features), it is possible to add special features to the iBRoad2EPC individually. This will allow an upgrade to the iBRoad2EPC that is tailored to the specific country's needs. When implementing iBRoad2EPC, countries can decide whether and which additional features they want to integrate, so that iBRoad2EPC fits well into the existing consulting landscape or with other existing policy instruments in the buildings sector. These flexible extensions are organised in so-called additional modules (see Chapter "Additional Modules"). There are modules for the integration of investment costs and funding, energy demand, indoor environmental quality and the smart readiness indicator. The additional modules can be implemented independently from each other and be combined without restrictions. They each include an extension of the online tool, the integration of a calculation method if necessary, and one output page each.

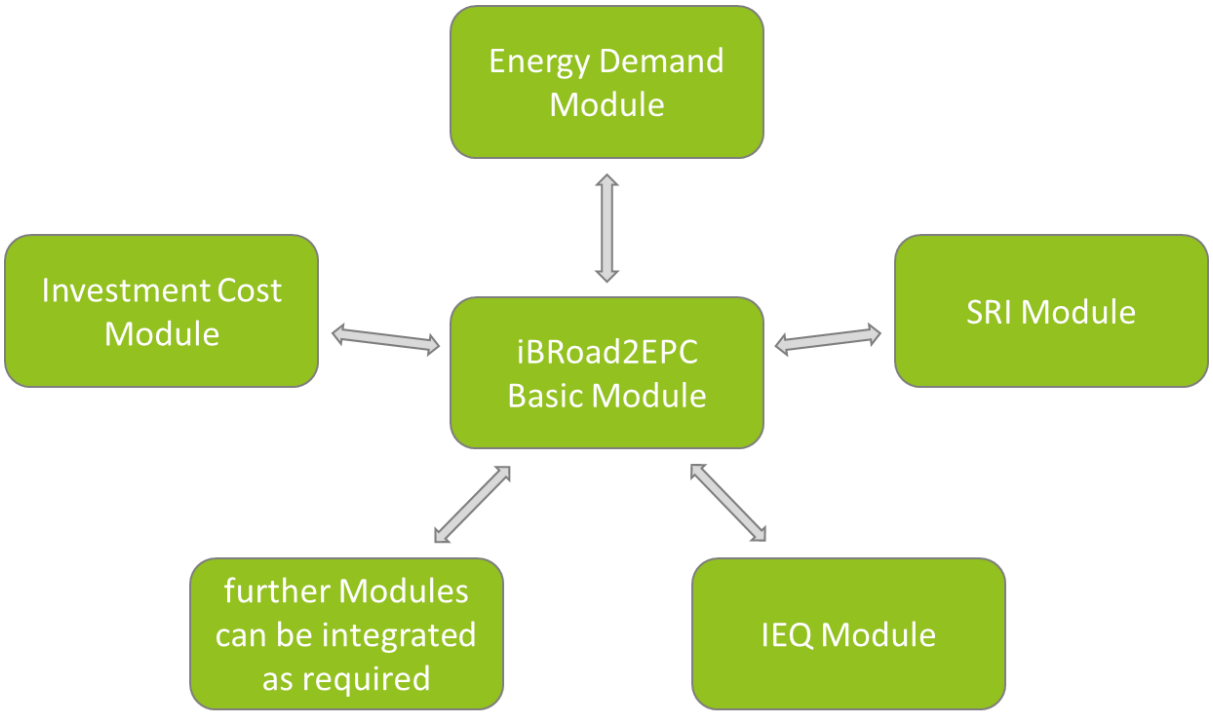


Figure 5: semi-flexible modular concept of iBRoad2EPC

Target Groups

iBRoad2EPC must satisfy the needs of all users involved and have a clear added value for them in order to be successfully implemented. Therefore, the groups involved are presented below.

Building Owners

The target group for the iBRoad2EPC is basically all building owners (within the project duration only residential buildings and public buildings) as they make the renovation decisions. This includes owners of owner-occupied one- and two-family houses as well as owners of apartment buildings and housing associations, condominium associations, owners of single apartments, property managers and other building societies. This also includes owners and operators of non-residential buildings. These are the same addressees that are addressees of the EPC, which is why coupling the iBRoad2PEC to the EPC makes sense. Thus, the target group is extremely heterogeneous. It includes building professionals as well as laymen. This must be taken into account in the design of the iBRoad2EPC (see chapter "Graphical design of iBRoad2EPC").

Assessors, Auditors, Issuers

Issuers of the iBRoad2EPC can vary depending on the Member State: they can be EPC issuers, but also specially trained energy auditors. The attractiveness of the iBRoad2EPC for them depends on the business model. It must therefore be possible to achieve an adequate margin with the iBRoad2EPC. To achieve this, it should be possible to use data that already has to be collected anyway. The additional effort for the creation of the iBRoad2EPC must not be higher than the additional willingness to pay by the building owners.

Public Authorities

From the public authorities´ point of view, the iBRoad2EPC should make a high contribution to the achievement of climate targets in the building sector. Furthermore, it must be in line with national legislation and fit in with other existing building instruments and advisory tools. At the European level, a harmonisation of the iBRoad2EPC is desirable.

The different national starting points of the Member States are presented in the report "Conceptualising iBRoad2EPC".

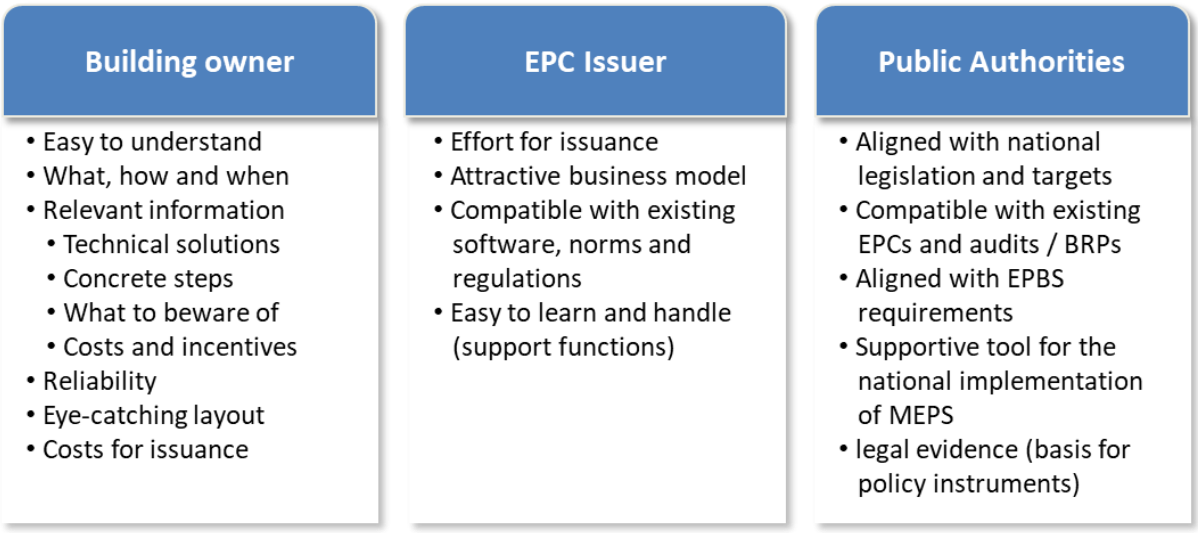


Figure 6: requirements to the iBRoad2EPC from different stakeholders´ perspectives

IBROAD2EPC BASIC MODULE

The iBRoad2EPC Basic Module comprises all core features of iBRoad2EPC as described in chapter "Key Features of iBRoad2EPC". It is the indispensable basis for the implementation of iBRoad2EPC. All other modules depend on the Basic Module, as it provides the basic structure for the processing, such as the online tool for editing and creating the iBRoad2EPC as well as the basic output format (see Figure 5). The main objective of the Basic Module is to provide the indispensable technical information for building owners that have to be included in every iBRoad2EPC (see Figure 4). This is achieved through:

- including improvement measures in a specific sequence to avoid lock-in effects
- ensuring that every measure implemented is part of a comprehensive renovation strategy
- complying with future regulatory and financial requirements, e.g. mandatory Minimum Energy Performance Standards (MEPS), mortgage portfolio standards or the EU taxonomy regulation
- presenting the recommendations in a way that can easily be understood by the end-users and taking their perspective

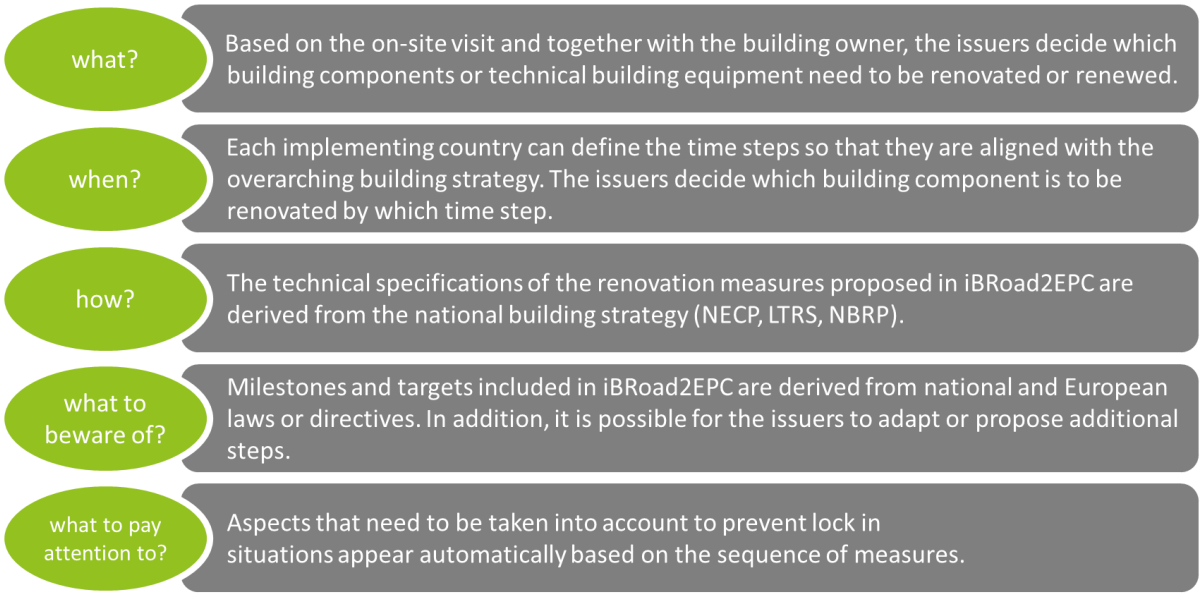


Figure 7: Approach to provide the indispensable technical information in the Basic Module

Figure 7 shows in an overview how the Basic Module answers the core questions. The following sub-chapters explain how exactly these responses are generated in the iBRoad2EPC.

What and when? Main Task of the Issuer

The central questions to be answered with a long-term renovation strategy for an individual building are when and what to renovate. Answering them is the main task of the issuer of iBRoad2EPC. The schedule for the renovations must take into account the implementing country's specified milestones on the way to a climate-neutral building stock, as well as the technically sensible sequence of measures in the respective building. Outlining future targets that the building should achieve and measures that will contribute to reaching them, gives the building owner a perspective and direction. The important service of sequencing renovation actions should not be automated but should be performed individually for each building based on the issuer's experience. If these questions were to be answered automatically, there would be a risk that the specific individual circumstances of a

building would not be taken into account sufficiently and the added value of the iBRoad2EPC for the building owner would be lost.

In contrast to the iBRoad Renovation Roadmap, where the issuer determines the ideal renovation period individually, in iBRoad2EPC default periods are fixed for each implementing country. They can be derived from national climate targets or legal obligations in the implementing countries. Example: if a country bans fossil fuels from 2035 on, this year should be displayed in iBRoad2EPC in order to create sufficient space to show the obligation and the measures to meet them. The implementing countries can decide individually how many and which periods to display in iBRoad2EPC. The number of renovation steps should apply consistently for all iBRoad2EPC in this country in order to keep a common layout and assure all relevant targets to be addressed.

The issuers create a long-term strategy for a building to reach the state specified by the climate targets of the respective country. For this purpose, all energy-relevant components of the building must be considered. The issuers can be guided in this task by the following points.

Full renovation or gradual renovation

The issuers should recommend a full renovation in one step if it is technically feasible and can be afforded by the owners. A full renovation has many advantages over a step-by-step approach. The GHG emissions of the building fall quickly to the target value, i.e., the cumulative emissions over the entire period are significantly lower. Building component connections can be made in such a way that all thermal bridge and airtightness requirements are met. They cause less disturbance for the inhabitants. In the case of a one-step renovation, however, it must be ensured that the target standard is achieved. Too low ambition would lead to the building having to be renovated again or the targets not being met. However, since full renovations are time-consuming and expensive, many building owners opt for stepwise renovations. The issuers have to find out which way suits the owners better.

Age of the Components

In the case of stepwise renovation, the building components can be prioritised according to their age. Components that have already reached or will soon reach the end of their normal technical life span must be renovated earlier than those that will still be usable for many years. The usual technical life span is individually different per component. For example, 20 years are often estimated for technical installations and over 40 years for façades or roofs. This can vary between implementing countries.

Sequence of Measures

The renovation measures must build on each other. For example, it often makes sense to improve the building envelop first, install a heat generator with a lower heat capacity, which is more cost-effective, later. Furthermore, many renewable heat generators, such as heat pumps, only work efficiently if a building is at least partially insulated.

Components that should be combined

In addition to the age of the components, issuers must also consider which components should preferably be renovated together. For example, many problems in connecting windows to the façade can be avoided if both components are renovated in one step.

Obligations that must be met

The renovation measures must be put together in such a way that obligations with which the building must comply, and which are already foreseeable, are fulfilled. For example, according to the draft of the EPBD recast (15.12.2021), it should be noted that buildings with efficiency classes G must be renovated by 2030 and buildings with efficiency class F by 2033.

The above points are to be understood as guidance for the issuer. Experienced issuers may include further or other aspects in the prioritisation of the renovation measures.

Descriptions of measures

iBRoad2EPC is a simplified renovation roadmap that explains to the building owner in the simplest and clearest possible way and in plain language which, how and when renovations should be carried out. iBRoad2EPC uses prefabricated text blocks that the issuer can select from (see 0) and adapt. However, the description of the measures does not serve as a construction instruction for the building owner and does not replace professional planning. In general, the work should be carried out by professional craftsmen in order to avoid construction errors.

Example descriptions of measures: Insulation of the external walls

The external wall is insulated with an "Exterior Insulation Finishing System (EIFS)". EIFS is a lightweight synthetic wall cladding that includes foam plastic insulation and thin synthetic coatings.

How? Deriving building targets from LTRS

After the issuers have determined which renovation measures are to be carried out and when, the type and manner of the measures must be specified. This includes the thickness of insulation layers on the building envelop or the types of heat generators, air conditioning systems, ventilation units, etc. In iBRoad2EPC, these specifications are to be assigned automatically. On the one hand, this reduces the effort for issuing and, on the other hand, it ensures that the recommendations fit the climate goals of the implementing country. For this purpose, a database is created that contains the individual insulation thicknesses and target-oriented building technologies for each implementing country. These can be derived from the respective Long Term Renovation Strategies (LTRS) or in the future from the National Building Renovation Plan (NBRP) of the countries (see info box below). In the databases, the specifications can not only be stored individually for each country, but also differentiated by region or building type.

Long-Term Renovation Strategy (LTRS)

All EU countries must establish a long-term renovation strategy to support the renovation of their national building stock into a highly energy efficient and decarbonised building stock by 2050.

The requirement for EU countries to adopt a long-term renovation strategy is set out in the Energy Performance of Buildings Directive (2010/31/EU), which was revised in 2018 (2018/844/EU). These strategies form part of EU countries' integrated national energy and climate plans (NECPs).

The long-term renovation strategies must include

- an overview of the national building stock
- policies and actions to stimulate cost-effective deep renovation of buildings
- policies and actions to target the worst performing buildings, split-incentive dilemmas, market failures, energy poverty and public buildings
- an overview of national initiatives to promote smart technologies and skills and education in the construction and energy efficiency sectors

The strategies must also include a roadmap with

- measures and measurable progress indicators
- indicative milestones for 2030, 2040 and 2050

- an estimate of the expected energy savings and wider benefits and the contribution of the renovation of buildings to the Union's energy efficiency target

Long-term renovation strategies must also be underpinned by a solid financial component (effective use of public funding, aggregation, de-risking).

National Building Renovation Plan (NBRP)

The Commission has proposed to review the current framework within the revision of the Energy Performance of Buildings Directive and suggests strengthening the long-term renovation strategies towards 'Building renovation plans'.

These national plans should be submitted every 5 years, following the submission of a draft plan and they should have clear and specific chapters, based on a common template. The plans will include national targets (instead of indicative milestones) in a more unified and comparable approach, an outline of the investment needs for their implementation and an overview of policies and measures.

Building renovation plans will be aligned with the Governance Regulation framework but will be better synchronised with the national energy and climate plans (NECPs).

(https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/long-term-renovation-strategies_en)

In general, the LTRS do not contain detailed technical specifications for the implementation of renovation measures or on the target state of single buildings. However, they are often based on scenario calculations, which are based on corresponding data. Implementing countries can fill the measure specification in the database themselves, using the scenario calculations as a guide. In doing so, general specifications may have to be differentiated and assigned to individual building types. Figure 8 uses the example of heating technologies to show how the differentiation can be made by building type. Scenario calculations for the building stock usually envisage a phase-out of fossil heating technologies and a broad introduction of renewable technologies. In this example (no specific Member State), the scenario calculation for the target state foresees that 70% of the buildings are heated with heat pumps (HP), 10% with biomass and 20% with district heating (DH). In order to differentiate this distribution by building type, the determinant facts are first considered: Which technology suits which building types better? In this case, it can be deduced that heat pumps are preferably allocated to smaller buildings in low-density areas. District heating, on the other hand, is better suited for larger buildings in dense settlements, and biomass should be used mainly in rural areas and in buildings with restrictions for the other two technologies. Based on such considerations, heating technologies can be automatically assigned to specific building types.

Figure 8: Approach to derive recommendations for heating technologies from Long-Term Renovation Strategies

The iBRoad2EPC databases store for each Member State and for each measure, in addition to the description, specific information on the measure. After selecting the measure, the specification of the measure is filled in automatically.

Example: Insulation of the exterior wall of a multi-family house.

iBRoad2EPC shows the thickness of the insulation to be applied to the exterior wall using a common insulation material. The target U-value is also displayed. The information is supplemented by the specification of the cm of insulation to show as simply as possible how much insulation is necessary. For many users, the statement about the U-value is not understandable and would have to be explained first.

Due to this automatic output of the specifications, the individual characteristics of the buildings may not be fully taken into account. However, such exact planning is intentionally not supposed to be part of iBRoad2EPC. The calculation effort for the issuer would be too high for the intended initial-tool character of iBRoad2EPC. At the same time, it is valuable for the building owners to know how high the demands on the renovation of their building are for achieving the target, even if they cannot fulfil them for certain reasons. Issuers can manually overwrite the automatic recommendations if they wish. For more details on the database please see chapter ”Databases”.

What to beware of? Foreseeable Obligations

An integral part of a long-term strategy are future obligations that are already foreseeable. The European Union aims to increase the rate and depth of renovation. The European Commission has therefore announced the introduction of **mandatory minimum energy performance standards (MEPS)** into the Energy Performance of Buildings Directive as part of its Renovation Wave strategy[2]. MEPS oblige existing buildings to meet a minimum performance by a given date or at a given trigger point in the building’s lifecycle. By setting a standard, or a trajectory of rising standards, MEPS can drive the desired depth of renovation. By setting out which buildings must be improved by when, they can also boost the renovation rate. When introduced, MEPS are embedded in a framework of financial and practical support for building owners and occupiers undertaking renovations, ensuring the standard is both effective and fair (Sunderland 2021). The iBRoad2EPC Basic Module provides the building owner with information on how to comply with MEPS and when they apply. Providing information about the obligations associated with the proposed renovation strategy will help building owners prepare their building to meet the obligations in a planned manner using meaningful steps.

Additional obligations that apply in the implementing countries can also be integrated into iBRoad2EPC. This way, building owners get a complete overview of obligations already decided that apply to their buildings. The iBRoad2EPC thus takes on an important communication task, as no other tools have yet condensed this information for building owners.

Obligations are reported in a specific text field in the Basic Module of iBRoad2EPC under a separate heading and for the respective time period.

What to pay Attention to? Ensuring that stepwise Renovation reaches the Target

Renovations carried out without a long-term strategy in mind can lead to so called lock-in effects. In particular, insufficient insulation thickness or a lack of preparation for later steps prevents a building from exploiting its full renovation potential. It then does not contribute to achieving the climate targets.

In the case of step-by-step renovations, it is particularly important to draw up an overarching plan in advance so that the individual renovation steps can be coordinated with each other. Component connections in particular must be carefully prepared so as not to lose sight of thermal bridges and

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&uri=CELEX:52020DC0662

air tightness even over several construction phases. Preparatory work for later renovation steps can often be carried out in an early renovation step. They can considerably facilitate the implementation of the later steps or even make them possible in the first place. This is the only way to ensure that all the individual components work together in the end, even in the case of a gradual renovation, and that a deep renovation is achieved.

In the iBRoad2EPC, instructions on how to prepare later steps and thus avoid lock-in effects are displayed in a separate text field. These "Notes to prevent lock-in situations" explain to the user what needs to be considered during a renovation. The notes are chosen automatically from a database based on the current measure and the future following measures:

Pattern:

If measure A is realised earlier than measure B we recommend …

Example (auditor selects):

Measure A: pitched roof insulation

Measure B: outer wall insulation

iBRoad2EPC text block from a data base:

"*if you insulate the roof make sure that the overhang is sufficient to cover the wall insulation in a later stage*"

Next steps

"Next steps" is another field on the Basic Module of iBRoad2EPC. Here the building owner will find helpful tips on how to concretely proceed with the renovation. The building owner is given guidance on what to do to initiate renovation and who to contact next. Depending on the country, these can be internet links to funding programmes or to lists of building experts. Here, references to local energy agencies in the community or to suitable craftsmen can also be given.

Interaction with other iBRoad2EPC Modules

The Basic Module is the core of iBRoad2EPC. Additional modules can be integrated completely independent of each other. While additional modules can be selected freely by an implementing country, it is not possible to omit the Basic Module. All general information about a building is entered in the Basic Module. The online tool to issue the iBRoad2EPC, the so called iBRoad2EPC Assistant (see chapter "Issuing an iBRoad2EPC with an Assistant Tool") creates the output of the Basic Module and can be extended to issue additional modules such as the Indoor Environment Quality Module (IEQ), the Smart Readiness Indicator Module (SRI), the Energy Demand and the Investment Cost Module (see chapter "Additional Modules").

GRAPHICAL DESIGN OF IBROAD2EPC

The contents of iBRoad2EPC described above are presented below in a graphical layout. The layout has the following objectives.

- Attractive appearance that arouses the interest of the addressees.
- Presentation of complex technical content in an easy-to-understand way.
- Raise interest of the target group for a very long-term perspective, which is unfamiliar to them.
- Create a recognisable brand that can be applied to existing iBRoad tools as a family of products.

Brand design

The brand design is used to create the iBRoad brand and the associated product family. The uniform visual appearance enables the recognisability of the iBRoad brand in all iBRoad tools and ensures that the iBRoad values, which have been and are being developed in past and ongoing projects, are appropriately visually communicated, disseminated, and understood.

The brand design is understood as a design toolbox and can be used for the layout of the iBRoad2EPC output document as well as the other iBRoad tools (Renovation Roadmap and Logbook). In addition, a central graphic is conceived and designed, which makes the most important results and facts comprehensible at a glance. The central graphic is also modular and can be adapted for all iBRoad tools and media.

In the development of the brand design, a user-centered perspective is to be adopted. Thereby, the needs, motives and problems of the respective users are to be addressed in order to achieve the greatest possible demand and use of the available iBRoad tools.

Attractiveness

The graphic layout of the iBRoad2EPC should communicate to building owners that it is a product-neutral audit. The layout should reflect the official nature of the document, expressing quality and value. In doing so, it should give building owners confidence that the content and recommendations take their perspective. The graphic design primarily addresses the colour scheme, page layout, fonts, and similar layout issues. The design pursues the following objectives:

- User-centred perspective
- Comprehensibility of complex contents for all target groups
- Should motivate to deal with content
- Development of a uniform brand design as a design tool-box
- Design for all media (print, web, app)
- Easy handling

Online and print version

In general, the iBRoad2EPC can be made available to building owners in two ways, as an online or print version. The implementing countries can choose which version is more suitable for them. However, the print version must be specifically adapted for each implementing country. It is therefore not being implemented in the current project. All tests will be carried out with the online version. Print versions can be developed in close consultation with the implementing countries, but this requires a dedicated conceptualisation process. The print version can be handed over to the building owners together with the EPC if it is also available as a print version. This means that the EPC and iBRoad2EPC are also physically linked and can be stored together in a building file. The print version is independent from the technical equipment of the building owner. The iBRoad2EPC can also

be delivered to the building owners as an online version. They can then open the information with an internet browser. The online version contains the same information as the print version. However, the navigation through the document is more comfortable online. The online version requires that the building owners have internet access.

Both versions are presented below.

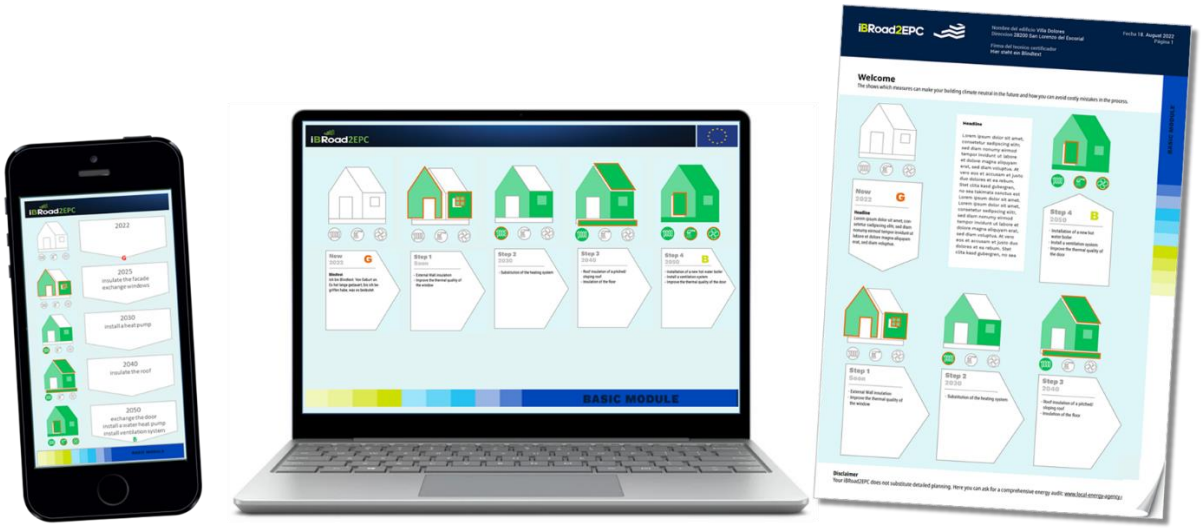


Figure 9: Output variants of iBRoad2EPC as online or printed version (pdf)

Tonality

Tonality is a term from the field of communication. Tonality conveys messages to recipients through style and atmosphere.

The Questions are: What character does the brand have? What atmosphere should the communication measures have?

In the development process of the brand design for iBRoad2EPC, we described the tonality with the following characteristics:

- clear
- fresh
- credible
- egalitarian

Design Components

Colour Systems

The brand design kit contains two colour systems.

a) Colour system for the design of the document frame.
This colour system signals seriousness, value, and trustworthiness in the header. In the lateral module register fresh and optimistic colours are chosen that become more radiant through the light-dark contrast and are based on the EU colour palette.

Figure 10: Colours header of the document

Figure 11: Colours lateral module register

b) Colour system for designing the content of the modules as well as the central graphics.
These colours signal climate protection and high energy efficiency.
To complement the colours green and blue, an orange-red tone is used as a signal colour and various grey values.

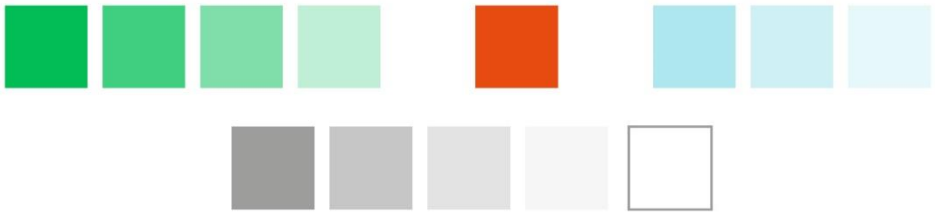


Figure 12: Colours central graphic and content of the modules

Typography

Two complementary fonts are used, both freely usable everywhere and for all media via Google fonts. Both fonts contain many different font styles and can therefore be used flexibly.

a) Roboto:
a typeface with a technical and rational character, also available in condensed weights. Roboto is also easy to read in small point sizes and can be used well for infographics and larger amounts of text or little space.

Roboto
Roboto
Roboto
Roboto
Roboto
Roboto

b) Work sans:
this typeface complements Roboto with its sympathetic, human, and optimistic character. The typeface is easy to read and can be used to emphasise or contrast with and complement Roboto.

Work sans
Work sans
Work sans
Work sans
Work sans
Work sans

Visual language

The visual language is clear, fresh and illustrative. It is meant to motivate and break down the inhibitions of users who are put off by the rather abstract and technical content. In addition to the technical texts, the visuals invite all users to engage with the content.

The visual language conveys the content of the texts on an additional level. The redundant presentation of the content increases the likelihood that more users will understand and engage with the content.

A pictogram of a house shows the measures to renovate the building envelop. It is designed to be universally valid and to symbolise all building types. All measures concerning the technical building equipment are symbolised by icons. Improvements of building components are shown by the respective symbol changing colour from grey or white to green.

Figure 13: Illustration of a house in different states of renovation

Figure 14: Alternative colour scheme

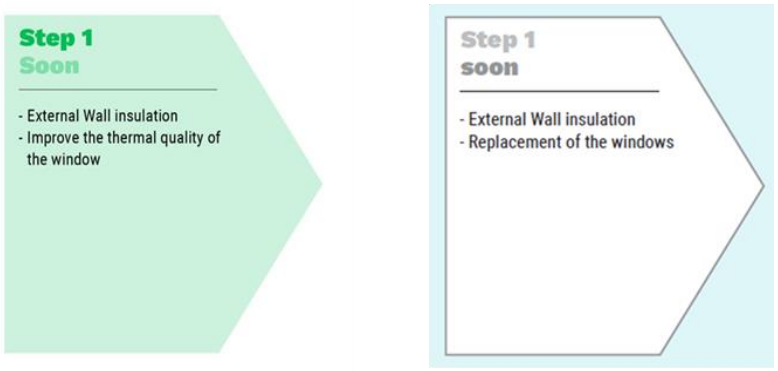


Figure 15: The texts are included in arrows to clarify the process

Central Graphic

iBRoad2EPC uses a central graphic that explains to the building owners at a glance what is being renovated and when. It has a modular structure and shows the most important results and facts at a glance.

The central graphic has a modular structure and can be adapted for all iBRoad tools and media.

The graphic should be easy to understand and appealing to the eye. It summarises the current building state, all renovation steps and renovation measures.

A pictogram of a house shows renovation measures on the building envelop step by step. It symbolises all building types, such as single- and multi-family houses, residential and non-residential buildings. The house icon shows the main building components which are present in every building: floor, exterior wall, windows and doors, and roof. Icons symbolise measures on the technical building equipment. By default, measures on the heating, cooling, DHW and ventilation technology are shown. However, implementing countries can choose to display other technologies. Renovations of building components are shown by the respective symbol changing colour (see Figure 13).

Arrows containing text clarify when the steps are to take place and which measures they contain. The steps are shown in chronological order. Components that are to be renovated in the respective step are visually highlighted.

The central graphic only distinguishes whether a building component has been refurbished or not, but not the energy quality of the renovation. In iBRoad2EPC, the energy quality of all renovation measures is derived from the long-term renovation strategy (LTRS) of the respective country. This means that all recommended renovation measures are in line with the climate targets. However, the iBRoad2EPC does not consider whether the proposed energy qualities can be technically realised in the respective building. Such individually coordinated renovation recommendations require a significantly higher planning effort than envisaged for the iBRoad2EPC, which is intended to be a "light version" of the Building Renovation Passport (BRP). Building owners who want such individual recommendations can request a complete BRP such as the iBRoad Renovation Roadmap. iBRoad2EPC takes up the common colour scheme of efficiency depictions, which runs from red to green. Since iBRoad2EPC only recommends measures that are in line with the targets, all renovations are always displayed in green. The renovation measures accumulate with each step. The house symbol and the icons therefore become greener and greener as time progresses.

In general, the efficiency class of the whole building is shown only for the current and target state. The efficiency class for the current state is taken from the energy performance certificate, for the

target state it is taken from the Long Term Renovation Strategy (LTRS). Therefore, no additional building calculations are required for the iBRoad2EPC.

In the central graphic, only the most important information is shown as an overview. Thus, it remains clear and does not intimidate building owners with too much technical data (see Figure 16). The technical details for each renovation measure are shown on a separate detail page for each renovation step (Figure 17).

The layouts shown below are designed in a first step for the print area/DIN A4 and will be adapted for other media in the next step (see chapter “Output / Backend”) because the layout of the print version is more demanding and less flexible than the online version.

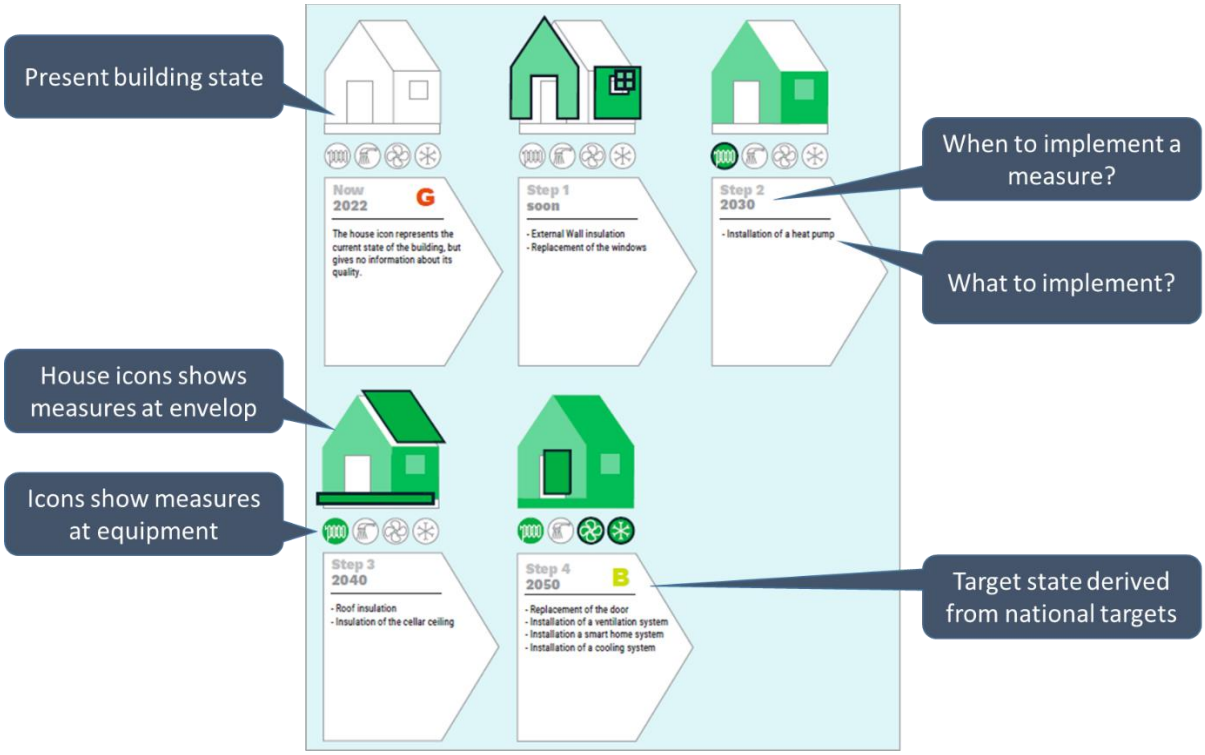


Figure 16: Central graphic, graphic implementation of the content in an overview page

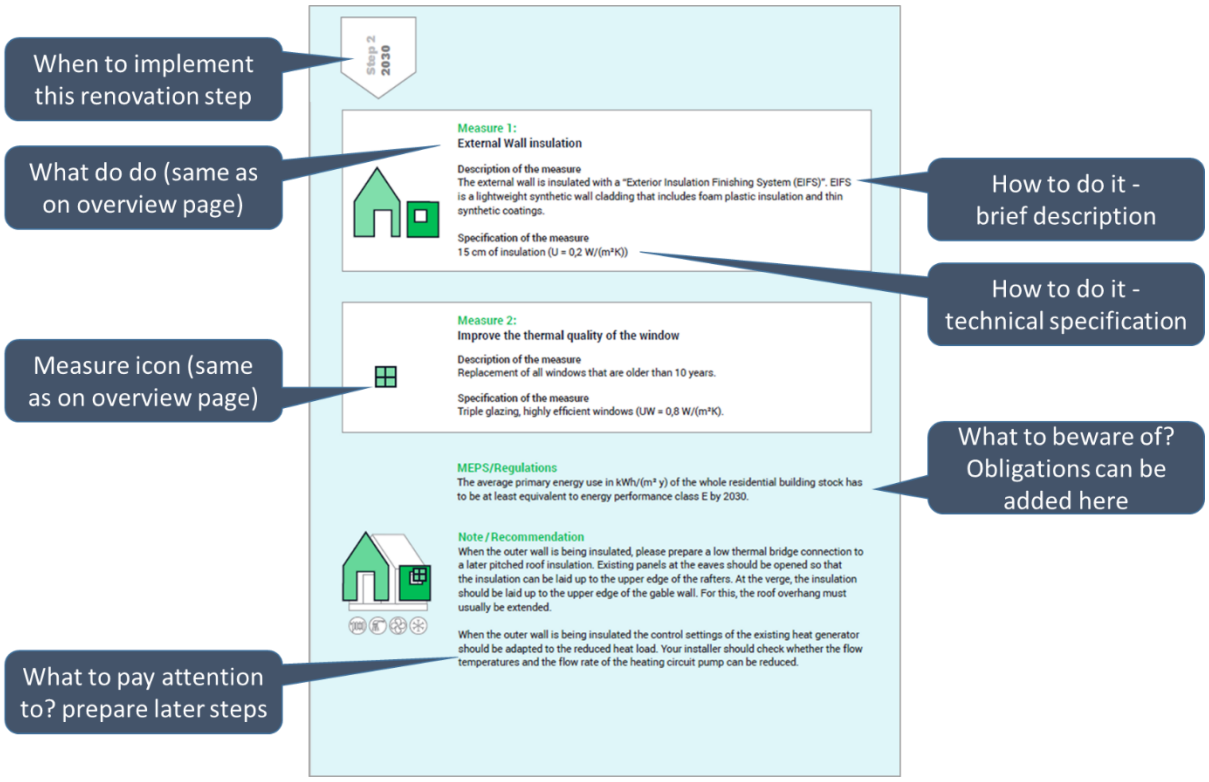


Figure 17: Graphic implementation of the content in a detail page for one single renovation step

Central Graphic IBRoad2EPC, Variant 1.1

During the development process, several variants for the graphical representation were created and discussed. In the following, the most important variants are briefly presented, and their respective characteristics are shown.

This variant visualises the sequence of steps and measures with colours. The steps are shown from left to right and from top to bottom.

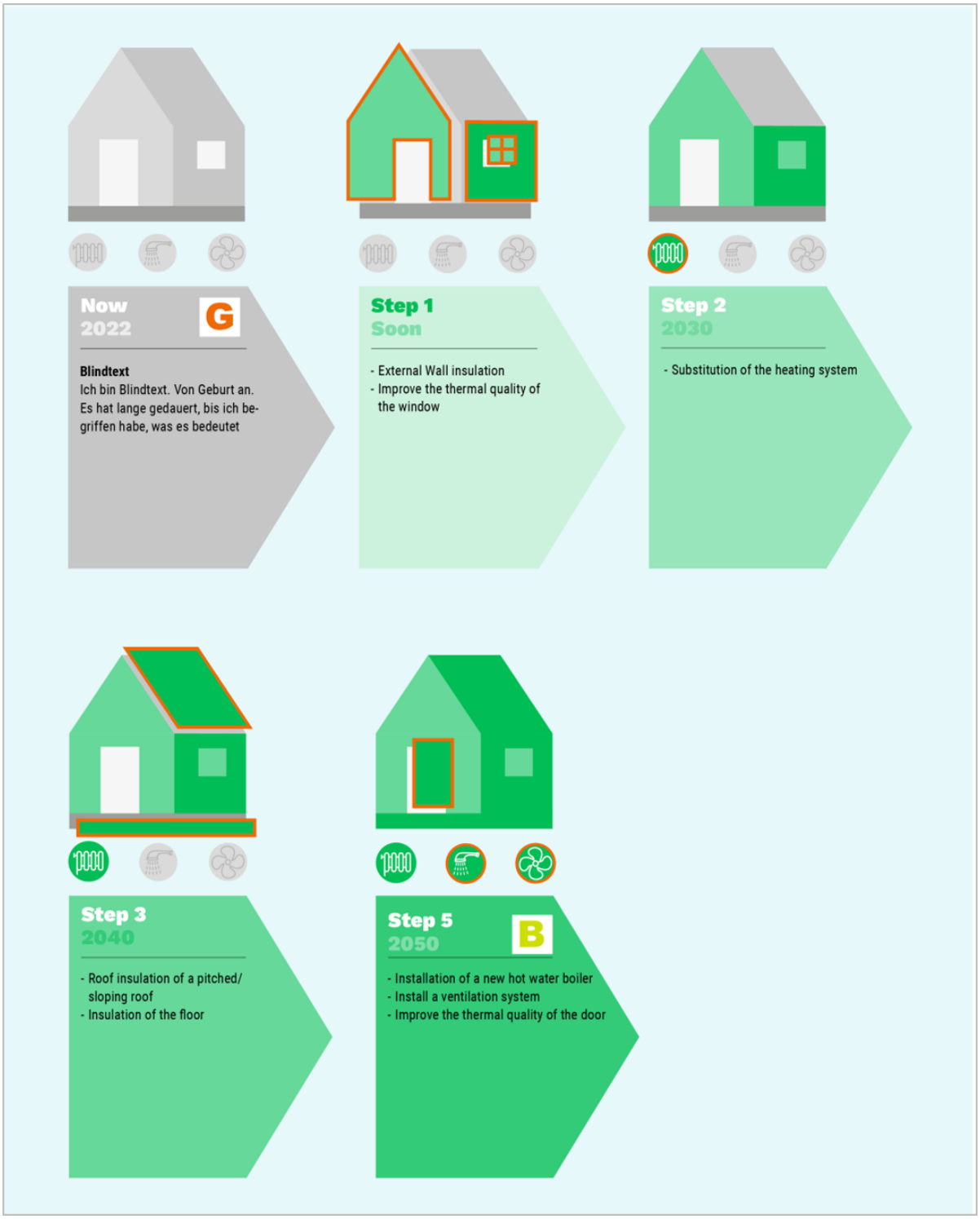


Figure 18: Central graphic, variant 1.1

Central Graphic IBRoad2EPC, Variant 1.2

The steps are represented in a shape that looks like a U. This means that the actual state and the target state are directly opposite to each other. The steps that are leading from one state to the other are shown below. The U-shape of the graphic creates a free space at the top centre that can be used for a general text or explanations of the graphic.

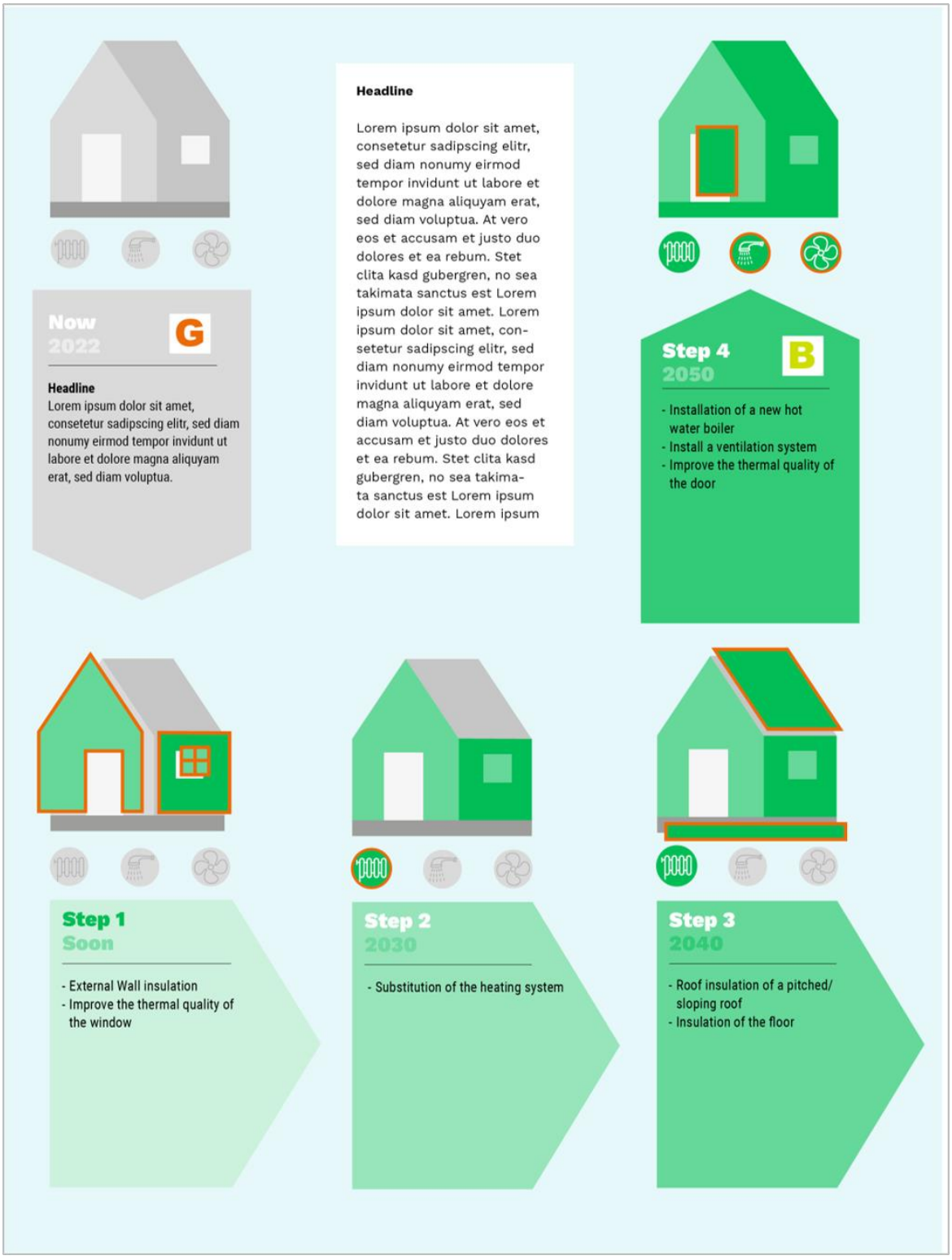


Figure 19: Central graphic, variant 1.2

Central graphic iBRoad2EPC, Variant 2.1

Variants 2.1 and 2.2 differ in their alternative use of colours. By not using coloured arrows and grey houses, the contrast is enhanced and it may be that this makes the graphic clearer and quicker to grasp.

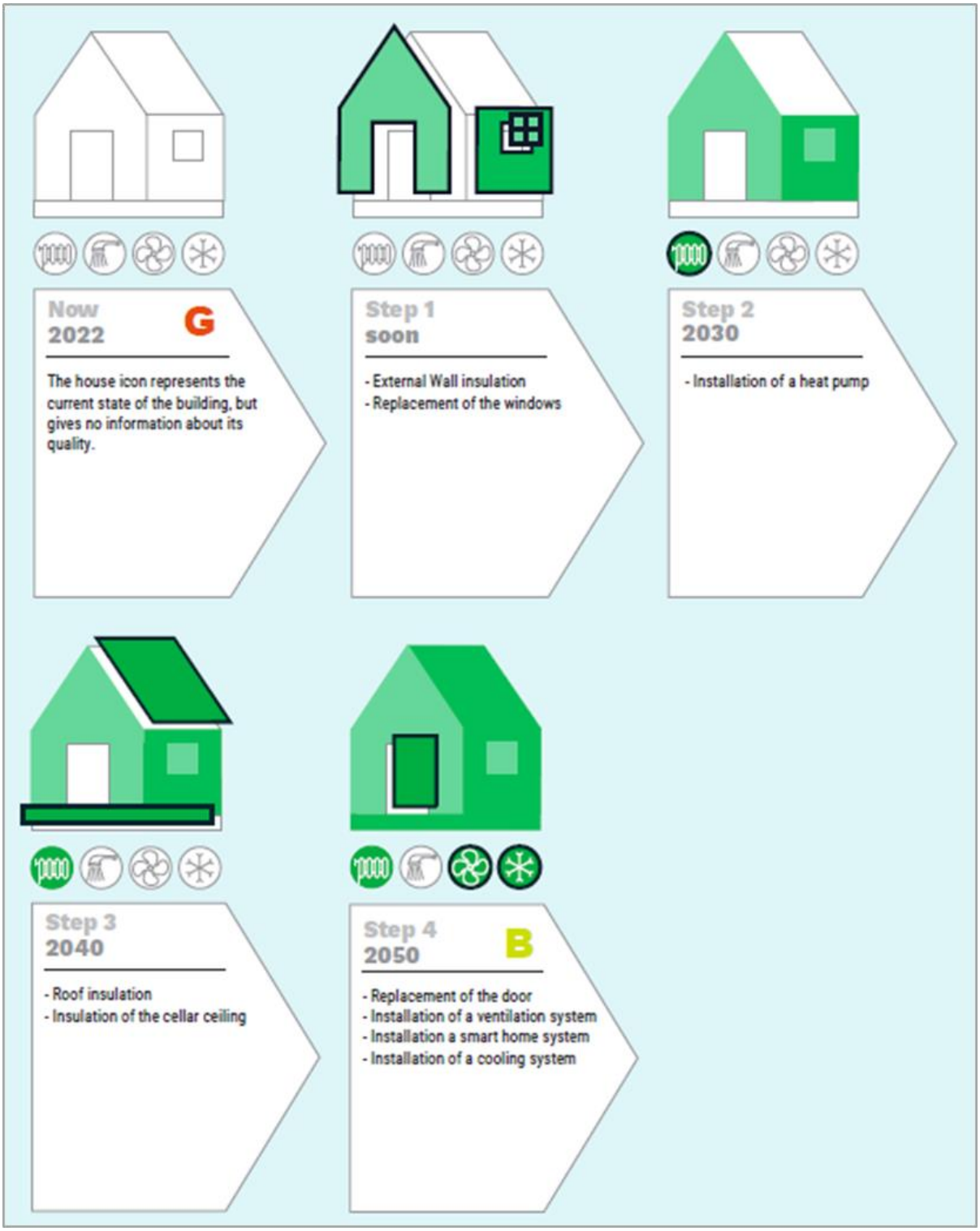


Figure 20: Central graphic, variant 2.1

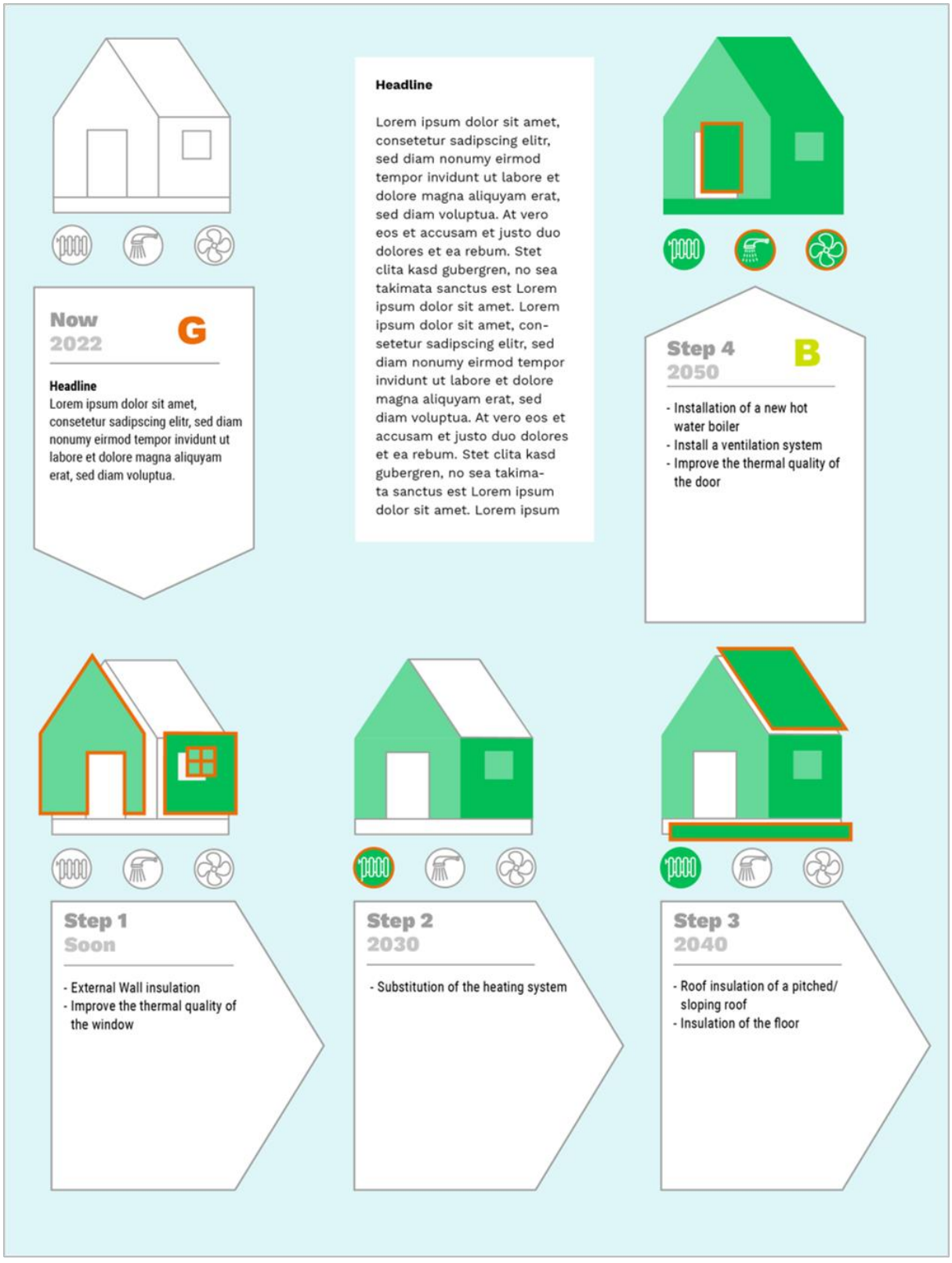


Figure 21: Central graphic, variant 2.2

Detail Pages

All renovation steps are shown in an overview on the central graphic. A detail page is shown for each renovation step. All relevant information for the respective step is shown here. As described in Chapter “iBRoad2EPC Basic Module”, the following questions are answered:

- What and when should be renovated?
  The name of the measures and the time period are taken from the central graphic.
- How should the renovation be carried out?
  For each recommended measure, the target execution quality is specified. For insulation measures, this is in particular the insulation thickness or the U-value.
- What to beware of?
  If there are certain obligations to be met by the date of the step, they will be shown in the detail page.
- What to pay attention to?
  For each renovation step, measures are recommended that can be used to prepare future renovation steps. In this way, deep renovation can also be achieved in several steps.

The renovation plan consists of several renovation steps. They mark certain occasions when construction work is carried out in the building. One renovation step can comprise several renovation measures. Measures refer to the renovation or renewal of one specific building component, e. g. the roof, the heating system or the windows.

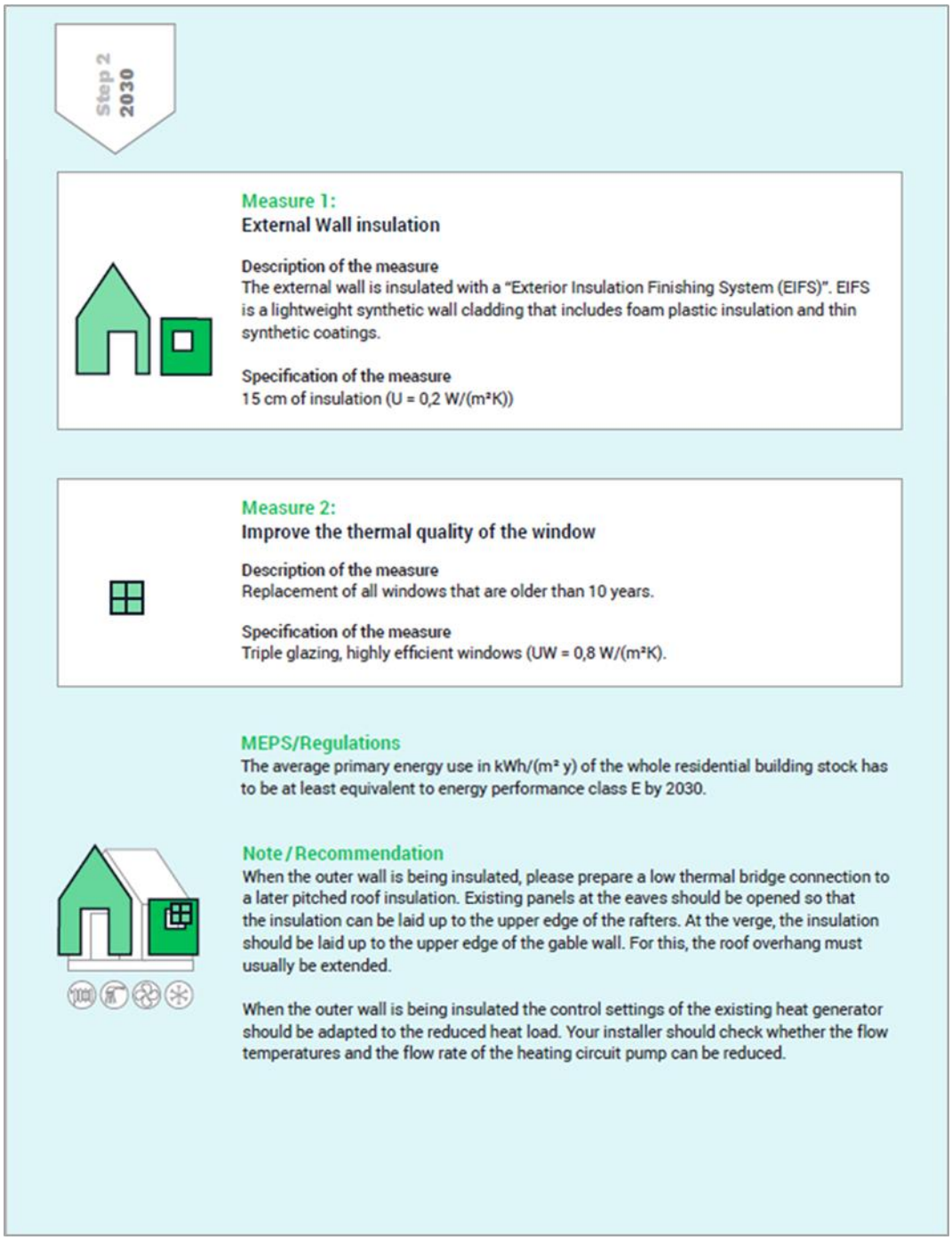


Figure 22: Detail page (example for Step 2), Basic Layout

Frame

The graphical content presented above is embedded in a framework document. This frame is the basis for all pages of the iBRoad2EPC and also for the online version. It contains basic information and a navigation system through the iBRoad2EPC document. The design of the iBRoad2EPC should express quality and value, reflecting the official nature of the document. The aim is to convey to building owners that this is a trustworthy, product-neutral and value-based consultation.

The header of the document contains the logo, address data, page number and date. The header colour dark blue signals the high-quality and official character of the document. On the right side of the document, there is a tab that shows which module you are in. This is built like a register in

different colours. The basic module shows the renovation strategy and is displayed in a blue register tab. The number of register tabs depends on how many additional modules are implemented in an MS.

In addition, below the current module, the other modules contained in the document are indicated by coloured bars. Additional information can be shown in the footer, such as a disclaimer.

Figure 23: Document frame, basic Layout

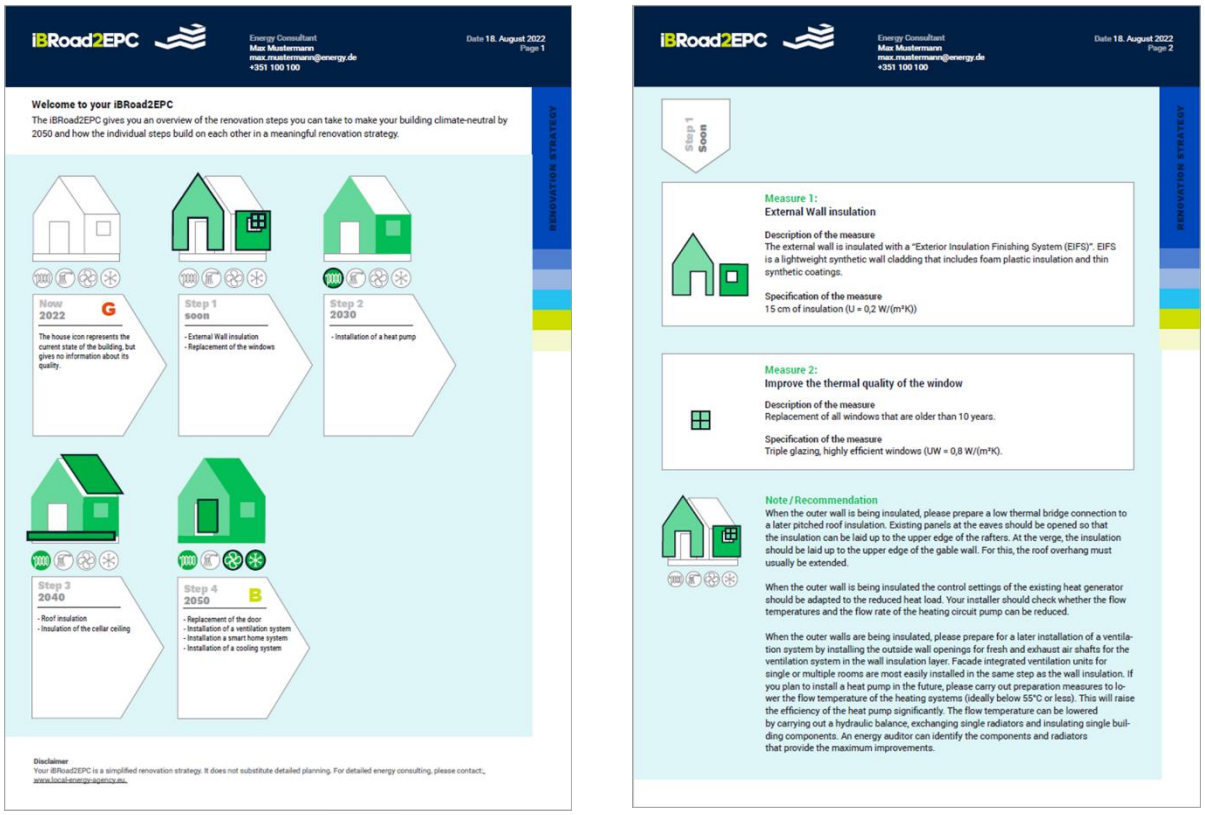


Figure 24: Document frame with central graphic and detail page inserted

Improvements of country-specific EPCs through iBRoad2EPC

The existing EPCs have a country-specific design in each Member State. Changes to this given design could only be made in close consultation with the responsible authorities and stakeholders in the respective Member States. Changes to the EPC design would also have to be implemented in country-specific instruments. Such a procedure would foreseeably lead to complex processes in the implementation of iBRoad2EPC. The content and design of iBRoad2EPC would have to be individually adapted to the existing EPC of the respective countries. This would make it impossible to implement a uniform design of iBRoad2EPC. A central quality assurance of iBRoad2EPC would hardly be possible in the case of various country-specific solutions.

iBRoad2EPC was developed as an annex to existing EPCs. This allows for a uniform design of iBRoad2EPC across the EU. The programming, maintenance and quality assurance of the software can be organised centrally for all participating countries. iBRoad2EPC is nevertheless designed to be flexible enough to adapt to the needs of the countries: it can be linked to the EPC software, but it can also be linked to other existing advisory tools in the countries. If coupling is not desired in a country, iBRoad2EPC can also be used as a standalone tool. iBRoad2EPC can be attached to a printed EPC, to a pdf file or to an online document. The content of iBRoad2EPC can be modularly adapted to the needs of the implementing countries. The development of iBRoad2EPC without a fixed coupling to the EPCs of the countries makes it possible to carry out a field test independently of the support of programmers in the partner countries.

The following figures show how the existing EPCs in Bulgaria, Greece, Poland, Portugal, Romania, and Spain are complemented and improved by the iBRoad2EPC. Although the addition in the form of an

annex to the EPC is uniform in all countries, the contents of the iBRoad2EPC will be adapted country-specifically. For this purpose, iBRoad2EPC has a modular structure (see chapter on semi-flexible unified method). The illustrations show the basic improvement of the EPC through the iBRoad2EPC. The report "iBRoad2EPC initial national guides" describes how iBRoad2EPC will be embedded in the national schemes of the countries.

Figure 25: Improving the information content, visual appearance and scope of the Bulgarian EPC with additional pages from iBRoad2EPC

Figure 26: Improving the information content, visual appearance and scope of the Greek EPC with additional pages from iBRoad2EPC

Figure 27: Improving the information content, visual appearance and scope of the Polish EPC with additional pages from iBRoad2EPC

Figure 28: Improving the information content, visual appearance and scope of the Portuguese EPC with additional pages from iBRoad2EPC

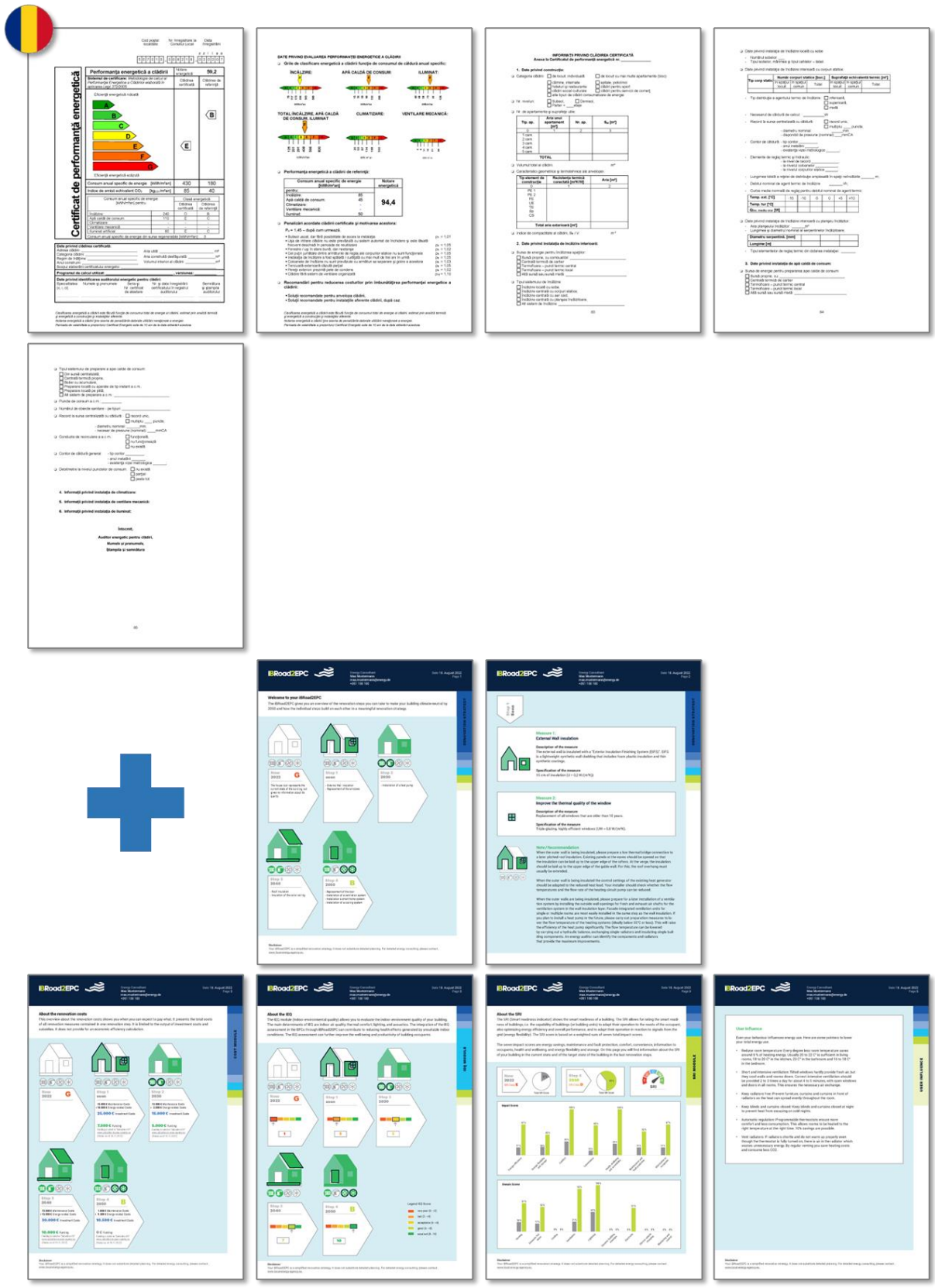


Figure 29: Improving the information content, visual appearance and scope of the Romanian EPC with additional pages from iBRoad2EPC

Figure 30: Improving the information content, visual appearance and scope of the Spanish EPC with additional pages from iBRoad2EPC

Outlook for a Component Assessment

The graphical layout of iBRoad2EPC can be transferred to the other iBRoad tools (iBRoad Renovation Roadmap and Logbook). The common layout elements create a brand that has a recognition effect. The interaction of the three iBRoad instruments is described in chapter “Online and print version”. In this chapter, only the possibilities of a graphical product family are discussed.

In the iBRoad Renovation Roadmap, there is a central graphic that shows the development of building efficiency in the future (Figure 31). The efficiency classes are symbolised with colours. As the Renovation Roadmap includes all requirements for a complete Building Renovation Passport, it is more complex to create than the iBRoad2EPC and contains more information. This additional information can be integrated into the iBRoad2EPC style by using more colours representing the energy quality of the building components (see Figure 33). Moreover, the efficiency classes are added for each renovation step.

In the iBRoad Logbook, there is currently a figure that shows an evaluation of the individual components of the building envelop and system technology over time (see Figure 32). This information can be transferred very well into the form of the central graphic of iBRoad2EPC. The energy quality of the building components is shown with the corresponding colours. This allows building owners to see not only when a building component was refurbished, but also its energy improvement. This also allows the current condition of a building to be evaluated in a differentiated manner. For example, renovation measures that have been carried out since the building was constructed can be shown in colour (see Figure 33). The colour schemes and thresholds for a rating of single components were developed during the iBRoad project.

It is therefore possible to use the style of iBRoad2EPC for the presentation of results in the Renovation Roadmap as well as in the Logbook. Using the same style clearly communicates to users that this is a product family whose elements complement each other.

The transferability of the layout and the suitability to form a brand are fundamental starting points when defining the iBRoad2EPC design. However, there are no plans to change the design of the Renovation Roadmap and Logbook within the current project.

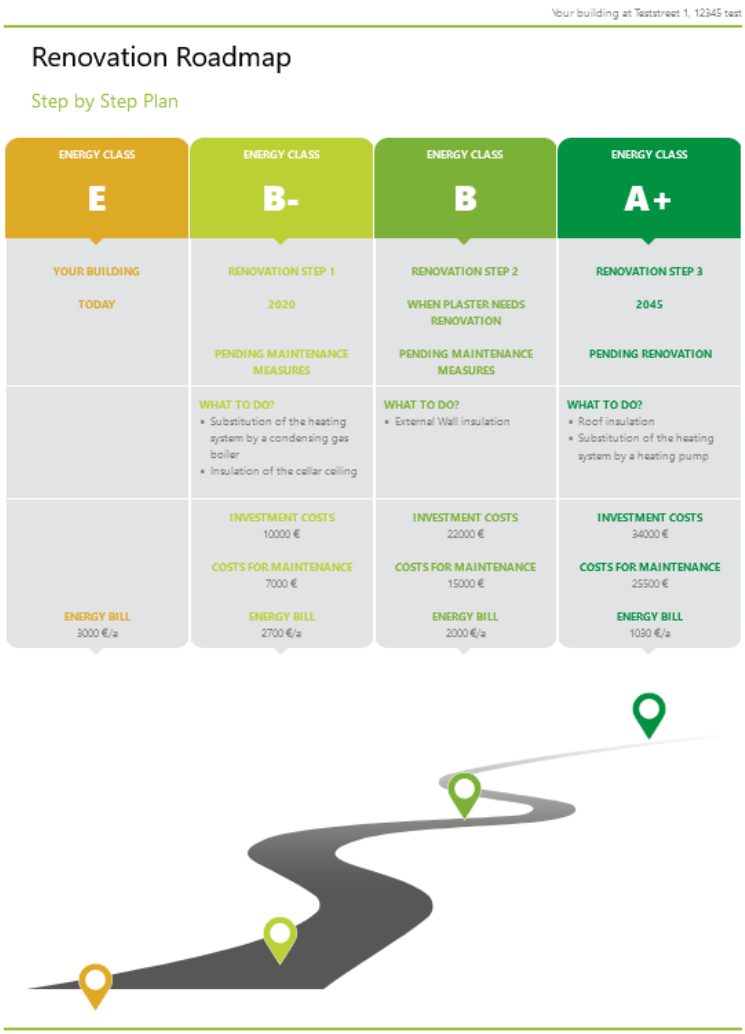


Figure 31: Current assessment of the efficiency class in the iBRoad Renovation Roadmap

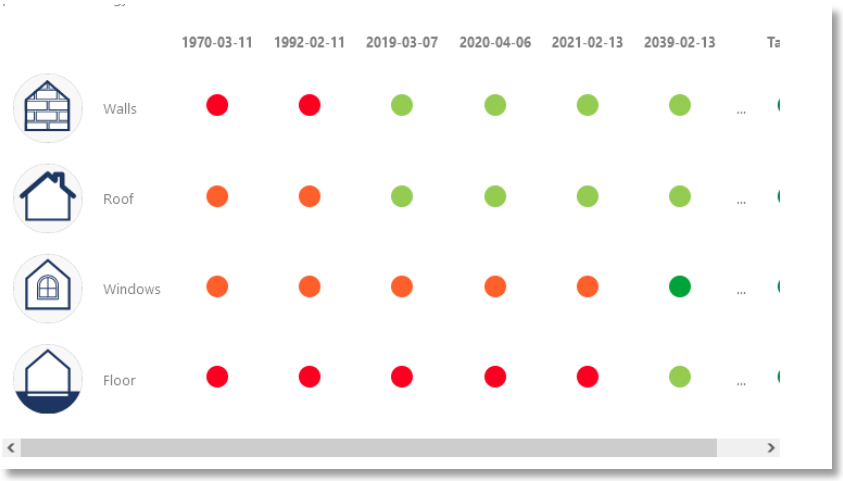


Figure 32: Current assessment of the components in the iBRoad Logbook

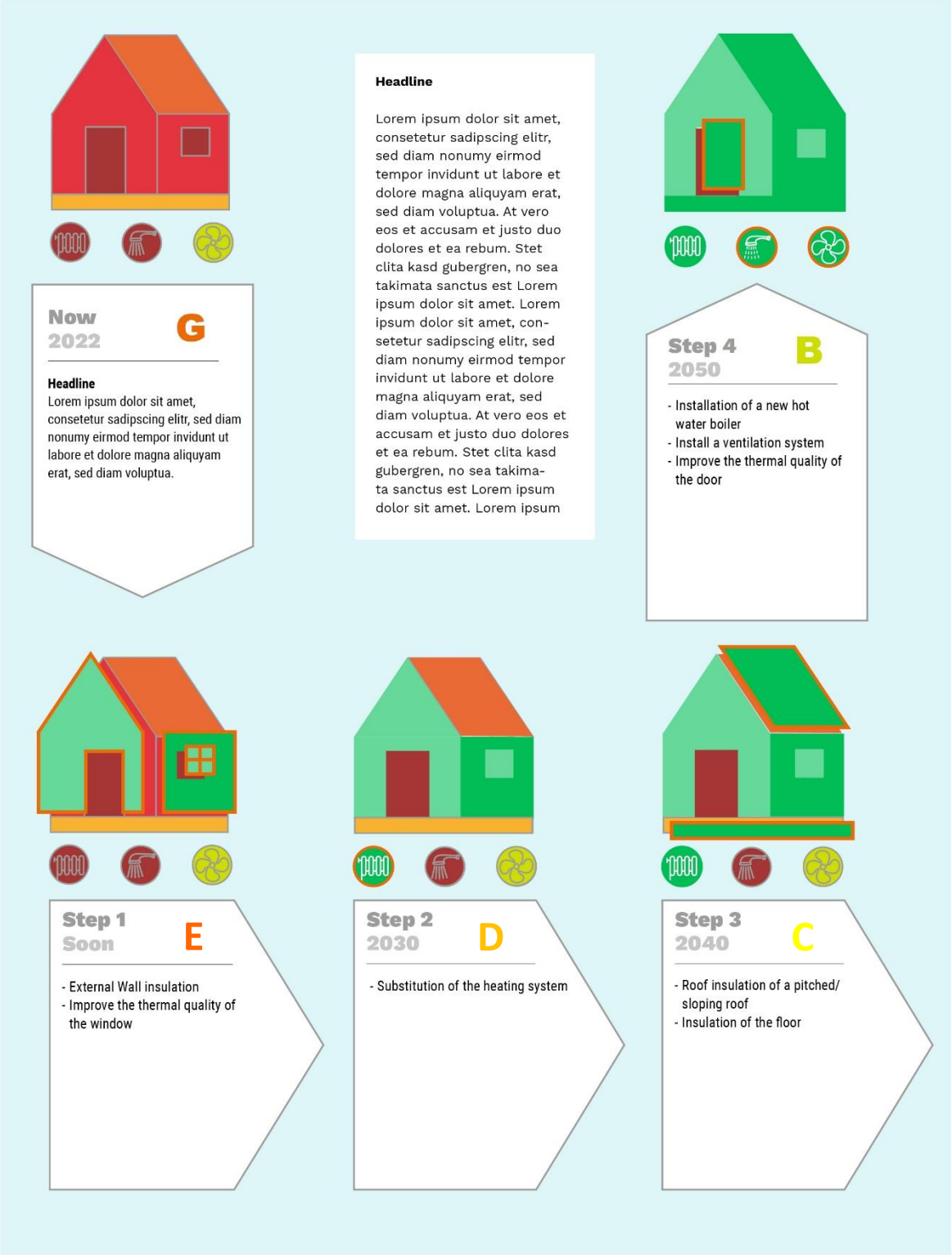


Figure 33: Presentation of the results in the iBRoad Renovation Roadmap and in the iBRoad Logbook with graphical elements from iBRoad2EPC

Online Version

In addition to the print version of iBRoad2EPC, there is an online version that makes iBRoad2EPC an attractive digital experience. The online version allows for additional functions, such as mouse-over texts and links to further information. It enables easy and intuitive navigation through the document. iBRoad2EPC will be implemented as a responsive website and will therefore adapt to all common screen sizes. The online version consists of the same elements as the print version. The following images show the online version of the central graphic and a detail page. Explanatory texts can be displayed on request ("About the iBRoad2EPC"). Users can navigate to other pages in several ways. They can use the navigation menu, which can be pulled out in the upper right corner. They can also click on a renovation step to go to the corresponding detail page.

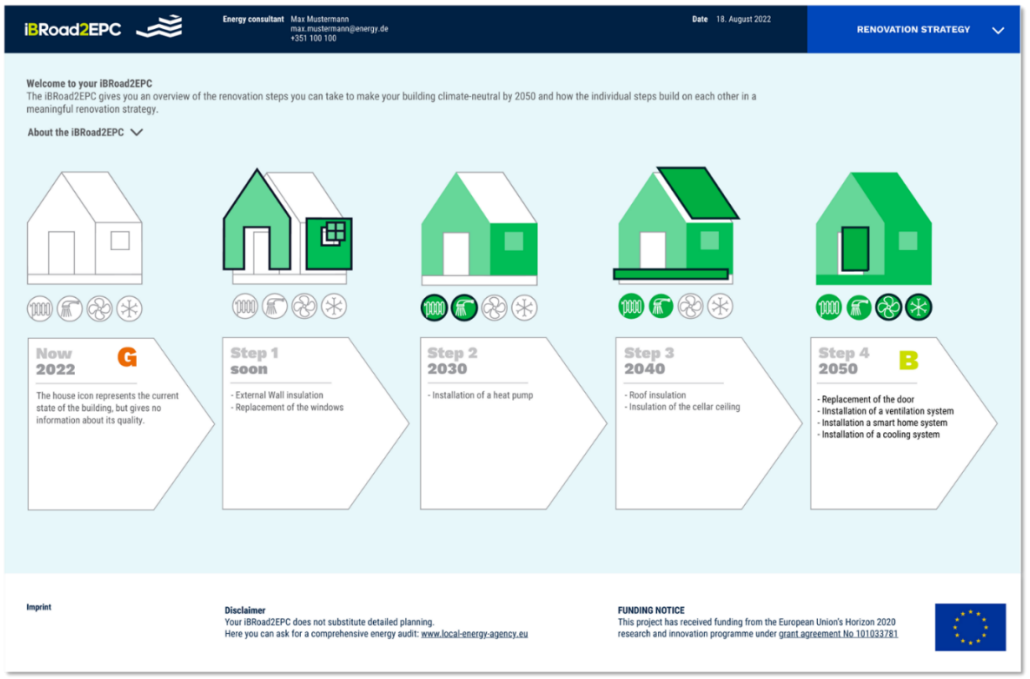


Figure 34: Online version of iBRoad2EPC: central graphic

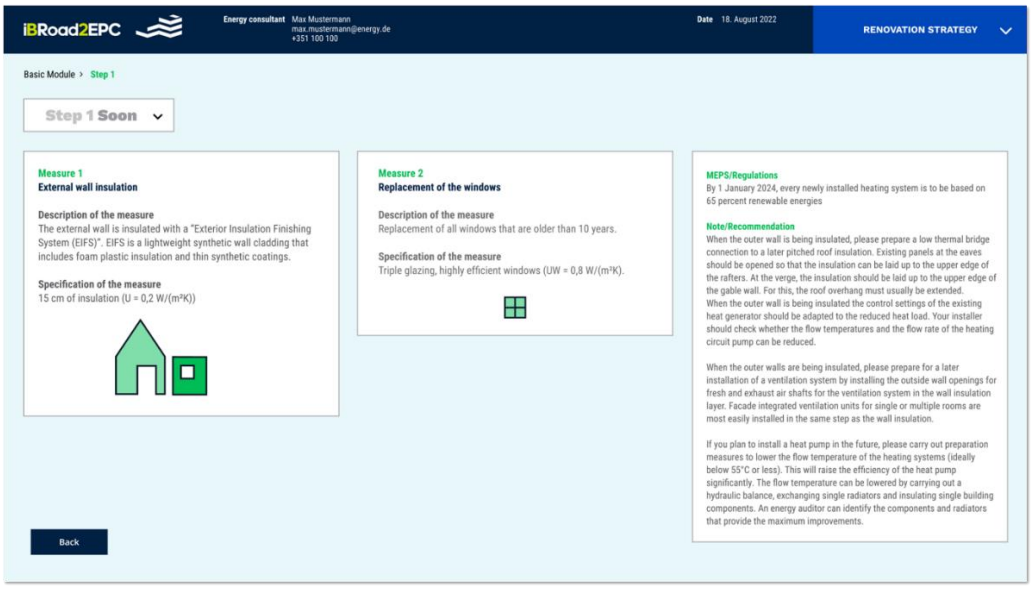


Figure 35: Online version of iBRoad2EPC: detail page

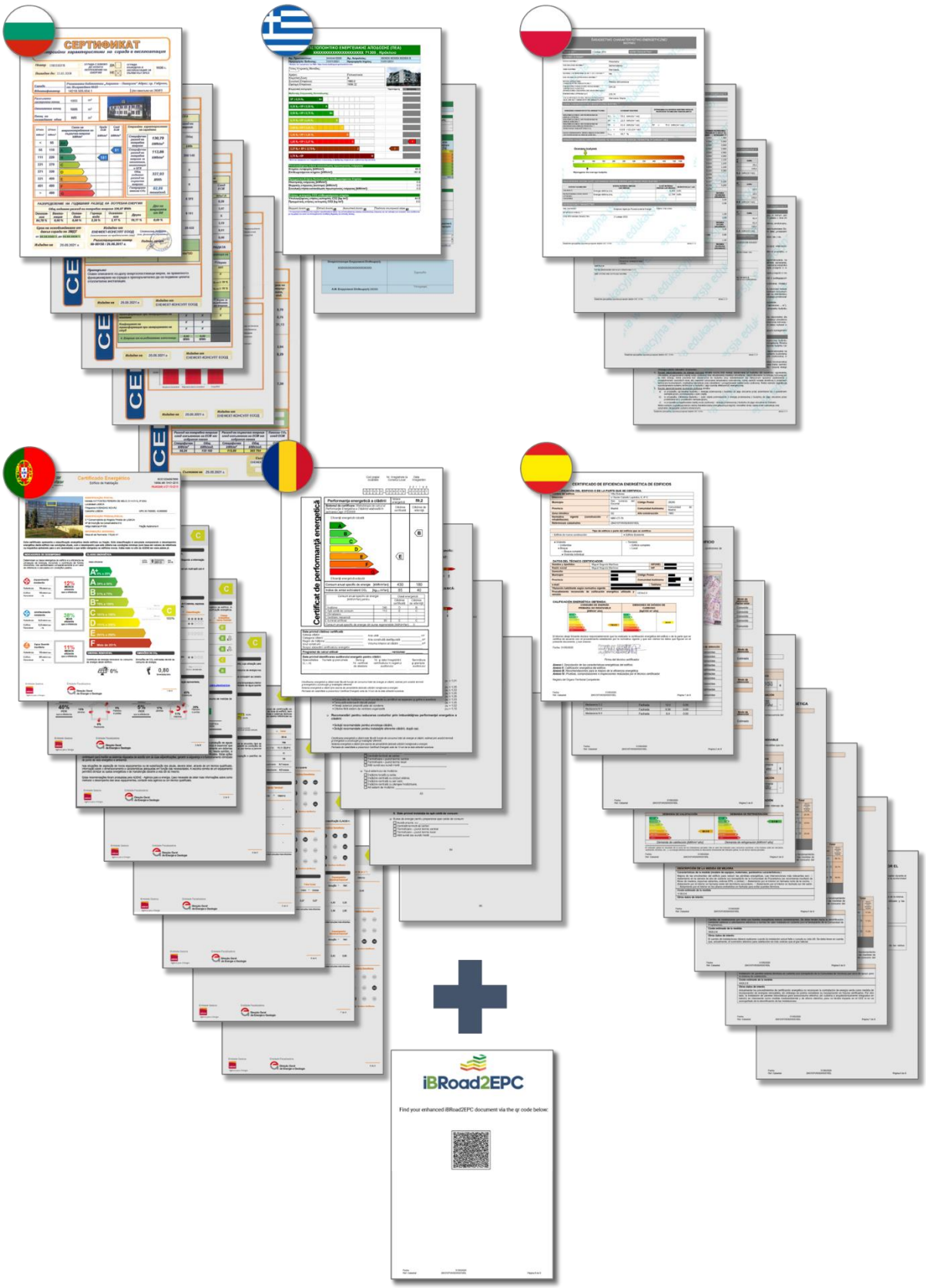


Figure 36: An additional page with a QR code and an internet link is added to the EPC. These will direct the building owner to their iBRoad2EPC output page

ISSUING AN IBROAD2EPC WITH AN ASSISTANT TOOL

Objectives

The iBRoad2EPC is created with an online tool called the iBRoad2EPC Assistant. The main objectives of this tool are

- create the iBRoad2EPC in a uniform design (see chapter “Graphical design of iBRoad2EPC”),
- output the iBRoad2EPC in an online version,
- create a printable page that can be attached to the EPC and leads to the iBRoad2EPC,
- provide clear and intuitive user guidance,
- facilitate issuers in assigning renovation measures at specific points in time,
- output clear selection of prefabricated content,
- allow easy overwriting of all default texts by the issuer,
- provide easy expandability with additional Modules

In the predecessor project iBRoad (2017-2020) , the iBRoad Roadmap Assistant is the corresponding software tool to create the Renovation Roadmap documents. The Roadmap Assistant is used by auditors only, not by building owners as it requires expert knowledge. For issuing the iBRoad2EPC, this concept of an online assistant tool is adopted. This iBRoad2EPC Assistant is a web application that serves as an input mask and produces the output documents.

The Assistant can be implemented independently of other tools or software. It does not need to be linked to the national calculation software or the national data base though such links are possible.

The structure used in the iBRoad2EPC Assistant allows a user-friendly input of the building information, supported by dropdown menus and prefabricated text fields, and functionalities.

Application Programming Interface

The iBRoad2EPC Assistant is a backend tool that compiles and transmits data for a specific building on request. The request can be submitted from different platforms or frontends. This allows the iBRoad2EPC Assistant to be connected to various existing tools in the Member States, such as EPC software or energy performance registers. In addition, a standardised frontend for the Assistant is delivered to enable data entry independently from external software.

The iBRoad2EPC Assistant uses a multi-faceted application programming interface (API) as an interface. The data is stored in relational databases. This avoids EPC schemes needing to call upon each parameter separately, which would make extracting building data too labour intensive. The backend code is programmed in a way that prepares the selected content for ease of transport. The extent to which data will be sent is defined in a way that allows the receiving end to manage the extraction of necessary parameters, without jeopardising the level of advice and conclusions provided to the end user.

Once data is ready to be communicated, it is called upon and transferred. To this end, a 'RESTful API' is built. REST takes in requests and breaks them down to smaller modular nodes and searches for the information. The API is based on the definition of the required domain models. They allow data to be aggregated in the backend / database / reports/… to offer the resources, exposed or attainable through the REST API, for third party communication.

The final step in the API construction is documenting and keeping the documentation up to date. This entails generating and hosting a 'swagger API site'. This requires a significant time investment upfront, but is quickly paid back, especially if multiple third parties will need to work with the API.

In order to connect the API to a frontend, user interface or software, this must allow the input of the required input data. Depending on the type of frontend, various required data may already be available anyway. For example, in an EPC software, the information about the efficiency class of a building is available. Data that is not already available in the frontend, however, must be entered via an input mask. This input mask must be integrated into the software products by the software producers in the respective implementing countries. In this way, issuers can create the iBRoad2EPC directly from one application without having to change to the iBRoad2EPC Assistant.

In case local software providers do not make or have not yet made these changes to their products, a standardised front-end is provided. Here, all the necessary data can be entered and the responses of the API can be displayed. This front end is particularly important for the planned field test because it cannot be presumed that the software providers in the pilot countries will implement the necessary changes at short notice and only for a test. An implementing country can start the introduction of iBRoad2EPC with the standard front end and gradually move to input via other software products. In general, the back end does not have to be changed for these conversions.

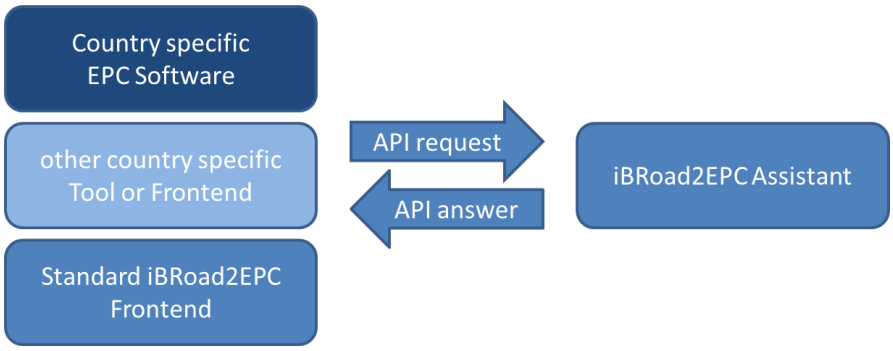


Figure 37: the iBRoad2EPC Assistant can be coupled with different kinds of frontends / user interfaces

Standard iBRoad2EPC Front End

The Standard iBRoad2EPC Front End is the default input mask for the Assistant tool to issue the iBRoad2EPC. It guarantees that all required input data to process the Assistant tool can be entered. This Front End can be replaced when the iBRoad2EPC is integrated in individual software tools in the respective implementing countries. In this case these software tools have to provide input fields for all required data to issue the iBRoad2EPC as shown below.

As the Standard iBRoad2EPC Front End is still under development at the time of editing this report, single layouts or functionalities may vary in the final version. However, the general functionality and layout will remain constant.

The Assistant tool has pages where basic settings can be made. They include information on the respective countries, accredited issuers and projects. The language of the assistant can be adapted to the implementing countries. Both the tool and the results output are translated in the national language. Currently, English, Bulgarian, Greek, Romanian, Polish, Portuguese and Spanish are foreseen. Only administrators get access to the language menu.

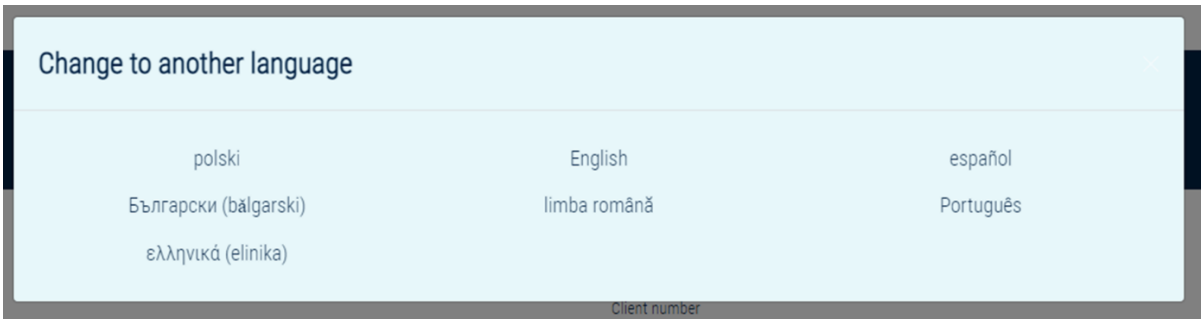


Figure 38: iBRoad2EPC Assistant Standard Front End: language menu

Issuers create one iBRoad2EPC per building. To this end, they need to enter a few important data and information about the building into the Assistant. With the help of this data, technical specifications, foreseeable obligations and notes to prevent lock-in situations are filtered from respective databases. The information on the current state of the building is divided into the categories:

- Building Information
  Issuers enter information that allow the building to be classified according to country, address, environment, climate zone, year of construction or building type. This data is crucial to filter the appropriate and individual renovation recommendations.
- EPC information:
  Issuers enter the tenure status, renovation triggers, addressees of the EPC and addressees of the recommendations. With these specifications, further text can be customised and recommendations can be adjusted.

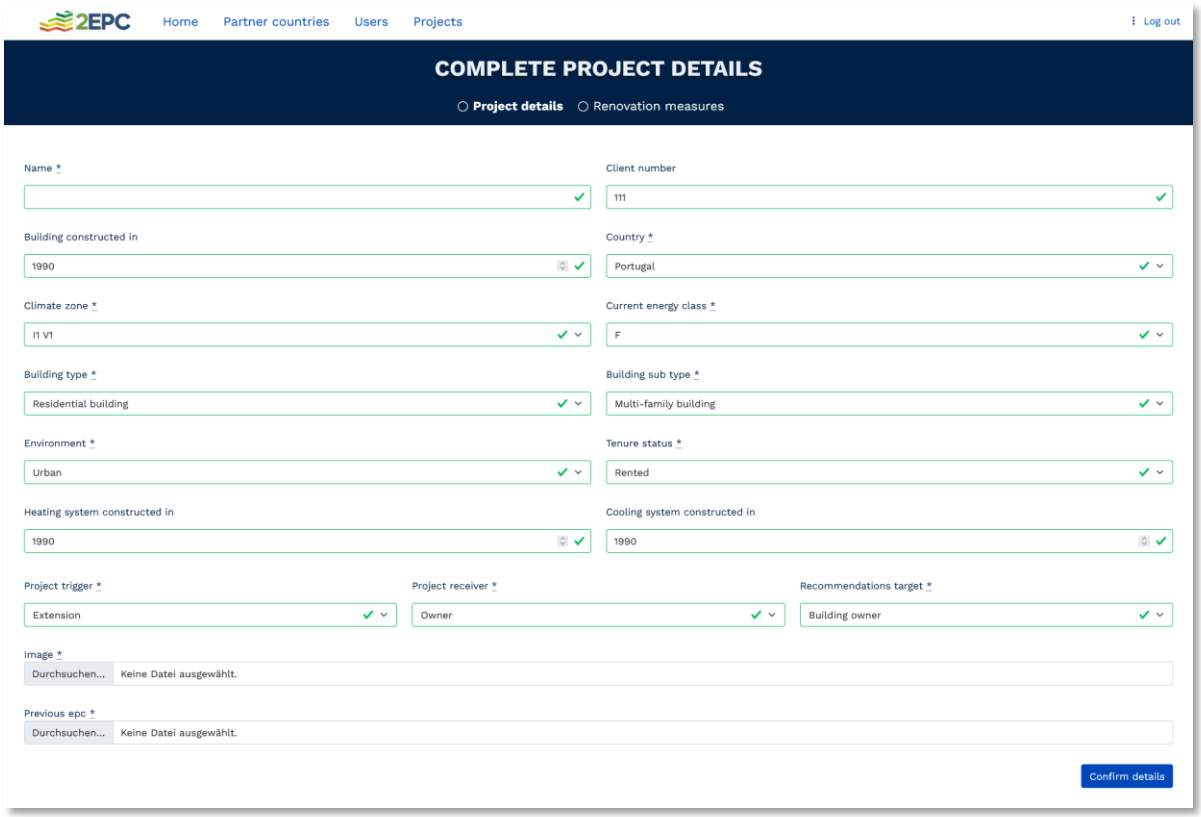


Figure 39: iBRoad2EPC Assistant Standard Front End: input mask for project details

At the bottom of the page, issuers can upload an image of the building and an EPC certificate in pdf format. This is the EPC certificate that they created for the respective building with their regular EPC software. The EPC upload function serves to add iBRoad2EPC information to the EPC document. Once the iBRoad2EPC process is finalised the results are output together with the EPC in a combined pdf document. An additional page with a QR code and an internet link is added to the EPC. These will direct the building owner to their iBRoad2EPC output page using either their mobile phone or computer.

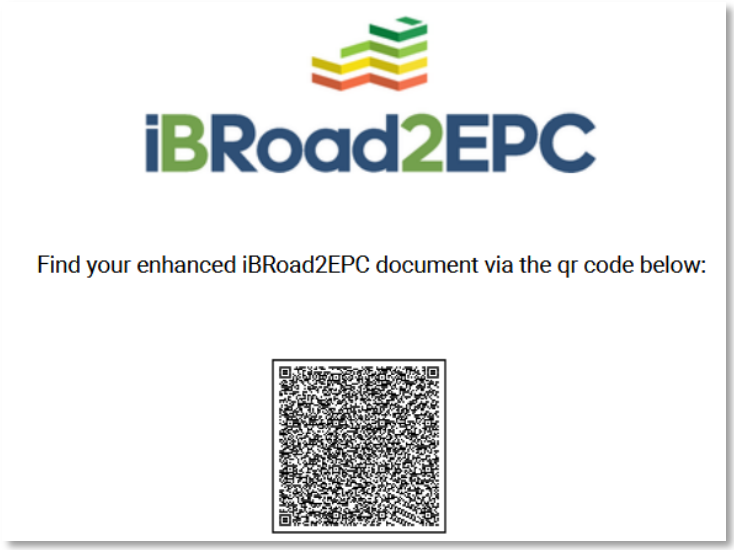


Figure 40: the iBRoad2EPC Assistant can attach an extra page to the EPC providing the link to the online output of the iBRoad2EPC document

Once the basic data has been entered, the steps of the renovation strategy can be entered. The procedure for defining the renovation steps is described in the chapter “What and when? Main Task of the Issuer”. The time frames for the renovation steps are predefined in the Assistant tool. Each implementing country can select them to fit specific points in time in the future, such as the entry into force of obligations or bans, compliance with minimum standards, etc. In the example in Figure 41, the time frames "as soon as possible", 2025, 2030 and 2035 are already filled in. The years 2040 and 2045 still have to be added. Several renovation measures can be entered for each renovation step. Issuers click “add measures” and can choose the type of measures from a drop down menu (Figure 42). This defines the name of the measure in the output document. In a submenu for each measure, the Assistant tool offers ready-made description texts for the measures. Technical specifications are provided automatically for many measures. They describe the quality of the measure according to the long term targets of the respective country. The issuer can edit these texts (Figure 43). These are displayed in the output document in the detailed description (Figure 22).

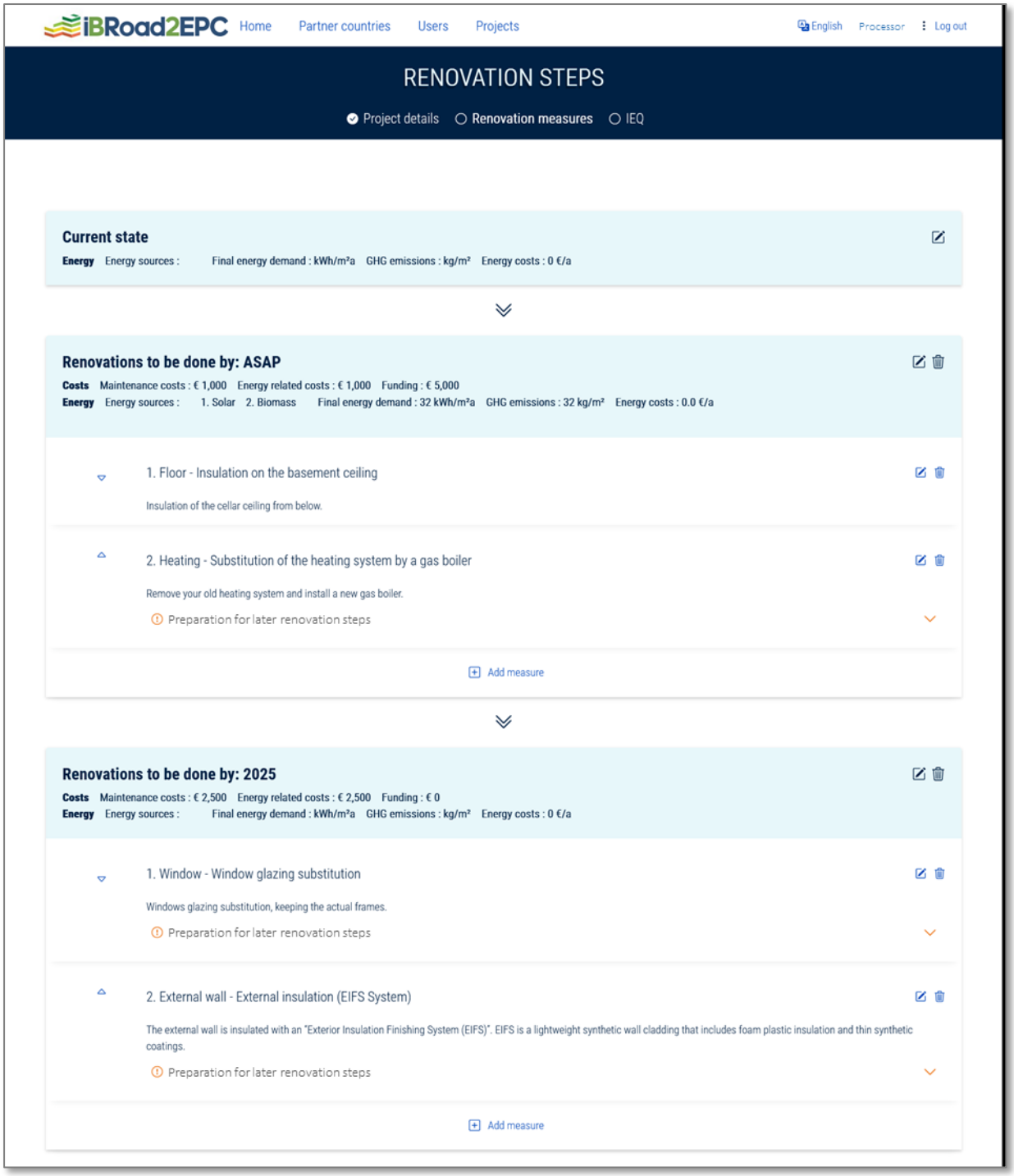


Figure 41: iBRoad2EPC Assistant Standard Front End: mask to assign renovation measures to given dates

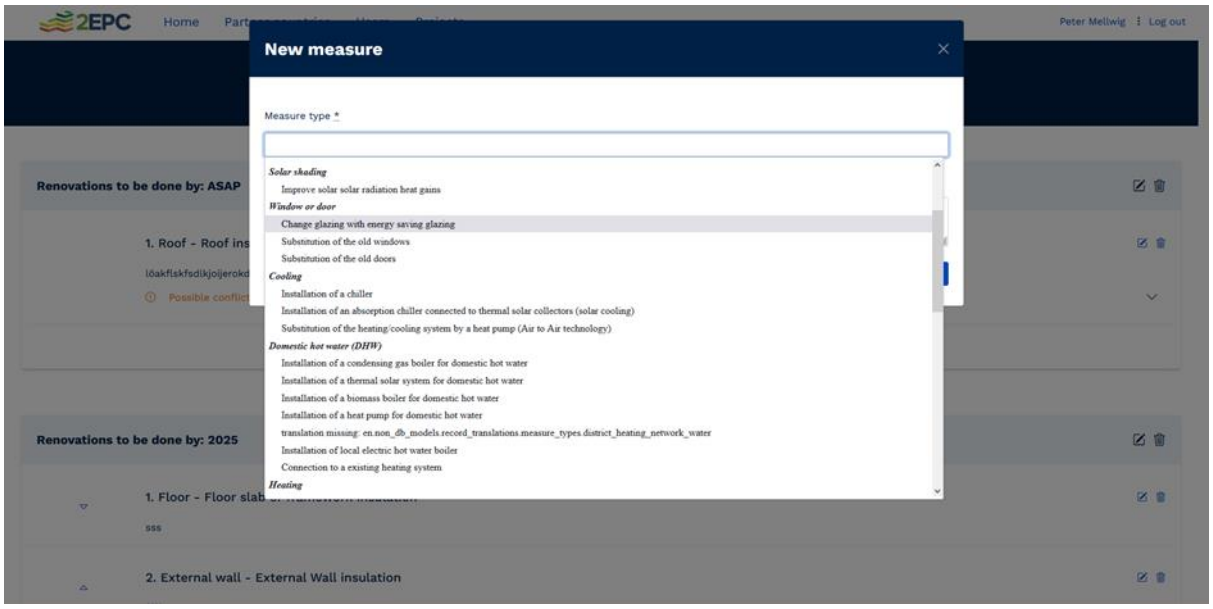


Figure 42: iBRoad2EPC Assistant Standard Front End: drop down menu to select the top category for a renovation measure

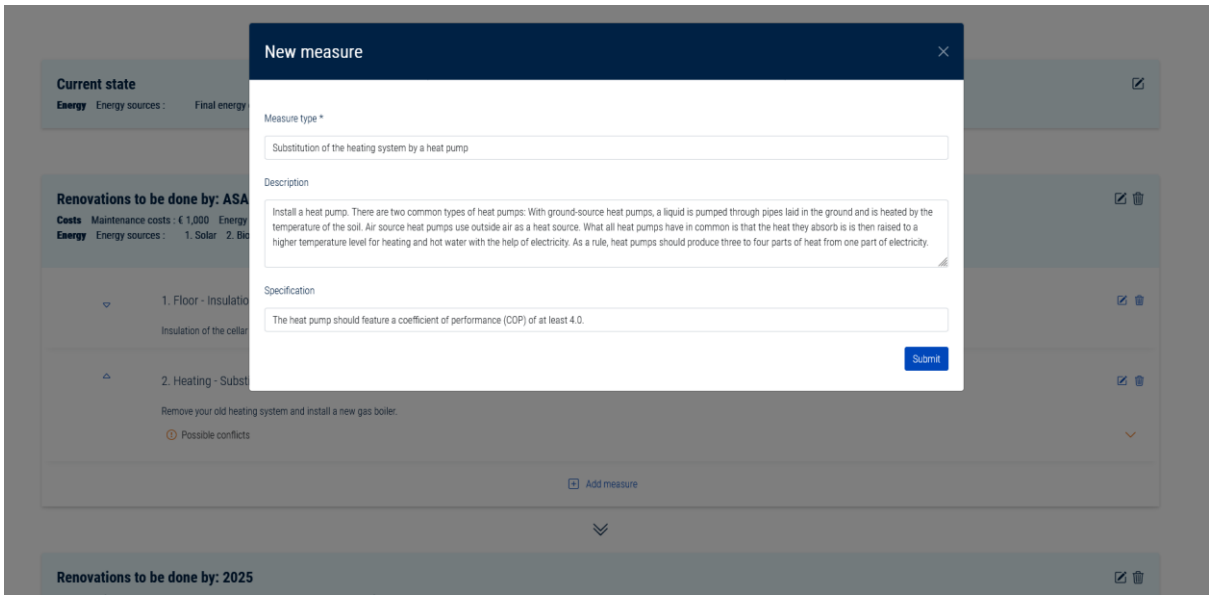


Figure 43: iBRoad2EPC Assistant Standard Front End: brief description of the renovation measure

After all renovation steps have been entered, the iBRoad2EPC Assistant automatically inserts notes to prevent lock-in situations. They refer to the interaction of the individual measures if they are not implemented simultaneously. Often, connection problems can be avoided by preparing later measures in an earlier step. The notes often describe the connection between different building components so that works can be executed in a way which ensures airtightness and avoids thermal bridges. The notes are intended to help ensure that deep renovation is achieved in the end, even if the measures are carried out in several steps (Figure 44). The notes (preparation for later renovation steps) are created automatically. Issuers can edit them if necessary.

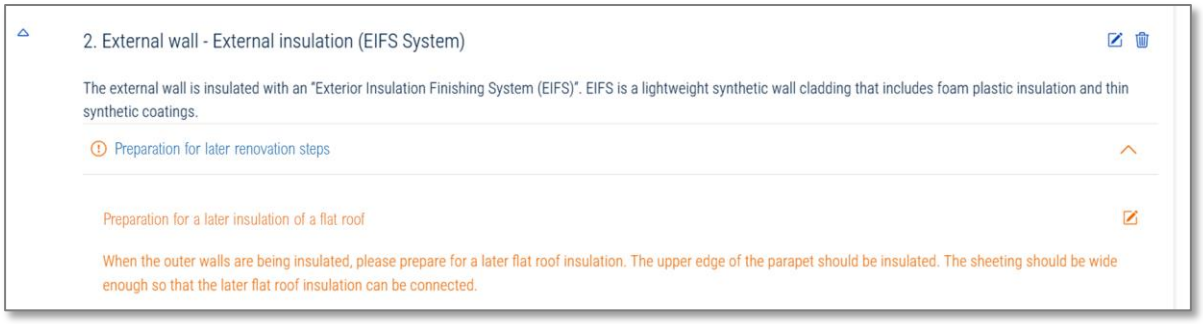


Figure 44: iBRoad2EPC Assistant Standard Front End: notes to prepare for later renovation steps and prevent log-in situations

Once all measures in all steps have been entered and the according notes are produced, issuers are offered an overview page of the developed renovation plan where they can check the completeness, consistency and correctness of the renovation strategy (Figure 45).

In the upper right corner is a menu that offers issuers to

- open a preview of the iBRoad2EPC output document (overview page). This opens the online version of the iBRoad2EPC output document (see 0) and allows navigating through all pages designed for the building owners.
- Download the enhanced EPC in pdf format. This will output the EPC that was uploaded in the project detail page together with together with an internet link and a QR-code to the iBRoad2EPC (Figure 40).
- return to the editing mode.

Figure 45: iBRoad2EPC Assistant Standard Front End: overview page to check completeness of data entry

Databases

The information in iBRoad2EPC is compiled from a number of different databases. Figure 46 shows how the content of an iBRoad2EPC is filled in from various databases. All databases are translated to the respective languages and pre-filled with country specific values. All texts, default values and graphics in the databases can easily be adapted to the implementing countries. Therefore, the database structures do not need to be changed. The “report on adaptation requirements for countries” contains the databases´ structures, content, and country adaptations.

The following paragraphs describe the basic concept of the databases. The software implementation is described in a separate report in detail.

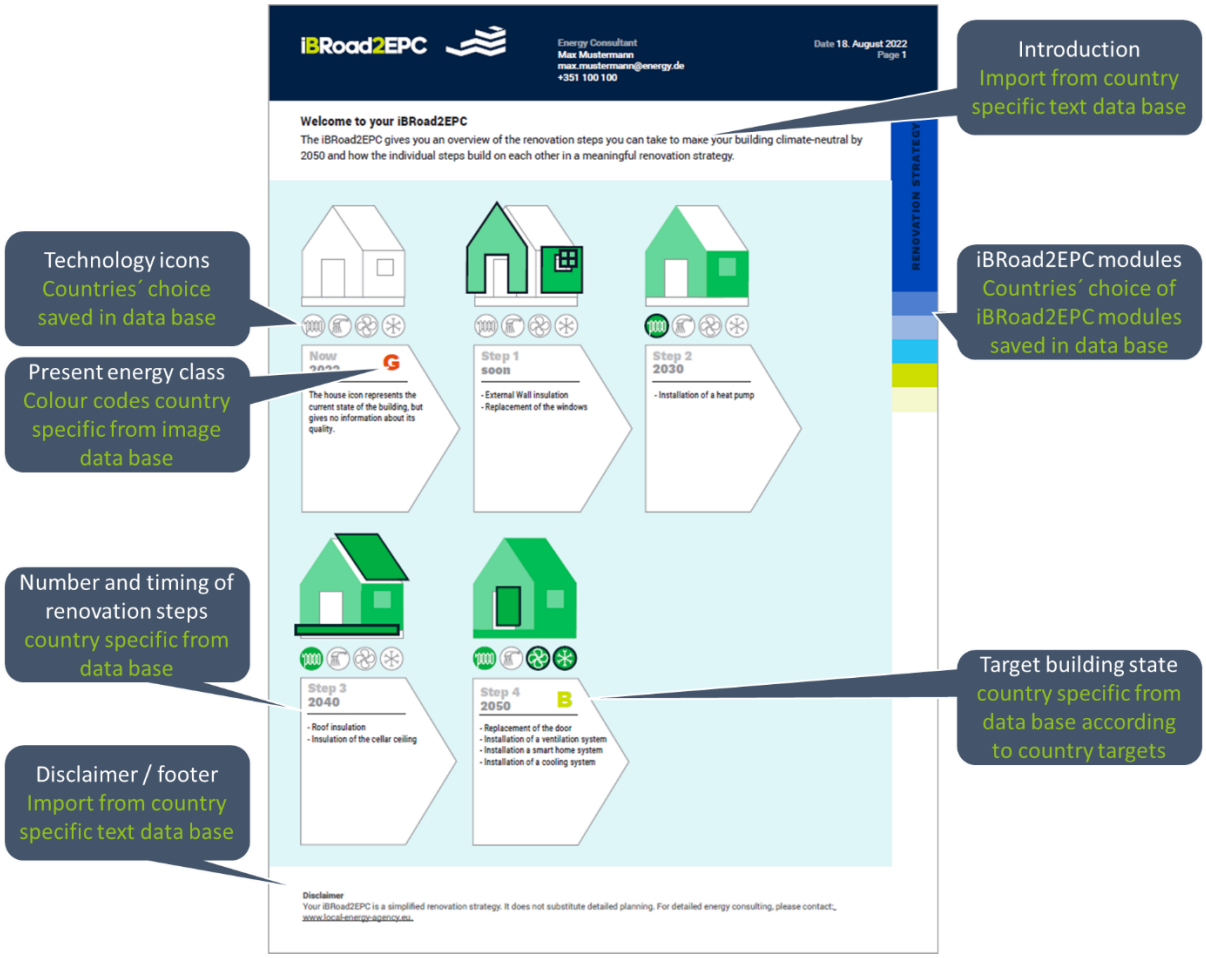


Figure 46: Assignment of the contents of iBRoad2EPC to the corresponding databases, overview page

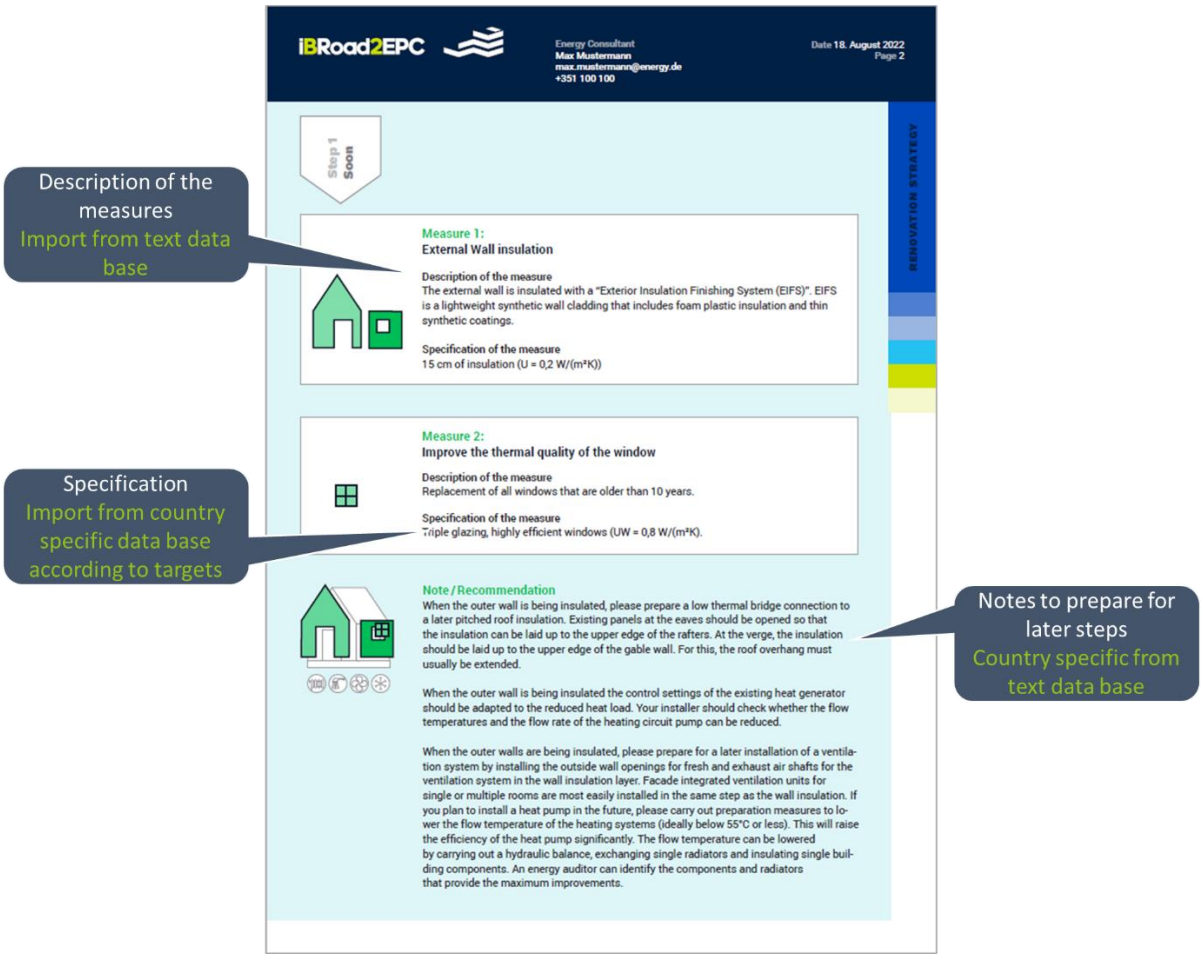


Figure 47: Assignment of the contents of iBRoad2EPC to the corresponding databases, detailed page

Image / Icon Database

This database contains all images and graphics. These include country-specific graphics like energy classes in specific colour codes as well as icons and symbols that represent certain building-specific features.

Measures Database

This database contains the description of renovation measures. Issuers can select renovation measures from a drop-down menu. The respective text blocks are inserted automatically in the iBRoad2EPC output form. Issuers can edit the text freely.

Measure Specification Data Base

The technical specifications of the renovation measures (such as U-values, types of heating or cooling generators) are not set by the issuer of iBRoad2EPC, but are pre-specified by the implementing countries in such a way that the respective national targets for the building sector are achieved (see chapter "How? Deriving building targets from LTRS"). Measure specifications are selected from the database depending on several data entries, most important country, building component, technology and building type, also region if applicable, population density and tenure status. The technical specifications are filled in the iBRoad2EPC form as default values and can be overwritten if necessary.

Notes Data Base

Notes to prepare for later steps and avoid lock-in situations are one central element in iBRoad2EPC. They are derived from the sequence of renovation measures and inserted automatically. Issuers can overwrite them if necessary. They are collected in the Notes database.

Text Data Base

The Text Data Base contains all texts in iBRoad2EPC that are not variable, such as welcome texts or disclaimers.

MEPS / Regulations Data Base

iBRoad2EPC gives building owners a preview of legal obligations that are already foreseeable today. These are, for example, the minimum energy performance standards (MEPS) envisaged in the current proposal for the amendment of the EPBD. In addition to such European requirements, obligations at national level can also be shown in iBRoad2EPC. This database contains standard content defined by the implementing countries.

Output / Backend

The iBRoad2EPC Assistant is used to create the iBRoad2EPC output form. iBRoad2EPC can be provided to the recipient

- as an online version
- as a printable page that can be attached to the EPC and leads to the online version

The printable page allows handing out a hard copy together with a paper version of the EPC. In this case, iBRoad2EPC works like an annex to the EPC and may replace the mandatory renovation recommendations inside the EPC. It can be publicly displayed in public buildings. This version only makes sense if a paper version of the EPC exists in the respective implementing country.

The online version of iBRoad2EPC offers more functionalities and options, such as intuitive user guidance, links to external information, such as authorities or funding schemes and context-sensitive help. In addition, the online version allows for a certain gamification factor to raise the recipients´ interest and ensure more active engagement with iBRoad2EPC. Such gamification factors are not incorporated in the present version of the online version but can be added in a later stage. Through the possibility to integrate links or further texts, building owners can be reached on several levels. The online version allows regular updates, e.g., for showing current funding conditions. To this end, the operators can update the text databases in the respective MS, which automatically leads to an update for all users.

In the future, an iBRoad2EPC app could be published as another output document. This would give building owners all the information they need on their mobile phones at all times. This option cannot be pursued in the iBRoad2EPC project due to its complexity.

Additional material

iBRoad2EPC will be field tested by energy experts and auditors. They test the functions of the iBRoad2EPC assistant and create an iBRoad2EPC for real buildings. For this purpose, an enhanced training toolkit, with which the energy experts are prepared to create an iBRoad2EPC, will be created in the further project phase and include the following parts:

- Handbook for energy auditors – This will provide guidance and advice on how to assess an iBRoad2EPC for buildings. The handbook will explain the basic processes and technical details, the structure, and the user interface of the iBRoad2EPC assistant.

- Presentations for the auditors´ training – The presentation show the use of the iBRoad2EPC assistant and explained how to assess the iBRoad2EPC step-by-step.
- Supporting material – The training toolkit also contains, for example, a prefabricated table with which the energy expert can already create a step-by-step renovation strategy during the on-site visit and consider the individual wishes and needs of the owner.

ADDITIONAL MODULES

As described in chapter “iBRoad2EPC Basic Module”, the Basic Module is the core of iBRoad2EPC. Additional Modules can be integrated freely and independently of each other. Based on project meetings and bilateral discussions with all pilot countries, the following modules will be developed during the project:

- Cost Module
- Energy Demand Module
- Indoor Environmental Quality (IEQ) Module
- Smart Readiness Indicator (SRI) Module

This list is not exhaustive. Further additional modules can be developed and integrated at a later stage e. g. Whole Life Carbon (WLC), Life Cycle Assessment (LCA) or water efficiency. This may happen on behalf of a single implementing country. Each additional Module includes

- an extension of the iBRoad2EPC Assistant tool
- if necessary, the integration of a calculation method

This chapter describes the additional Modules in detail.

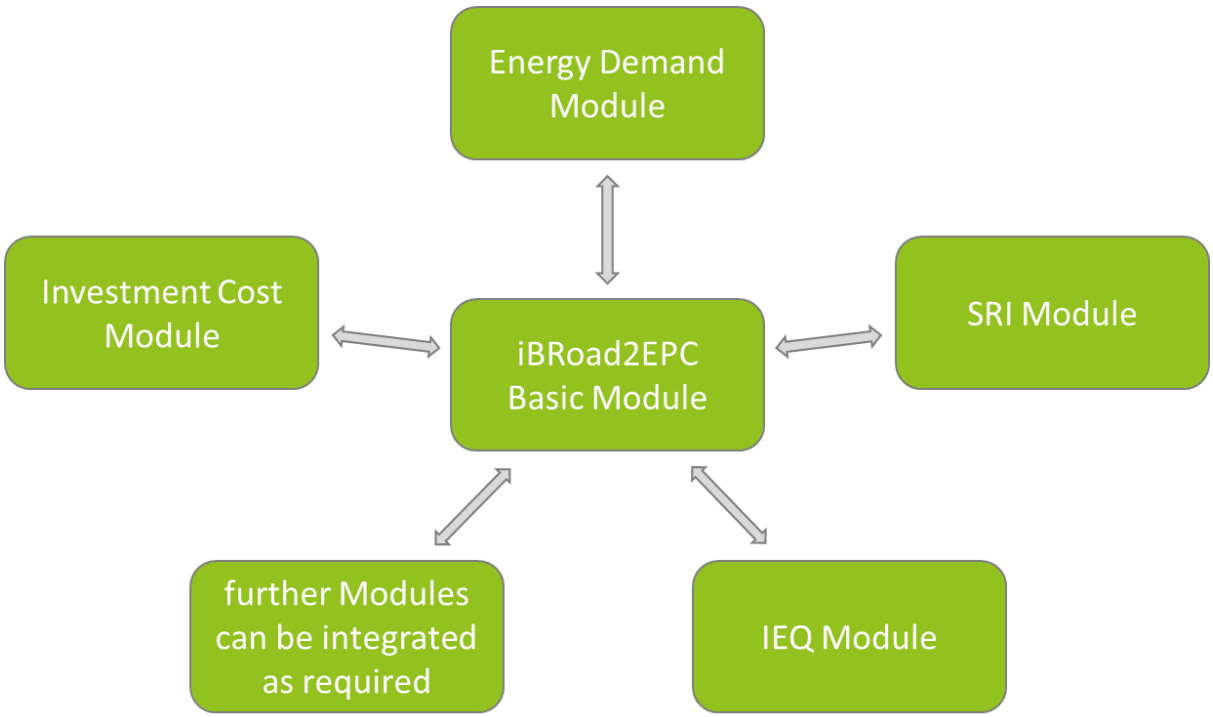


Figure 48: Modular concept of iBRoad2EPC: the Basic Module can be enhanced with additional modules to adapt iBRoad2EPC to the requirements in implementing countries

Output

The output information of the additional Modules is displayed in specific pages. In general, they follow a standardised pattern: Additional pages are inserted for each additional Module. They take up the layout of the central graphic from the Basic Module so that the building owners can easily and intuitively assign the information to the corresponding renovation steps (see Figure 52).

Energy Demand Module

The Basic Module of iBRoad2EPC shows the building owner the information about what will be renovated and when. It contains a specification of the dates, descriptions of the renovation measures and steps, and the specification of the type of renovation measures (e.g. specification of the thickness and type of insulation). The Basic Module does not contain any information on the energy consumption, greenhouse gas emissions or energy costs after a renovation step. This information requires an additional energy calculation for each renovation step, which does not fit the fundamental principle of minimised effort in the Basic Module. Implementing countries can choose to include information on energy demand for each renovation step if the required calculation effort fits their implementation concepts.

Objectives

With the Energy Demand Module, issuers get the possibility to indicate

- energy demand,
- efficiency class,
- greenhouse gas emissions,
- and energy costs

of the building after each renovation step. This clearly shows the impact of the step on the building and the savings. Building owners receive additional information that may support the decision to renovate.

Implementation in iBRoad2EPC Assistant

The energy demand is not calculated within the iBRoad2EPC Assistant tool. While this may be desirable for ease of use of the tool, it is essential that the calculation results comply with the regulations of the respective country. These calculations are complex and must be carried out with the energy performance certificate software of the respective country. The calculation routines of the energy performance certificate software cannot be transferred to the iBRoad2EPC Assistant tool. Simplified energy calculations cannot be integrated into the tool either, because they bear the risk of implausible results.

If the iBRoad2EPC is linked to the issuing of an EPC, the issuers carry out an energy calculation with the EPC software anyway. This means that they have already recorded the building with its dimensions and energy characteristics in the software. In order to calculate the energy demand after each renovation step, they have to replicate the measures planned for the renovation steps in the EPC software. From the energy demand for each step, the efficiency class, greenhouse gas emissions and energy costs can be calculated. When these results are available, they can be entered manually into the iBRoad2EPC Assistant input screen. If the Assistant is linked to an EPC software via the API interface, the results can also be transferred automatically (see chapter “Issuing an iBRoad2EPC with an Assistant Tool”). The functionalities to issue the Energy Demand Module are added to the iBRoad2EPC Assistant tool.

Output

The Energy Demand Module creates an extra page in the online output of iBRoad2EPC (see Figure 50). The sequence of the renovation steps equals the sequence in the Basic Module. It shows the energy demand, efficiency class, GHG emissions and energy costs for each renovation step in the format of the central graphic (see Figure 49).

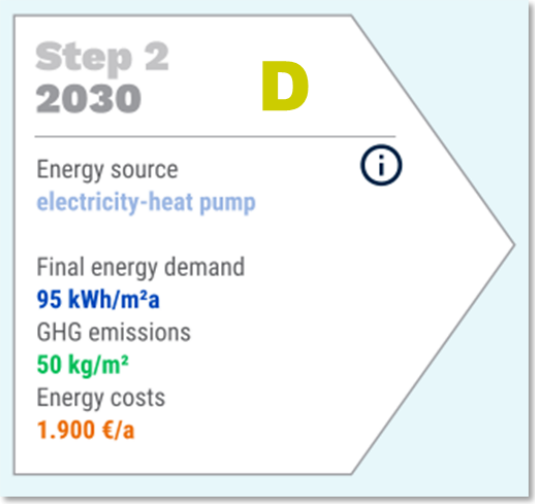


Figure 49: Additional information from the Energy Demand Module

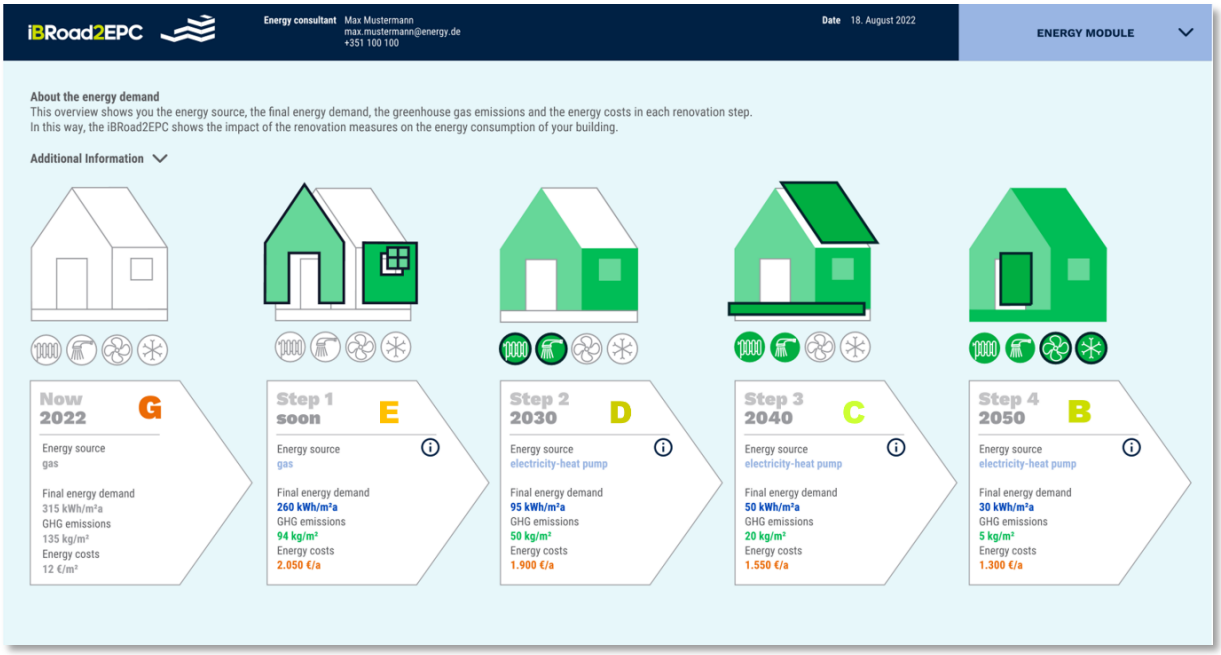


Figure 50: Output page of the Energy Demand Module in the online version

Investment Cost Module

Objectives

The Investment Cost Module allows for the display of renovation costs in iBRoad2EPC. The following cost types can be presented:

- Total investment costs
- Maintenance costs
- Energy-related additional costs
- Funding

For building owners, the question of costs of energy renovation is central. Energy efficiency measures reduce costs and thus have the potential to compensate investment cost. Although a reduction in

total costs is a strong motivation for many building owners, it cannot be used as the sole guide for the depth of renovation. The economic viability of renovation measures depends heavily on the price of energy. A long-term view such as that of iBRoad2EPC must take into account the long-term development of energy prices. If the climate crisis continues to worsen in the future or emissions in the building sector do not fall quickly enough, further policy measures can be expected to make fossil fuels more expensive, such as CO2 prices or CO2 taxes. Furthermore, the war in Ukraine has shown how volatile energy prices can be. The depth of renovation should therefore not only be based on current economic efficiency but must above all pursue the goal of a climate-neutral building stock. The evaluation of economic efficiency should therefore not only focus on short payback periods, but rather on the affordability and reasonableness of the costs.

Implementation in iBRoad2EPC Assistant

The Investment Cost Module is limited to indicating the investment costs and subsidies. It does not provide for an economic efficiency calculation. An economic efficiency calculation would require information on energy consumption or savings. This is gathered separately in the Energy Demand Module (see chapter “Energy Demand Module”). A combination of the Investment Cost Module and the Energy Demand Module is purposely avoided so that both modules can be implemented independently of each other. A complete economic efficiency calculation is possible only if a country implements both modules. However, there is no standardised calculation method foreseen. If required, an economic calculation would have to be tailored for specific country requirements.

The Investment Cost Module comprises an additional input mask in the iBRoad2EPC Assistant. It enables the input of all relevant details for the output of cost information. The Investment Cost Module also includes an output page in the iBRoad2EPC document. Alternatively, the iBRoad2EPC Assistant tool provides an API interface. If cost data are calculated within the EPC software results can be transferred automatically into the iBRoad2EPC Assistant (see chapter “Investment Cost Module”).

Variants of the Investment Cost Module

The iBRoad2EPC Investment Cost Module shows the investment costs for all recommended renovation measures. The Investment Cost Module can be implemented in two variants:

- Simplified: the Investment Cost Module offers the entry and display of investment costs and funding for each renovation step. Issuers calculate the costs with their common methods outside iBRoad2EPC
- Individual: integration of a country specific cost calculation method in iBRoad2EPC. This is not part of the project but has to be developed together with respective countries.

Implementing countries can choose the preferred variant.

Simplified Cost Module

The aim of the simplified variant of the Investment Cost Module is to show the investment costs and the expected funding for the individual renovation steps in a standardised format. The effort for the implementing countries is low with the simplified variant. They do not have to provide cost data or a calculation procedure. The cost calculation has to be carried out by the issuer and creates an additional effort. It is up to the issuers in which way they calculate the costs and on which sources they rely. The costs of all measures contained in one renovation step must be summed up and results be transferred manually into the iBRoad2EPC Assistant input fields. The simplified Investment Cost Module enables the issuers to enter the renovation costs of each renovation step in the iBRoad2EPC Assistant through respective input fields that are added to the iBRoad2EPC Assistant. The output is shown in a separate display page, which only appears when implementing countries opt for the

Investment Cost Module. The output is graphically aligned with the output of the Basic Module, so that building owners can understand the information intuitively (see Figure 52).

The Investment Cost Module presents the total costs of all renovation measures contained in one renovation step. The total costs may be split into maintenance costs and energy-related additional costs. The maintenance costs are the costs that have to be spent anyway for the upkeep of the building. They would arise in renovations without any energy improvement. On the other hand, the energy-related additional costs arise only from the energy improvement. The presentation of the funding mainly refers to grant subsidies. They can easily be shown for each renovation step. The benefits of subsidised loans, on the other hand, can hardly be assigned to a single point in time. Therefore, loans should preferably be described in writing. A corresponding input field for free text is provided. Here, issuers can also provide links to further information. In addition, issuers can specify the date when iBRoad2EPC was created. This specification is important because the funding schemes can change in time. This is briefly explained in a glossary. The issuer does not necessarily have to enter all cost types. If a cost type is not entered, it will not be displayed in the output document.

Figure 51: Additional information from the Investment Cost Module

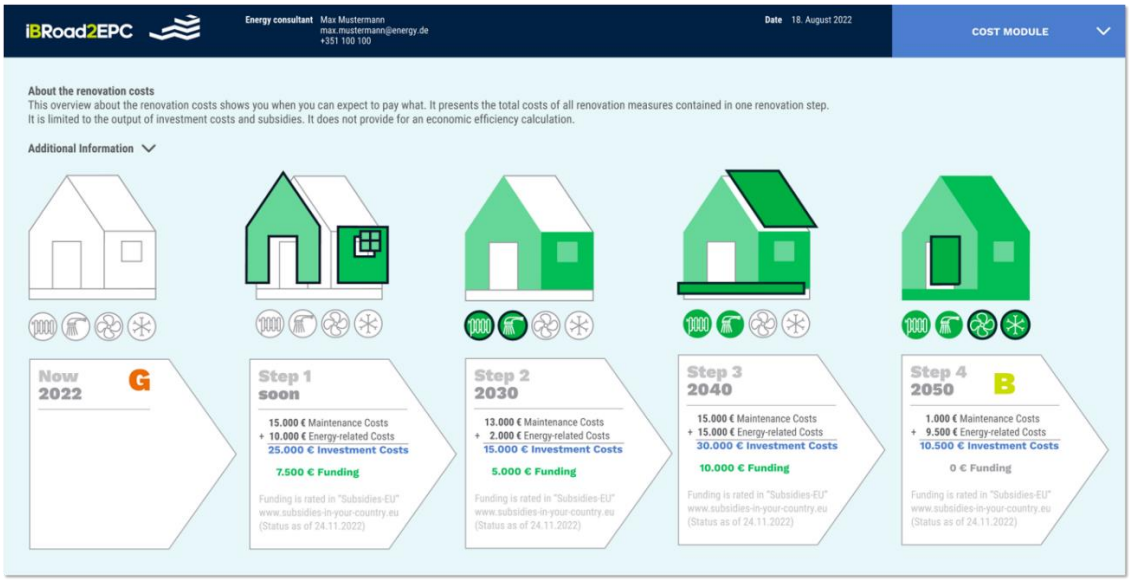


Figure 52: Display of the results from the Investment Cost Module in the online version

The simplified Investment Cost Module gives building owners an overview of when they can expect to pay what.

Integration of a country specific calculation method

Beyond the simplified method of cost calculation, a more detailed and automated method can also be chosen. However, no standardised procedure is proposed for this method because the calculation methods and required data may differ significantly between Member States. Instead, an implementing country may integrate an individual economical calculation method into iBRoad2EPC. This can be particularly useful if a certain calculation method and way of presenting the cost-effectiveness of energy efficiency measures has already been established in a country. This is not part of the project but has to be developed together with the respective countries.

A country-specific module can be created for the implementation of individual calculation methods. It can include a customised input mask in the iBRoad2EPC Assistant, a customised result output and country-specific cost databases. Figure 53 shows what an input mask in the iBRoad2EPC Assistant might look like. The implementing countries have to provide the calculation methods, calculation bases, price tables and the graphical presentation of results. They are responsible for the accuracy of the data. The country-specific Investment Cost Module is then used instead of the simplified Cost Module. It must be commissioned and implemented by the implementing country itself.

Step	Measure	Number / Surface Area	Description of Measure	Unit Price	Total Price
1	Facade insulation	130 m²	thermal insulation system, 180 mm, thermal conductivity 0,035 W/mK	110 €/m²	14.690,00 €
1	Windows	29,5 m²	repacing windows with new windows with triple glazing and a heat transfer coefficient of 0.8 W/m²K	350 €/m²	10.325,00 €
1			**total investment cost**		**25.015,00 €**
2	Heat Pump	1	replacing the heating boiler with an air/water heat pump, nominal power 11 kW	15.000 €	15.000,00 €
2			**total investment cost**		**40.015,00 €**
3	Roof insulation	180 m²	thermal insulation between rafters, 200 mm, thermal conductivity 0,035 W/mK	150 €/m²	27.000,00 €
3	Insulation of the cellar ceiling	100 m²	thermal basement ceiling insulation from below, 100 mm, thermal conductivity 0,035 W/mK	30 €/m²	3.000,00 €
3			**total investment cost**		**30.000,00 €**

Figure 53: Example for the structure of a country specific input mask for cost calculation

The results of the country specific method can be presented in a separate page of the iBRoad2EPC, e.g., with a figure, table and text. The integration of individual methods requires a great deal of effort in the creation of the necessary software. This can only be justified if a country decides to implement iBRoad2EPC. Within this project, automated individual economic efficiency calculations cannot be created.

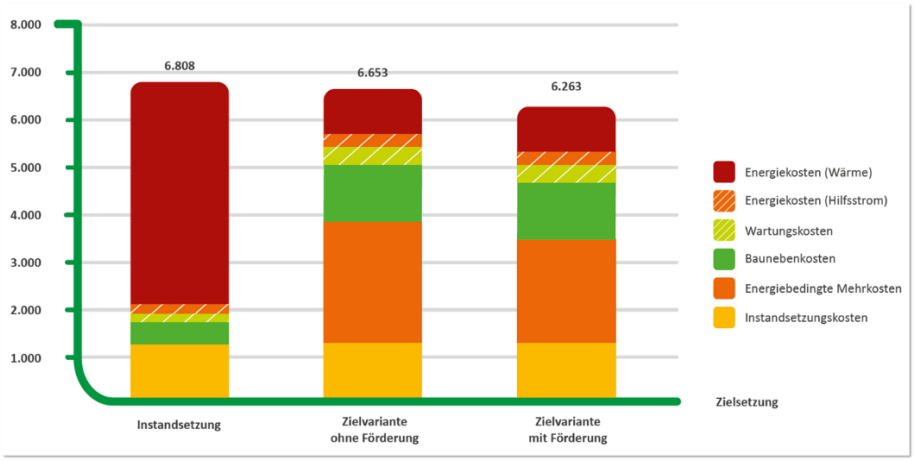


Figure 54: Example for a country specific display of renovation costs (iSFP Germany) that countries may prefer as an alternative to the standard display (Figure 52)

Indoor Environmental Quality (IEQ) Module

The IEQ module allows issuers to evaluate the indoor environmental quality of a building. The methods for calculating IEQ are described in the iBRoad2EPC reports "Experience from other Projects related to Links between EPCs and the BRP" and "Extending the iBRoad Building Renovation Passport II: Report on potential indicators to expand the scope of iBRoad". They are integrated into the IEQ Module. The reports give an overview of available and existing methods to assess indoor environmental quality, they outline a way to integrate them in iBRoad2EPC, considering necessary adjustments and adaptations to meet the specific requirements. Based on both reports the IEQ is integrated into the iBRoad2EPC with a specific module.

Objectives

Input from the iBRoad2EPC report "Extending the iBRoad Building Renovation Passport II: Report on potential indicators to expand the scope of iBRoad"

The indoor environmental quality (IEQ) has a direct effect on health, comfort, wellbeing, and productivity. The recent global pandemic has amplified the importance of IEQ, while the creation of a satisfactory indoor environment is one of the most important benefits and drivers of building renovation. Considering that people spend approximately 90% of their time in indoor environments, building legislation and relevant instruments must ensure adequate IEQ standards in buildings to maintain a healthy indoor environment.

The main determinants of IEQ are indoor air quality, thermal comfort, lighting, and acoustics. For the time being, these aspects are not covered in most of the existing EPCs. Considering that EPCs are a key source of information on the energy performance of the building stock, they have a great potential in becoming a market tool that can support improvements in energy efficiency and IEQ. The integration of the IEQ assessment in the EPCs through iBRoad2EPC can contribute to reducing health effects generated by unsuitable indoor conditions. The IEQ assessment can further improve the well-being and productivity of building occupants. Considering that energy efficiency and IEQ improvements are interrelated and should be simultaneously achieved, EPCs have the potential to become a compelling market tool to develop demand for energy efficiency in buildings.

In view of integrating IEQ in EPCs, the H2020 X-tendo project developed the IEQ indicator (comfort indicator), which includes an assessment approach for the calculation of Asset and Operational comfort rating covering all aspects of IEQ. The assessment approach is a robust methodology based on international standards, reliable frameworks, and existing well-grounded methods. The assessment of comfort builds on evidence-based inputs (Comfort Asset Rating Procedure (CARP)). The asset rating uses checklists, while the operational rating uses measurements, surveys, and checklists for the assessment of all determinants of IEQ (Comfort Operational Rating Procedure (CORP)).

Available methods to assess IEQ

Comfort Asset Rating Procedure (CARP): The comfort asset rating procedure is designed for new, renovated, and existing buildings that are not occupied. Asset rating for comfort can be issued for transactional or business purposes. For the assessment of the indoor environment, the required information can be captured through checklists. The checklists are filled in by the expert issuing the EPC during an on-site visit to inspect the building.

Comfort Operational Rating Procedure (CORP): For a more in detail evaluation of the IEQ for occupied buildings, the comfort operational rating procedure is recommended. Operational rating is issued with a longer validity (5 years) in years in comparison to CARP (1 year). Operational rating registers the actual comfort level of occupants over the course of a period and provides real

information about how comfortable the building is based on its use and operation. The assessment approach for operational rating is more holistic based on the measurements (objective), surveys (subjective), and checklists.

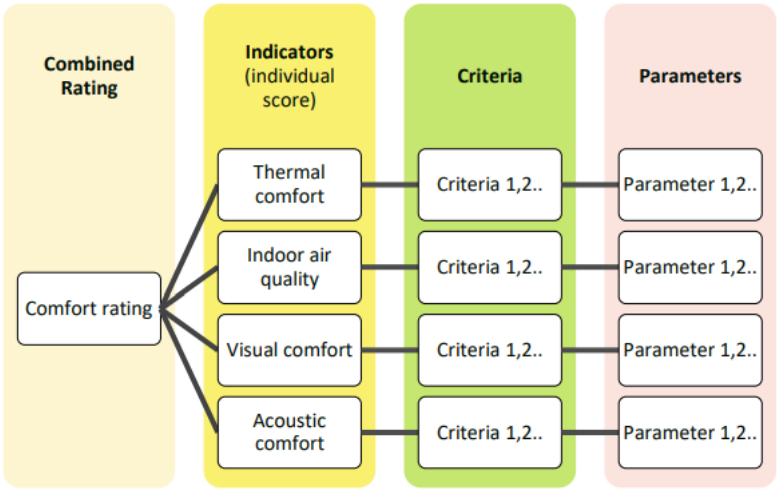
The report on potential indicators to expand the scope of iBRoad describes two methods for determining IEQ: Comfort Asset Rating Procedure (CARP) and Comfort Operational Rating Procedure (CORP). The IEQ indicator can be applied to single-family houses, multi-family apartments, schools, and offices, covering both private and public buildings.

The CORP method causes high effort for measurements and assessments. This does not fit with the iBRoad2EPC´s approach of providing basic information with very little extra effort. The CARP method fits well with the processing of iBRoad2EPC and is therefore implemented.

For the needs of iBRoad2EPC and those interested in a quicker, less expensive, and less time-consuming approach, CARP can also be applied to occupied buildings. In this case, it must be noted that CARP assesses only the capacity of the building to provide a comfortable indoor environment. Information related to impacts of the building's use and actual operation may not be captured accurately. However, the method still gives an appropriate indication of the IEQ levels.

Scoring and weighting

The main indicators assessed within CARP are: (1) thermal comfort, (2) indoor air quality, (3) visual comfort, (iv) acoustic comfort. To identify the overall IEQ level all four indicators are assessed independently based on multiple different criteria. Under each criterion specific parameters are assessed. A combined rating is possible to assess all indicators but is also possible to rate individual indicators as shown in the following figure[3]:



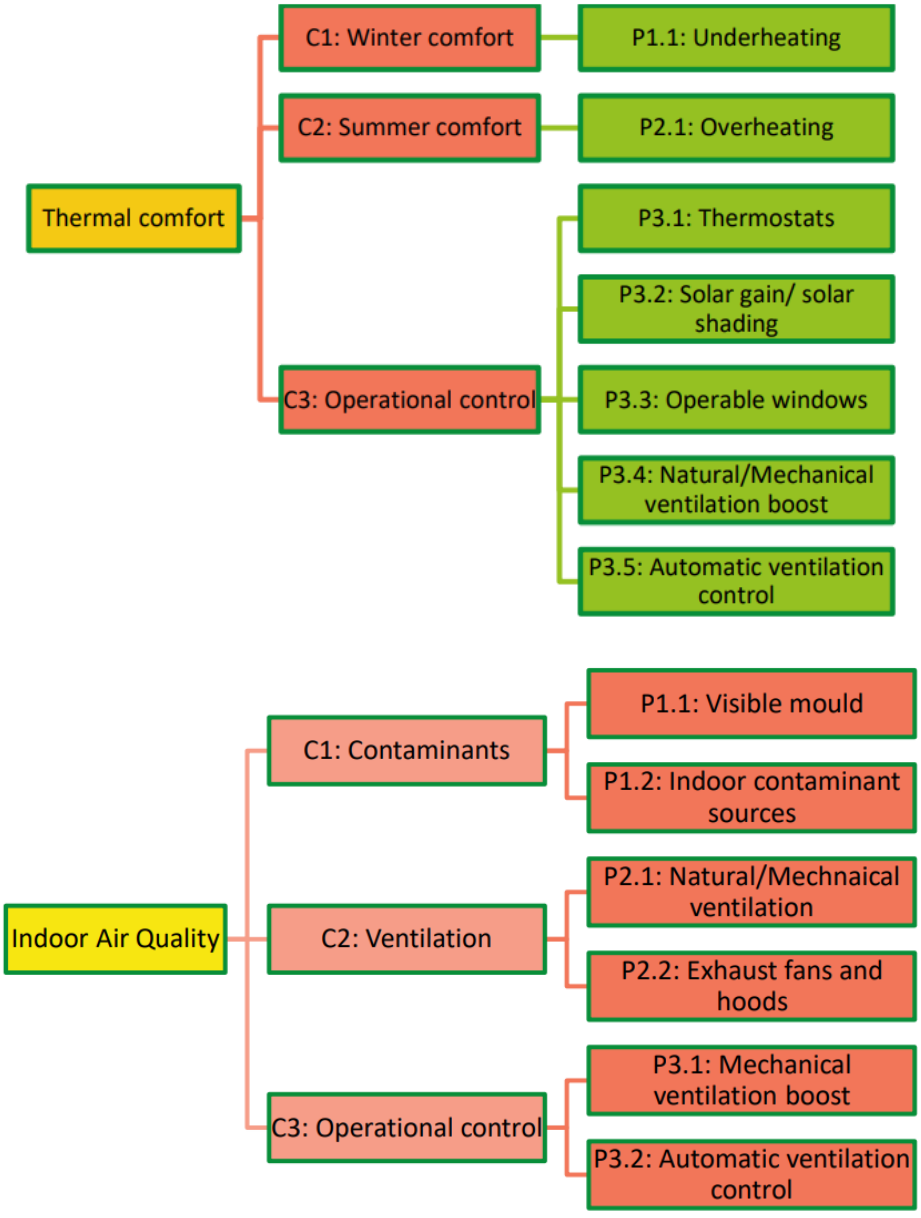
Indicators: Refers to the four main components of the comfort feature. These components may be assigned equal or different relative weightage depending on the different aspects, e.g. region, type of buildings etc. Each indicator will be assessed based on several criteria.

Criteria: The criteria are the aspects that are assessed under each indicator. The list of criteria is prepared based on existing literature. Criteria are assigned different or similar relative weightages based on expert inputs in the tool.

[3] https://x-tendo.eu/toolboxes/comfort/ User guide and calculation tools of CARP

Parameters: Certain parameters are used to assess each criterion based on the impact on comfort and health and well-being of the occupants. Relative weightage is assigned to each parameter based on expert inputs. Each parameter can obtain a score of 0 (worst) to 10 (best) which is assessed using a checklist. Individual scales for each parameter are developed for their scoring.

The criterial (C1 – C3) and parameters (P1.1 – P3.5) of the thermal comfort indicator are shown below:



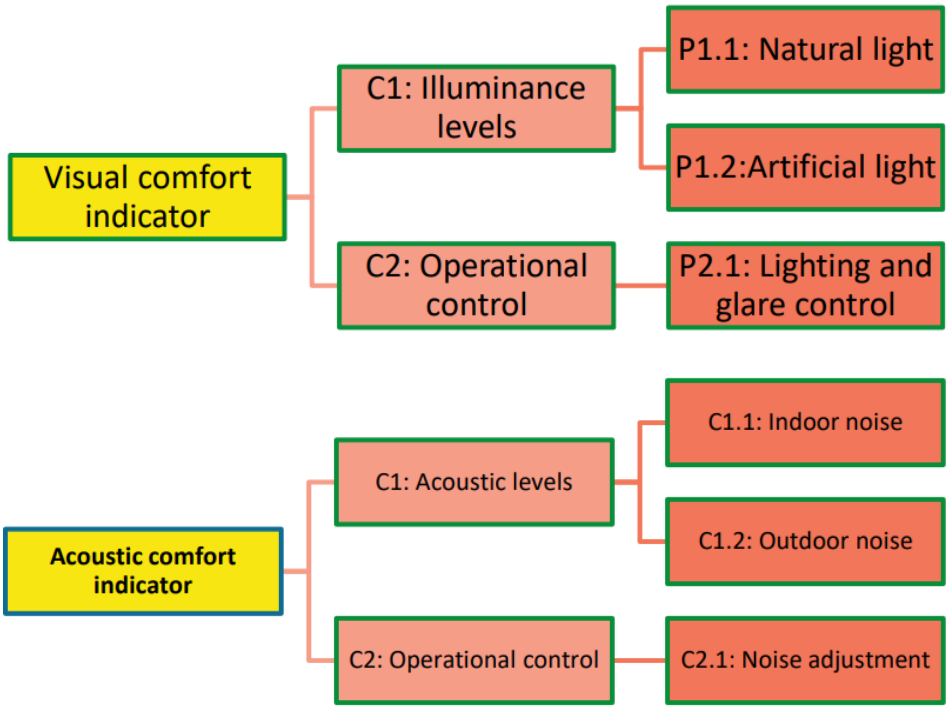


Figure 55: Presentation of the different criteria and parameters in IEQ

Implementing countries are free to choose the CORP method as well. CORP method is a more detailed and accurate method based on measurements, surveys and checklists. Operational rating records the actual comfort level of occupants and provides real information about how comfortable the building is based on its use and operation.

Regarding the assessment approach of the operational rating, on-site measurements are conducted by the assessor and cover measurements of temperature, relative humidity and carbon dioxide. Surveys are filled in by the building occupant (during the assessor's visit onsite) and checklists are filled in by the assessor.

If there are country specific methods for the assessment of indoor environmental quality already existing and in use the implementing countries can use these methods and insert the results in the IEQ Module.

CARP and CORP are already tested and designed for Greece, Romania and Portugal. Information such as the different climate zones need to be added in the Excel spreadsheets for the pilot countries Bulgaria, Spain and Poland. More information can be found in the "Report on adaptation requirements for countries".

Implementation in iBRoad2EPC Assistant

The IEQ Module adds a specific input mask to the iBRoad2EPC Assistant. It will not be possible to add all the required information in the form of a data request to the iBRoad2EPC Assistant. The xls-spreadsheet for this feature is available from the X-tendo project[4] and will be applied within the IEQ Module. To this end, the IEQ Module in the iBRod2EPC Assistant integrates a link to a download page

[4] x-tendo.eu

of the IEQ spreadsheet. The spreadsheet is not downloaded from the original x-tendo site, but a copy is provided in the iBRoad2EPC Assistant. This ensures that issuers can find the tool even if the external providers at x-tendo should change the link in the future. It also ensures that issuers download the appropriate version of the spreadsheet to which the iBRoad2EPC Assistant is aligned if updates are generated in the x-tendo project in the future. The issuers fill in all necessary information for the CARP method in this spreadsheet and thus calculate the IEQ. They then upload the spreadsheet to the iBRoad2EPC Assistant. The Assistant checks the plausibility and completeness of the spreadsheet and imports the IEQ result automatically.

Output

The visualisation of the IEQ indicator is described in the reports as follows:

All IEQ indicators are assessed in both CARP and CORP methods: (i) thermal comfort, (ii) indoor air quality, (iii) visual comfort, and (iv) acoustic comfort. All four indicators are evaluated independently based on multiple criteria to identify the overall IEQ level. For each criterion, certain parameters must be evaluated. A combined rating covering all IEQ indicators can be estimated, and equal weightage is assumed for all indicators by default. Individual rating of indicators is also an option (see iBRoad2EPC report on potential indicators to expand the scope of iBRoad).

Based on the provided inputs, Figure 49 visualises the achieved rating of comfort after assigning weights to each of the indicators (thermal comfort, indoor air quality, visual comfort, and acoustic comfort).

Figure 56: Visualised comfort rating in the X-tendo project[5]

The IEQ score is displayed in the IEQ page of iBRoad2EPC in the respective renovation step (Figure 57). As in Figure 56, there is a range from very poor to Excellent. The IEQ score is displayed for each individual renovation step. Issuers only need to calculate the IEQ for steps that affect the IEQ. If a renovation step does not affect the IEQ (e.g. heating replacement), the score remains unchanged as in the previous step.

[5] X-tendo (2022): Comfort Asset Rating Procedure (CARP), User-guide, Version 1.0. 2022

Figure 57: Display of IEQ score in iBRoad2EPC

In addition to this figure, IEQ and the result are described. Issuers can use prefabricated text blocks or override them in the IEQ Module in the iBRoad2EPC Assistant.

The issuers can calculate IEQ for every renovation step in order to show the influence of renovation measures to the IEQ. If a renovation step has no influence on the IEQ there is no need to recalculate the indicator. In this case, the IEQ is copied from the previous step.

Smart Readiness Indicator Module (SRI Module)

The concept of a Smart Readiness Indicator (SRI) was introduced in the European Energy Performance of Buildings Directive (EPBD) in 2018. Vito (2021) describes its main targets: "the indicator allows for rating the smart readiness of buildings, i.e. the capability of buildings (or building units) to adapt their operation to the needs of the occupant, also optimizing energy efficiency and overall performance, and to adapt their operation in reaction to signals from the grid (energy flexibility)."[6]

The reports "Experience from other Projects related to Links between EPCs and the BRP" and "Expanding Indicators" describe the methods for calculating SRI and outline a way to integrate that in iBRoad2EPC.

Objectives

Input from the iBRoad2EPC report on potential indicators to expand the scope of iBRoad [7]

The SRI framework supports technological innovation in the building sector and creates an incentive for smart building technologies integration, which are beneficial for increasing energy efficiency, reducing CO2 emissions, and improving the comfort and convenience of building occupants. Since the concept of the SRI is rather new, the authors are not aware of any implementation in a certification or EPC framework within Europe.

There are three methods to assess the SRI: the simplified method (method A), the expert SRI assessment (method B), and the in-use smart building performance method (method C).

Method A is based on a checklist approach with a limited services list focusing on residential buildings and small non-residential buildings. The method allows both (online) self-assessment and a third-party expert assessment, but only the latter would result in formal certification. It is a quick method that would not take more than one hour.

[6] Vito et al. 2021

[7] "Extending the iBRoad Building Renovation Passport II: Report on potential indicators to expand the scope of iBRoad", 2022

Method B is an extension of method A, with a more detailed assessment based on the checklist approach covering a full catalogue of smart services. The method focuses on non-residential buildings and would require an on-site inspection by a qualified third-party expert. It could also potentially allow a self-assessment by a non-independent expert. However, only a qualified third-party expert may issue a formal certification. Due to its complexity, the assessment time could range between half a day and a full day.

Method C is a metered/measured method that quantifies the actual performance of in-use buildings. This method assesses the actual performance based on measurement of energy consumption by end-uses, appliances, and behavioural factors. This results in a quantification of savings, flexibility, or comfort improvements that can be delivered as a result of smart technologies. Alternatively, the scope could be broadened beyond the scope of the current SRI to become an assessment of actual performance rather than solely focusing on smart controls.

Method A is considered the most relevant and realistic to be implemented in iBRoad2EPC. iBRoad2EPC is generally designed to provide a brief overview consulting service. It is intended to be issued in high volumes and therefore may require the least possible effort to produce. Methods B and C are aimed at higher accuracy and comprehensive processing. These approaches are more suited to a complete Building Renovation Passport (BRP) such as the iBRoad Roadmap. For iBRoad2EPC, they would create an imbalance in processing effort. Method A fits better to the iBRoad2EPC concept.

Implementation in iBRoad2EPC Assistant

The SRI Module adds a specific input mask to the iBRoad2EPC Assistant. It differs from the pattern of the input masks of the other additional modules. For the calculation of the SRI, a large amount of information has to be entered. This comprises heating, cooling, domestic hot water, ventilation, dynamic building envelope, electricity, electric vehicle charging and monitoring and control. Up to 15 subgroups can be processed for each of these services.

The European Commission provides the SRI calculation sheet online[8]. This is an Excel spreadsheet that allows for data entry, processing and displaying the SRI results in a unified layout. The iBRoad2EPC Assistant will not integrate these functionalities. This would require duplicating the SRI tool completely. On the one hand, this would create the risk that the algorithms are not reproduced exactly and thus cause discrepancies in the calculation results. On the other hand, possible updates of the Excel tool could not be adopted automatically. Instead, the SRI Excel tool is downloaded automatically in the iBRoad2EPC Assistant. The Excel file with the completed calculations can be uploaded to the iBRoad2EPC Assistant. Here the results for the SRI are automatically extracted and inserted into the output format of the iBRoad2EPC SRI Module. The following input from the iBRoad2EPC report on potential indicators to expand the scope of iBRoad, describes the general processing in the SRI Excel tool.

[8] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/smart-readiness-indicator/sri-implementation-tools_en

The technical implementation process of the SRI (focusing on methods A and B) consists of three parts that will be described in detail; (1) necessary data requirements and data collection methods, (2) processing of the collected data to rate the smartness of the various components and services present in the building, and (3) procedures for storing and updating SRI data.

For both methods A and B, to start with the assessment, the user needs to input general building information that includes building type, building usage, building state, and location. Building type has two options, residential and non-residential. In the case of residential buildings, building usage can be the following, single-family house, small multi-family house (ten residential units or less), large multi-family house (more than ten residential units), or other, i.e., student housing, care homes, etc. Building usage for non-residential buildings can be offices, educational buildings, healthcare, or other. The building state can be either renovated or original. Renovated buildings are those that have undergone important energetic upgrades and/or upgrades to the technical building systems since the year of construction. At last, there is the location of the building. Five climate zones are identified, and the appropriate climate zone is determined according to the location of the building[9].

The following nine domains (Figure 51) are in the scope of assessment: space heating, domestic hot water, space cooling, ventilation, lighting, dynamic building envelop, electricity, electric vehicle charging, and monitoring and control. For each of these services, the user shall be able to select several features.

It is not necessary to assess all domains. The user can omit some services if not relevant or not applicable. However, that should be indicated in the methodology section, where users shall choose options for three fields, (1) preferred weightings, (2) preferred assessment method, and (3) domains present, which will be explained in detail in the following text.

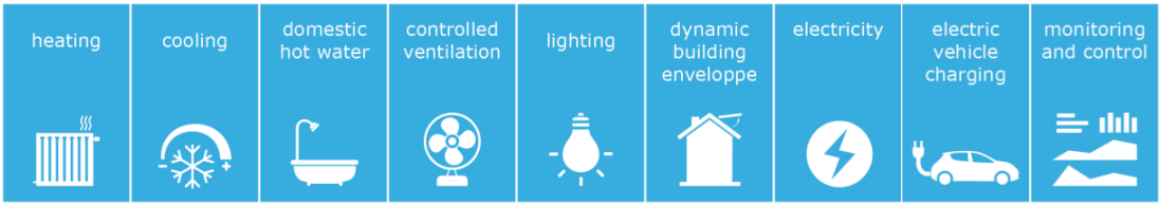
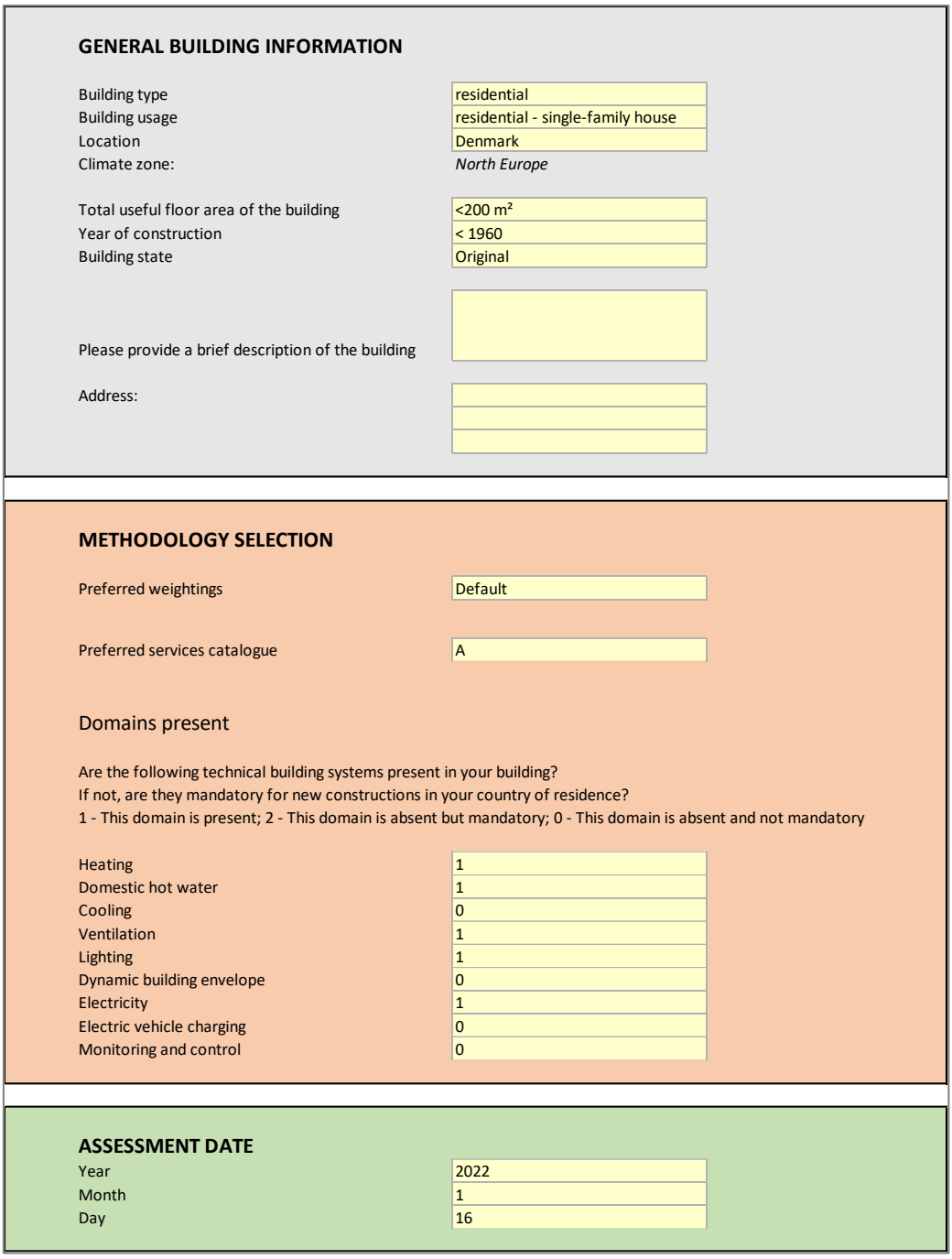


Figure 51: Domains structuring the SRI catalogue [1]

[9] Northern Europe (Denmark, Finland, Sweden, Norway, Iceland), Western Europe (Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands, United Kingdom, Liechtenstein, Switzerland), Southern Europe (Greece, Italy, Malta, Portugal, Spain, Cyprus), North-Eastern Europe (Czech Republic, Estonia, Latvia, Lithuania, Poland, Slovakia), and South-Eastern Europe (Bulgaria, Croatia, Hungary, Romania, Slovenia)



GENERAL BUILDING INFORMATION

Building type	residential
Building usage	residential - single-family house
Location	Denmark
Climate zone:	*North Europe*
Total useful floor area of the building	<200 m²
Year of construction	< 1960
Building state	Original
Please provide a brief description of the building	
Address:	

METHODOLOGY SELECTION

Preferred weightings	Default
Preferred services catalogue	A

Domains present

Are the following technical building systems present in your building?
If not, are they mandatory for new constructions in your country of residence?
1 - This domain is present; 2 - This domain is absent but mandatory; 0 - This domain is absent and not mandatory

Heating	1
Domestic hot water	1
Cooling	0
Ventilation	1
Lighting	1
Dynamic building envelope	0
Electricity	1
Electric vehicle charging	0
Monitoring and control	0

ASSESSMENT DATE

Year	2022
Month	1
Day	16

Figure 58: Excerpt from the SRI Excel tool: general building information and selection of the calculation method and services to assess

This should be done first for the current state of the building. Second, the issuer should check for every renovation step whether the package of measures is expected to result in a change in any of the input variables for the SRI calculation. Third, the issuer should carry out the SRI calculation for those renovation steps with a possible change of the SRI input variables.

code	service	1						
H-1c	**Storage and shifting of thermal energy**		Service group:	Control heat production facilities				
Functionality levels		**IMPACTS**						
		Energy efficiency	Energy flexibility and storage	Comfort	Convenience	Health, well-being and accessibility	Maintenance and fault prediction	Information to occupants
level 0	None	0	0	0	0	0	0	0
level 1	HW storage vessels available	1	0	1	1	0	0	0
level 2	HW storage vessels controlled based on external signals (from BACS or grid)	2	0	1	1	0	0	0
level 3	-	-	-	-	-	-	-	-
level 4								
	Information sources							
	Standard?	EN 15232						

code	service	0						
H-1d	**Control of distribution pumps in networks**		Service group:	Heat control - demand side				
Functionality levels		**IMPACTS**						
		Energy efficiency	Energy flexibility and storage	Comfort	Convenience	Health, well-being and accessibility	Maintenance and fault prediction	Information to occupants
level 0	No automatic control	0	0	0	0	0	0	0
level 1	On off control	1	0	0	0	0	0	0
level 2	Multi-Stage control	2	0	0	0	0	0	0
level 3	Variable speed pump control (pump unit (internal) estimations)	2	0	0	0	0	0	0
level 4	Variable speed pump control (external demand signal)	2	0	0	0	0	0	0

Figure 59: Excerpt from the SRI Excel tool: rating for different services

Output

After the assessment is completed, the results are obtained in three different levels, according to the level of detail and granularity that the user would like to see: (1) the total SRI score, (2) the impact scores and (3) by domain scores. These three levels are also shown in Figure 60 where the SRI method is tested within the X-tendo project [11] in a new single-family house situated in Palermo.

We recommend to display these three levels of information for the status quo, the final status and every step where a change of the SRI may occur, i.e. where the package of measures foreseen in the corresponding renovation step results in a change of input data in the SRI tool.

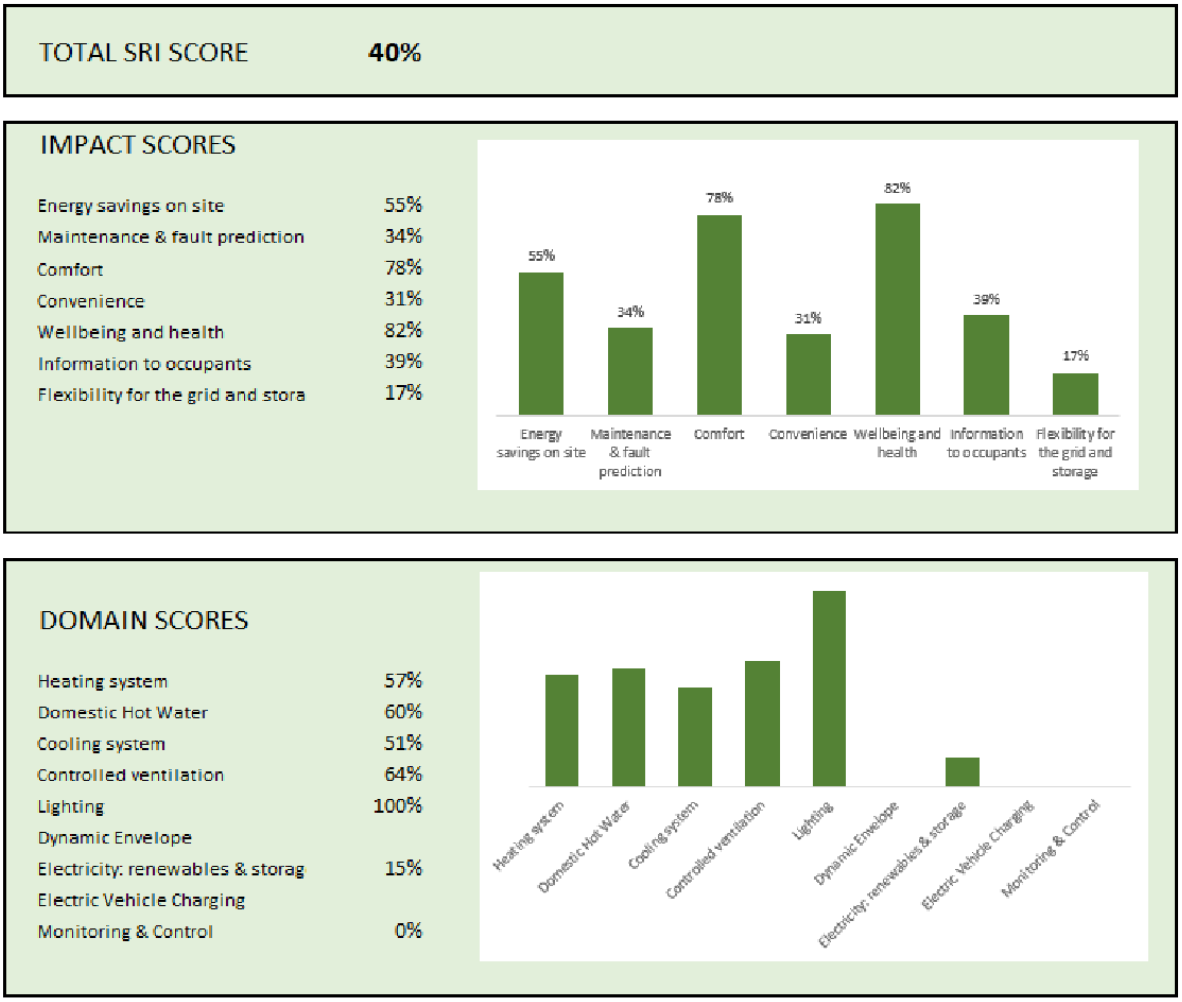


Figure 60: Exemplary test result of the SRI indicator in a new single family house in Palermo [11]

Outlook for possible further Modules

Within the project duration, only the modules described above will be realised. The modules were defined in a discussion and decisions process together with the pilot country partners. However, the flexibility provided by the modular structure in iBRoad2EPC allows for the development and integration of additional modules, at later stages, if required. This can also be done at the level of individual Member States if they want to add country specific information. The following topics are examples of possible additional modules.

- Water efficiency
- Electromobility
- Renewable energy resources
- Summer heat protection
- Municipal heat planning
- Photo Module

EMBEDDING IBROAD2EPC INTO EXISTING INSTRUMENTS

This chapter addresses the basic technical issues of how iBRoad2EPC can fit into the existing "ecosystem" of building and energy related instruments such as EPC software, building databases, funding, renovation obligations and occasions that trigger the issuance of EPCs in the respective implementing countries. Possible additional functions of iBRoad2EPC, which could result from an exchange of data between these instruments, are anticipated in order to prepare them already during the development of iBRoad2EPC. The chapter shows the basic possibilities of embedding iBRoad2EPC and does not go into concrete country-specific solutions. These aspects will be shown in a separate report on initial national guides, which is in progress at the time of finalising this report. Rather, it shows the basic possibilities of how iBRoad2EPC can be integrated into existing structures and what functionalities and opportunities arise from this. The chapter first looks at the interactions between iBRoad2EPC and the other iBRoad tools already developed. It then looks at the other instruments that may be available in certain countries.

Considering iBRoad Products in the development of iBRoad2EPC

iBRoad2EPC follows on from the products of the predecessor project: the iBRoad Renovation Roadmap, which provides a detailed Building Renovation Plan (BRP) as introduced in the EBPD, and the iBRoad Logbook, which is a Digital Building Logbook (DBL) as defined by the EPBD. As described in chapter “Key Features of iBRoad2EPC”, the iBRoad2EPC comes to fill in a market gap between the EPC and the BRP. A possible interaction of iBRoad2EPC with the other products in the iBRoad family must be considered in its development so that it fits in well with the existing products and together with them makes a meaningful whole. The existing iBRoad tools and their relationship to each other are briefly described. Then the various possible combinations are described. They allow highly customised adaptation to the requirements of the implementing countries.

iBRoad Renovation Roadmap

The iBRoad Renovation Roadmap is an energy audit for individual buildings. It outlines a customised renovation plan with a long-term horizon for deep staged renovation of single- and two-family houses as well as small multi-family houses. Thus, the iBRoad Renovation Roadmap allows building owners to have an overview over the full range of the building’s renovation strategy adapted to the individual preferences of the building owners and occupants. As a result, the iBRoad Renovation Roadmap facilitates the owners’ decision to invest in deeper renovation. It includes detailed energy consulting based on an on-site inspection and a comprehensive interview of the building owners. Ideally, the auditor together with the owner determine when each renovation step is to be carried out and what it should involve. The age of the existing building components is the starting point for this plan, but so are the owners' personal circumstances. Then, for each future renovation step, the auditor calculates the energy savings, retrofit costs and greenhouse gas savings. In addition, it indicates for each renovation step what additional benefits will follow, such as comfort improvements. In the case of step-by-step renovation, it is particularly important to pay attention to the interaction of the individual renovation steps so that they actually achieve deep renovation in the end. This applies in particular to component connections. They must be airtight and without thermal bridges. The fact that all refurbishment steps are planned from the start means that important preparatory work for later steps can already be carried out in the early renovation steps. This avoids planning errors and the so-called lock-in situations.

The iBRoad Renovation Roadmap document consists of four main elements:

- description of the current building state with energy demand and energy costs as well as hints for energy-saving behaviour,

- a Roadmap overview showing the most important information, such as what should be done when and what are the costs and savings,
- a detailed Roadmap showing additional results, such as greenhouse gas savings and additional benefits,
- an in-depth description for each renovation step.

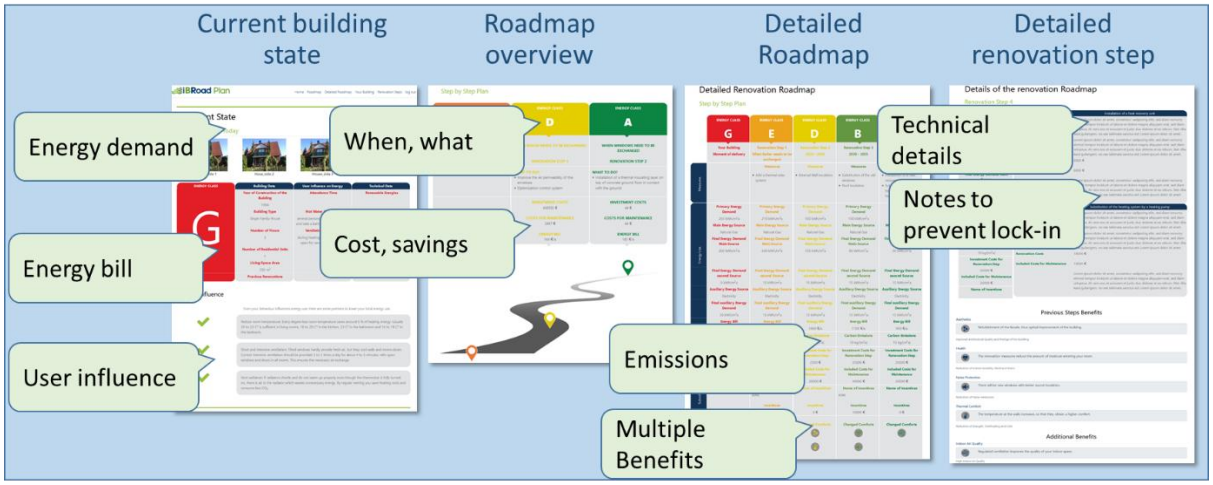


Figure 61: pages and main content of the iBRoad Renovation Roadmap (iBRoad 2020)

For more information on the iBRoad Renovation Roadmap see ADENE (2018)[10].

The Renovation Roadmap was field tested in three iBRoad pilot countries, i.e., Bulgaria, Poland, Portugal, and Ireland. The average time needed to create a Renovation Roadmap was 13.5 hours (ifeu et al. 2018)[11]. Thus, the Renovation Roadmap is not suitable for mass production when coupled with an EPC, as intended with the iBRoad2EPC. The iBRoad2EPC could rather be called a "light version" of the roadmap.

iBRoad Logbook

The iBRoad Logbook is the second product of the iBRoad project. It is a digital building logbook that serves as a building repository. The Logbook can store all energy-related data of a building, such as surface areas, U-values and orientation of building components, types of heat generators, fuels and their coverage percentages, ventilation, and air-conditioning systems as well as the type of water heating.

Building owners can digitally store all building-related information (e.g., energy bills, incentives, loan and tax documents). In addition, the iBRoad Logbook provides feedback on the temporal improvements of the energy-related components of the building envelop and technical building systems. The efficiency is symbolised with colours as known from efficiency labels (see Figure 61 and Figure 62). In principle, the Logbook can be extended so that it can be used as a national EPC database if one does not yet exist in a Member State. However, this is not its original objective and a number of further adjustments would be required to achieve this. For example, a standardised interface between the EPC software and the logbook would be essential in this case, as described in the

[10] Report on suggested elements, concept and layout of the iBROAD document, ADENE, September 2018
[11] Test driving the Individual Building Renovation Roadmap and Logbook, ifeu – Institute for Energy and Environmental Research, August 2019

following chapter. The stored data can be made available to public authorities in order to record the energy status of the entire building stock and to monitor progress towards a climate-neutral building stock. The Logbook can serve as a basis to support or enable further policy instruments, such as renovation obligations (MEPS), subsidies or fiscal instruments. Full compliance with GDPR requirements must be ensured. If there is already an EPC database in an implementing Member State, it may be coupled with the Logbook. Since the logbook can also store the renovation strategies and foreseen future target states of the buildings, it can be used to check the target compatibility of the current policy instruments and allow for a continuous target vs. actual control of the national building strategy. For a detailed description of the iBRoad Logbook see ADENE et al., 2018[12].

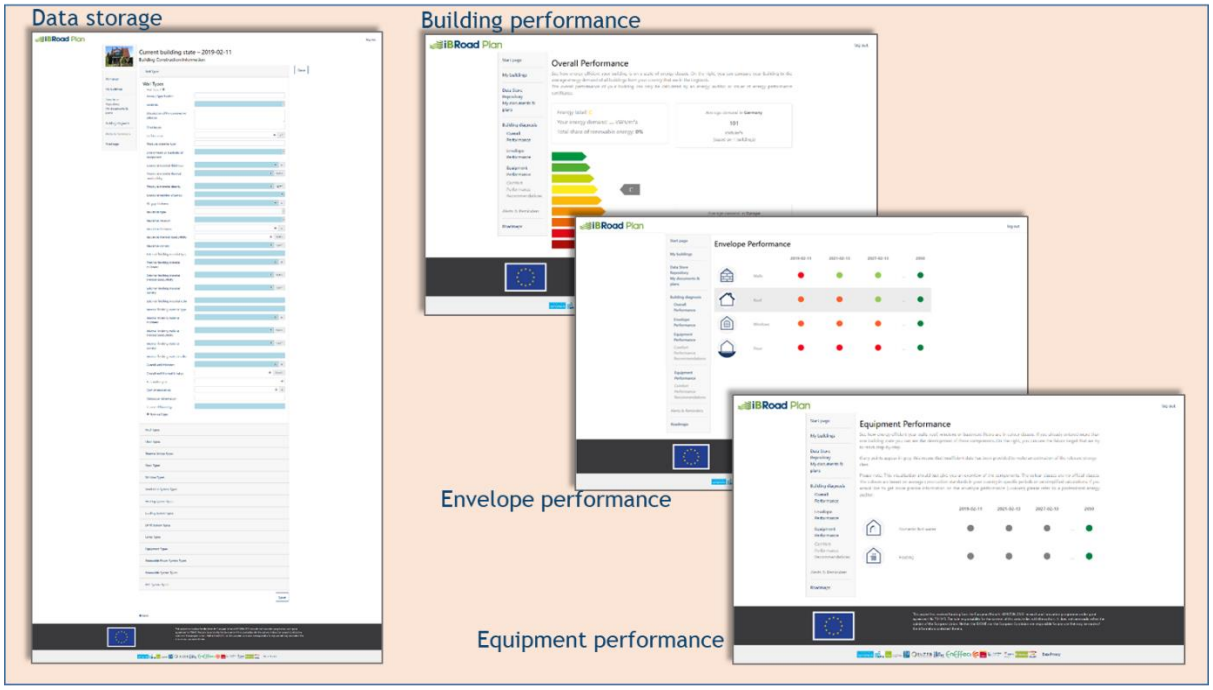


Figure 62: pages and main content of the iBRoad Logbook (iBRoad 2020)

Issuers usually enter this energy-related building data into the EPC software of their respective country. Therefore, it is recommended to set up an interface to automatically transfer the data from the EPC software to the logbook. This avoids having to enter the data twice. As EPC software products are always created for the specific requirements of a country, there are many and very different EPC software products. For this reason, at least one individual interface has to be provided for each implementing country. This effort could not be made during the development of the logbook. The following chapters show how the iBRoad Logbook and Renovation Roadmap are linked and how they can integrate the iBRoad2EPC.

Interaction between Renovation Roadmap and Logbook

The Renovation Roadmap and the Logbook have been developed to complement each other. The output document of the Renovation Roadmap is automatically saved and displayed in the Logbook. Building owners can enter the renovation steps that they are implementing in reality in the Logbook

[12] The logbook data quest, Setting up indicators and other requirements for a renovation passport, ADENE – Agência para a Energia, July 2018

and thus monitor the renovation progress in the actual state. The Renovation Roadmap serves as a benchmark for each step. This makes it easy to see whether the building is still on the planned renovation path.

It is also possible to store the complete calculation data of the Renovation Roadmap in the Logbook. This allows owners to manage the energy data of their buildings themselves, such as surface areas, wall layers or system data. Even years after the Renovation Roadmap was issued, they can make the data available to planners, architects and craftsmen. The calculation data are not stored in the Renovation Roadmap but are located in the calculation software of the energy consultants. Since large buildings can generate considerable amounts of data, an automatic data transfer from the calculation software to the logbook is essential. However, no automatic interface has been realised yet, as it would always have to be adapted to the respective calculation software of the individual countries. For smaller buildings, the data can also be transferred manually to the logbook.

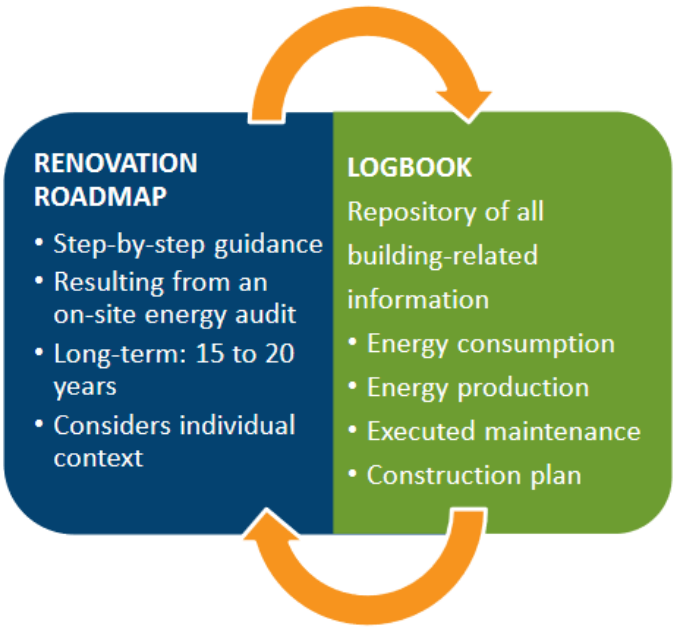


Figure 63: Interaction between Renovation Roadmap and Logbook (ADENE et al. (2018))

Interaction between iBRoad2EPC and the iBRoad Renovation Roadmap and Logbook

Together with the Renovation Roadmap and the Logbook, the iBRoad2EPC forms the iBRoad product family. Various combinations are conceivable as to how the individual tools can be interconnected. These combinations are presented below and their implications for the development of the iBRoad2EPC are explored, in particular a possible data exchange between the tools (Figure 64). This is to anticipate and prepare future use cases for the iBRoad product family.

Figure 64: iBRoad product family with possible connections between iBRoad2EPC, Renovation Roadmap and Logbook

Table 1 shows a comparison of the features of iBRoad2EPC, iBRoad Roadmap, iBRoad Logbook,and the EPC. The EPC only shows information about the current building state and in general does not contain a renovation strategy. The iBRoad Roadmap and iBRoad Logbook provide the building owner not only with a comprehensive renovation strategy, but also with other additional benefits, such as a comprehensive overview of the costs of the renovation measures.

ategory	Content	iBRoad2EPC	iBRoad Roadmap	iBRoad Logbook	EPC
Present building state	Efficiency class	yes	yes	yes	yes
	Energy consumption	yes	yes	yes	yes
	SRI rating	yes	can be included	can be included	country specific
	IEQ rating	yes	can be included	can be included	country specific
	Obligations from EU MEPS	yes (optional feature)	yes	can be included	no
	User behaviour	no	yes	yes, through iBRoad Roadmap	no
Future renovation steps	Estimated date of renovation	yes, in standardised steps	yes	yes	no
	Description of renovation measures	yes	yes	yes	country specific
	Technical details of renovation measures	yes	yes	yes, through iBRoad Roadmap	can be included
	Notes to prevent lock-in situations	yes	yes	yes, through iBRoad Roadmap	no
	Energy demand after measure	yes (optional feature)	yes	yes	no
	Indication of additional multiple benefits	no	yes	yes, through iBRoad Roadmap	no
	Total investment	yes (optional feature)	yes	yes, through iBRoad Roadmap	no
	Costs for maintenance	yes (optional feature)	yes	yes, through iBRoad Roadmap	no
	Incentives	yes (optional feature)	yes	yes, through iBRoad Roadmap	no
	Energy bill	yes (optional feature)	yes	yes	no
Target building state	Required energy class according to LTRS	yes	can be included	can be included	no
	Calculated best possible energy class	yes (optional feature)	yes	yes, through iBRoad Roadmap	no
	Calculated best possible energy demand	yes (optional feature)	yes	yes, through iBRoad Roadmap	no
	SRI rating	yes	can be included	yes	no
	IEQ rating	yes	can be included	can be included	no
General	Advice for concrete next steps	yes	yes	yes, through iBRoad Roadmap	no
	Reference to other iBRoad products	yes	yes	yes	can be included
	Renovation strategy	yes	yes	yes	no
	Digital store of building-related information	no	no	yes	depending on country specific database
	Funding information	yes (optional feature)	yes	yes, through iBRoad Roadmap	no
	Connection to the EPC database	yes (optional feature)	no	can be included	country specific
	Connection to municipal planning	can be included	can be included	can be included	no
	Mandatory on-site visit	yes	yes	no	country specific

Table 1: Comparison of the features of iBRoad2EPC, iBRoad Roadmap, iBRoad Logbook, and EPC

iBRoad2EPC and iBRoad Renovation Roadmap

iBRoad2EPC and the iBRoad Renovation Roadmap both aim to create a long-term renovation strategy. Therefore, it is important that the differences between the two tools are clearly communicated to avoid confusion. While the Renovation Roadmap provides very comprehensive, detailed and elaborate information, the iBRoad2EPC is an improved version of the renovation recommendations in the EPC. This means that the renovation recommendations in the iBRoad2EPC are automated to a high degree and are primarily based on the national targets for the building sector rather than the individual circumstances of each building. Elaborate energy and cost calculations are not included in the Basic Module of iBRoad2EPC in order to align the effort and cost with the issuance of an EPC. The iBRoad2EPC can also be described as a "light version" of the Renovation Roadmap.

For building owners who already have a Renovation Roadmap, it doesn't make sense to purchase an iBRoad2EPC because the information in the Renovation Roadmap is much more customised and accurate. On the other hand, it makes sense to have a Renovation Roadmap issued if you had an iBRoad2EPC before. In this case, the iBRoad2EPC serves to raise general interest in a long-term renovation strategy. The iBRoad2EPC should therefore contain a specific reference to the Renovation Roadmap in order to direct interested building owners in a targetted manner.

Ideally, a Renovation Roadmap builds on the content of an already existing iBRoad2EPC. However, it is not mandatory that the renovation recommendations in the Renovation Roadmap are completely congruent with those in an existing iBRoad2EPC. If discrepancies arise, it is important that the auditor explains to the building owners why they arise. Here, it is important to point out the fundamental differences between the two tools (iBRoad2EPC: largely automated advice, low effort, low cost, Renovation Roadmap: comprehensive energy audit). The risk of confusing building owners by differences between the iBRoad2EPC and the iBRoad Renovation Roadmap is considered relatively low. The auditor presents the Renovation Roadmap to the owner in a personal consultation and can explain possible differences.

It is not intended to establish a direct interface between the iBRoad2EPC and the Renovation Roadmap or their assistant tools. Even though it seems reasonable to develop a renovation roadmap from an existing iBRoad2EPC, the amount of data that could be automatically transferred is small. The implementing countries can thus build an interface as an individual solution, should it be helpful in their specific case.

iBRoad2EPC and iBRoad Logbook

iBRoad2EPC and the iBRoad Logbook complement each other very well. The iBRoad2EPC can be stored and displayed as a document in the Logbook. Similarly, it is possible to integrate a link to the online version of the iBRoad2EPC in the iBRoad Logbook. Building owners can enter concretely implemented renovation measures in the Logbook and thus document their renovation progress. They can align planned renovation measures with the iBRoad2EPC and check after completion whether the building is still on the target path. The auditor can create a record in the logbook along with each iBRoad2EPC issued. He hands over the access data to this record to the building owner together with the iBRoad2EPC. The auditor can voluntarily add the first building data he has collected to the Logbook as a service to the building owner. Thus, the building owner receives the full functionalities of the Logbook together with the iBRoad2EPC. This makes the Logbook the central point of contact for building owners when it comes to improving the energy efficiency of their building.

When the iBRoad2EPC is linked to the EPC by obligation (which is not necessarily the case, it can also be carried out as voluntary audit), the Logbook can take over the function of the national EPC database if none exists in a Member State. The auditors would create an entry in the Logbook along with each iBRoad2EPC issued and insert the minimum required content as defined by the government.

Preferably, the interface between EPC software and Logbook (as described above) should also be set up so that all input data for the calculation can be transferred to the Logbook.

A direct interface between iBRoad2EPC and the iBRoad Logbook is not required. No significant data exchange is to be expected in either direction. To integrate the iBRoad2EPC into the logbook, it can either be copied as a document into the document memory of the logbook or a link to the online version can be integrated. This link can be created with the iBRoad2EPC Assistant and linked to a record in the logbook. No data exchange is required in the other direction either - from the logbook to the iBRoad2EPC. Even if there is an extensive collection of building data in the Logbook, this cannot be used directly to issue the iBRoad2EPC. The energy calculations for the iBRoad2EPC have to be performed in the national EPC software. Logbook data is not required for the entries in the iBRoad2EPC Assistant.

Coupling iBRoad2EPC with Energy Performance Certificates (EPC)

An implementing country can determine whether the iBRoad2EPC should be issued as an extension of the EPC or independently as a voluntary energy advice tool. The coupling to the EPC was the starting point for the development of iBRoad2EPC. Here, the intention was that the renovation recommendations included in the EPC would be improved by

- linking them to climate targets,
- aligning them with national strategies for the building sector,
- enhancing them to consider also staged renovations,
- and including the main elements of a Building Renovation Passport (BPR) already in the EPC.

Linking iBRoad2EPC with EPCs means the trigger points for issuing the EPC also apply to the iBRoad2EPC. In general, these are the purchase, rental, or renovation of a building. These triggers determine the situation in which iBRoad2EPC reaches the building owners. This needs to be considered in the development of iBRoad2EPC. For example, it must be ensured that when a building is sold, the recommendations are directed to the new owner, because only the new owner can implement the renovation strategy. This is a fundamental difference to energy consultations, which are usually ordered when the owners are already planning a concrete renovation project. This means that the renovation strategy comes as additional information to the EPC but was not ordered by the client. The advantage of coupling iBRoad2EPC with the EPC is the large number of EPCs issued each year. This enables a wide distribution of the iBRoad2EPC renovation strategies.

iBRoad2EPC as Stand-alone Tool

It is possible to implement and operate the iBRoad2EPC consulting tool almost independently of existing tools. It then consists of a defined audit procedure, the framework for an audit report and an online assistant with which the report is created. However, even in this case several connections to existing structures are essential for the iBRoad2EPC to function.

Coupling of iBRoad2EPC with the national EPC Software

The energy calculations for the iBRoad2EPC are carried out with the EPC software of the respective implementing country. An internal calculation in the iBRoad2EPC Assistant is not provided. The calculation routines of the underlying standards are far too complex to include in the iBRoad2EPC Assistant. They must be able to calculate a wide range of different building types and technical building equipment. Even simplified procedures for energy calculations should not be included in the iBRoad2EPC Assistant because they would lead to deviations from the results of the original EPC software. This could confuse the building owners.

The results can be transferred from the EPC software to the iBRoad2EPC Assistant either manually or via an automated API interface. Manual data transfer is particularly suitable if only few iBRoad2EPC

modules are implemented in a country. In this case, the standardised front end of the iBRoad2EPC Assistant tool is used (see chapter "Standard iBRoad2EPC Front End"). This means that issuers have to use two software tools: the EPC software and the iBRoad2PEC Assistant.

The API interface is provided by the iBRoad2EPC consortium. It allows issuing the iBRoad2EPC from within their EPC software. It enables issuers editing all required entries in their EPC software. However, software companies have to insert the respective input fields in the EPC software.

Coupling of iBRoad2EPC with the national EPC Database or Digital Building Logbook

The following functionalities are not included in the scope of this project and are not realised during the project duration. Nevertheless, they are presented in this chapter to showcase potential future features and explain that these possibilities have been considered during the conceptualisation of iBRoad2EPC.

Interaction of iBRoad2EPC and EPC Database

iBRoad2EPC can be well coupled with existing EPC databases. This would allow data for planned future building conditions to be transferred to the EPC database, such as planned dates of renovation measures, types of planned renovation measures, types of planned technical building equipment, planned energy sources for heating, planned efficiency classes, planned dates for achieving climate-neutral status. The concrete way of data transfer between iBRoad2EPC and the EPC database has to be adapted in each implementing country to the respective objectives, the existing data exchange formats and the existing organisation of data transfer between EPC software and EPC database. Manual, assisted or fully automated data exchange is possible.

The interaction provides the database with additional information about the future planned energy status of the buildings. In this way, the future development of the building stock can be modelled with the EPC database. As this modelling is based on the concrete renovation strategies of individual buildings, it is well suited as a bottom-up cross-check of overarching renovation strategies such as the Long Term Renovation Strategies (LTRS) or National Building Renovation Plans (NBRP), which have a top-down perspective.

By evaluating the overall renovation strategies from iBRoad2EPC of the individual buildings, it is possible to check how targeted the current policy instruments are.

Interaction of iBRoad2EPC and spatially resolved Data in a Building Database

The use of energy-related building data, both current and expected in the future, in a database opens up many additional analysis possibilities. If these data are spatially evaluated, for example with geoinformation systems, they can be an important basis for municipal heat planning. It is thus possible to identify the heat demand, GHG emissions or energy costs not only for individual buildings, but also for neighbourhoods or settlements. This allows to predict whether areas are suitable for the construction or expansion of district heating. As district heating networks are long-lasting infrastructures, knowledge of the future development of heat demand is particularly important in planning. In this way, the long-term economic viability can be checked in advance. The spatially resolved iBRoad2EPC data can also be used to assess other infrastructures, such as electricity distribution networks in areas where the iBRoad2EPCs envisages particularly large numbers of heat pumps.

By connecting iBRoad2EPC with geodata in a building database, the recommendations in iBRoad2EPC can also be improved. If preferred areas for the construction of district heating networks are already

spatially resolved in the database, the building owners can be recommended in iBRoad2EPC to connect to the heating network in the future.

The above functions can also be provided when using the iBRoad logbook instead of the EPC database.

The options for embedding iBRoad2EPC into existing policy instruments shown above were taken into account during the development of iBRoad2EPC in order to create a tool that can be widely adapted and flexibly used. The scope of this project comprises the implementation of iBRoad2EPC in connection with the issuance of EPCs. Other options are not being realised within the project duration.

CONCLUSIONS

This report defines the concept for the technical implementation of iBRoad2EPC. It includes the possibility of adaptation to the different requirements in the pilot countries through a modular concept, the inclusion of the different target groups, the definition of the standardised basic functions and the additional optional functions, the graphic design, the concept for an issuing tool and the connectivity and expandability with both iBRoad products and existing country tools.

The concept strictly follows the core objectives of iBRoad2EPC: improving renovation recommendations in EPCs with the help of BRP elements, aligning the recommendations with the national climate targets for the building sector. iBRoad2EPC takes the perspective of building owners and provides them with clear advice on how to meet the future legal requirements for their buildings in a well-timed manner. In the basic version, issuing the iBRoad2EPC requires little additional effort and can be attached to any issued EPC as an extension. The modular extensions allow additional information such as smart readiness or indoor environment quality to be included. iBRoad2EPC can make a valuable contribution to the next generation of EPC with this flexible concept.

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iBRoad2EPC

www.ibroad2epc.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 101033781