



Test-driving the Individual Building Renovation Roadmap and Logbook

Evaluation of the pilot implementation of iBRoad

ifeu – Institute for Energy and Environmental Research
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TABLE OF CONTENTS

I.	Executive Summary.....	4
II.	Introduction	5
III.	Implementation	5
IV.	Methodology for evaluation	6
V.	Evaluation of iBRoad	7
i.	Homeowners' questionnaire results.....	7
	Participant Data.....	7
	Building information.....	11
	Energy audit: On-site visit	16
	iBRoad Renovation Roadmap.....	20
	iBRoad Logbook	34
ii.	Results from the energy auditors' questionnaire	44
	Energy audit: on-site visit.....	44
	Planning and calculation of renovation steps and measures	48
	Roadmap Assistant	52
	iBRoad Renovation Roadmap.....	59
	Handbook for energy auditors	70
	iBRoad Logbook	71
iii.	Compliance with the iBRoad Roadmap principles	82
	Best-possible-principle	82
	Individual renovation Context.....	82
	Long-term perspective	82
	Timing and sequencing.....	83
	Attractive and motivating.....	83
	iBRoad principles in practice: compliance check	83
	Field test Logbook in Germany	97
VI.	Summary of findings, lessons learnt and outlook.....	98
i.	Summary of findings	98
	Homeowners feedback	98
	Energy auditors' feedback	98
ii.	Lessons learnt and outlook	98
	Outlook to improve manageability of the software	98
	Outlook to improve the content of the software	99

I. EXECUTIVE SUMMARY

The concept of the iBRoad individual Building Renovation Roadmap and Logbook was field-tested in Bulgaria, Poland and Portugal from March to May 2019. In parallel, the iBRoad Logbook was also field-tested in Germany. During the field test, 15 - 20 buildings per pilot country were examined in cooperation with certified local energy auditors. The local energy agencies, KAPE, EnEffect and ADENE, managed the field tests in their respective countries and strongly supported the implementation. The design and execution of the field tests are described in the "Report on Experiences of the iBRoad Field Test".

In order to evaluate the field test results, detailed questionnaires for the participating homeowners and energy auditors were created, collected and analysed. A total of 98 questionnaires were collected and evaluated – 50 homeowners' questionnaires and 48 energy auditors' questionnaires. Almost all of the field test participants filled-in and returned a generally complete evaluation questionnaire. In addition, the created Renovation Roadmaps and Logbooks were evaluated in order to check if the underlying iBRoad principles were correctly understood and implemented. The present reports give a detailed overview of the field test outcomes and evaluation results.

Overall, homeowners considered the on-site visit of the energy auditor as very useful. The homeowners' and auditors' feedback concerning the iBRoad Renovation Roadmap was very positive. The vast majority of respondents would recommend the Roadmap to their family and friends. Most importantly, the majority of the field test participants said they are planning to implement renovation measures in the next five years because the iBRoad Renovation Roadmap motivated them to do so.

With respect to the iBRoad Logbook, participating homeowners "tend to agree" or "completely agree" with the statement "The iBRoad Logbook enables and motivates me to realise concrete renovation measures in the near future".

With one exception, all energy auditors were able to work well with the Roadmap Assistant. The majority of them needed some time to get used to it but had no major problems nor needed much time to understand it. Overall, the vast majority considered the features of the Roadmap Assistant as "very useful" or "rather useful".

Furthermore, most of the attending auditors evaluated the iBRoad Logbook as very useful or rather useful. They rated the existing Logbook features as sufficient and did not consider additional features necessary. According to that, the majority of auditors said it was likely or very likely that they would recommend the Logbook to their colleagues.

In addition to the evaluation of the questionnaires amongst auditors and homeowners, all Roadmaps and Logbooks that were produced during the field test were reviewed concerning technical content and compliance with the iBRoad principles¹. The five iBRoad principles were introduced to the auditors during the relevant training and are also included in the training material. In general, the iBRoad Renovation Roadmaps that were produced during the field test are compliant with the iBRoad Roadmap principles.

The **best-possible-principle** depends on various issues. A renovation measure should always be best possible with regard to the technical conditions of the specific building or the financial capabilities of the owners. The majority of the auditors took the best-possible-principle very seriously.

¹ The five iBRoad principles are: Best-possible-principle, individual renovation context, long-term perspective, timing and sequencing, attractive and motivating

Compliance with the principle of an **individual renovation context** of the Roadmaps may best be indicated by the technical improvement measures on the one hand, and by the description of the user influence in the present building state and the comfort improvements, on the other. Overall, all Roadmaps followed the individual renovation context principle.

All Renovation Roadmaps take a **long-term perspective**. They consider periods beyond the pending renovation measures and prepare future measures in order to avoid lock-in effects and reach deep renovation targets. Auditors chose the considered periods individually depending on the specific needs. They considered both principles, long-term perspective as well as **timing and sequencing** correctly. This is also confirmed by the homeowners' answers in the questionnaire, where they agreed to a high degree that the Roadmap provided them with a long-term plan.

Finally, the Renovation Roadmap needs to be **attractive, easy to understand and motivating** for the homeowners. Auditors and homeowners gave positive feedback about the layout of the Roadmap. Homeowners agreed to a high extent that it motivates them to realise concrete measures.

II. INTRODUCTION

This report is the direct follow-up of the report on experiences of the iBRoad field test (Report on Experiences of the iBRoad Field Test). While the first report shows the setting and preparation of the field tests and overall experiences, this report presents the findings of the field test implementation and evaluation by homeowners and auditors involved. For questions about the training sessions, training materials or the field test's framing please see the "Report on Experiences of the iBRoad Field Test".

In order to gain as much insight as possible into the real audit situation in the three pilot countries, all attending energy auditors and homeowners were asked to answer specific questionnaires. The questionnaires comprised questions on the iBRoad Renovation Roadmap as well as on the Logbook. The auditors were asked additional questions on the iBRoad Roadmap Assistant and the procedure of creating the Roadmap. Finally, all participants were asked for their proposals to improve the iBRoad tools.

III. IMPLEMENTATION

The field test was carried out in the pilot countries Bulgaria, Poland and Portugal from March to May 2019. Additionally, the iBRoad Logbook was field-tested in Germany. In each country, certified local energy auditors examined 15 - 20 buildings. The local energy agencies, KAPE, EnEffect and ADENE, managed the field tests in their respective countries and strongly supported the whole implementation of the field tests. They received an online train-the-trainer seminar in advance of the field test period. In total, 27 energy auditors participated in the iBRoad field test. The energy auditors received a full-day face-to-face comprehensive auditors' training in their country before the field test. The training events were organised by the country partners ADENE, EnEffect and KAPE. One trainer from ifeu carried out the training in all three pilot countries in cooperation with the respective country partner to avoid influences on the field test results from different trainers. With the training, the auditors received the iBRoad handbook and the training presentation explaining all relevant details.

Detailed questionnaires were created and analysed for the participating homeowners and energy auditors, in order to evaluate the field test results. A total of 98 questionnaires were evaluated – 50 homeowners' questionnaires and 48 energy auditors' questionnaires. Almost all of the field test participants filled-in and returned a generally complete evaluation questionnaire.

IV. METHODOLOGY FOR EVALUATION

For the purpose of evaluating the iBRoad field test in the pilot countries Bulgaria, Poland, and Portugal, detailed questionnaires for participating homeowners and energy auditors were collected and analysed (see *Homeowners' questionnaire results* and *Results from the energy auditors' questionnaire*). Due to potential language barriers, the partners in the pilot countries translated the questionnaires from English into the respective national language. The questions were divided into categories as presented in Table 1. Questions that related to both homeowners and auditors were designed in parallel, in order to allow for comparison of the different target groups' viewpoints on common issues.

Home owners' questionnaires	Energy auditors' questionnaires
Participant information	
Building information	
On-site visit	On-site visit
	Planning and calculation of renovation steps and measures
	Roadmap Assistant
iBRoad Renovation Roadmap	iBRoad Renovation Roadmap
	Handbook for energy auditors
iBRoad Logbook	iBRoad Logbook

Table 1: Questionnaire categories

Overall, the response rate was very high: a total of 98 questionnaires were evaluated – 50 homeowners' questionnaires and 48 energy auditors' questionnaires. Almost all field test participants filled-in and returned a generally complete questionnaire.

Due to the comparably low number of answers, all evaluation results are hereon indicated as absolute figures, and not as share or percentage. In general, the questionnaires related to one building. This enabled the auditors who processed two buildings to differentiate their answers for each building. However, some auditors filled only one questionnaire as their answers were valid for both their buildings. In this case, their answers were counted twice to fit to the number of buildings. In the following graphs, the sample size ("n") relates to the number of buildings.

In addition, the created Renovation Roadmaps were made available for the purpose of evaluation. On that basis, it was checked if the underlying iBRoad principles were properly understood and implemented (see *Compliance with the iBRoad Roadmap principles*).

V. EVALUATION OF iBRoad

i. Homeowners' questionnaire results

Overall, the questionnaire's response rate was very high. Except for Bulgaria, ten energy auditors per pilot country participated in the field test. In Bulgaria, only seven energy auditors were willing to participate in the field test. Ten buildings were examined in Bulgaria, 20 buildings each in Poland and Portugal. Almost all homeowners who participated in the field test filled in and returned a generally complete questionnaire for the purpose of evaluation. However, feedback from a few homeowners could not be obtained. As a result, the following number of homeowners' questionnaires were evaluated (if applicable, deviations are indicated in the following):




Pilot country	Number of home owners' questionnaires evaluated
 Bulgaria	10
 Poland	20
 Portugal	20

Table 2: Number of homeowner questionnaires evaluated per country

Participant Data

Most homeowners that participated in the field test were aged 50 or older. The distribution shows a relatively low variance between Bulgarian, Polish, and Portuguese homeowners as illustrated in Figure 1.

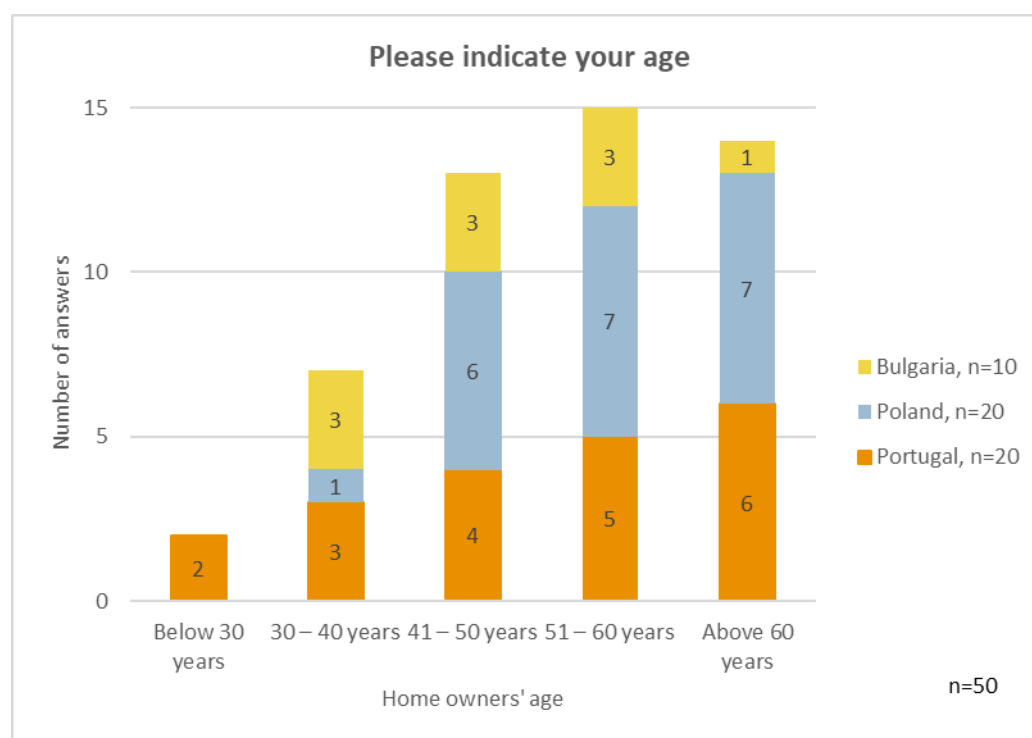


Figure 1: Homeowners' age

Awareness around building renovation

To begin with, homeowners were asked to indicate to what extent the statement “I am well informed about building renovation and modernisation” applied to them. The majority of Portuguese and Polish field test participants believe that this statement applies to them fully or almost fully (see Figure 2 and Figure 3). Bulgarian field test participants were more moderate in their answers (see Figure 4).

About half of the Polish respondents and almost all Bulgarian respondents said that they would carry out renovation themselves as far as this would be possible (see Figure 3 and Figure 4).

About half of the respondents said that it would be a burden for them to constantly have to take care of the building (see Figure 2, Figure 3 and Figure 4).

Yet, the majority of the respondents seems to “care” about their buildings in a kind of emotional way (see Figure 2, Figure 3 and Figure 4).

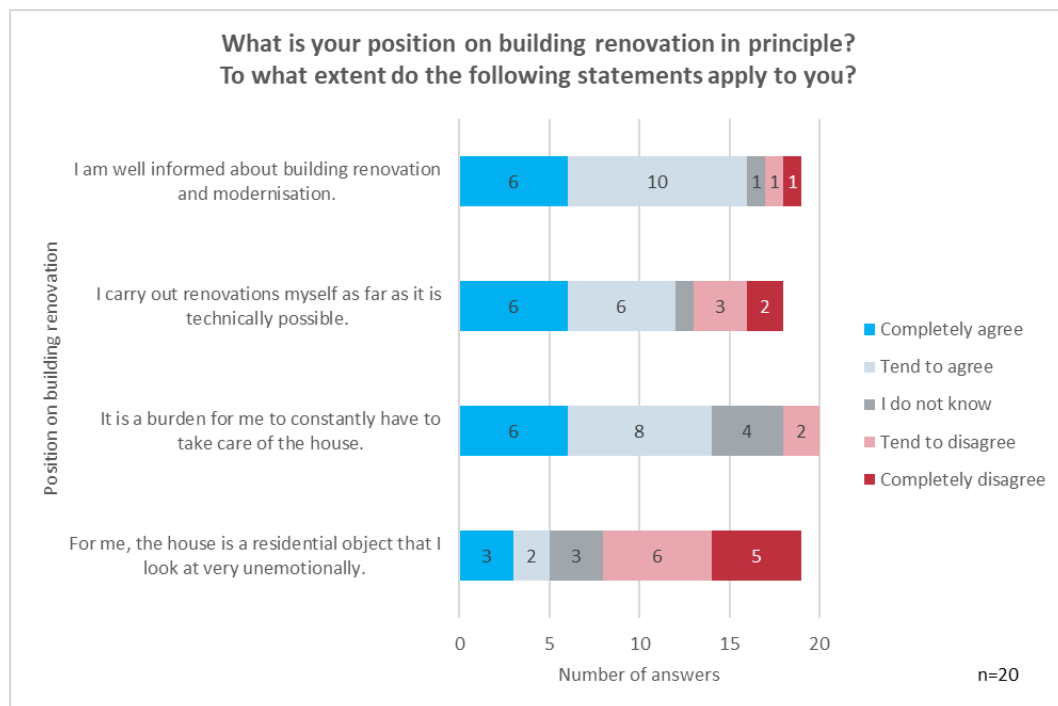


Figure 2: Homeowners' position on building renovation (Portugal)

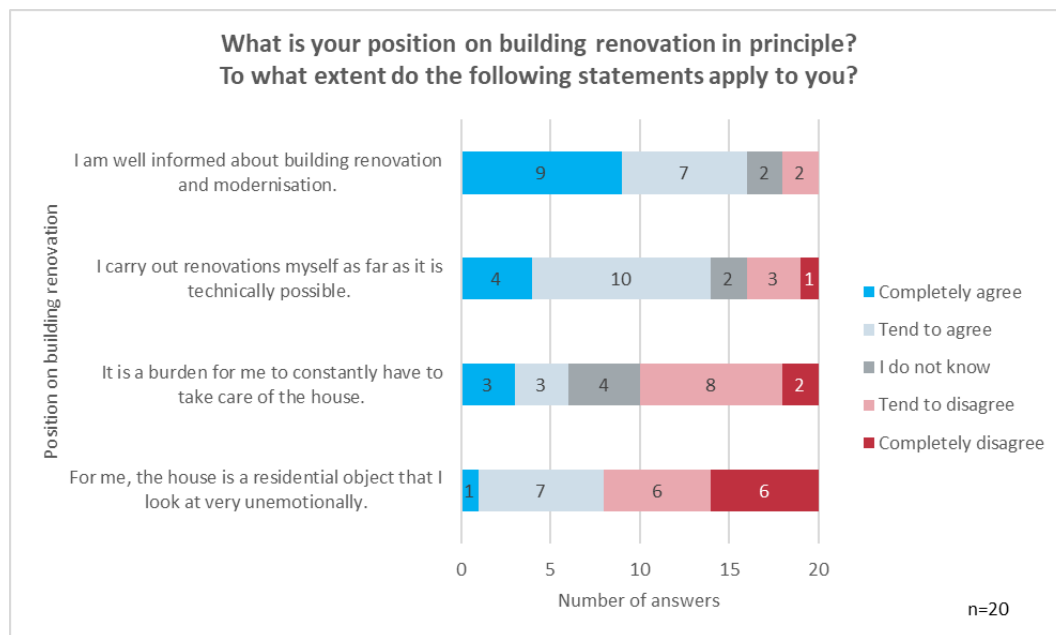


Figure 3: Homeowners' position on building renovation (Poland)

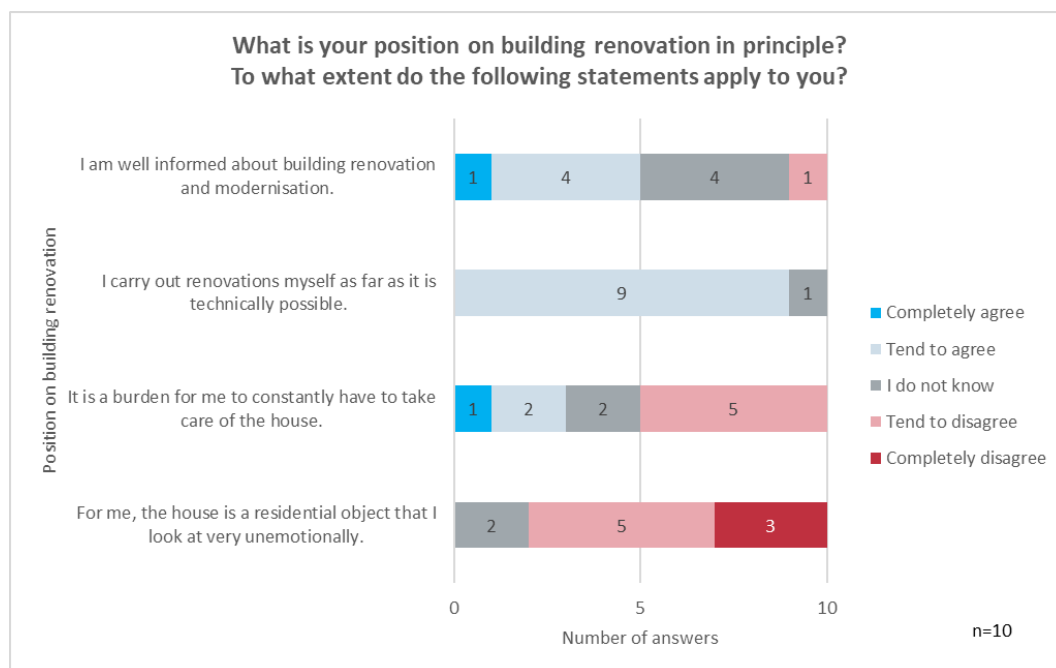


Figure 4: Homeowners' position on building renovation (Bulgaria)

Homeowners' attitudes towards professional building renovation audits

Homeowners were asked about their attitudes towards professional renovation audits (see Figure 5). Multiple answers were allowed for respondents to this question. The majority of respondents, and especially the Portuguese field test participants, said that they would always use professional advice in the context of building renovation. However, about half of the Polish field test participants reported that they would not need a professional audit, either due to a personal network that they could count on in case of building renovation or due to (alleged) sufficient self-knowledge and experience in the field of building renovation. To what extent this result possibly affects the quality of renovation measures cannot be assessed in the context of iBRoad.

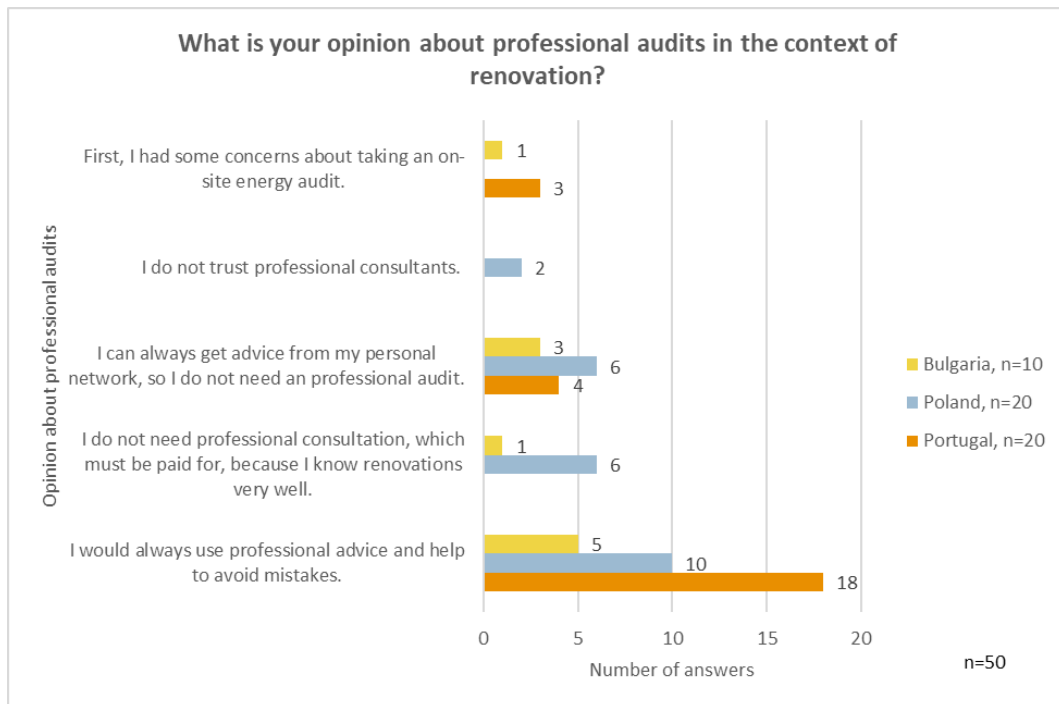


Figure 5: Homeowners' attitudes towards professional building renovation audits

Homeowners' attitudes towards economic efficiency of renovations

In addition, homeowners were asked about their attitude towards economic efficiency of renovations (see Figure 6). The majority of the Portuguese field test participants said they would check very carefully whether a renovation measure pays off. In contrast, only half of the Polish and Bulgarian homeowners rated economic reasons with the same importance, stating that it was sufficient to know that energy was saved, but pay-off was less important to them.

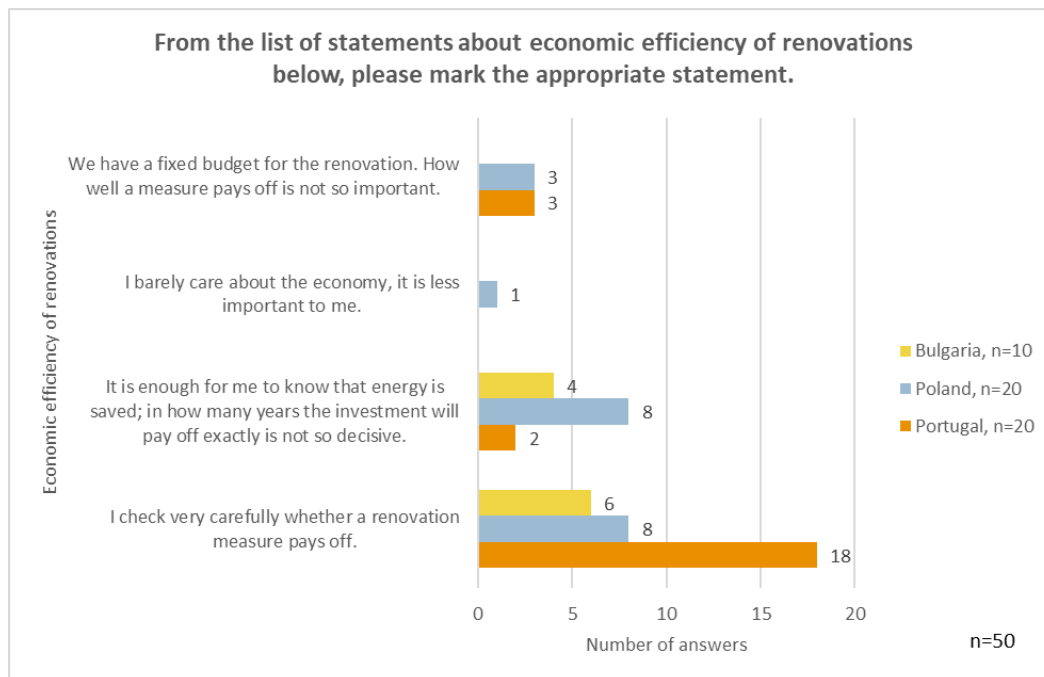


Figure 6: Homeowners' attitudes towards economic efficiency of renovations

Building information

Building type

Most examined buildings were owner-occupied single-family houses, built before the 1970s and in the 1980s (see Figure 7, Figure 8, and Figure 9).

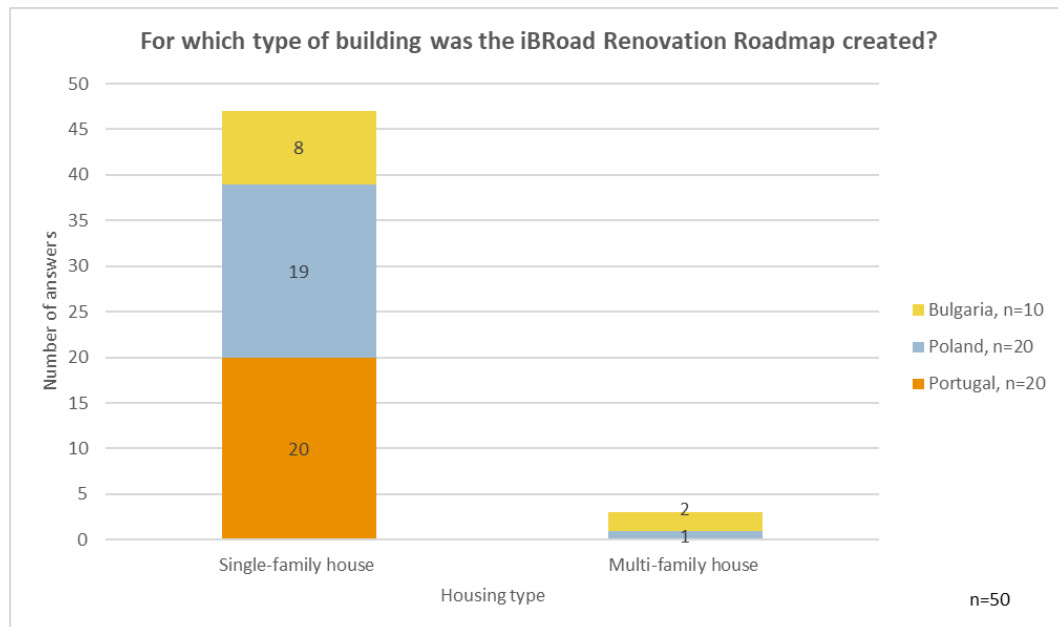


Figure 7: Building type

Owner-occupied residential property

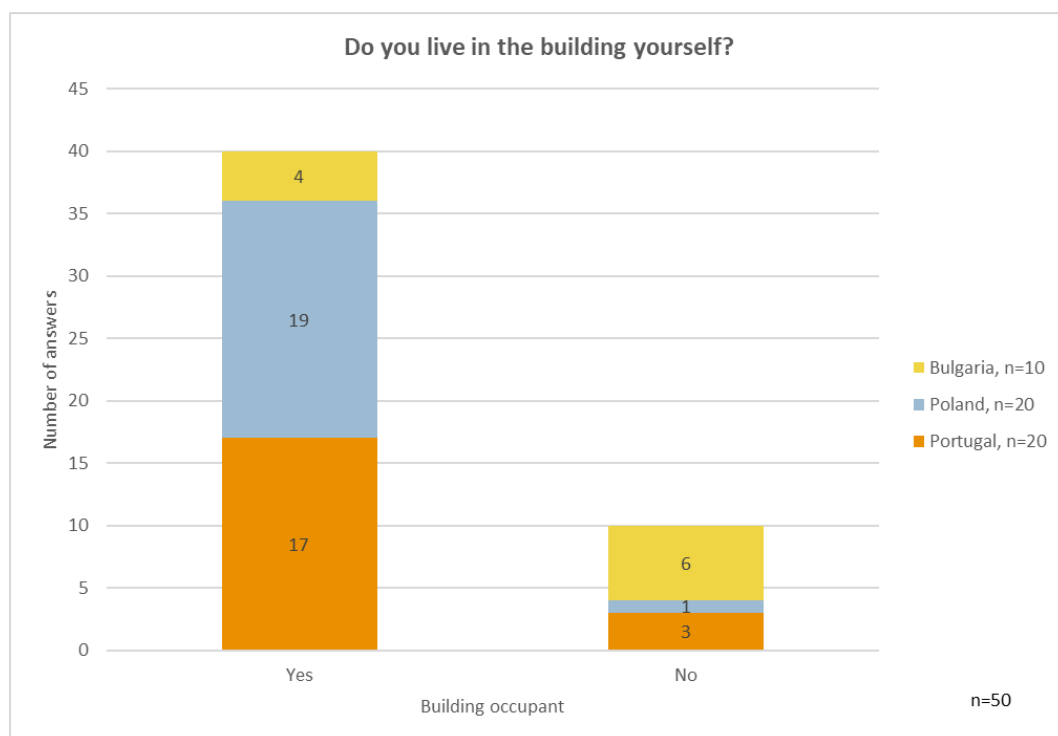


Figure 8: Owner-occupied residential property

In contrast to Poland and Portugal, the majority of Bulgarian field test participants do not live in the examined building but rent it to third parties (see Figure 8). However, no relevant conclusions can be drawn from that, as the number of answers, especially in the Bulgarian case, is limited.

Buildings' construction year

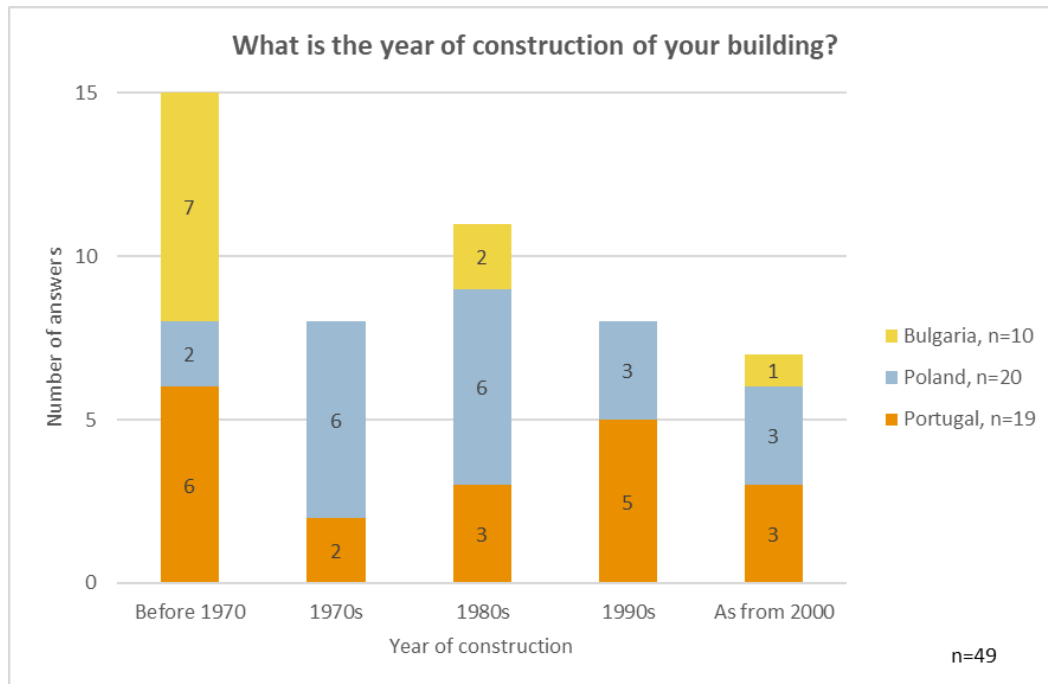


Figure 9: Buildings' construction year

In contrast to Poland and Portugal, buildings examined in Bulgaria were mostly built before 1970. Examined Polish buildings were mainly built in the 1970s and 1980s. Distribution amongst examined Portuguese buildings is relatively consistent, but with a tendency towards before 1970 and in the 1990s (see Figure 9).

Buildings' living space area

The living space area ranges between 151 and 400 m² for nearly half of the examined buildings (see Figure 10). Buildings in Bulgaria are smaller compared to Polish and Portuguese buildings.

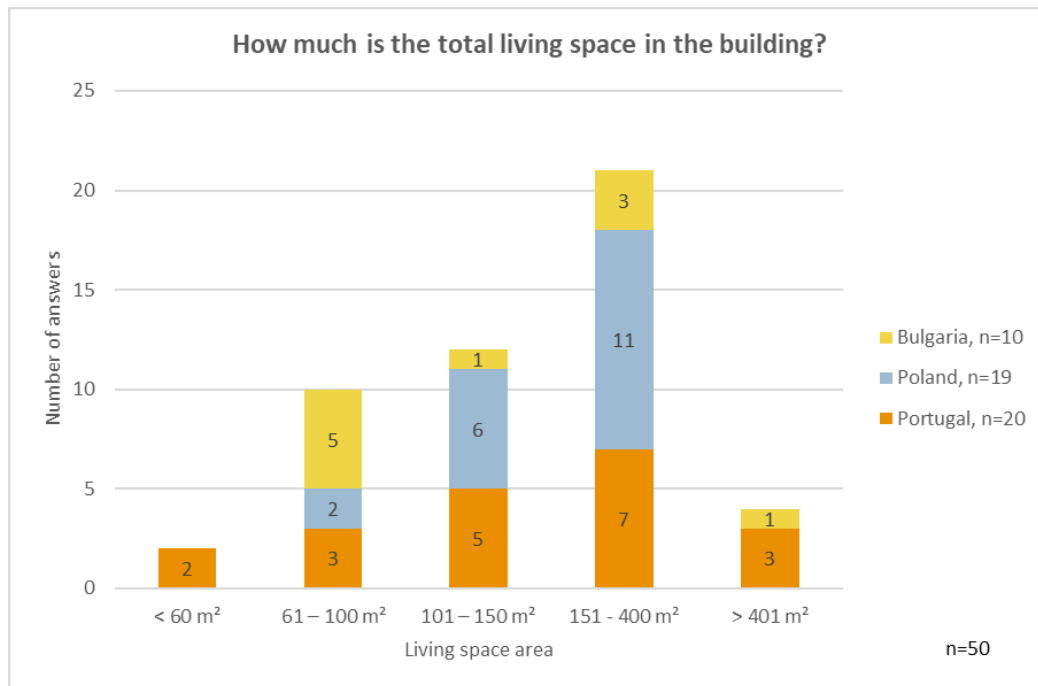


Figure 10: Buildings' living space area

Previous renovation measures

About half of the surveyed homeowners already implemented renovation measures in previous years (see Figure 11).

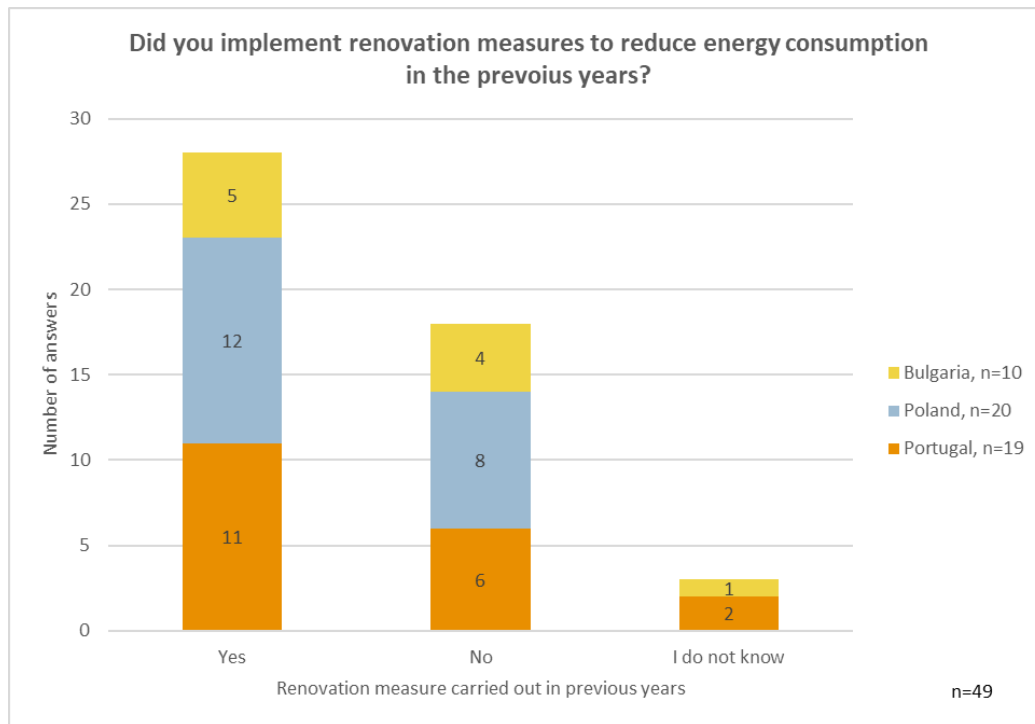


Figure 11: Previous renovation measures

Most commonly implemented renovation measures concerned more efficient windows or a more efficient heating system (see Figure 12). Considering the examined buildings' age, the results are not surprising as windows and heating systems have a shorter lifespan than other building components.

Particularly, the surveyed Polish homeowners state to have implemented more than one renovation measures, among which, in a number of cases is also the installation of a more efficient hot water system.

Implemented renovation measures

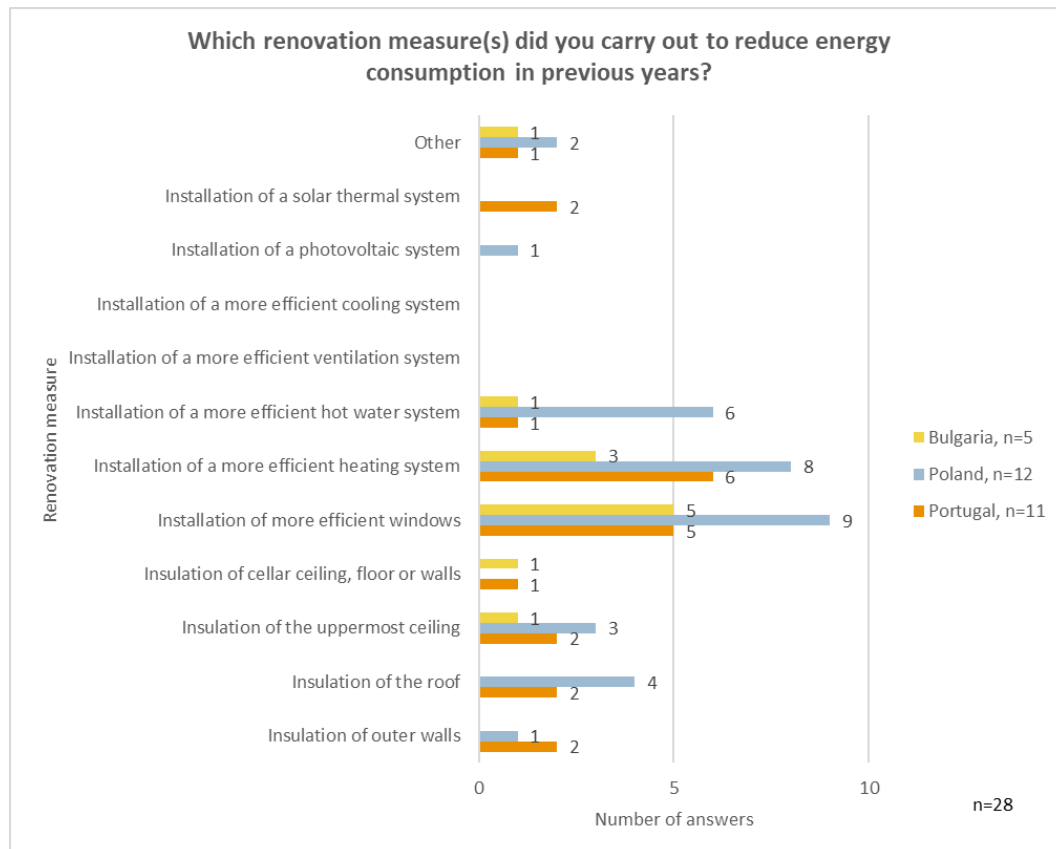


Figure 12: Implemented renovation measures

Existence of an EPC

With regard to the existence of an Energy Performance Certificate (EPC), it can be said that Portugal is leading (see Figure 13). Almost all Portuguese field test participants indicated that they already had an EPC at the time of the iBRoad field test. In contrast, almost all buildings examined in Poland and Bulgaria did not have an EPC. Noteworthy, a few Polish and Bulgarian homeowners reported they do not need or want an EPC, or even do not know what an EPC is.

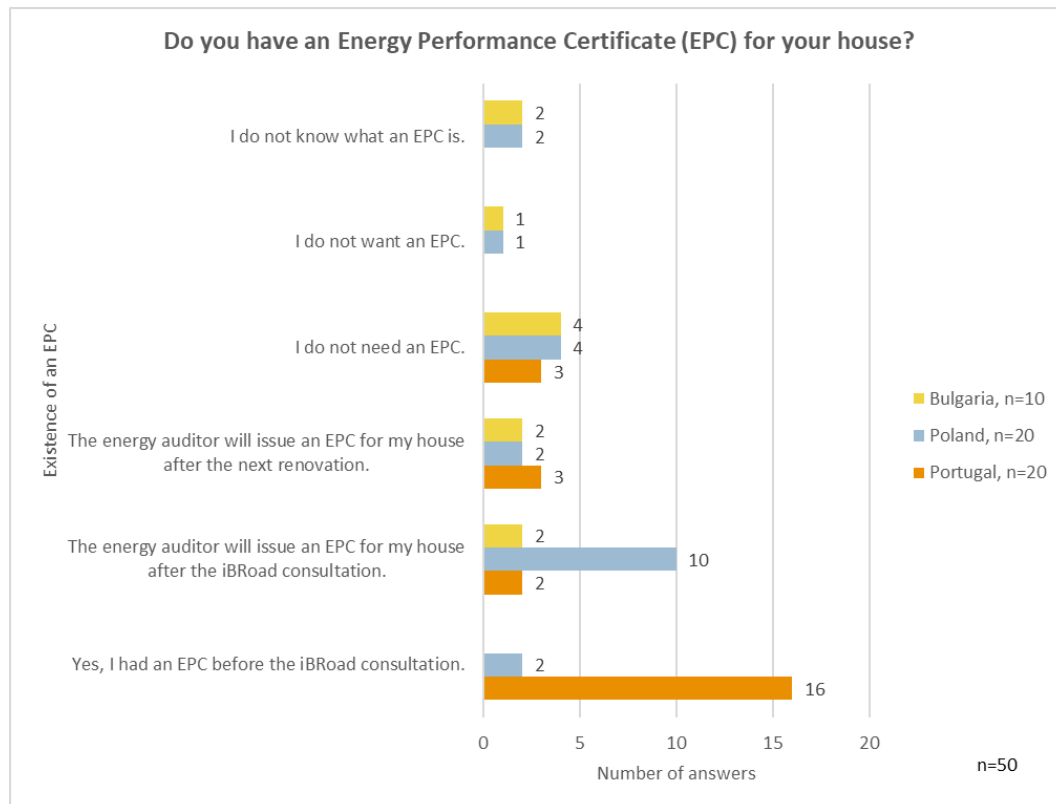


Figure 13: Existence of an EPC

Energy audit: On-site visit

Overall, homeowners considered the on-site visit of the energy auditor very useful. It should be noted however that the voluntary recruitment of field test participants may to some degree have influenced those results. Presumably, participants had a more positive attitude towards energy audits than the average homeowner, already before the field test.

On average, the energy auditors' on-site visit lasted about three hours. The individual averages per pilot country do not show high variation. According to the homeowners, the shortest on-site visit lasted one hour, the longest one eight hours.

According to the homeowners, the energy auditors quite predominantly considered the iBRoad principles (see also Compliance with the iBRoad Roadmap principles): All surveyed owners indicated that they were asked for their individual preferences and circumstances (e. g. wish for warmer or cooler indoor temperatures). Also, almost all homeowners (with two exceptions) were informed about the so-called "best-possible-principle" and asked about their financial possibilities (with three exceptions).

Feedback of the Bulgarian, Polish and Portuguese homeowners as concerns the on-site visit is illustrated below (see Figure 14, Figure 15, and Figure 16).

Overall, the Portuguese feedback was very positive. Only “information on the current building state” was more critically assessed. It can be assumed, that the surveyed Portuguese homeowners were already informed about the current building state, e.g., by way of EPC (see also above Figure 13).

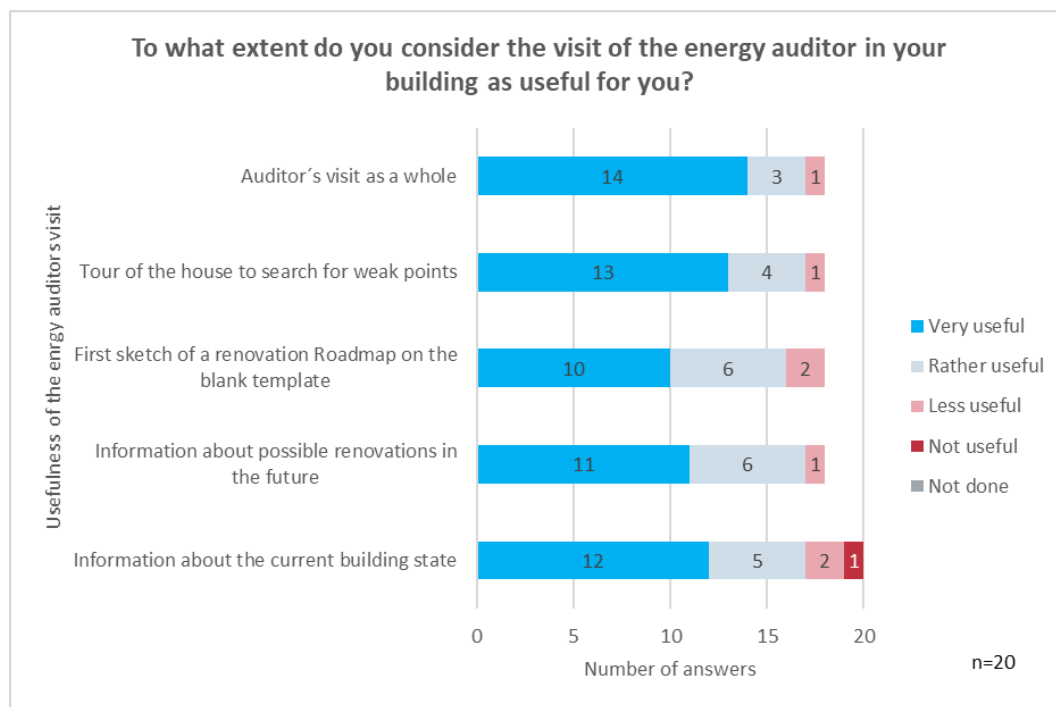


Figure 14: Usefulness of the on-site visit of the energy auditor (Portugal)

The Polish feedback on the on-site visit was also very positive. However, Polish homeowners' opinions to the action of drawing a "first sketch of a Renovation Roadmap on a blank template" differed.

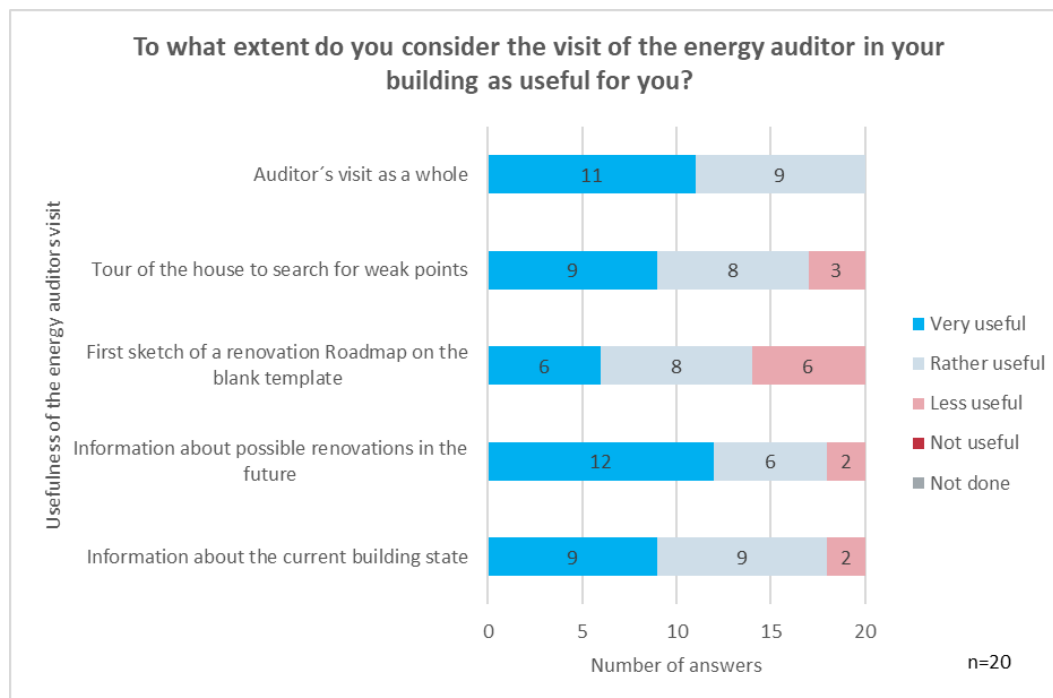


Figure 15: Usefulness of the on-site visit of the energy auditor (Poland)

Bulgarian feedback is, in general, also very positive.

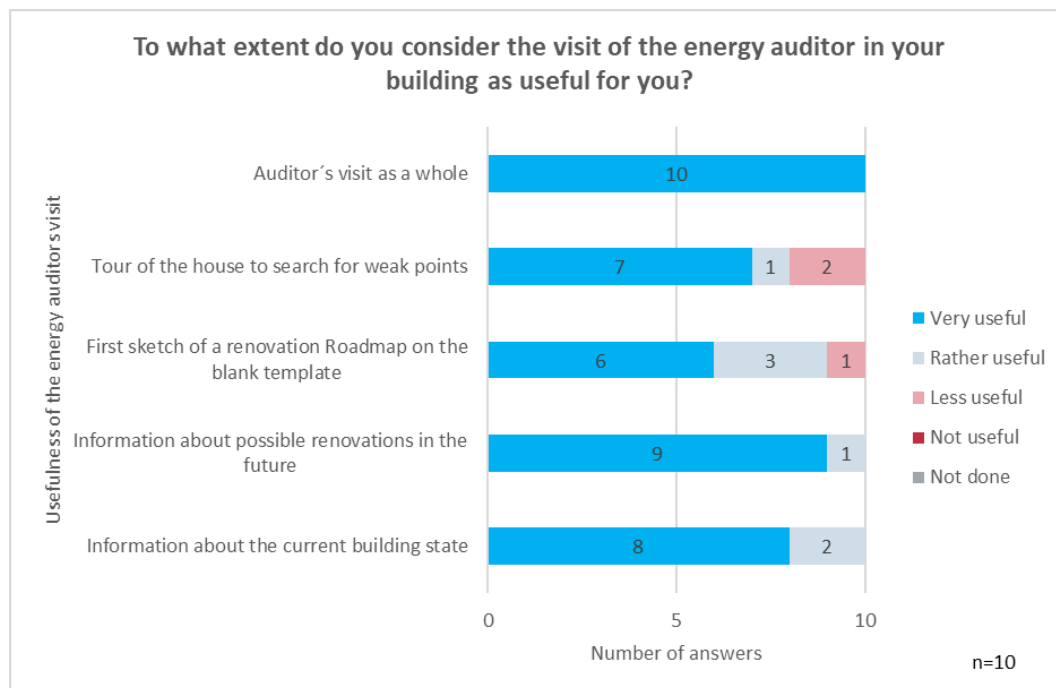


Figure 16: Usefulness of the on-site visit of the energy auditor (Bulgaria)

iBRoad Renovation Roadmap

General assessment of the Roadmap

At first, homeowners were asked for a general assessment of the Renovation Roadmap (see Figure 17, Figure 18, and Figure 19). Overall, the feedback was very positive.

Portuguese field test participants particularly appreciated that the Roadmap is providing them a long-term building renovation plan. Their assessment of comprehensibility, transparency and clarity of the Roadmap was more moderate (see Figure 17).

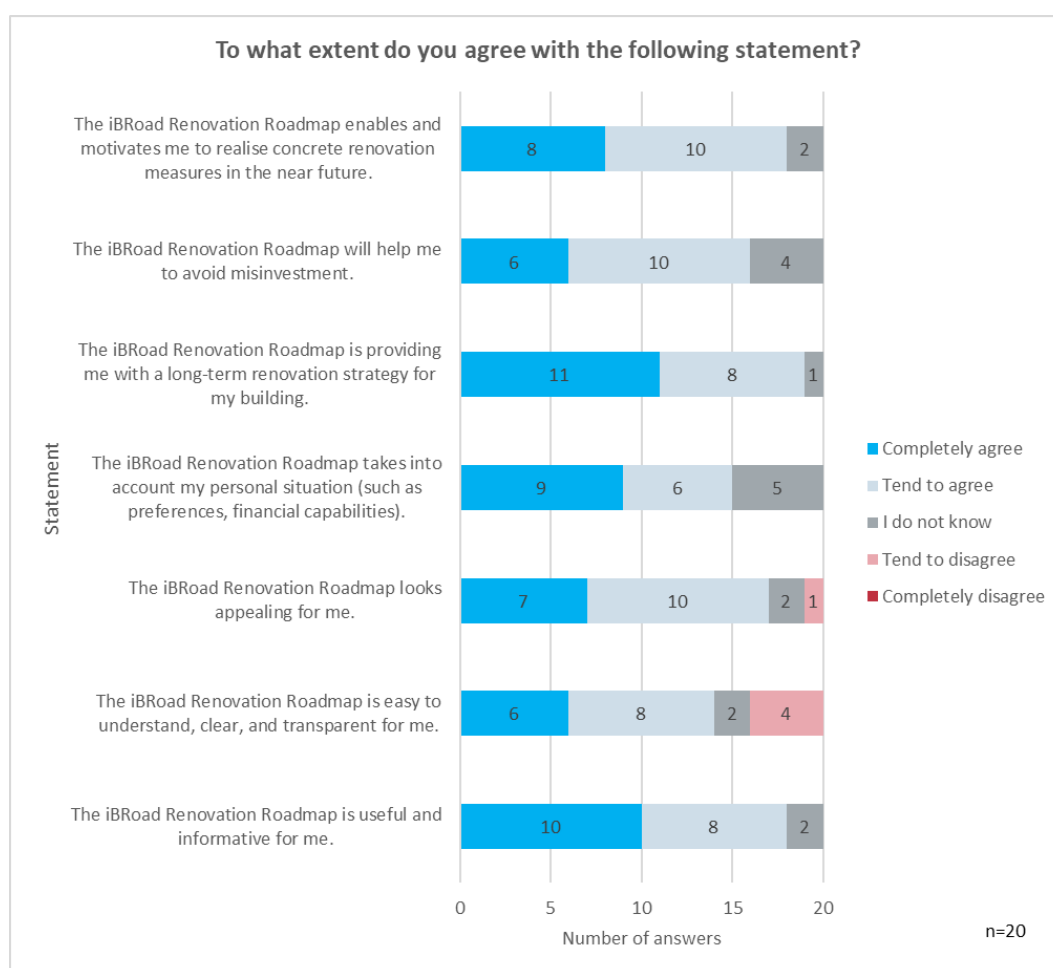


Figure 17: General assessment of the Roadmap (Portugal)

Polish feedback was less positive than the Portuguese one. However, significant complaints, also, were not recorded (see Figure 18).

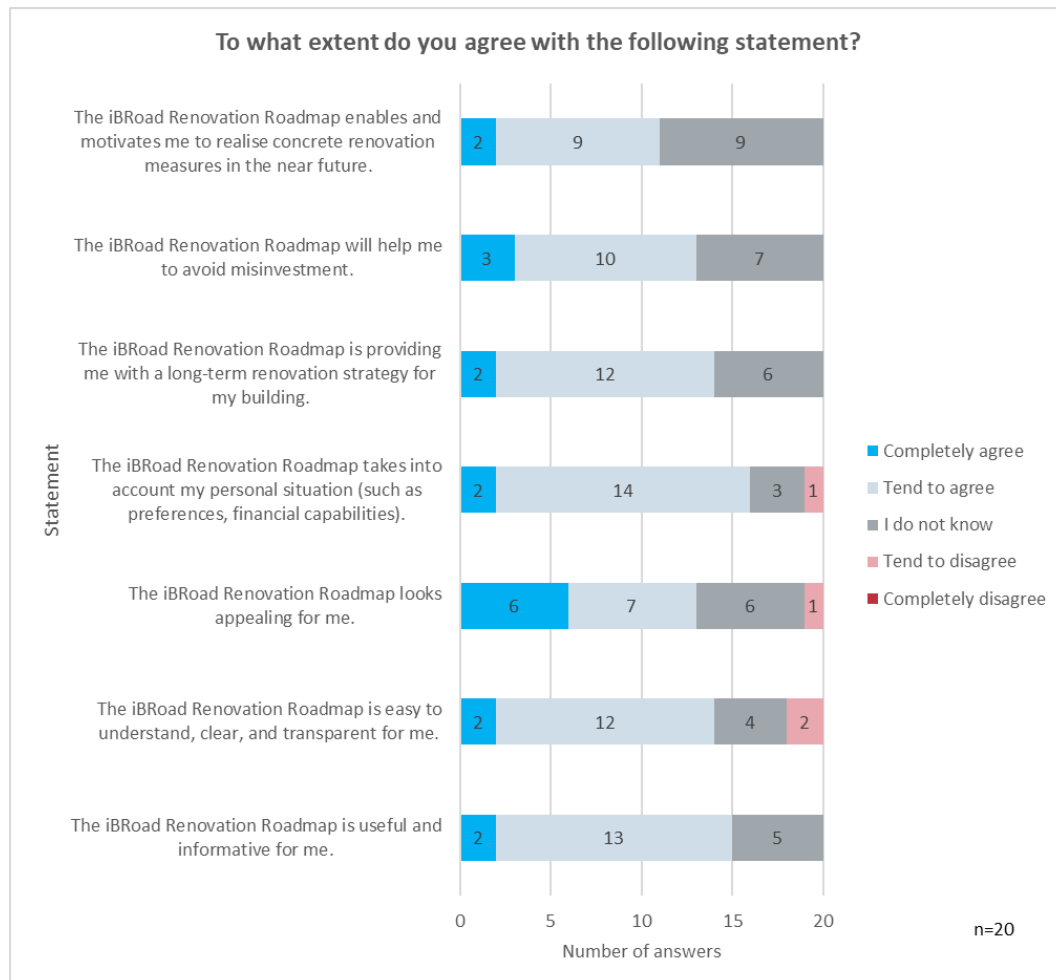


Figure 18: General assessment of the Roadmap (Poland) C:\Users\user\Dropbox\Desktop.alma

Just as the Portuguese field test participants, Bulgarian field test participants particularly appreciated that the Roadmap is providing them a long-term building renovation plan (see Figure 19).

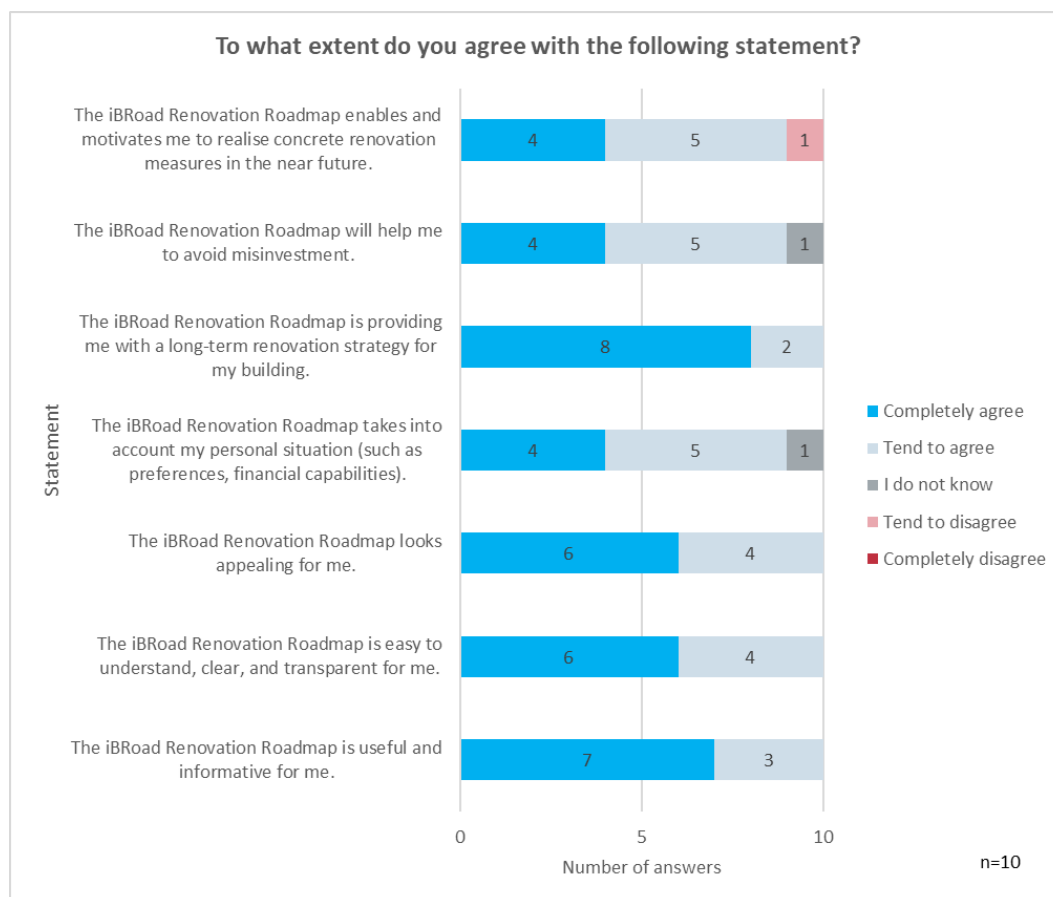


Figure 19: General assessment of the Roadmap (Bulgaria)

Learning effect from the Roadmap

The majority of homeowners reported that they quite learned from the Roadmap (see Figure 20).

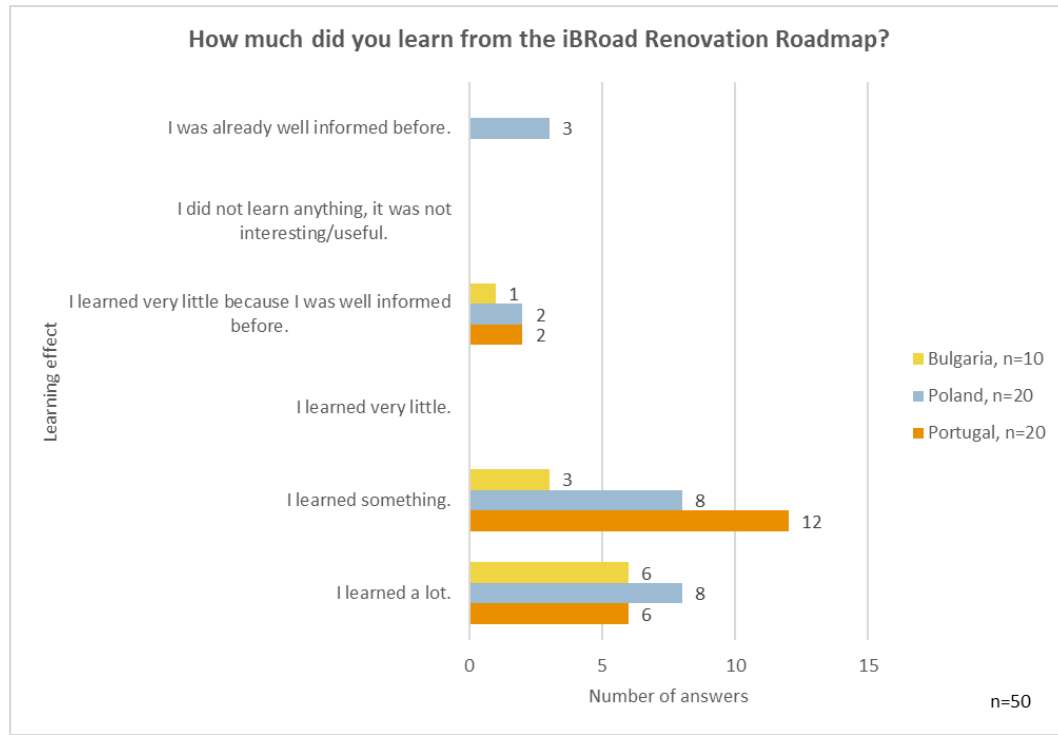


Figure 20: Learning effect from the Roadmap

Roadmap recommendation rate

The vast majority of respondents would recommend the Roadmap to their family and friends (see Figure 21).

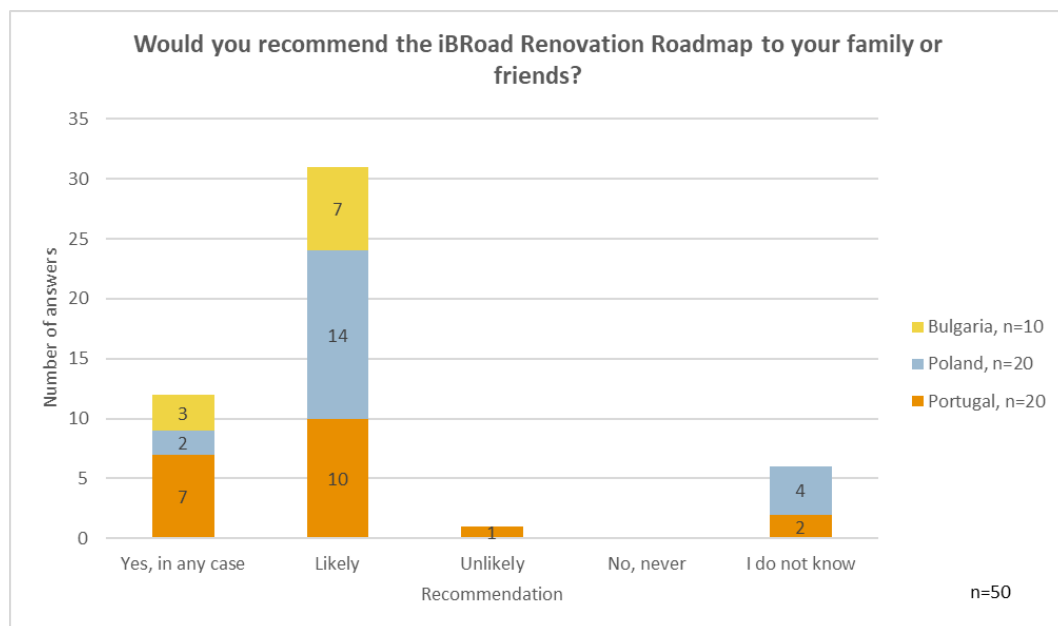


Figure 21: Roadmap recommendation rate

Homeowners' satisfaction with Roadmap features

Homeowners were asked to rate how satisfied they were with the Roadmap features developed within the project (see Figure 22, Figure 23 and Figure 24). Overall, the results are very positive.

Portuguese field test participants especially appreciated the information on “the economic efficiency” and the information on “the energy benefits of renovation”. In contrast, feedback on “the clarity of the Roadmap and the renovation perspective”, and the “degree of detail of the renovation measures proposed” was less positive (see Figure 22).

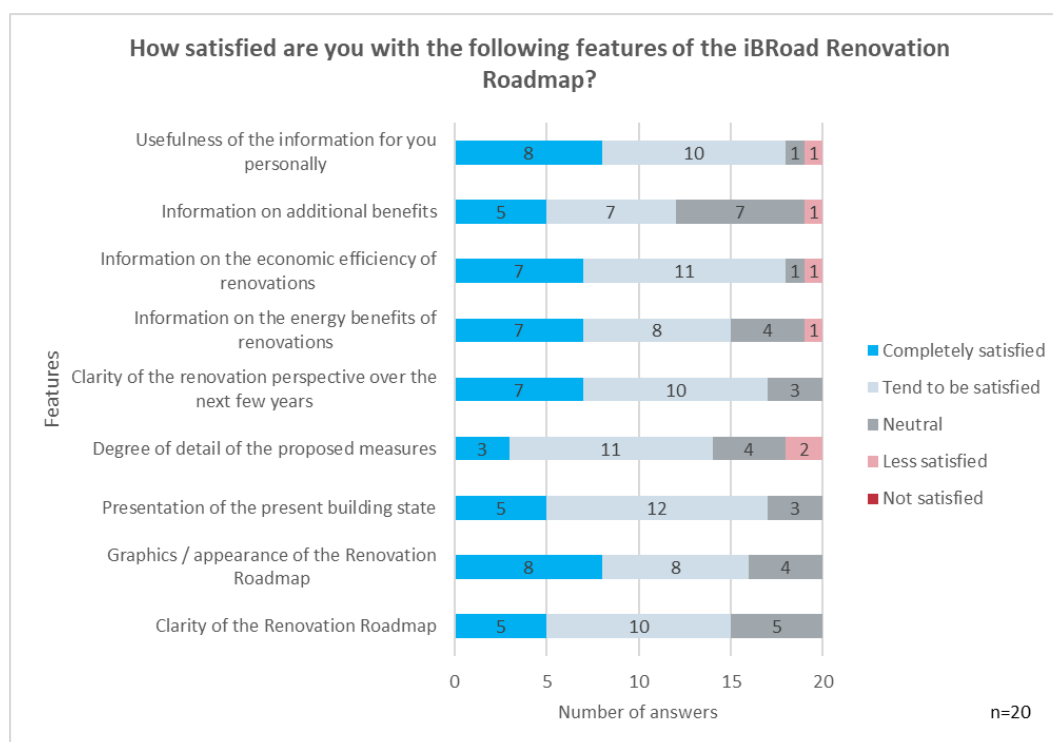


Figure 22: Homeowners' satisfaction with Roadmap features (Portugal)

Polish field test participants especially appreciated the information on the “economic efficiency” and the information on “energy benefits of renovation”. The Polish feedback on the “clarity of the renovation perspective” and the “clarity of the Roadmap as a whole” was less positive (see Figure 23).

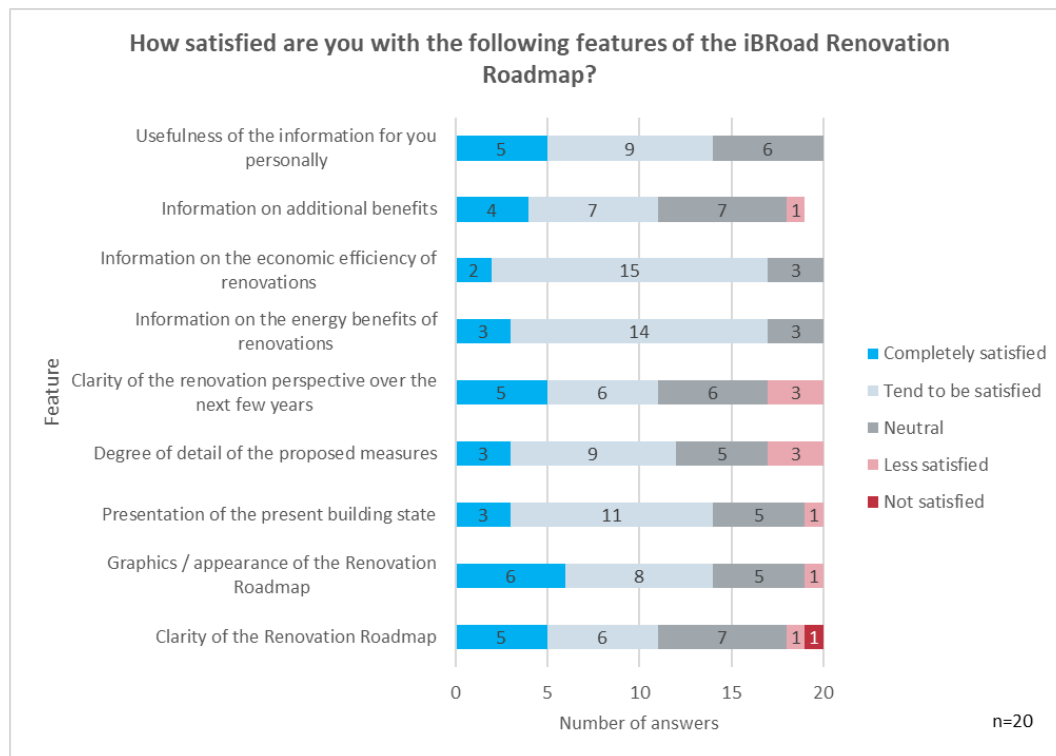


Figure 23: Homeowners' satisfaction with Roadmap features (Poland)

Bulgarian field test participants especially appreciated the information on “the economic efficiency”, the information on “energy benefits of renovation”, and the “clarity of the renovation perspective” (see Figure 24).

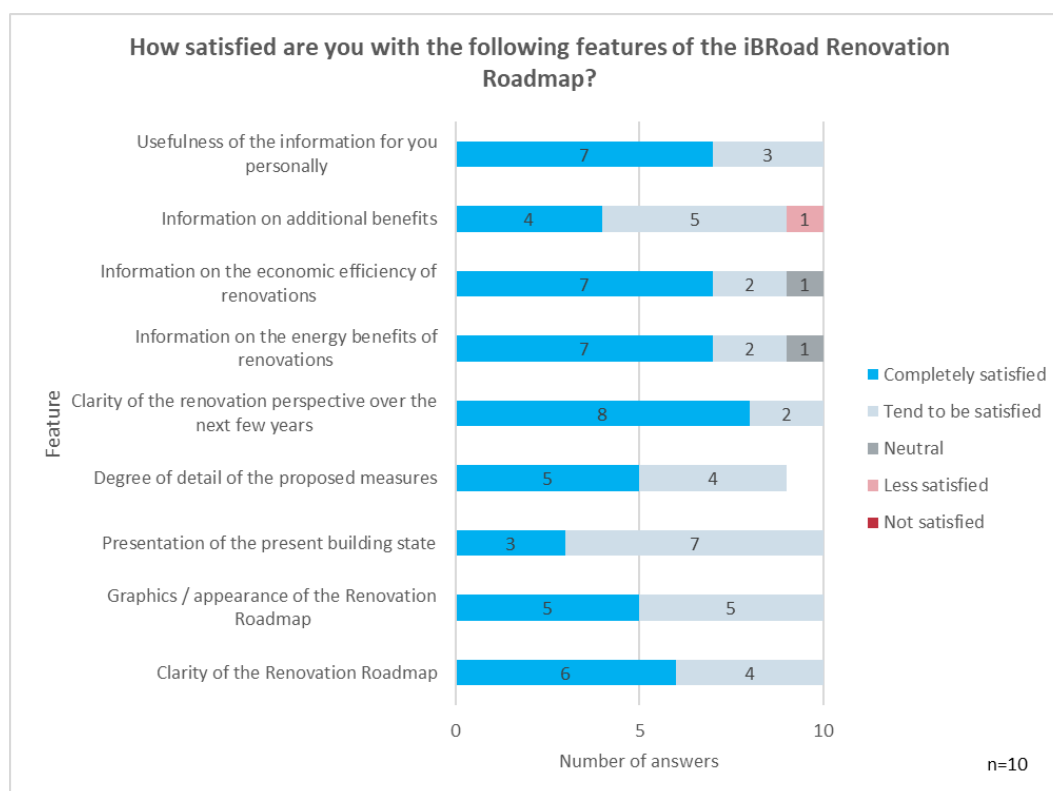


Figure 24: Homeowners' satisfaction with Roadmap features (Bulgaria)

Usefulness of Roadmap information

Homeowners were asked for their opinion concerning the Roadmap output and the special information it contains, for instance, information on incentives or renovation costs. Overall, results were very positive (see Figure 25, Figure 26, and Figure 27).

Portuguese field test participants especially appreciated the information on technical details, on renovation costs, and the description of renovation measures. In contrast, information on incentives was rated less positively (see Figure 25).

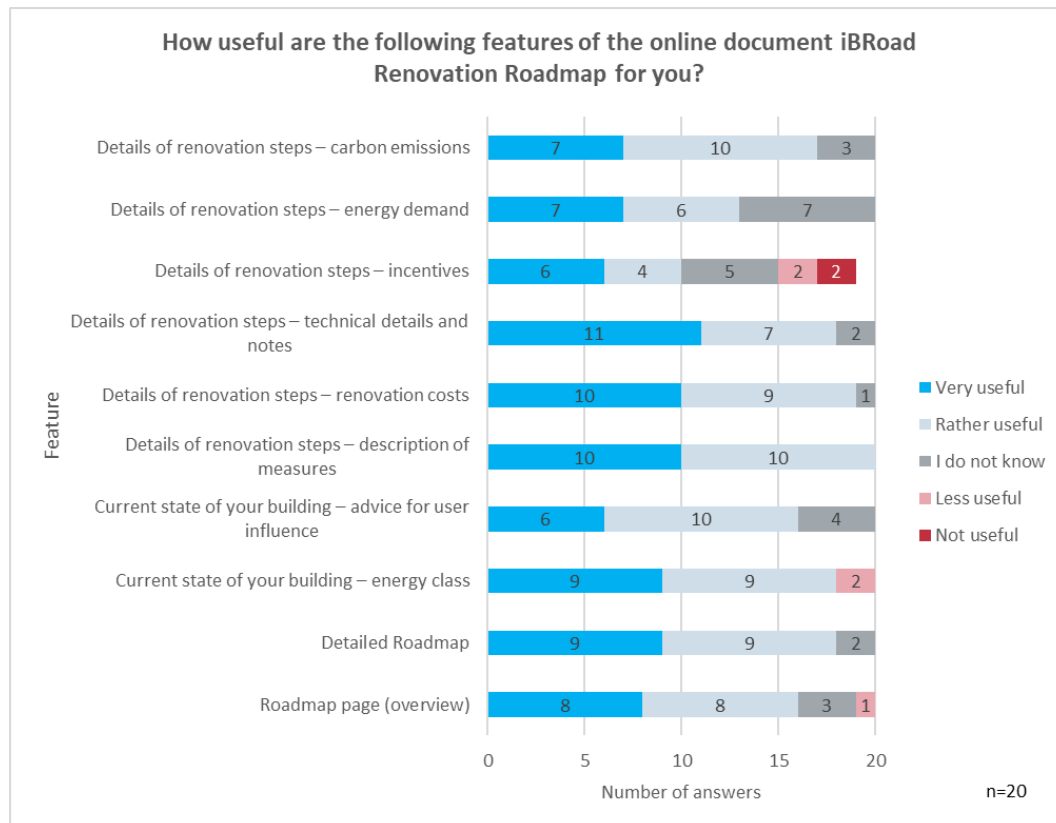


Figure 25: Usefulness of Roadmap information (Portugal)

The Polish feedback concerning the output and information provided by the Roadmap was not as positive as the Portuguese feedback, even if the majority assessed the information as “rather useful”. Polish field test participants especially appreciated the information on renovation costs (see Figure 26).

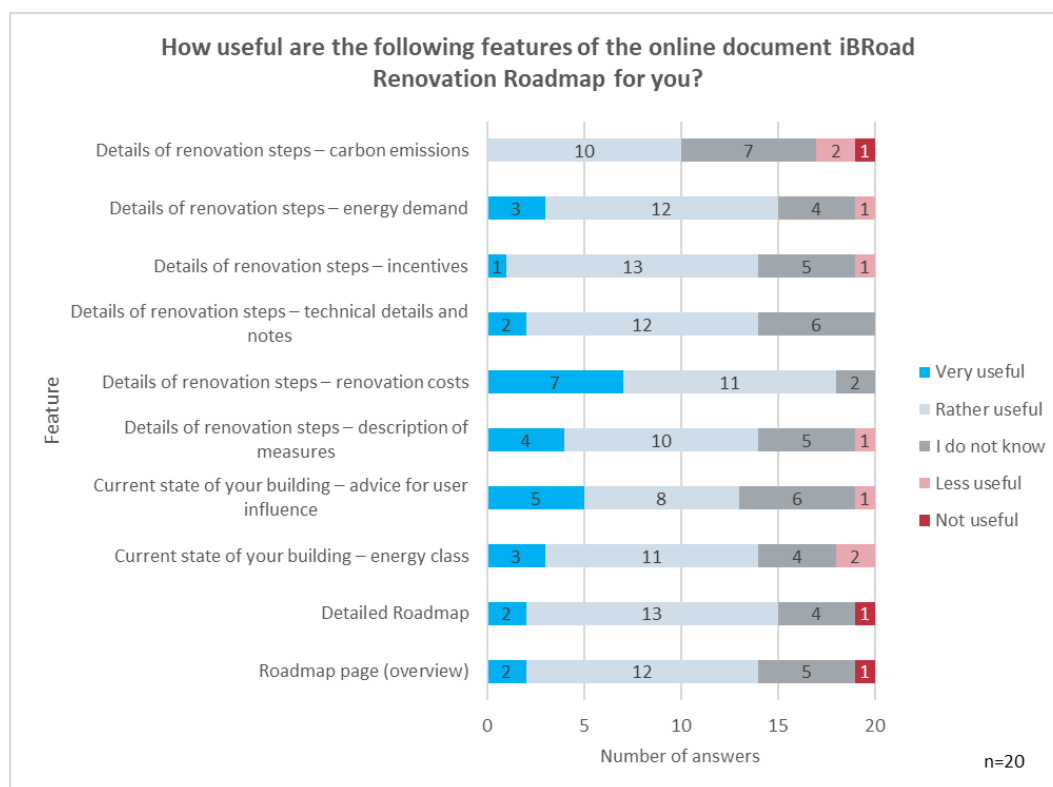


Figure 26: Usefulness of Roadmap information (Poland)

Bulgarian field test participants especially appreciated the information on renovation costs, too. In contrast, information on incentives was rated less positively (see Figure 27).

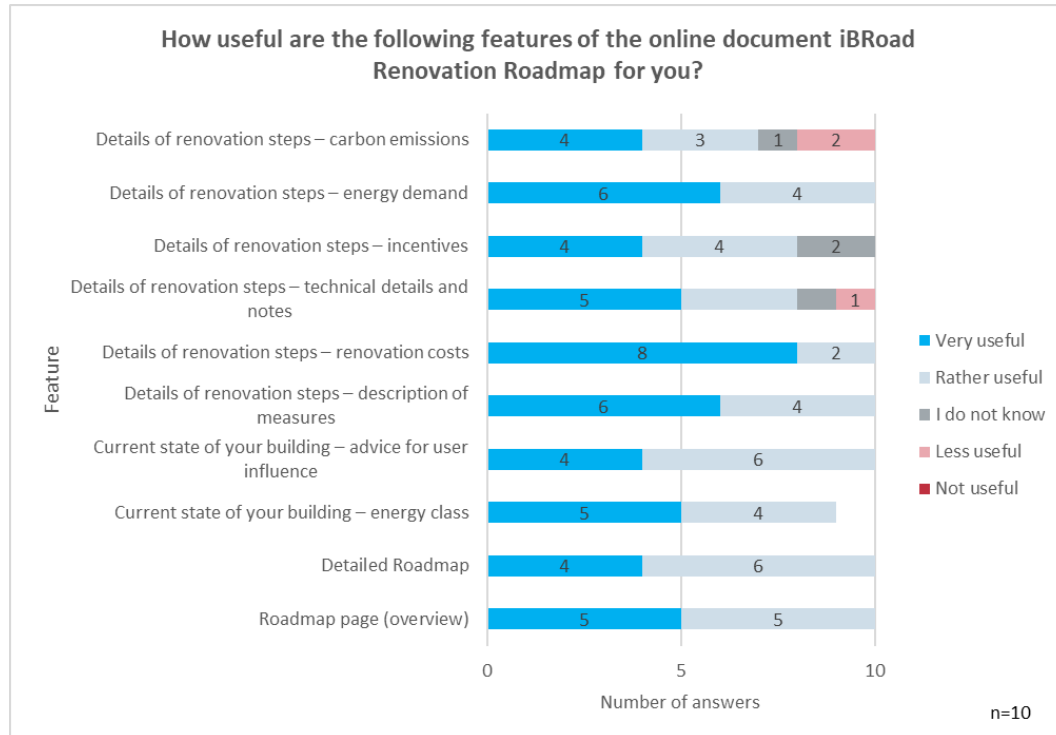


Figure 27: Usefulness of Roadmap information (Bulgaria)

Planned implementation rate of renovation measures

Very promising are the answers regarding renovation measures planned in the near future due to the Renovation Roadmap (see Figure 28). The majority of field test participants said that they are planning to implement renovation measures in the next five years because the iBRoad Renovation Roadmap motivated them to do so. This is the case particularly for Bulgarian and Polish field test participants.

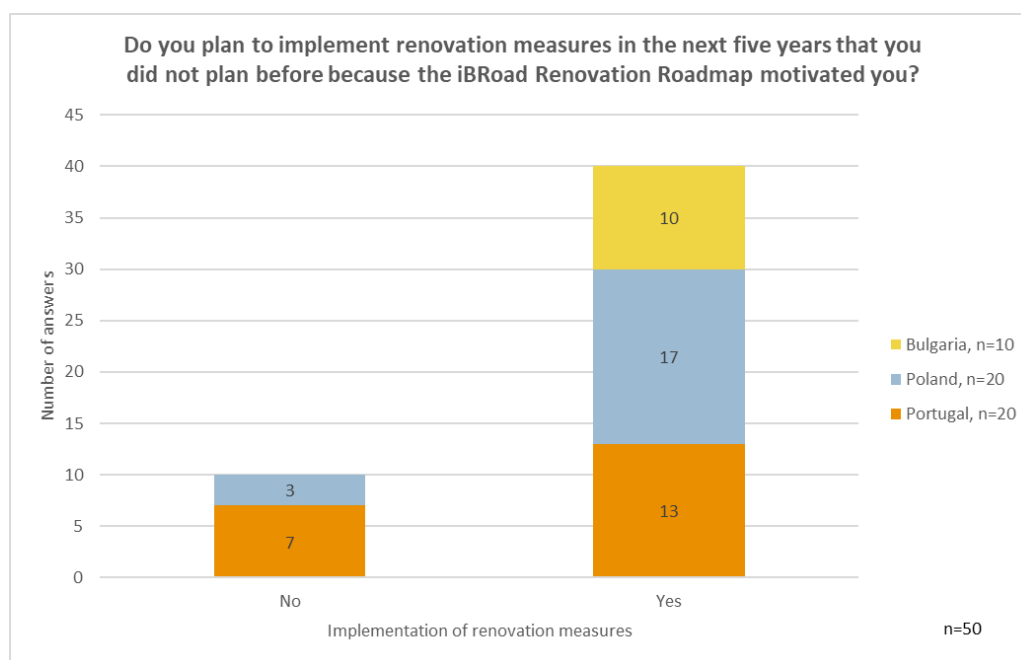


Figure 28: Planned implementation rate of renovation measures

The measures most commonly planned are the insulation of the roof, the insulation of outer walls, and the installation of a more efficient heating system.

Usefulness of comparison variants in the Renovation Roadmap

Homeowners were asked if they think an option to comparing variants of the renovation plans delivered by the Roadmap would be helpful. The majority of participants replied favourably (see Figure 29).

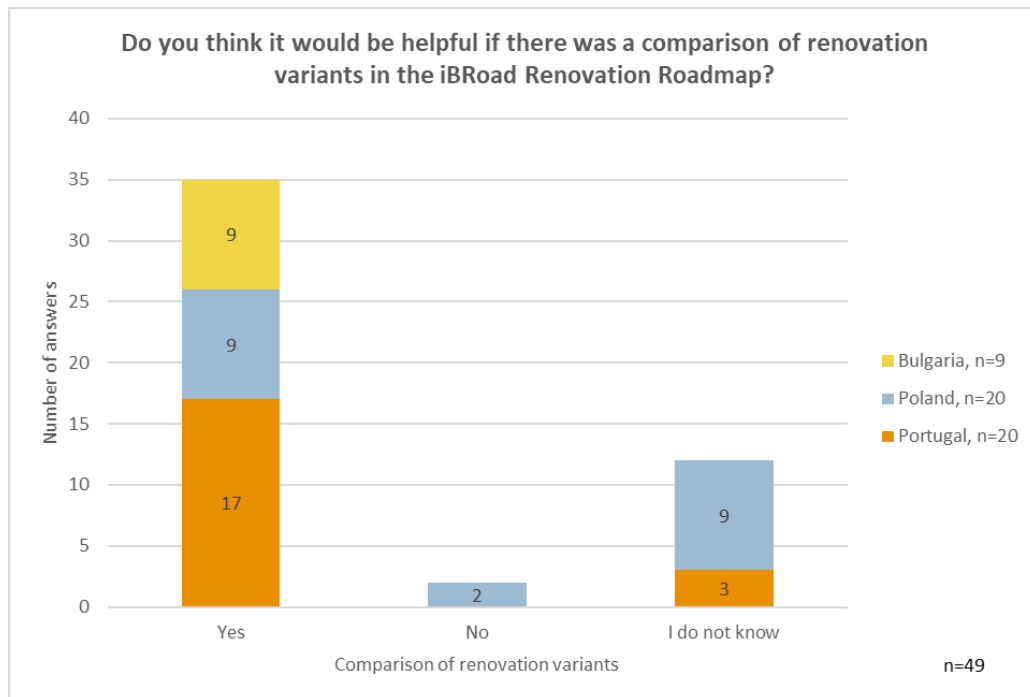


Figure 29: Usefulness of comparison variants in the Renovation Roadmap

Preferred type of presentation of the Renovation Roadmap

Homeowners were asked what type of presentation they would prefer for the Roadmap (see Figure 30). Polish and Portuguese participants said that they would like to receive a printed document in addition to the online Roadmap presentation.

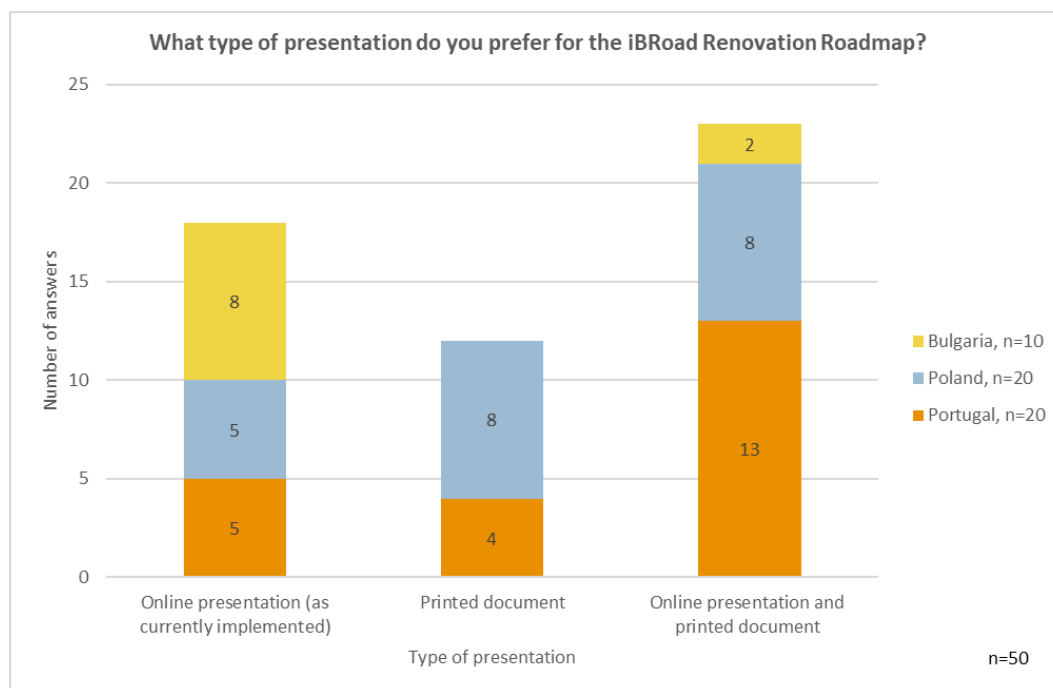


Figure 30: Preferred type of presentation of the Renovation Roadmap

Homeowners' willingness to pay for a Renovation Roadmap

Field test participants were also asked about their willingness to pay for the Renovation Roadmap (see Figure 31). The majority of respondents would pay only a small amount or not pay for it.

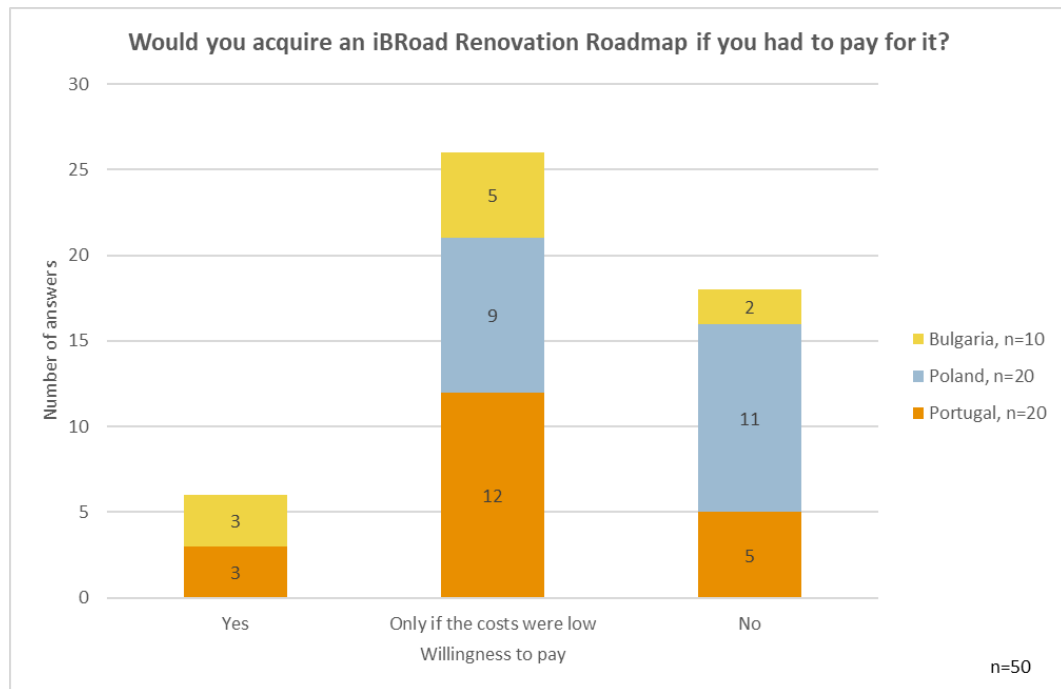


Figure 31: Homeowners' willingness to pay for a Renovation Roadmap

iBRoad Logbook

General assessment of the iBRoad Logbook

At first, homeowners were asked for a general assessment of the iBRoad Logbook (see Figure 32, Figure 33, and Figure 34). Overall, the feedback was positive.

Portuguese field test participants affirmed that it would be good to have all building-related information gathered in one place. Particularly, respondents appreciated the presentation of building envelope efficiency. More than half of the Portuguese field test participants “tend to agree” or “completely agree” with the statement “The iBRoad Logbook enables and motivates me to realise concrete renovation measures in the near future” (see Figure 32).

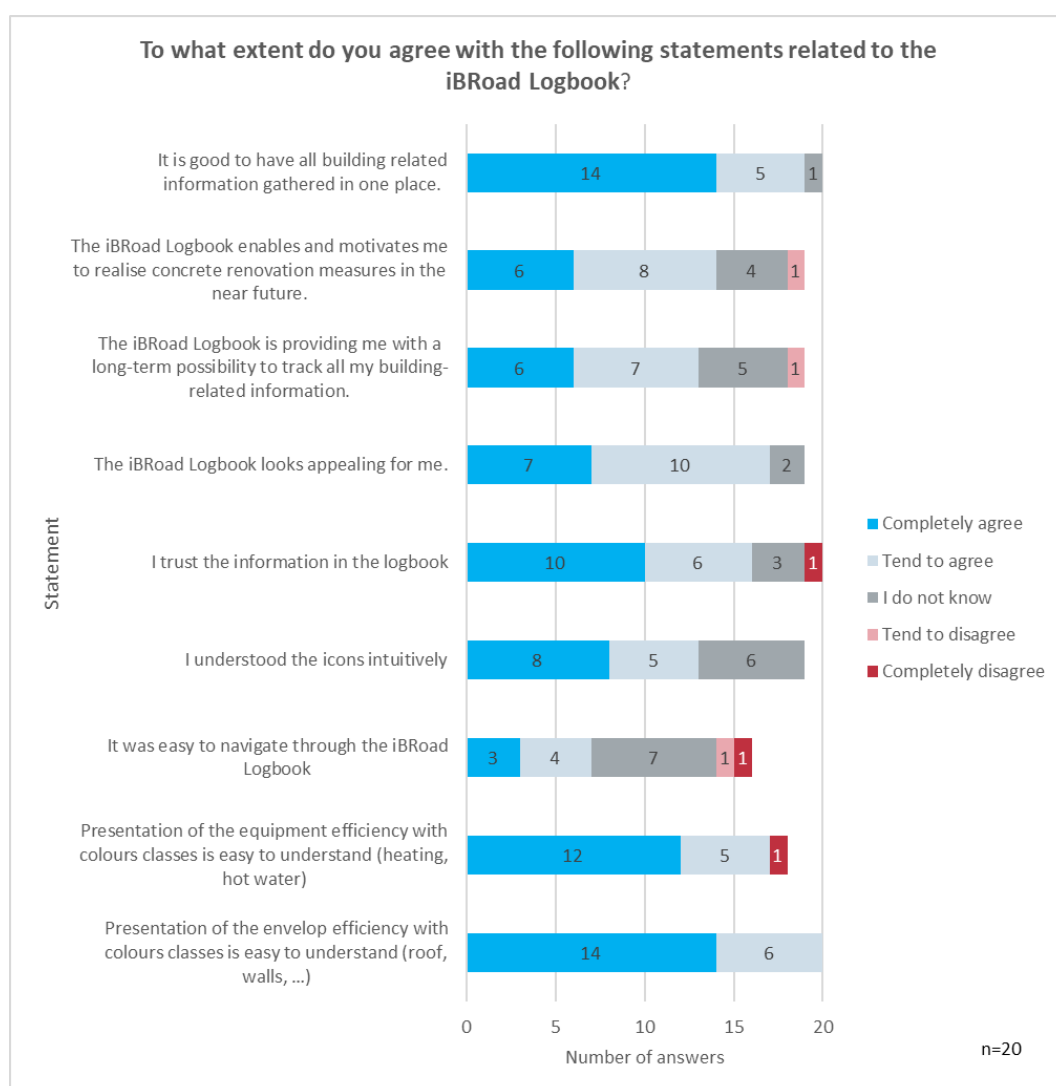


Figure 32: General assessment of the iBRoad Logbook (Portugal)

The Polish feedback turned out less positive than the Portuguese one, but significant criticism was not recorded (see Figure 33). Like the Portuguese participants, Polish field test participants “tend to agree” or “completely agree” with the statement “It is good to have all building-related information gathered in one place”. Particularly, respondents appreciated the presentation of building envelope efficiency

and building equipment efficiency. About half of the Polish field test participants “tend to agree” or “completely agree” with the statement “The iBRoad Logbook enables and motivates me to realise concrete renovation measures in the near future”.

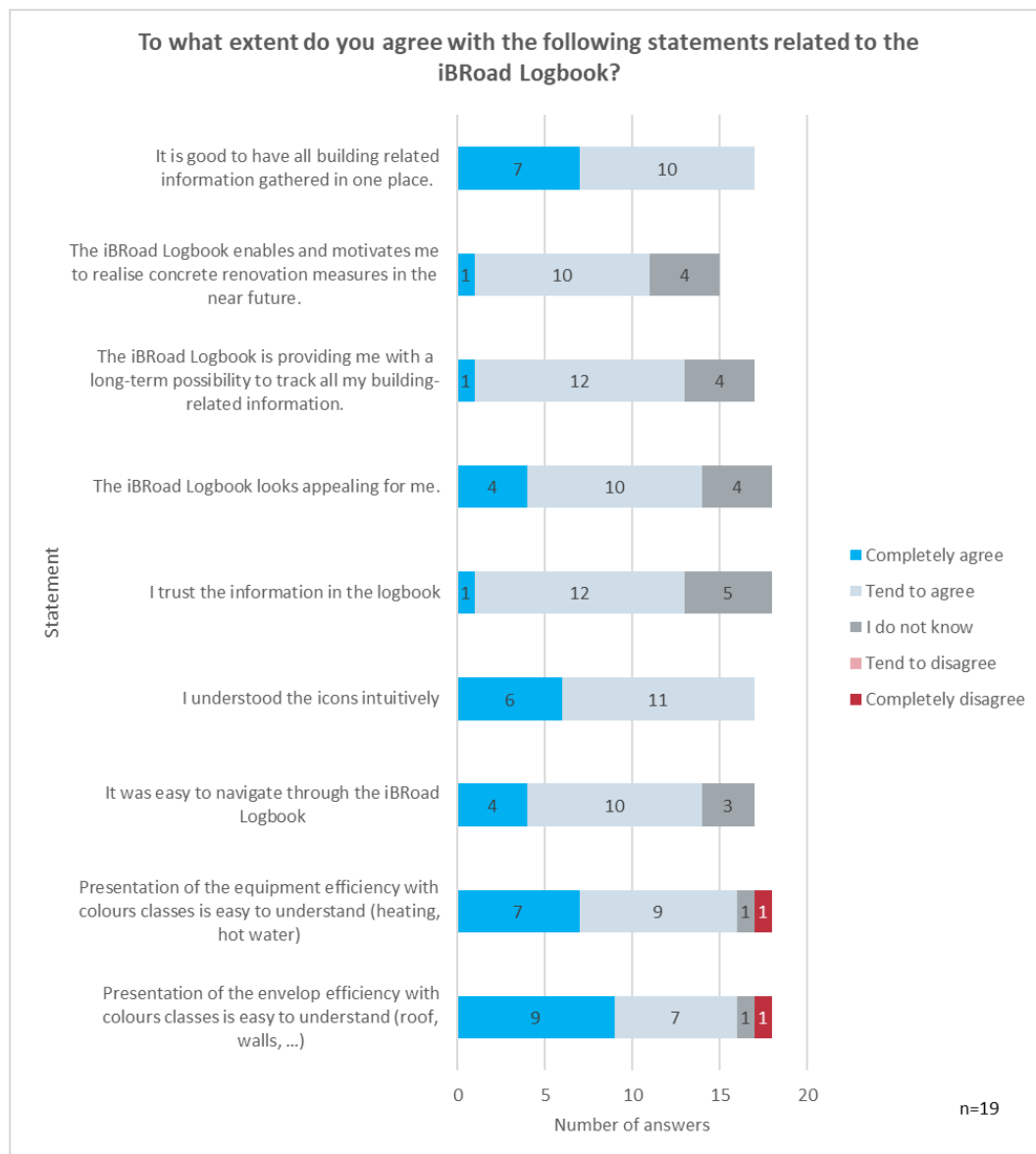


Figure 33: General assessment of the iBRoad Logbook (Poland)

The majority of Bulgarian field test participants affirmed that it would be good to have all building-related information gathered in one place (see Figure 34). Significant criticism was not recorded. Almost all the Bulgarian field test participants also “tend to agree” or “completely agree” with the statement “The iBRoad Logbook enables and motivates me to realise concrete renovation measures in the near future”.

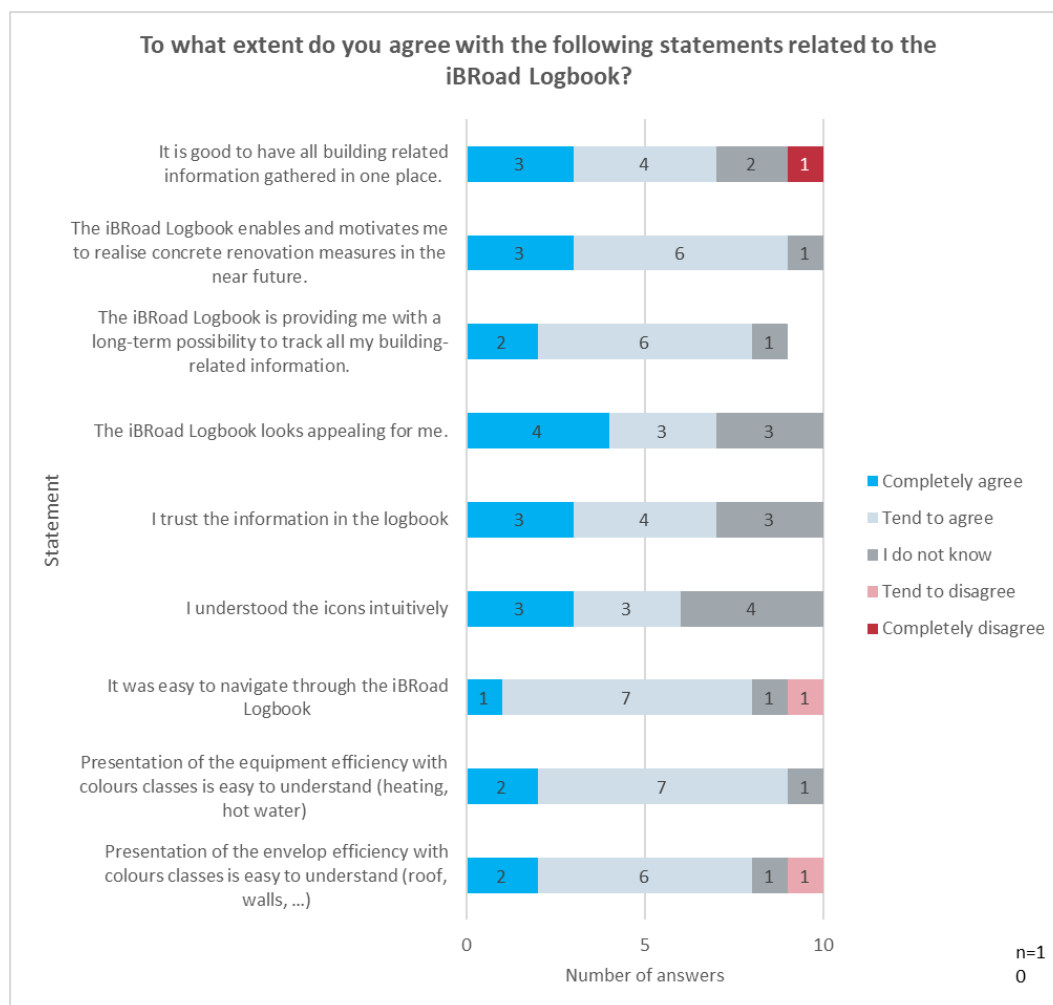


Figure 34: General assessment of the iBRoad Logbook (Bulgaria)

Usefulness of Logbook features

Homeowners were also asked about their opinion towards the usefulness of individual iBRoad Logbook features (see Figure 35, Figure 36, and Figure 37). Overall, respondents' feedback was positive.

Portuguese field test participants especially appreciated the "building diagnosis" (see Figure 35). They rated the "storage of smart information" as least useful.

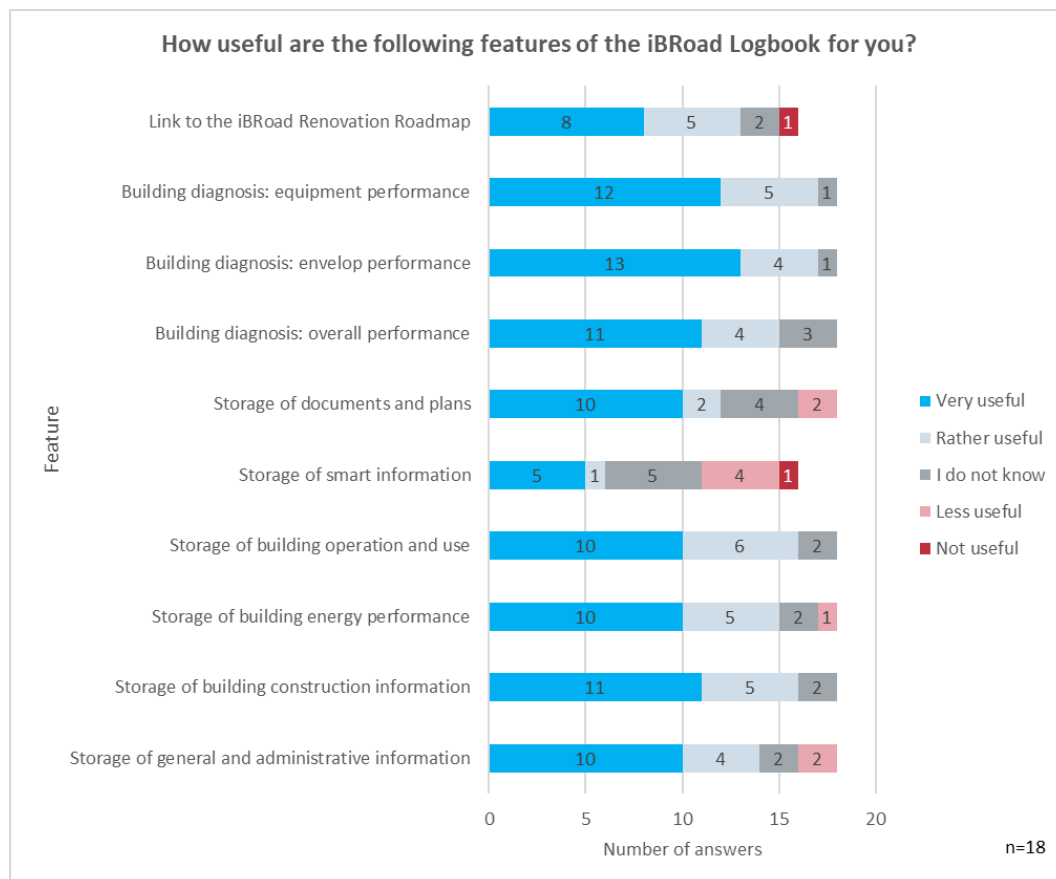


Figure 35: Usefulness of Logbook features (Portugal)

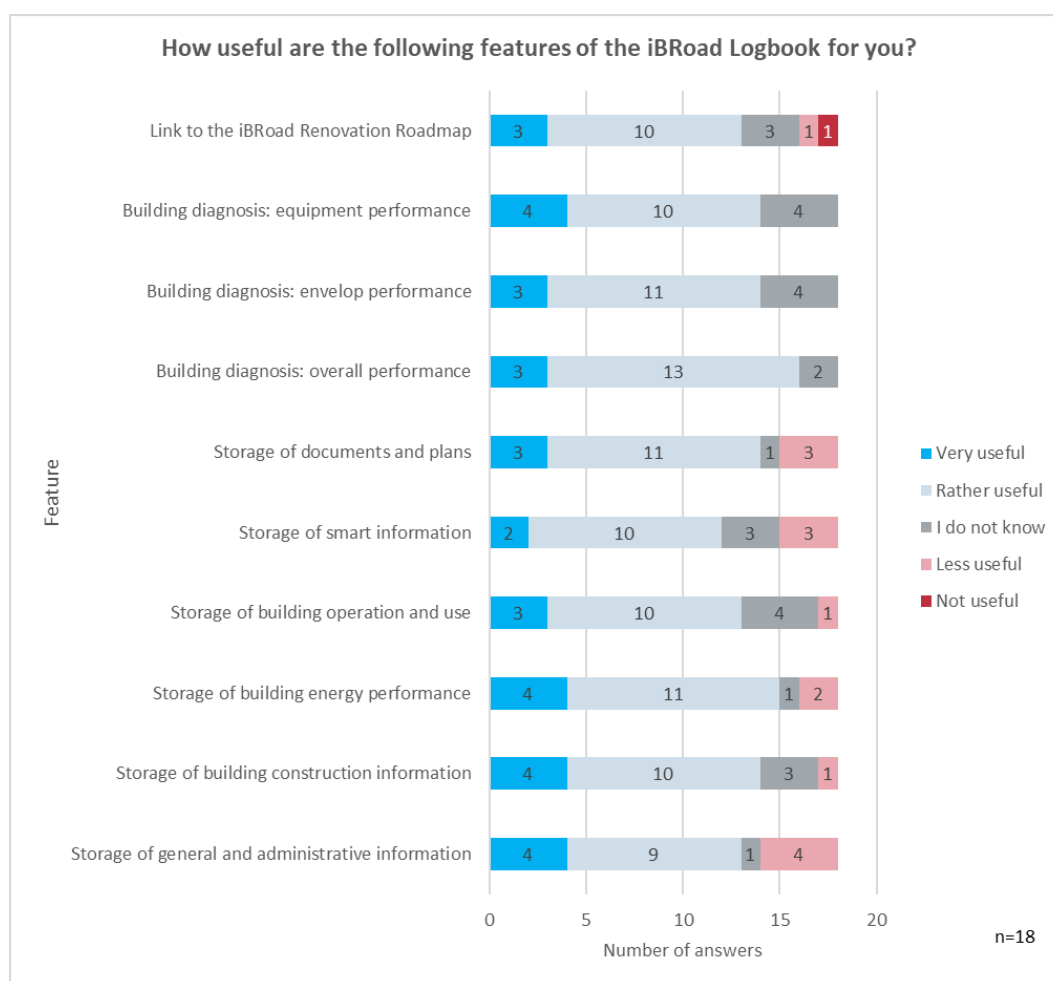


Figure 36: Usefulness of Logbook features (Poland)

Bulgarian respondents assessed the Logbook features a bit more moderately in general (see Figure 37). Their rating shows only small differences between the Logbook features.

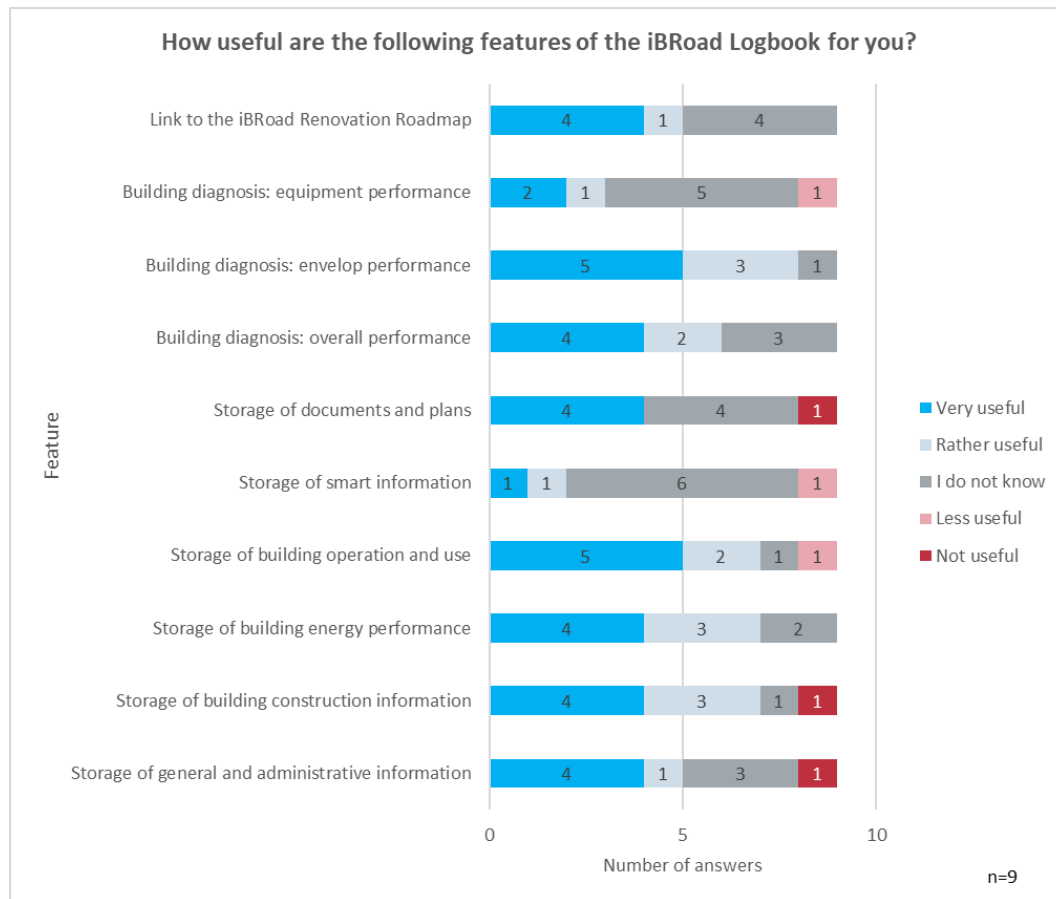


Figure 37: Usefulness of Logbook features (Bulgaria)

Usability of Logbook features

Homeowners were requested to indicate how easy or complicated individual Logbook features were to use (see Figure 38, Figure 39, and Figure 40). Portuguese and Bulgarian field test participants assessed the usability of Logbook features, e.g., “uploading building images” and “creation of new building states”, often as “neutral”. Polish field test participants tend to find the Logbook features as “rather easy” to use.

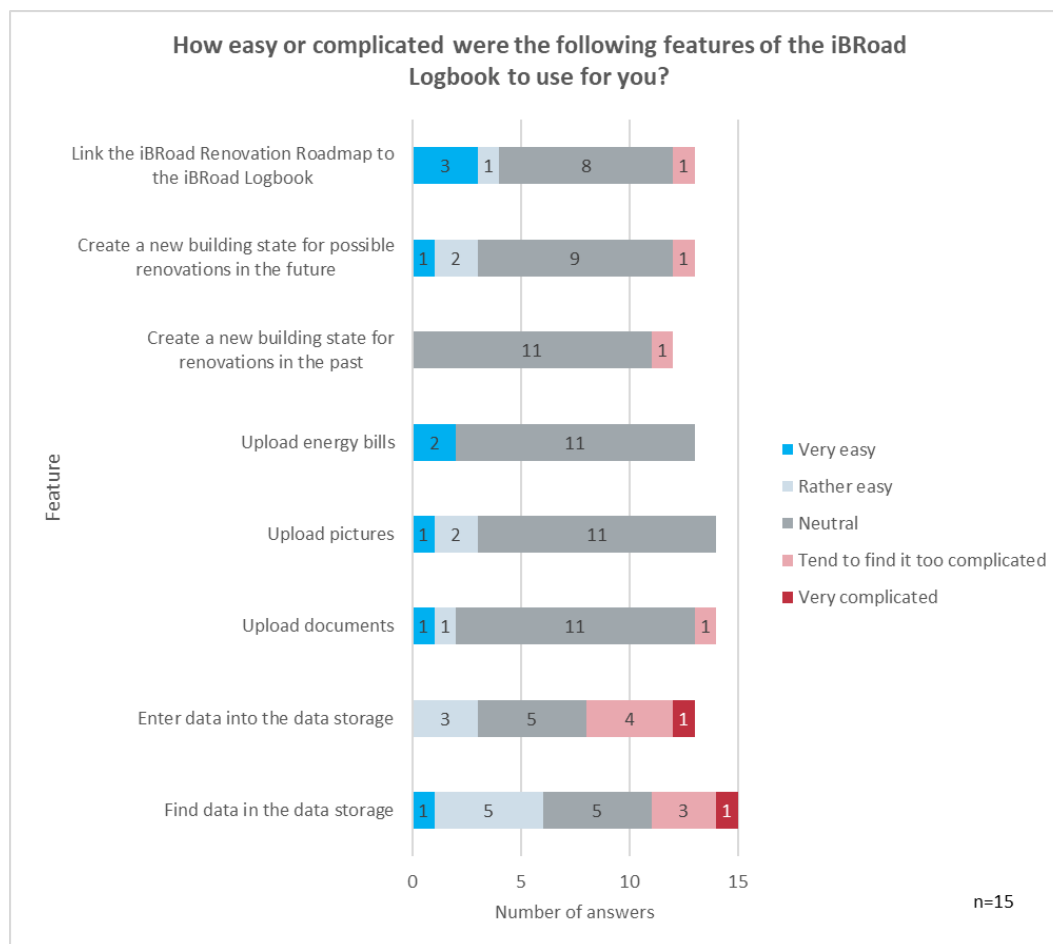


Figure 38: Usability of Logbook features (Portugal)

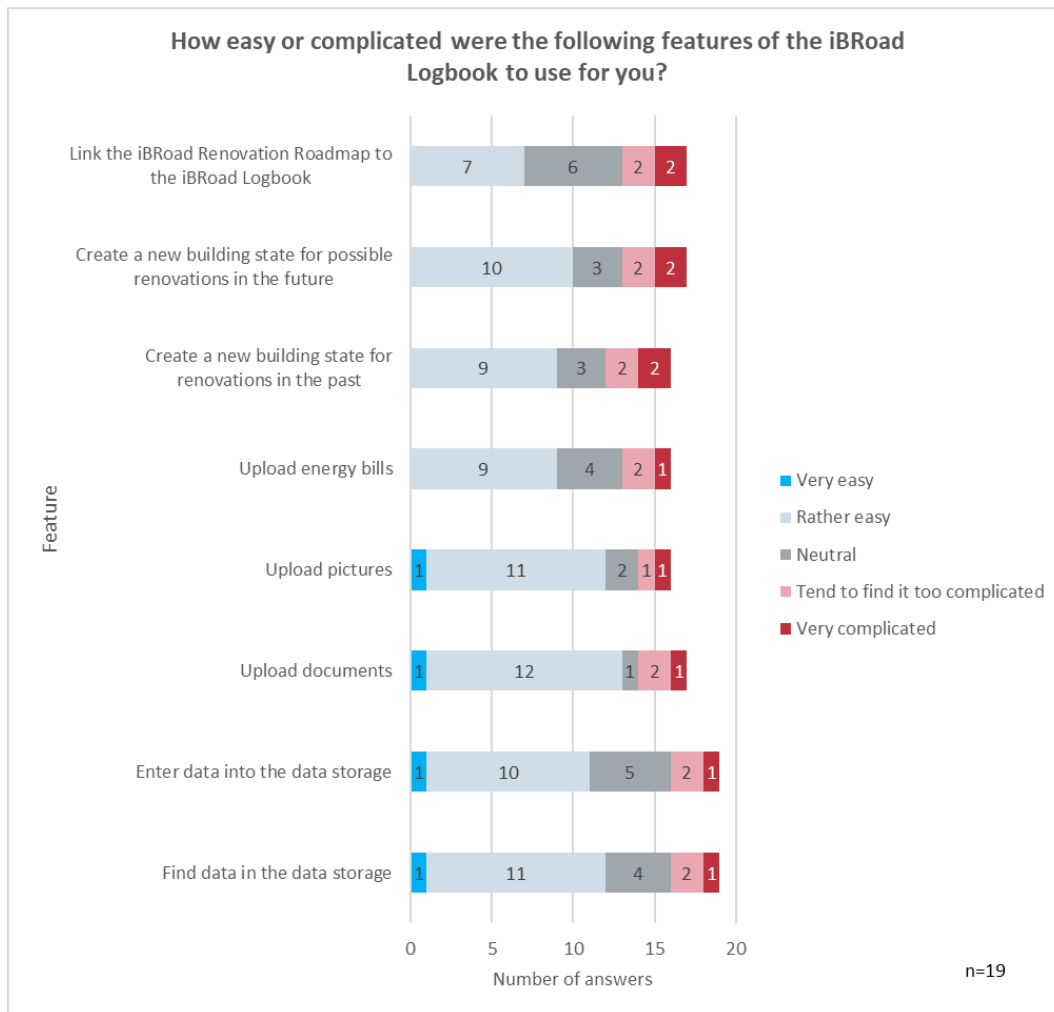


Figure 39: Usability of Logbook features (Poland)

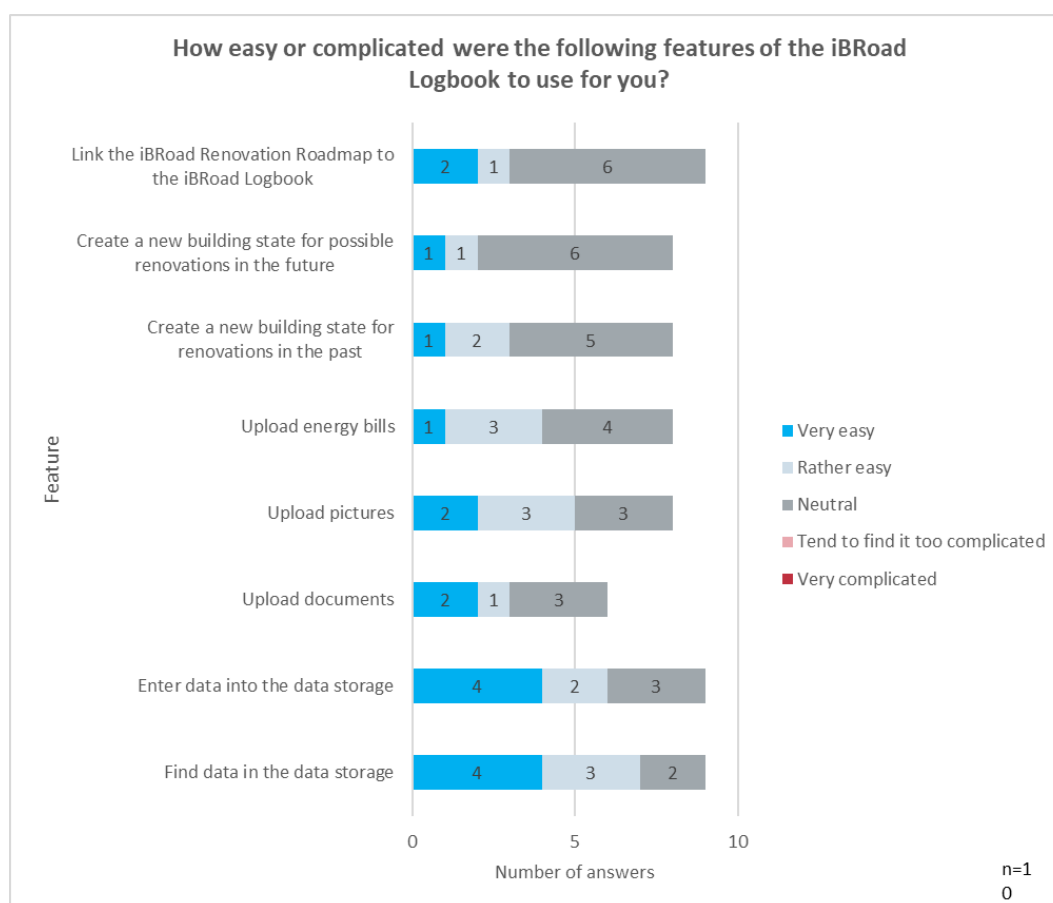


Figure 40: Usability of Logbook features (Bulgaria)

Logbook recommendation rate

Finally, homeowners were asked if they would recommend the iBRoad Logbook to their family and friends. Here, the results were very positive (see Figure 41).

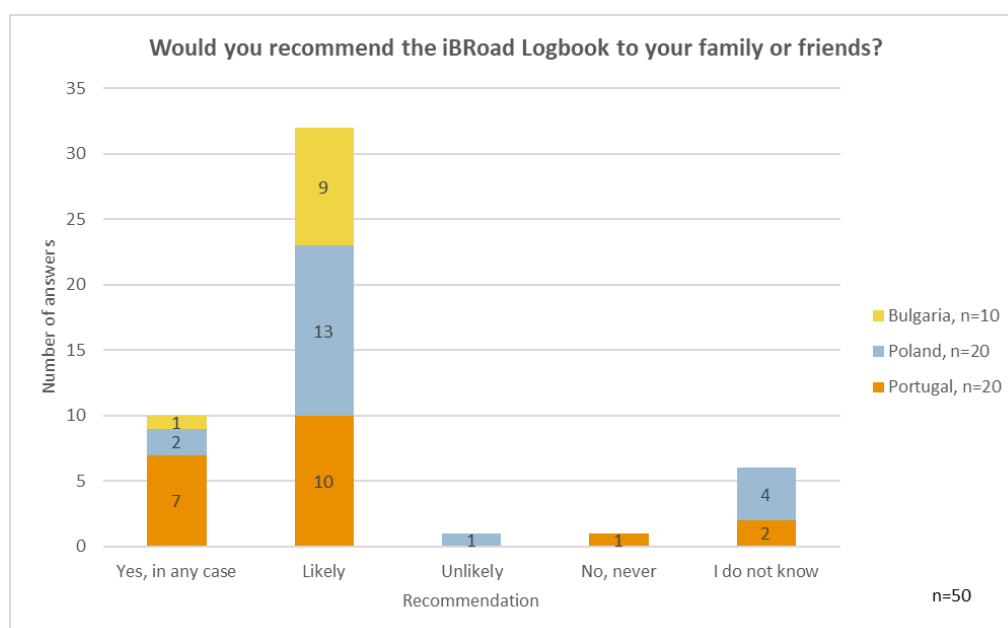


Figure 41: Logbook recommendation rate

Homeowners' willingness to pay for the Logbook

The majority of homeowners would only be willing to pay a small amount for the Logbook or not pay for it at all (see Figure 42)

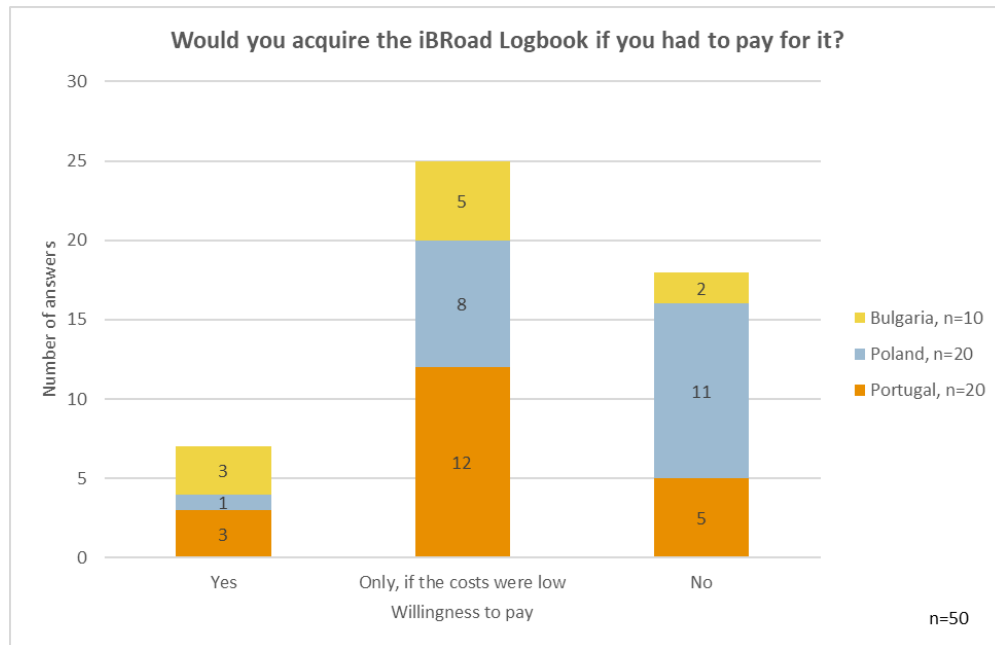


Figure 42: Homeowners' willingness to pay for the Logbook

ii. Results from the energy auditors' questionnaire

All energy auditors returned at least one completed evaluation questionnaire, while some returned several - when they assessed more than one building it came to different conclusions for each. Following this, the number of questionnaires does not match the number of buildings in the field test.

As a result, the following number of auditors' questionnaires were evaluated (if applicable, deviations are indicated in the following):

Pilot country		Number of energy auditors' questionnaires evaluated
	Bulgaria	13
	Poland	20
	Portugal	15

Table 3: Number of auditors' questionnaires evaluated per country

Energy audit: on-site visit

The iBRoad field test included the creation of a Logbook and a Roadmap based on an on-site-visit. During this visit, the energy auditors examined the buildings and made an initial assessment of components that need renovation. They assessed the layer structures of components and measured surface areas. The energy auditors also enquired about certain habits and usage patterns, as well as the needs, wishes and financial capabilities of the building owners.

On average, the on-site visit lasted about 3 hours regardless of the pilot country. Approximately half of all building owners already had an idea for a long-term renovation perspective for their building.

The energy auditors found that the individual preferences for the renovation went even further than the wish for improved indoor comfort. Frequently cited reasons for renovation were:

- finding a long-term source of investment;
- direct problems with the construction of the building;
- a wish for lower energy bills.

Usefulness of the on-site visit for the energy auditor

Energy auditors' feedback regarding the usefulness of the on-site-visit is shown in Figure 43, Figure 44 and Figure 45. Auditors' were asked about the usefulness of the visit in general, but also of the usefulness of its individual parts, i.e:

- identification of building weaknesses;
- first sketch of a Renovation Roadmap on a blank template;
- information on future renovation measures;
- information on the current building state;
- how the personal information of the building owners could be taken into account while creating the Roadmap.

The large majority of the energy auditors from Portugal considered all aspects of the on-site-visit very useful. The information gained about possible future renovations was rated most positively. The lowest

share of “very useful” ratings can be seen at those issues that go beyond the regular energy audit and thus are rather new to the auditors, i.e., related to personal conditions and preferences of the owners, and the sketch on the blank template. However, these issues were still voted “very useful” by a majority.

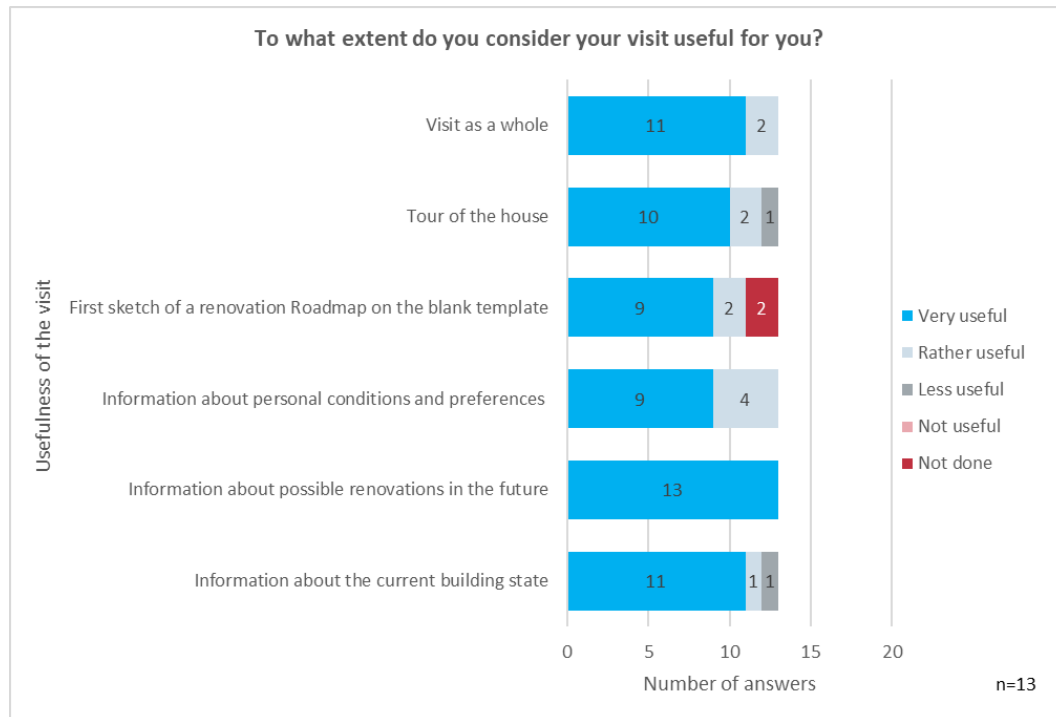


Figure 43: Usefulness of the on-site visit for the energy auditor (Portugal)

Polish energy auditors were less enthusiastic in general. The overall tendency is similar to the Portuguese auditors' rating: the sketch with the blank template and the owner's preferences are rated lowest. The tour of the house and the information about possible future renovations received one "not useful" rating each.

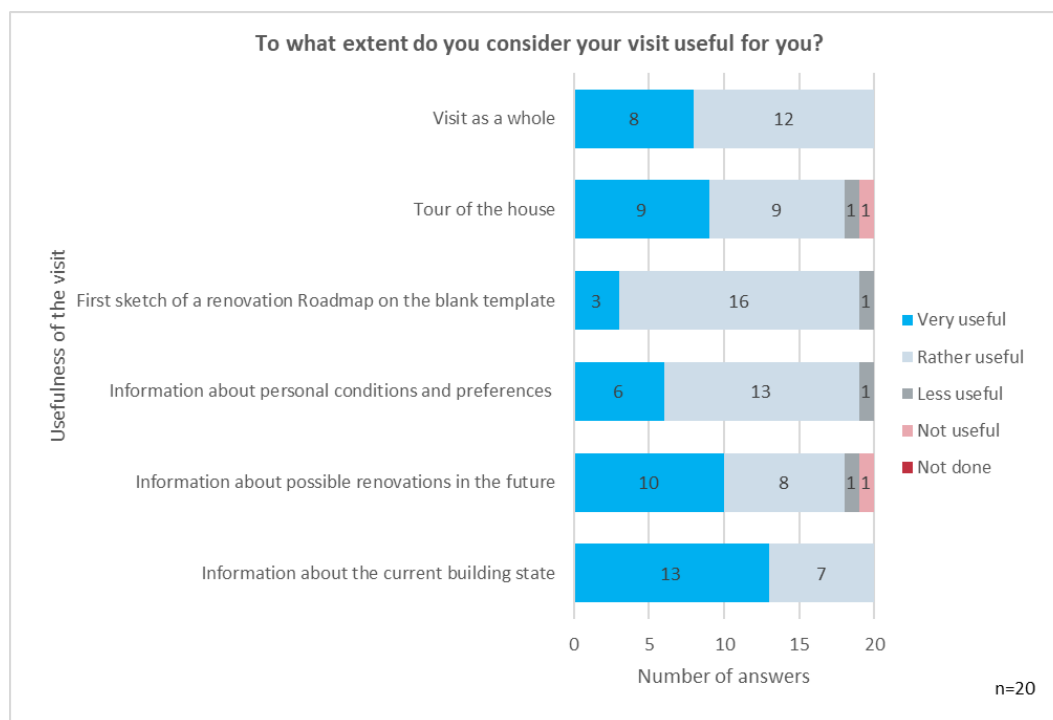


Figure 44: Usefulness of the on-site visit for the energy auditor (Poland)

In Bulgaria, a large majority of the auditors rated the on-site visit as “very useful”. Like the Polish and Portuguese auditors, they considered the blank template and the information about personal conditions and preferences to be the least useful compared to the other items. In contrast to the other pilot countries, the tour of the house is regarded less useful in Bulgaria.

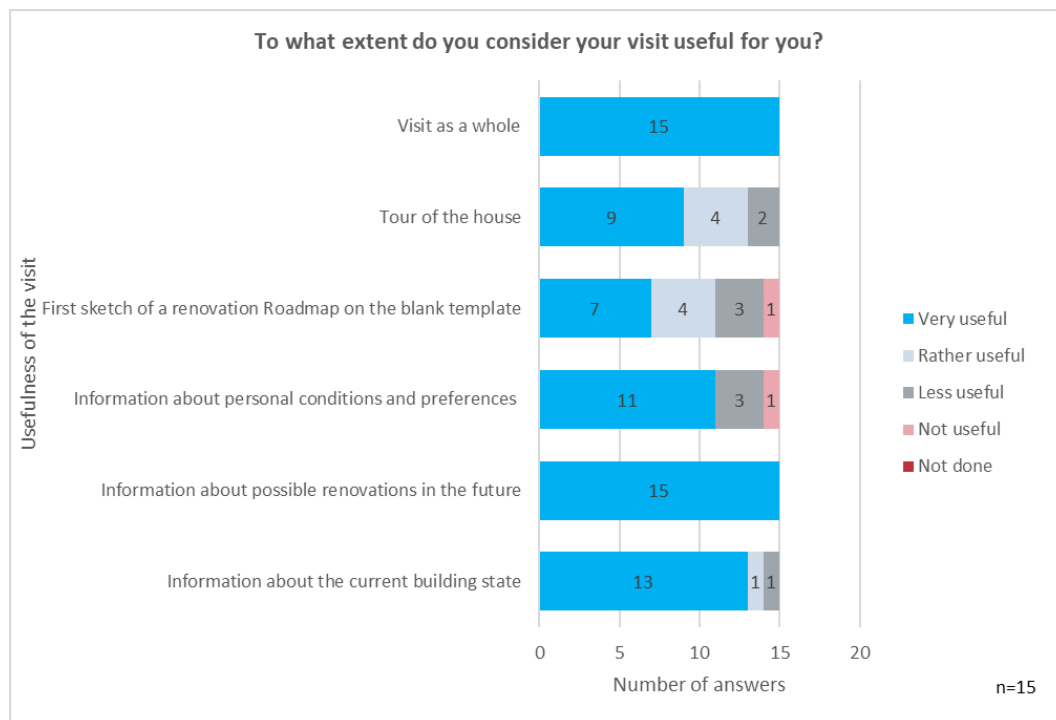


Figure 45: Usefulness of the on-site visit for the energy auditor (Bulgaria)

Planning and calculation of renovation steps and measures

The preparation of the iBRoad Roadmap requires an exact analysis of the building by the energy auditor. The energy auditor must at least calculate the energy consumption and the quality of the building envelope in order to make future renovation recommendations. Ideally, the auditor can then use the homeowner's personal preferences to recommend renovation steps and measures that lead to the lowest possible energy consumption.

To create the Roadmap, a variety of data needs to be entered into the Roadmap Assistant. The current building status is entered first. The energy auditors needed between half an hour and 15 hours to enter the data into the calculation software. Twelve energy auditors needed less than three hours, nineteen about three hours and fifteen longer than three hours. On average, the energy auditors needed 3.5 hours to enter the data. The processing time is distributed evenly among the pilot countries; only the Portuguese needed a little longer on average to enter the data for the current building state.

The creation of the future renovation steps took between 1 and 24 hours. On average, it took the Portuguese energy auditors 3.6 hours, 4 hours for the Polish and 4.1 hours for the Bulgarian auditors.

Existence of an EPC (auditors view)

As shown in the homeowners' evaluation, almost all buildings in Portugal already had an EPC or will soon have one in connection with a pending renovation. In contrast, none of the building owners in Poland and Bulgaria had an EPC before the field test. In Poland, auditors state that most homeowners do not need an EPC. In Bulgaria is a high share of homeowners who do not wish an EPC. Like in Poland, an EPC had already been issued for only two of the examined buildings (see Figure 46).

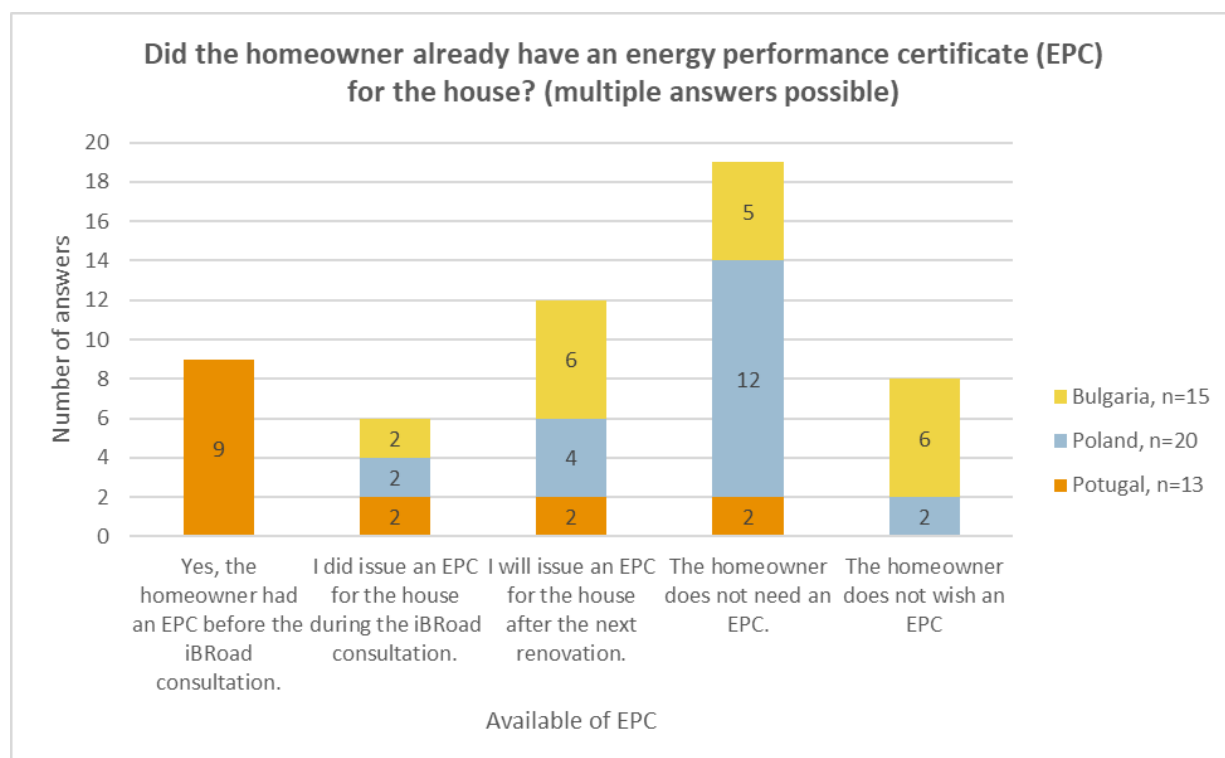


Figure 46: Existence of an EPC (auditors view)

Existing data

For those Portuguese buildings already equipped with an EPC, energy auditors were able to transfer all data on the current building state (e.g., surface areas, U-values, etc.). The majority of the Polish auditors had to measure essential data from existing plans. Most Bulgarian energy auditors needed to measure the building during the on-site visit (see Figure 47).

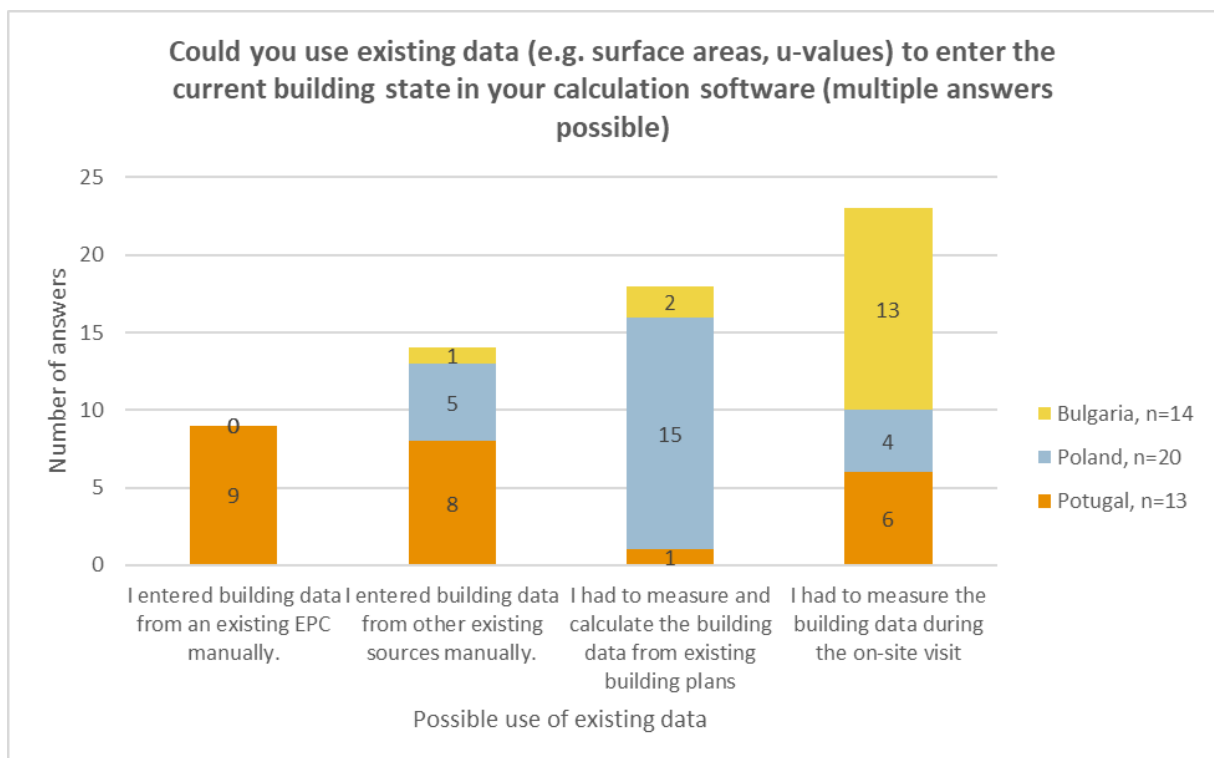


Figure 47: Existing data

Renovation variants

The iBRoad Roadmap presents only one final renovation variant. This variant is elaborated and adapted to the building and the owner. During the definition of the final variant, there may be several options to discuss with the building owner. In the best case, auditor and owner decide together which variant is most suitable.

Figure 48 shows that the majority of energy auditors, regardless of the pilot countries, took the time during the on-site visit to talk about different renovation variants. Fewer energy auditors discussed the different variants with the owner after the on-site-visit. In other cases, variants were not discussed because there was only one sensible way to renovate the building.

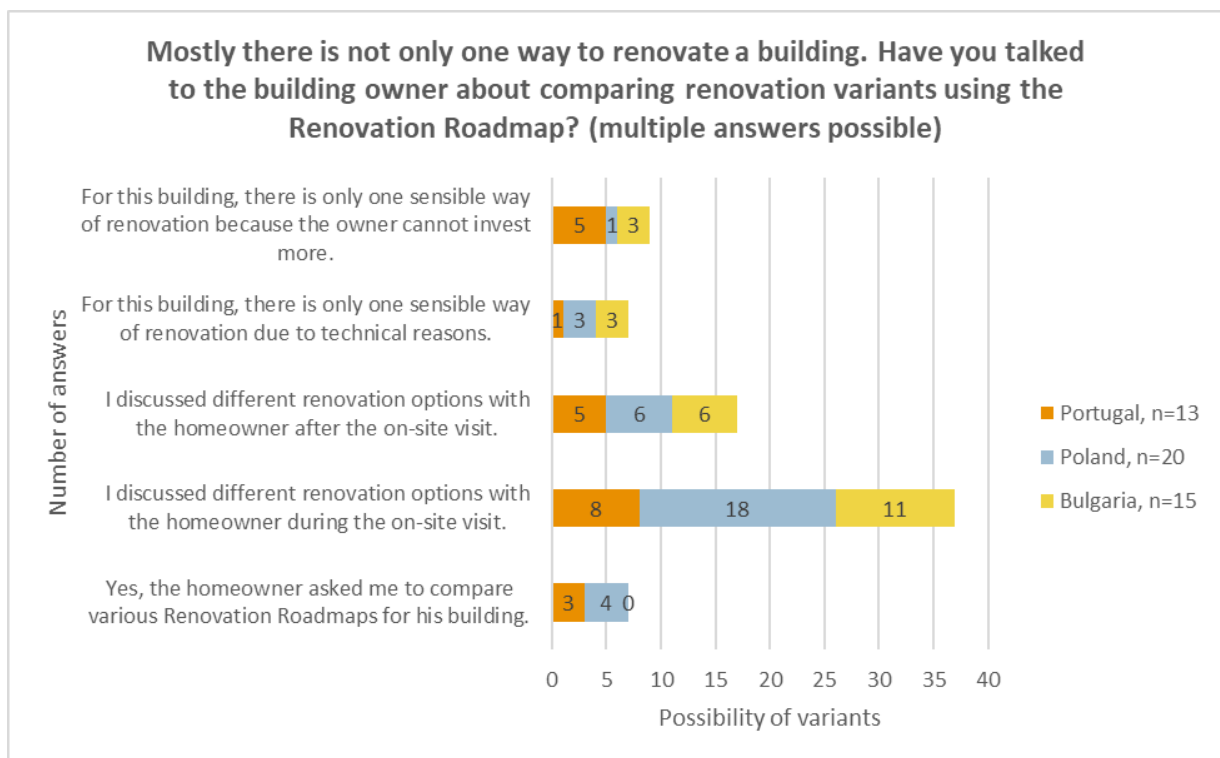


Figure 48: Renovation variants

During the evaluation, auditors were asked whether it would be helpful if they had the opportunity to compare different variants when developing a Renovation Roadmap (see Figure 49). The vast majority of energy auditors said that this would indeed be helpful. Only one auditor from each pilot country did not find this useful.

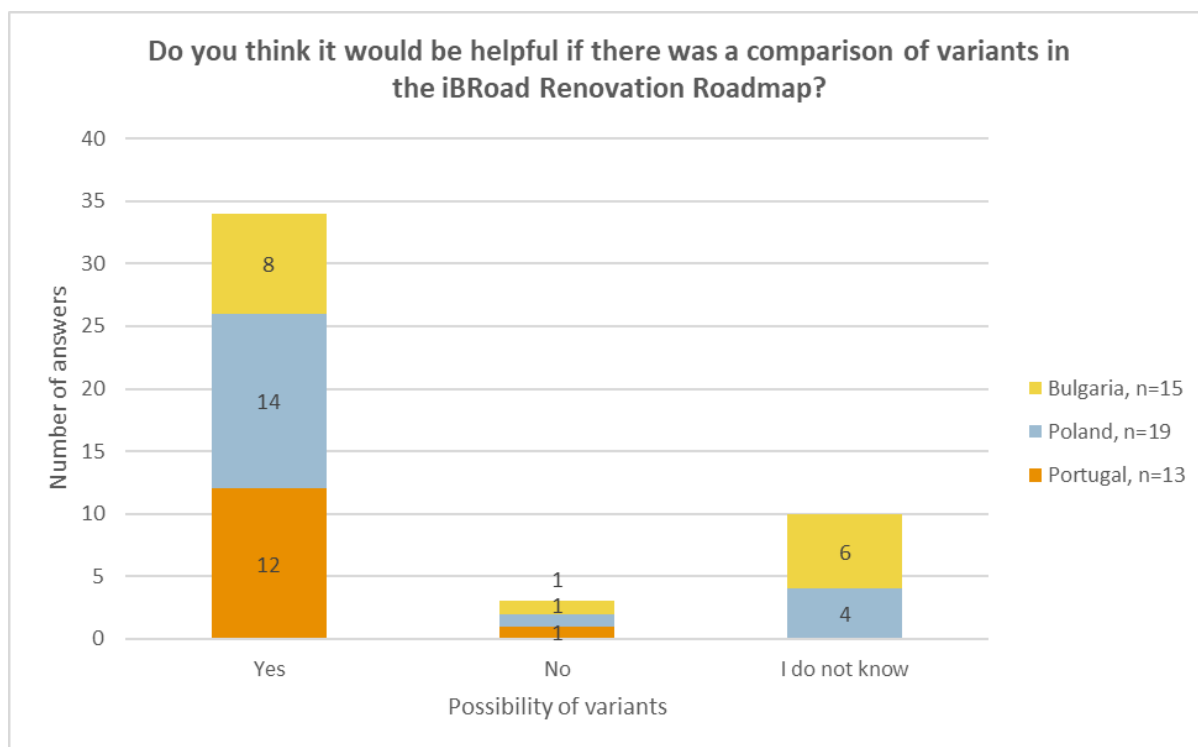


Figure 49: Renovation variants in the iBRoad renovation Roadmap

Roadmap Assistant

Based on the building state and the created renovation steps, the energy auditor produced the Roadmap with the help of the iBRoad Roadmap Assistant. The iBRoad Roadmap Assistant is a tool that displays the Roadmap data in a unified iBRoad format and supports the auditors with preconfigured text blocks.

The screenshot displays the iBRoad Roadmap Assistant interface. On the left, the 'Roadmap Assistant' header is visible. Below it, the 'Building Address' section includes fields for Street (Examplestreet), Number (1), Postal Box, Municipality (Berlin), Zip Code (12159), and Country (Germany). The 'Building Facts' section lists four building sides (House_side 1 to 4) with corresponding images and a button to 'Attach new Building Image'. Below this, fields for 'Number of Residential Units' (1), 'Living Area' (250), 'Year of Construction of the Heating System' (1994), and 'Number of Floors' (3) are shown. A blue callout box points to these fields with the text 'Here you can edit the data ...'. On the right, the 'Current State' section shows 'Your Building Today' with four images of the building. Below this, a table displays key data points:

ENERGY CLASS	Building Data	User Influence on Energy	Technical Data
G	Year of Construction of the Building 1994	Attendance Time several persons take a shower daily and take a bath at least once a week	Year of Construction of the Heating System 1994
	Building Type Single Family House	Hot Water Use Habits several persons take a shower daily and take a bath at least once a week	Energy Bill 4600 €/a
	Number of Floors 3	Ventilation Use Habits during heating period one window open for several hours per day	
	Number of Residential Units 1		
	Living Area 250 m²		
	Previous Renovations		

Below the table, the 'User Influence' section lists three green checkmarks and three text blocks providing advice on energy use. A blue callout box points to this section with the text '... that is shown in the Renovation Roadmap'.

Figure 50 : How the Roadmap Assistant works

Manageability of the Roadmap Assistant

First, the auditors were asked, if they could easily work with the Roadmap Assistant (see Figure 51). Almost all auditors were able to work with the Roadmap Assistant, except for one energy auditor where the assistant did not work. The majority of the energy auditors needed some time to get used to the Roadmap Assistant but had no major problems to understand it.

Many auditors described the assistant as intuitive to use. However, some auditors reported minor issues with the creation of the renovation steps and measures.

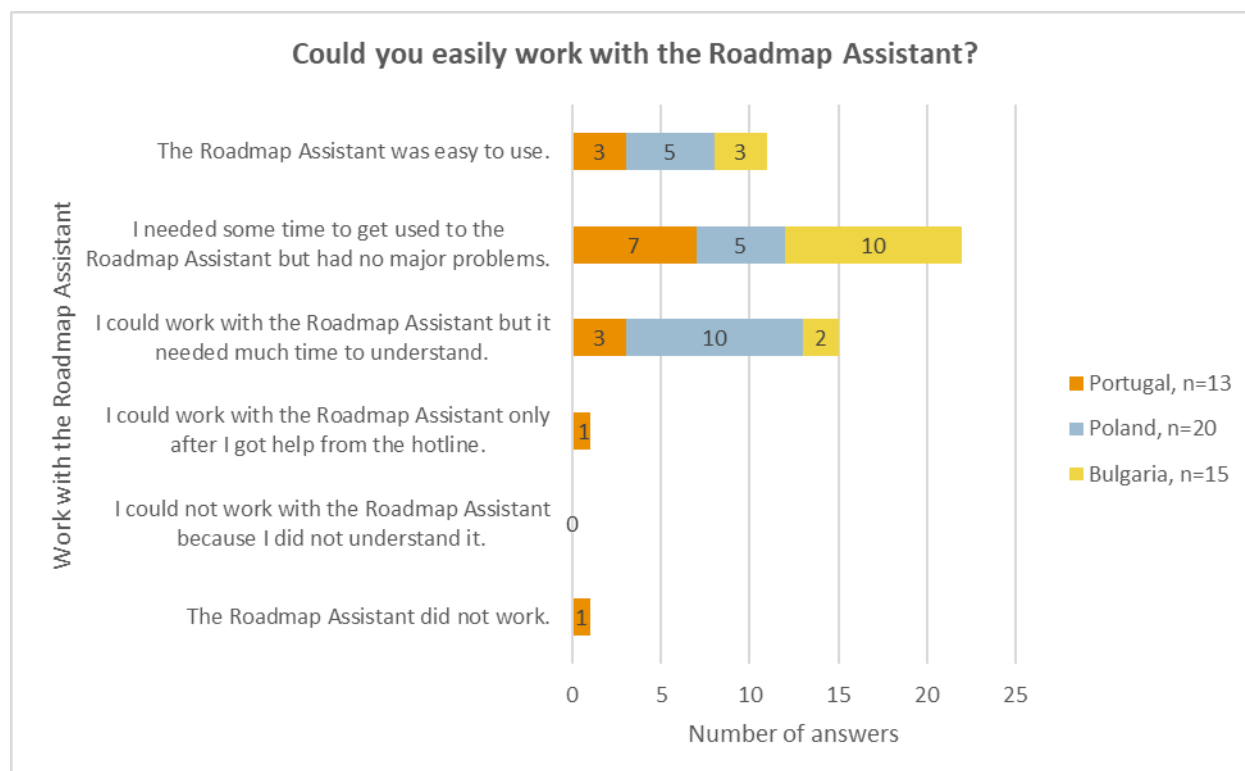


Figure 51: Work with the Roadmap Assistant

Usability of the features of the Roadmap assistant

The energy auditors were also asked how easy or complicated specific features of the Roadmap Assistant were to use. The majority of auditors considered the specific features "very easy" or "rather easy" to use (see Figure 52, Figure 53 and Figure 54). While auditors in Bulgaria rated the features rather positive, by only rating "very easy" or "rather easy", auditors in Poland and Portugal made more use of the ratings "neutral" and "rather complicated". Worst overall rating was given by all pilot countries for the feature "editing additional benefits for a renovation step". Other features were rated differently between the countries. The navigation through the tool in general received a very divers rating.

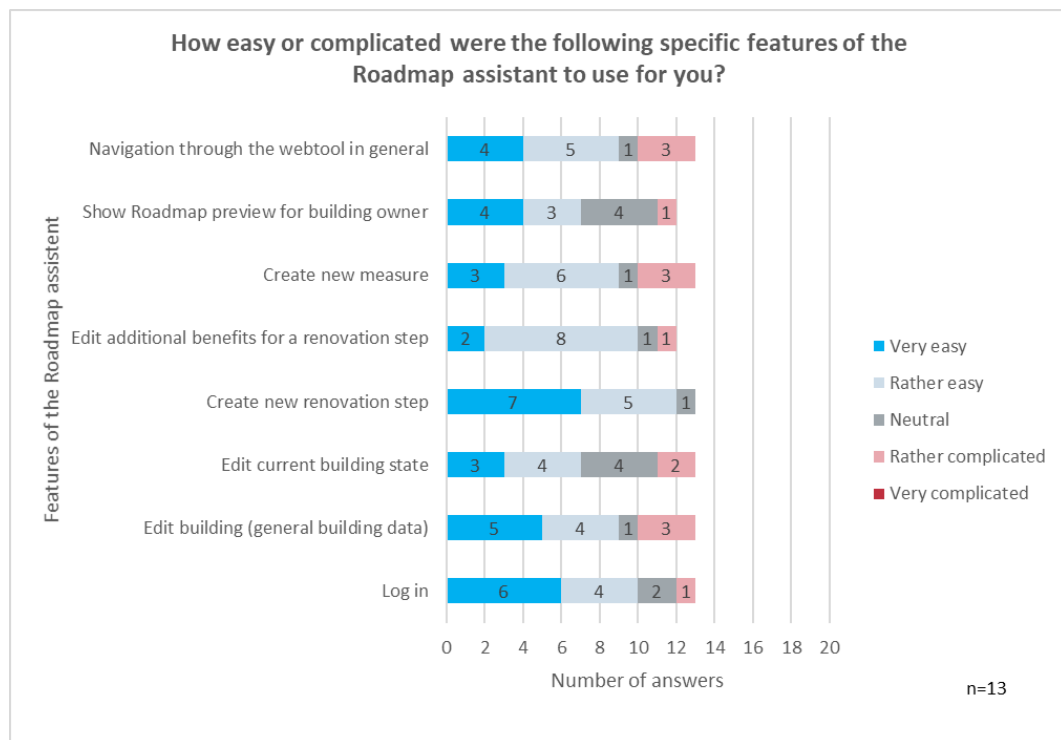


Figure 52: Usability of the features of the Roadmap assistant (Portugal)

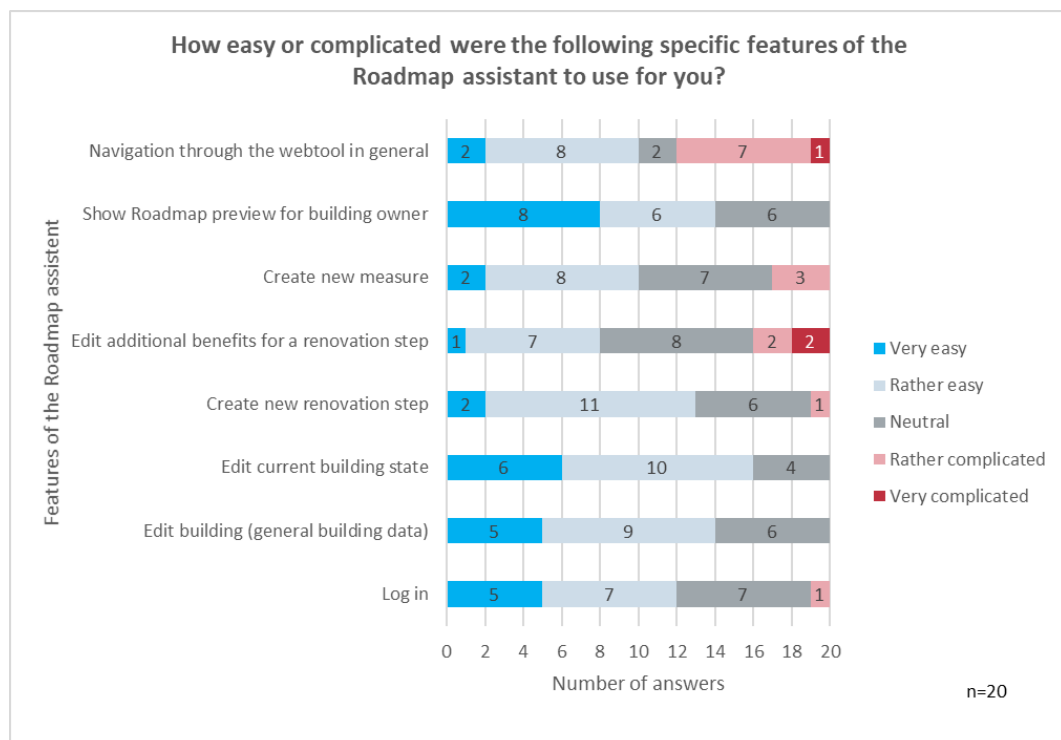


Figure 53: Usability of the features of the Roadmap assistant (Poland)

The assessment of the Bulgarian energy auditors is more positive than that of the other pilot countries (see Figure 54). Bulgarian auditors rated the feature "Navigation through the web tool in general" more negative, which confirms also the Polish feedback. Noteworthy is the quite negative rating of the log-in function by Bulgarian auditors. Some energy consultants commented that they had problems signing in.

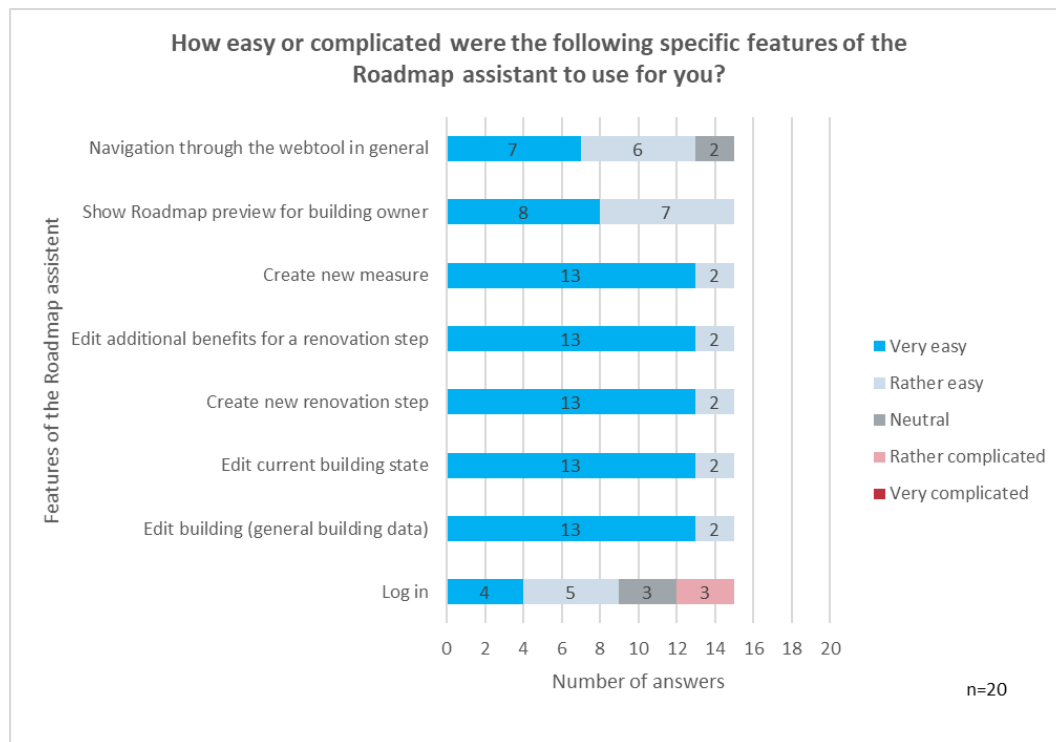


Figure 54: Usability of the features of the Roadmap assistant (Bulgaria)

The energy auditors were also asked how long it took them to enter data into the Roadmap Assistant and to create the Roadmap. The Portuguese auditors averaged 4.2 hours, the Polish 2.9 hours and the Bulgarian 2.6 hours. On average, the Portuguese required more than one additional hour to edit the logbook compared to Bulgarian and Polish auditors.

Usefulness of the Roadmap assistant features

Finally, the auditors were asked how useful they found specific features of the Roadmap Assistant. Overall, the vast majority of the auditors considered the features of the Roadmap Assistant as “very useful” or “rather useful” (see Figure 55, Figure 56 and Figure 57).

The Portuguese feedback saw some single ratings as “not very useful” or “not useful”, in particular for the features “details of renovation steps – energy demand” and “current state of your building – advices for user influence”.

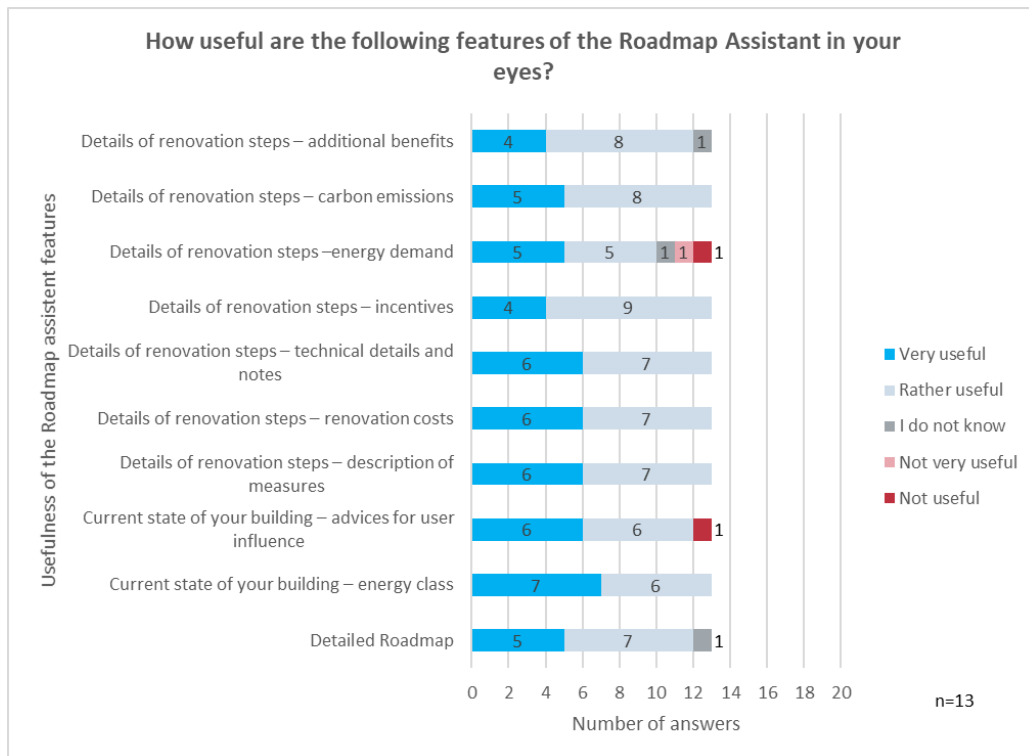


Figure 55: Usefulness of the Roadmap assistant features (Portugal)

The Polish energy auditors rated the features predominantly as “rather useful”. Showing the energy demand as a detail was rated “not useful” once.

The Polish energy auditors considered the “technical details and notes” and “renovation costs” most useful.

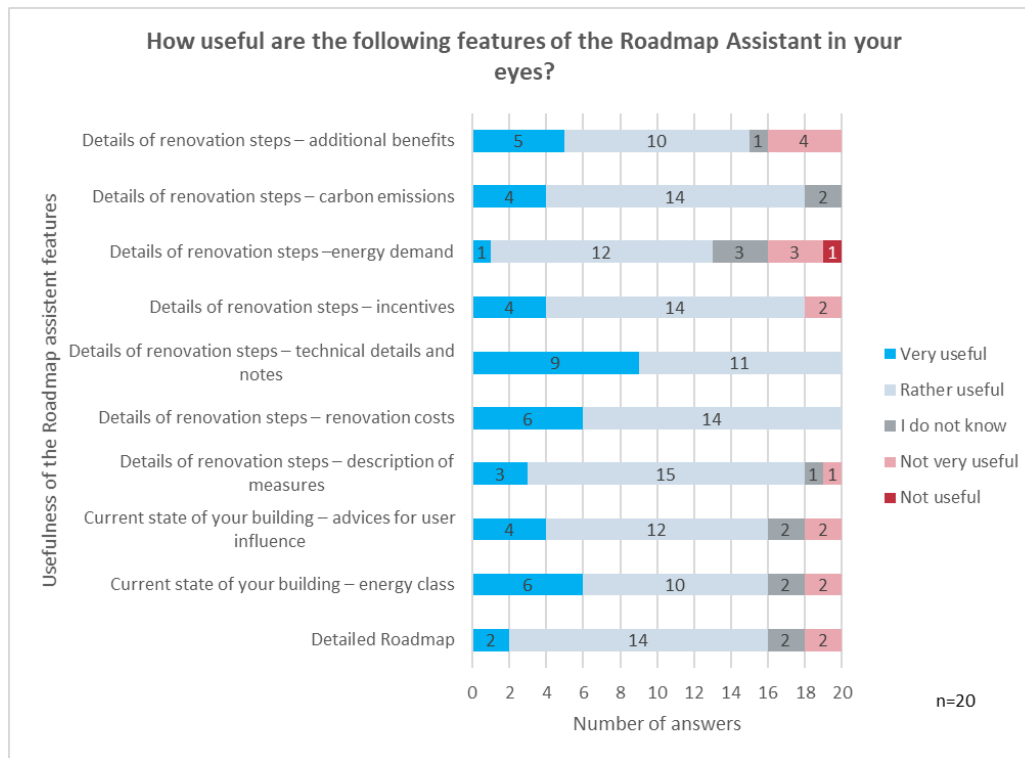


Figure 56: Usefulness of the Roadmap assistant features (Poland)

Compared to Portugal and Poland, Bulgarian energy auditors rated the features more often “very useful” in general. Worst ratings were given for the features “energy demand” and “description of measures”.

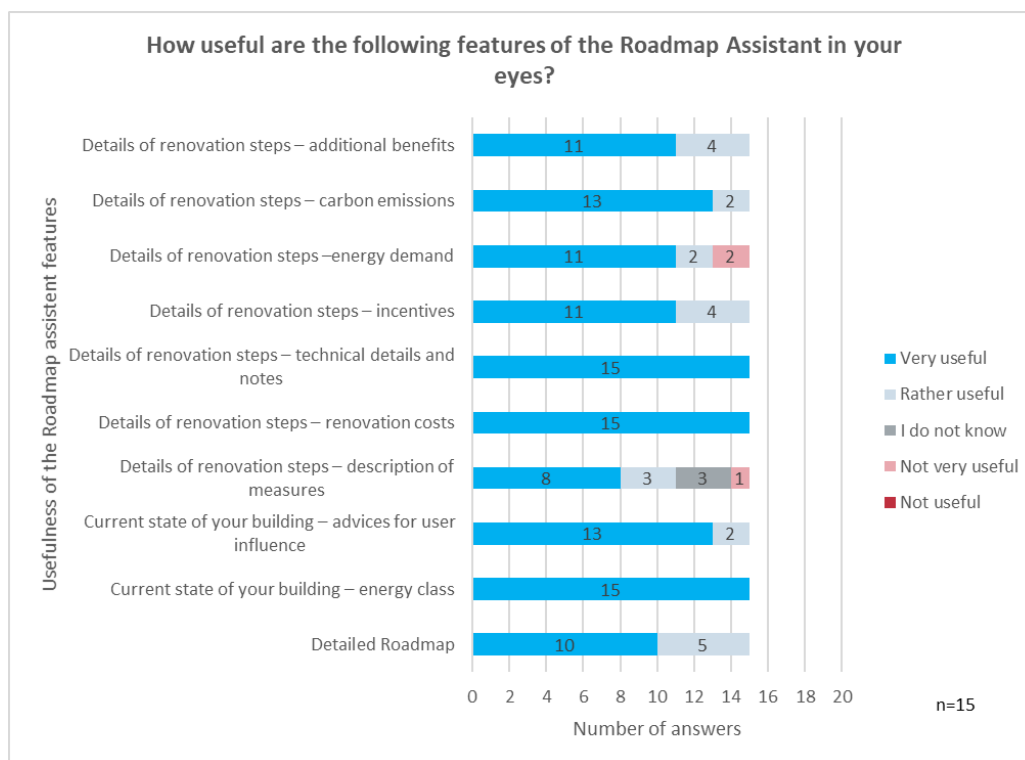


Figure 57: Usefulness of the Roadmap assistant features (Bulgaria)

iBRoad Renovation Roadmap

During the field test, energy auditors created renovation Roadmaps for the homeowners as an online document. In the following analysis, auditors were asked to assess the quality and usefulness of the Roadmap.

Satisfaction with the iBRoad Renovation Roadmap features

First, energy auditors were asked in detail how satisfied they were with the Roadmap features (see Figure 58, Figure 59 and Figure 60). The majority of the auditors was “completely satisfied” or “rather satisfied” with the Roadmap features in general.

Portuguese auditors stressed their satisfaction with the clarity of the Roadmap and the information on additional benefits of renovation. In contrast, the feedback on the aspect of graphics / appearance of the Roadmap and the degree of detail of the proposed measures was more mixed (see Figure 58). On this issue, the energy auditors’ views differ significantly from the homeowners’, who, for example, have been rather moderate in their assessment of clarity of the Roadmap (see Figure 22).

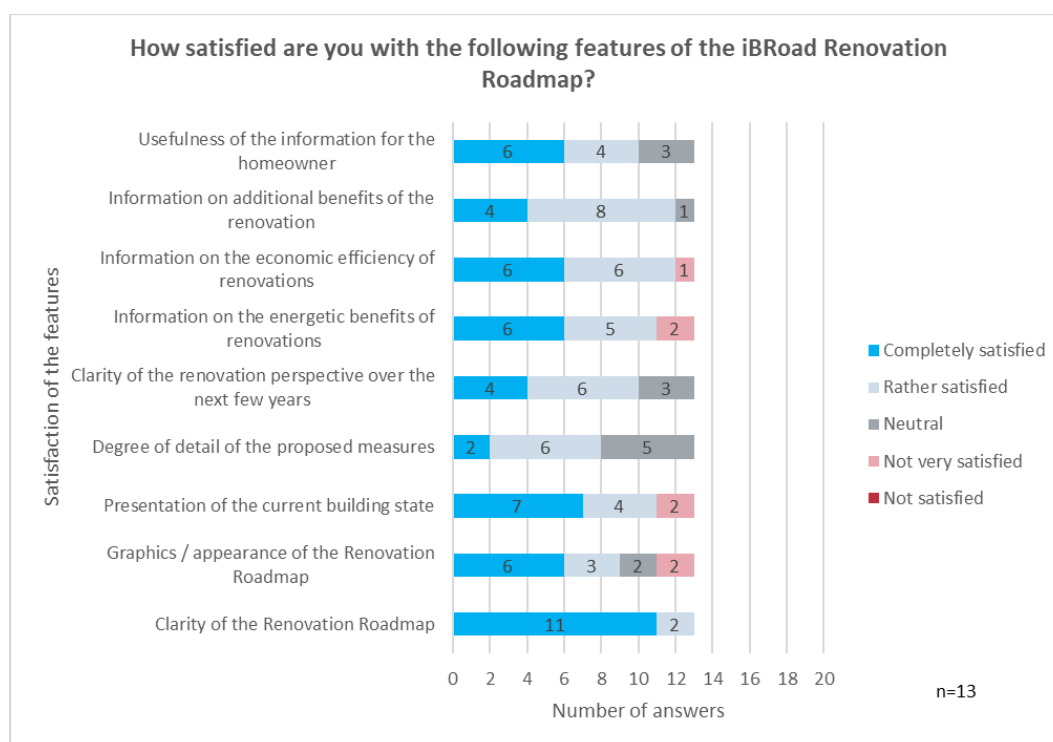


Figure 58: Satisfaction with the iBRoad Renovation Roadmap features (Portugal)

Polish auditors' evaluation of the Roadmap features was rather mixed. Numerous auditors declared to be "completely satisfied" with the "information on the economic efficiency" and the "information on the energetic benefits"; at the same time, two auditors were not satisfied by these features. In addition, only about half of the auditors were "completely satisfied" or "rather satisfied" by the "usefulness of the information for the homeowner" and the "clarity of the renovation perspective" (see Figure 59).

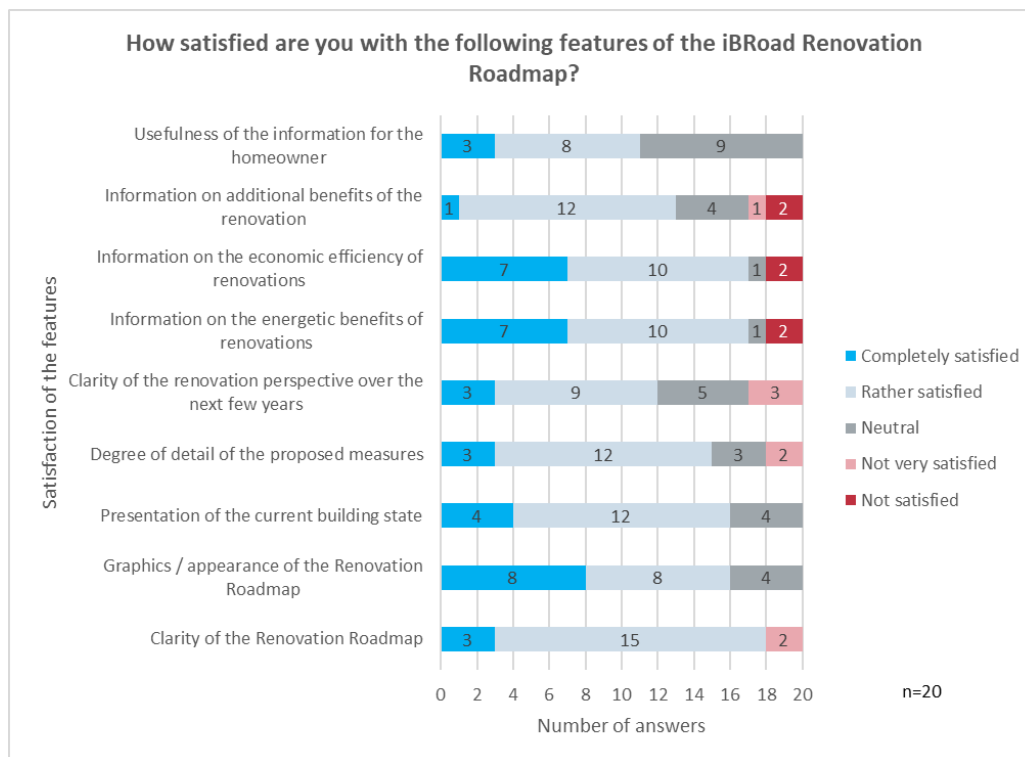


Figure 59: Satisfaction with the iBRoad Renovation Roadmap features (Poland)

The feedback from the Bulgarian auditors is more positive than that from the Portuguese and Polish auditors. Yet again, the “information on additional benefits of renovation” received the lowest rating.

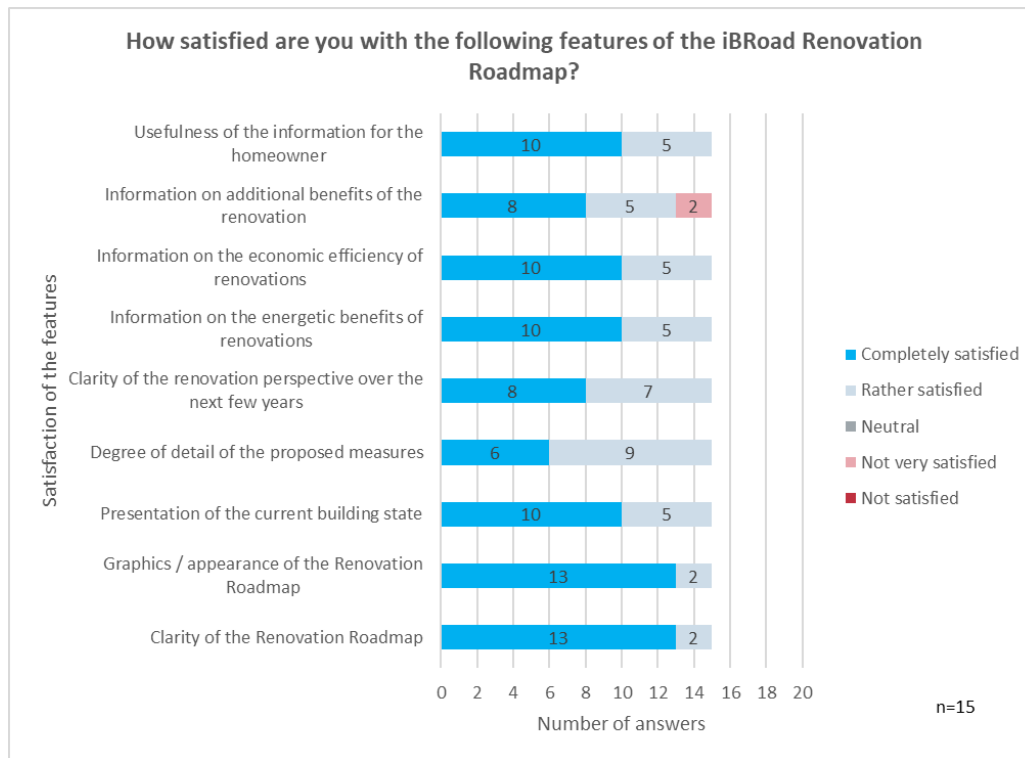


Figure 60: Satisfaction with the iBRoad Renovation Roadmap features (Bulgaria)

Usefulness of the iBRoad Renovation Roadmap features

The energy auditors were also asked to state their opinion concerning the online Roadmap document. Overall, the majority rated the Roadmap features as “very useful” or “rather useful” (see Figure 61 , Figure 62 and Figure 63).

Portuguese auditors especially appreciated the information on the energetic benefits of renovations and the graphics / appearance of the Roadmap. Information for the homeowners, information on the additional benefits of the renovation and information on the economic efficiency of the renovations was less positively rated, though still quite useful, see Figure 61.

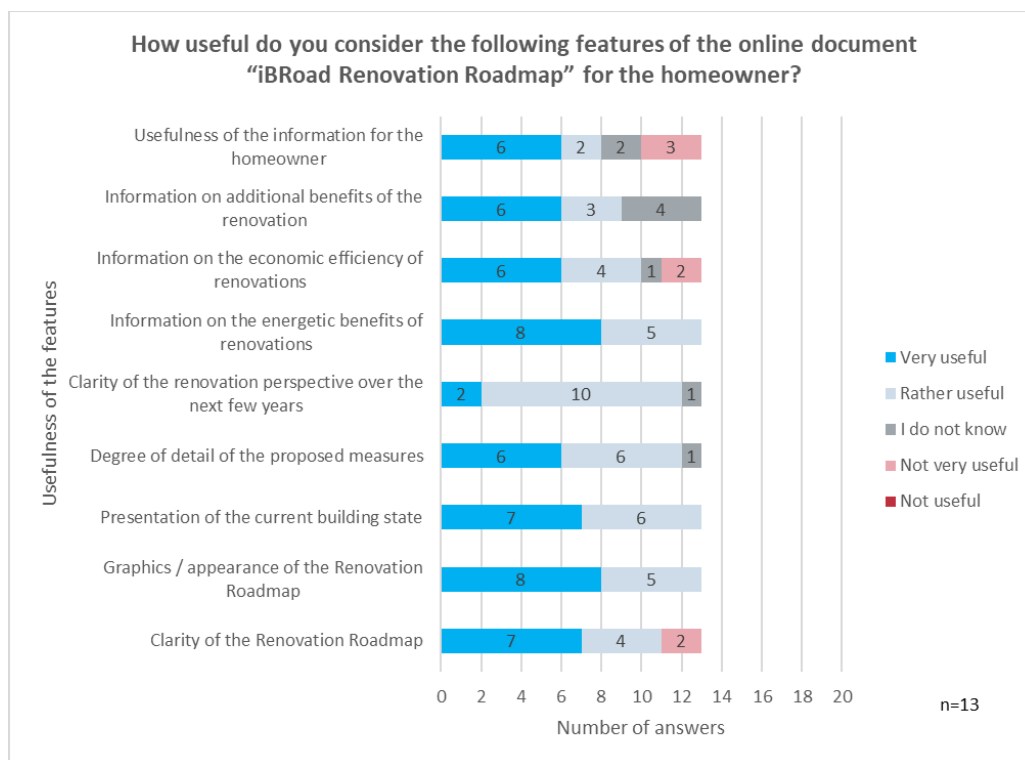


Figure 61: *Usefulness of the iBRoad Renovation Roadmap features (Portugal)*

The majority of Polish auditors rated the information on energetic benefits of renovation best (see Figure 61). The clarity of the renovation perspective over the next few years, however, was rated comparably low. The appearance and the general clarity of the Roadmap are the only items that did not receive any “not useful” rating. All other items got this worst rating from one or two auditors.

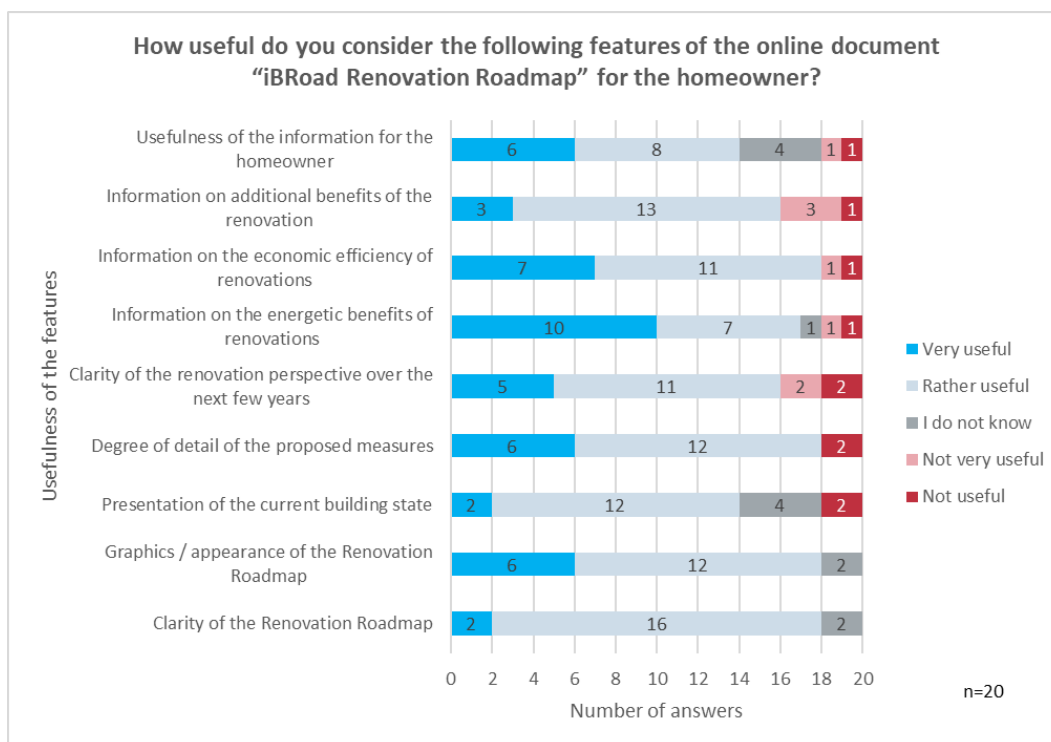


Figure 62: Usefulness of the iBRoad Renovation Roadmap features (Poland)

The feedback of the Bulgarian auditors is generally very positive. Worst items in comparison are the degree of detail of the proposed measures and the clarity of the Roadmap.

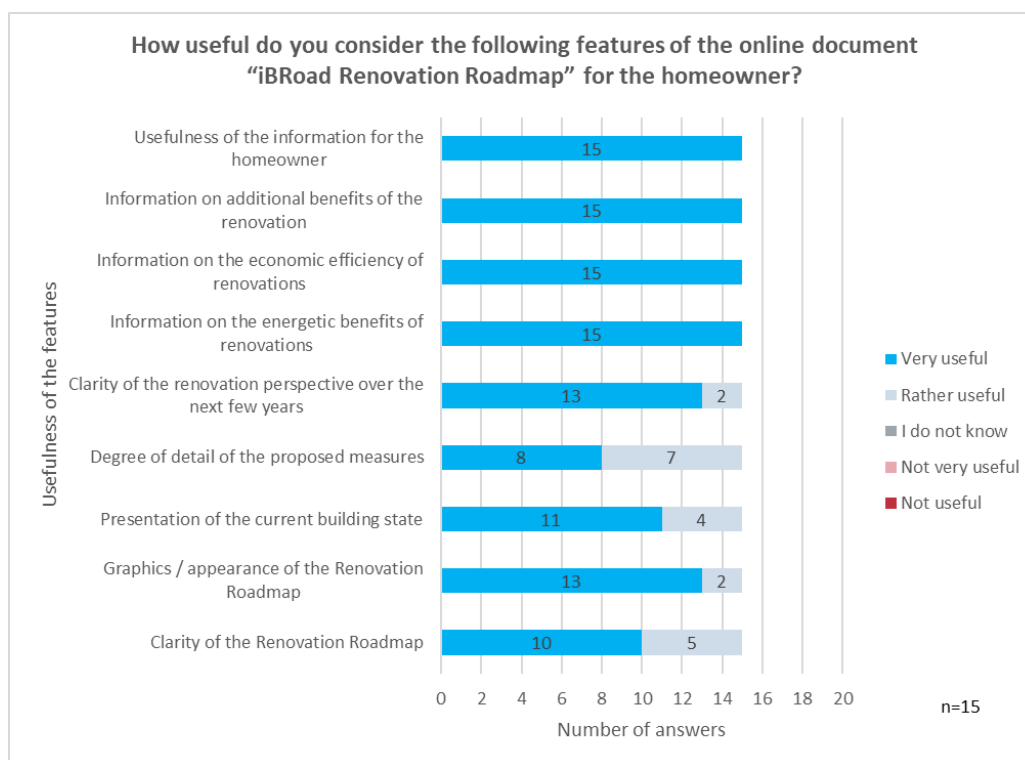


Figure 63: Usefulness of the iBRoad Renovation Roadmap features (Bulgaria)

General assessment of the iBRoad Renovation Roadmap

Auditors were also asked for a general evaluation of the Renovation Roadmap (see Figure 64, Figure 65 and Figure 66). Again, the overall feedback was positive.

Portuguese auditors particularly agreed that the Roadmap was useful and informative for the building owner (see Figure 64). Two auditors “tend to disagree” that the Roadmap is easy to understand. Again, the appearance is seen more critical than most other features. Only three auditors “completely agree” that the Roadmap takes into account the personal situation of the homeowner.

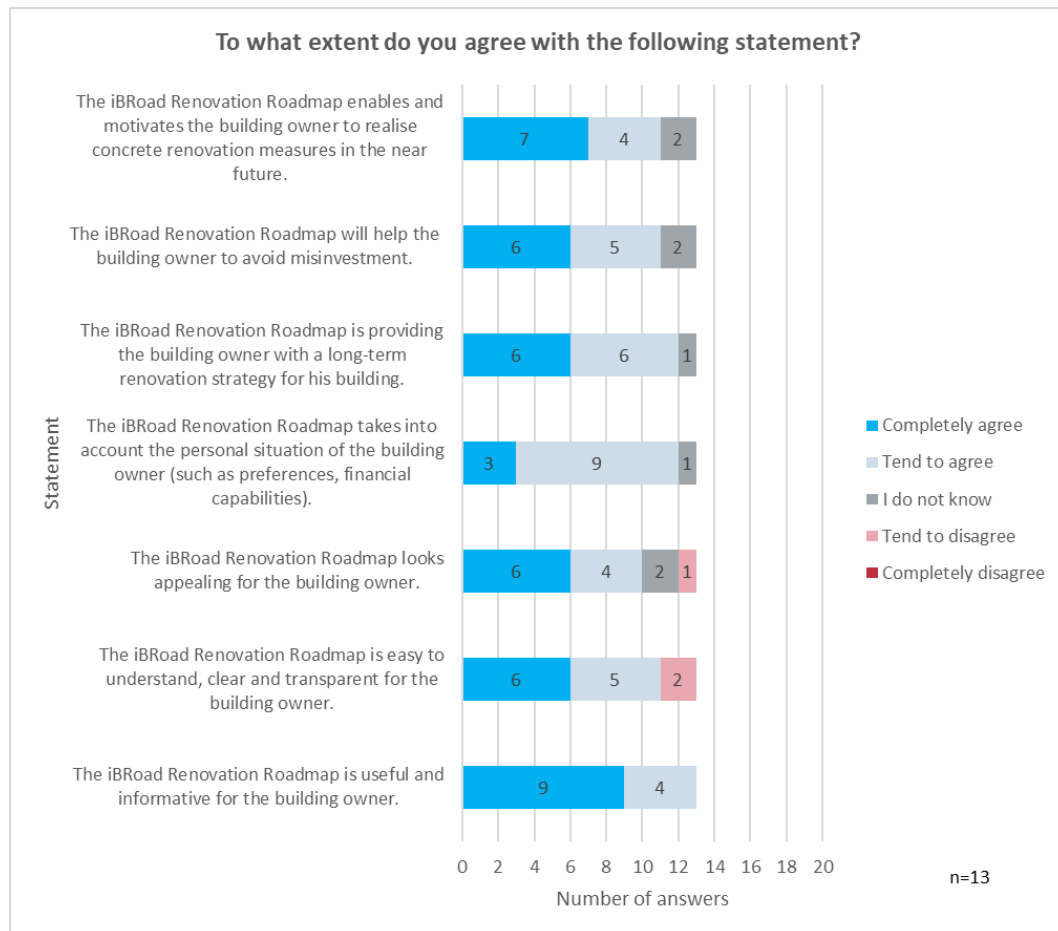


Figure 64: General assessment of the iBRoad Renovation Roadmap (Portugal)

Polish auditors voted quite heterogeneously. Features with comparably many high ratings at the same time received many low ratings. Most heterogenous results can be seen at “the Roadmap takes into account the personal situation of the building owner”.

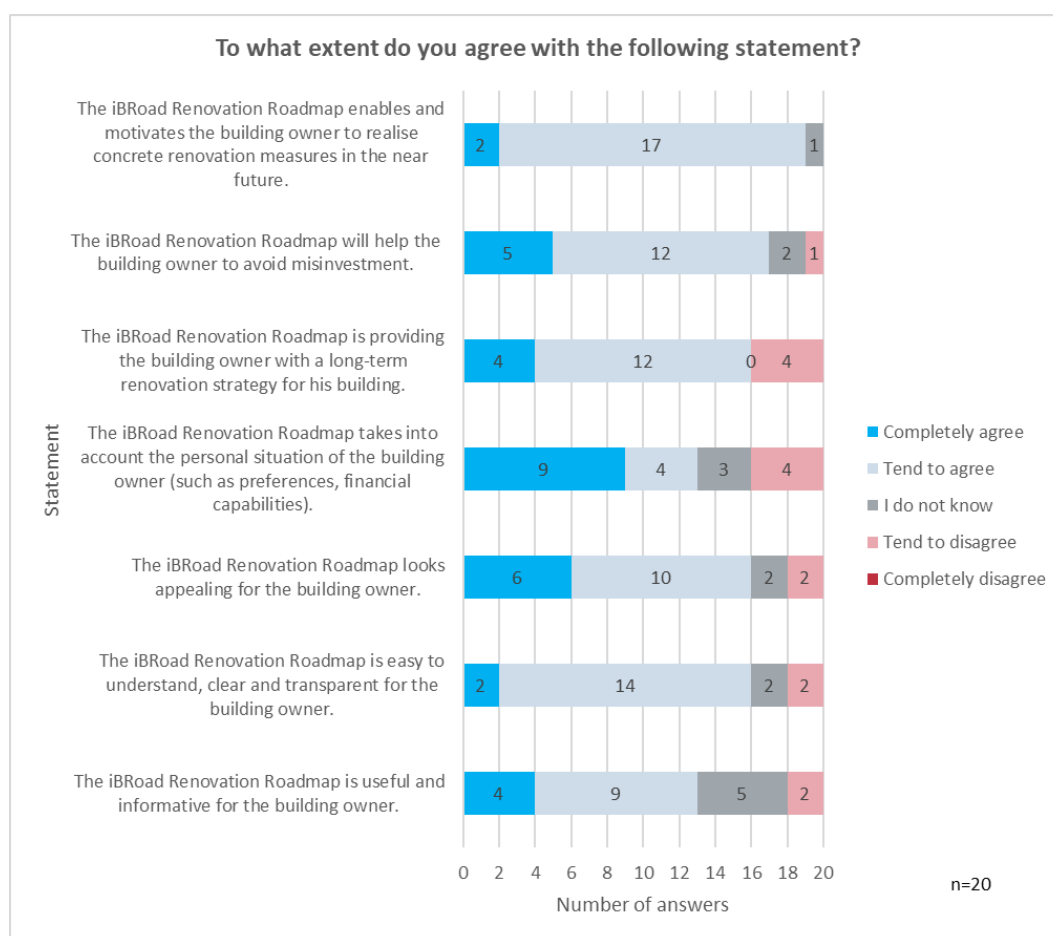


Figure 65: General assessment of the iBRoad Renovation Roadmap (Poland)

The Bulgarian auditors' feedback is in general very positive. Heterogeneous was, however, the voting for the features "the Roadmap will help to avoid misinvestment" and "the Roadmap takes into account the personal situation of the owners" (see Figure 66).

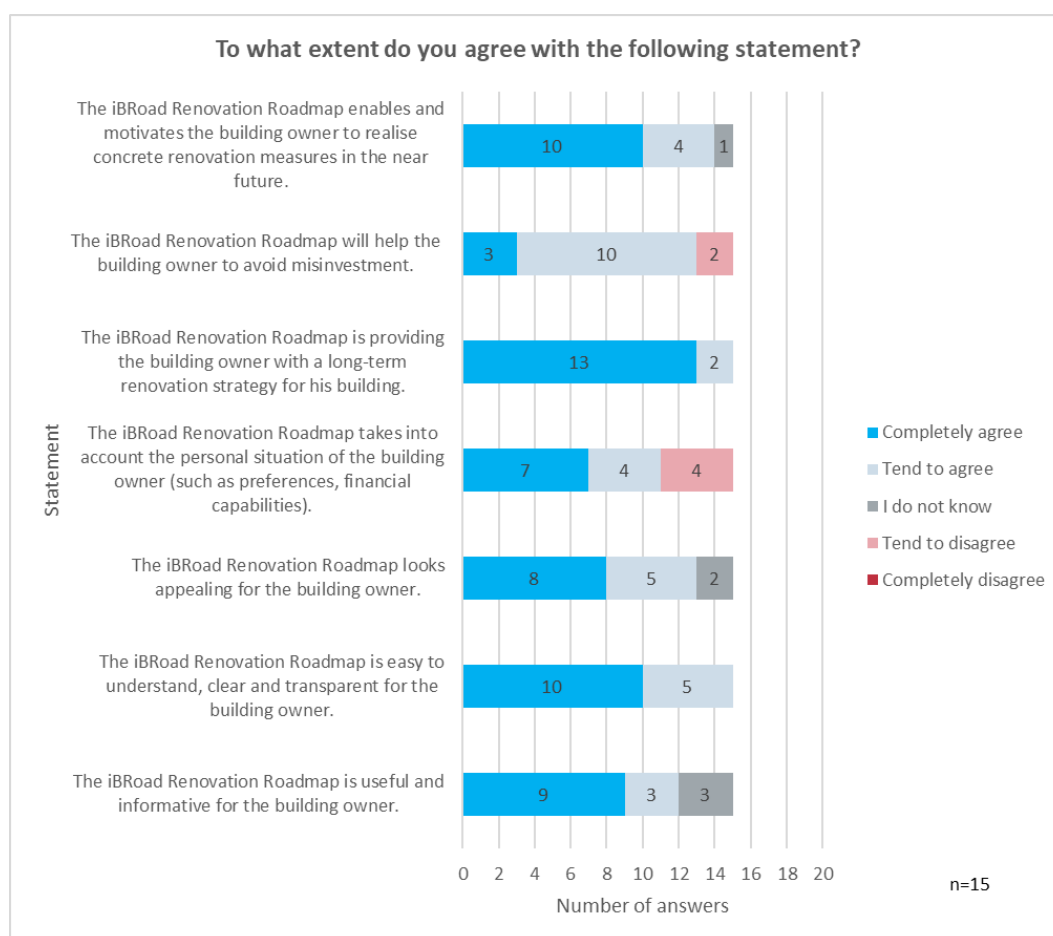


Figure 66: General assessment of the iBRoad Renovation Roadmap (Bulgaria)

Preferred presentation of the Renovation Roadmap

In addition, auditors were asked what type of presentation they would prefer for the Roadmap (see Figure 67). Multiple answers were allowed here. Especially, Polish and Portuguese field test participants said that they would appreciate a printed document in addition to the online Roadmap presentation.

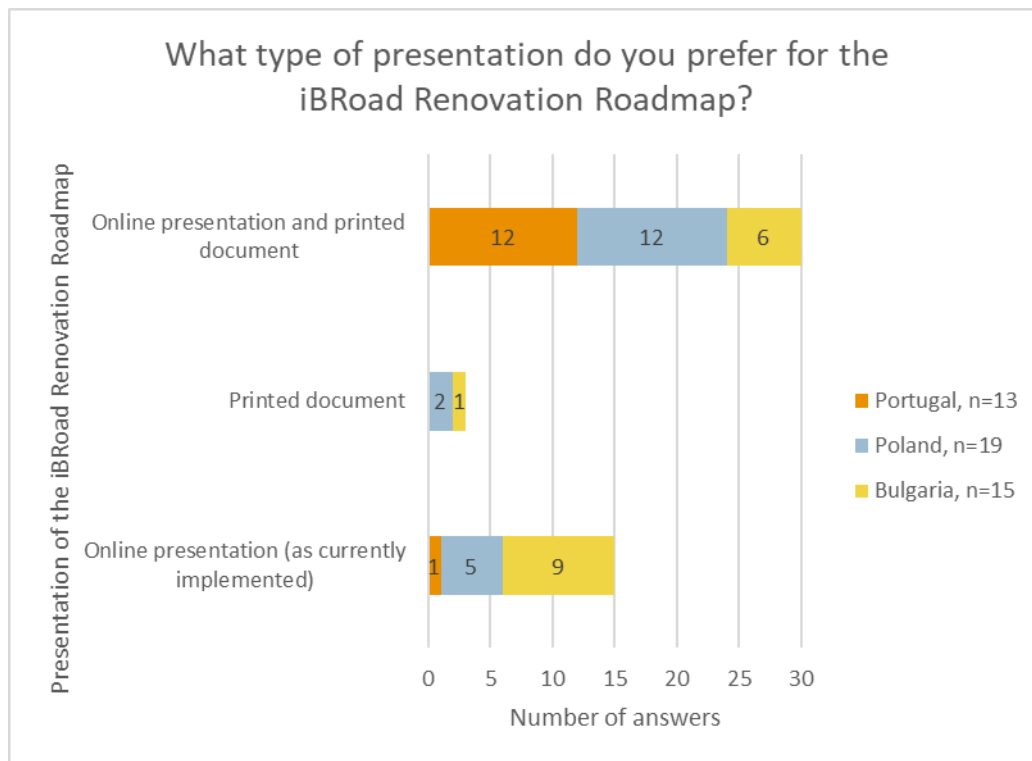


Figure 67: Preferred presentation of the Renovation Roadmap (auditors view)

Completeness of the iBRoad Renovation Roadmap

Energy auditors were asked whether the Roadmap should foresee to include certain additional functions which are currently missing. The majority of auditors answered that the current Roadmap functions are sufficient (see Figure 68).

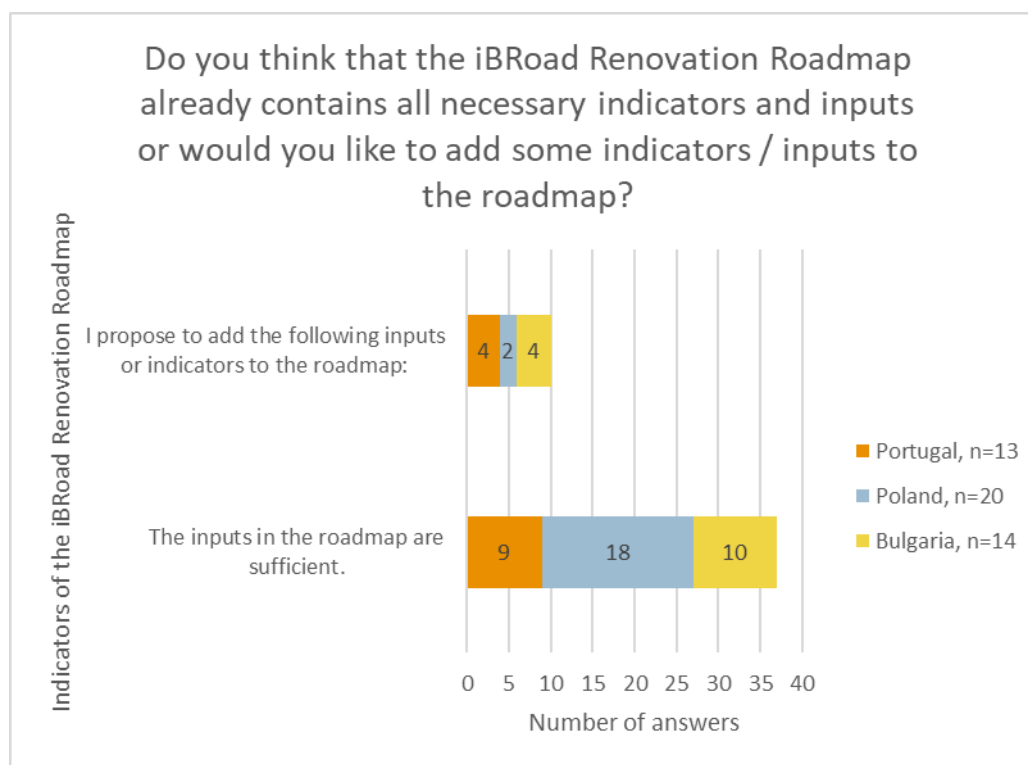


Figure 68: Completeness of the iBRoad Renovation Roadmap

Nevertheless, the energy auditors proposed improvements for the Roadmap, for example:

- special field for historic buildings
- translation to the respective language
- printable version of the Roadmap

Renovation Roadmap recommendation rate

The vast majority of auditors would also recommend the Roadmap to their colleagues (see Figure 69).

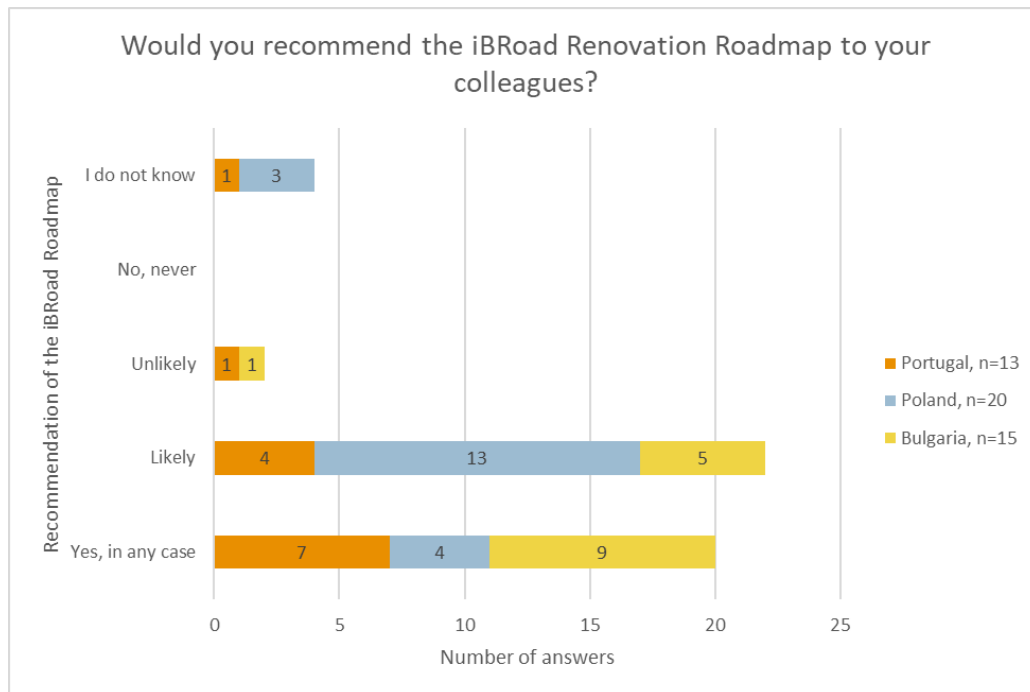


Figure 69: Renovation Roadmap recommendation rate

Handbook for energy auditors

Usefulness of the handbook

The vast majority of the auditors regarded the Handbook for energy auditors “helpful” or “very helpful” (see Figure 70). Another quarter of the auditors judged it to be “somewhat helpful”. The distribution tends to be very similar in all three pilot countries with a clear peak on the “helpful” rating. In Portugal, however, auditors voted broader than in Poland and Bulgaria. One Portuguese auditor rated it “not very helpful” and another one “did not use it”.

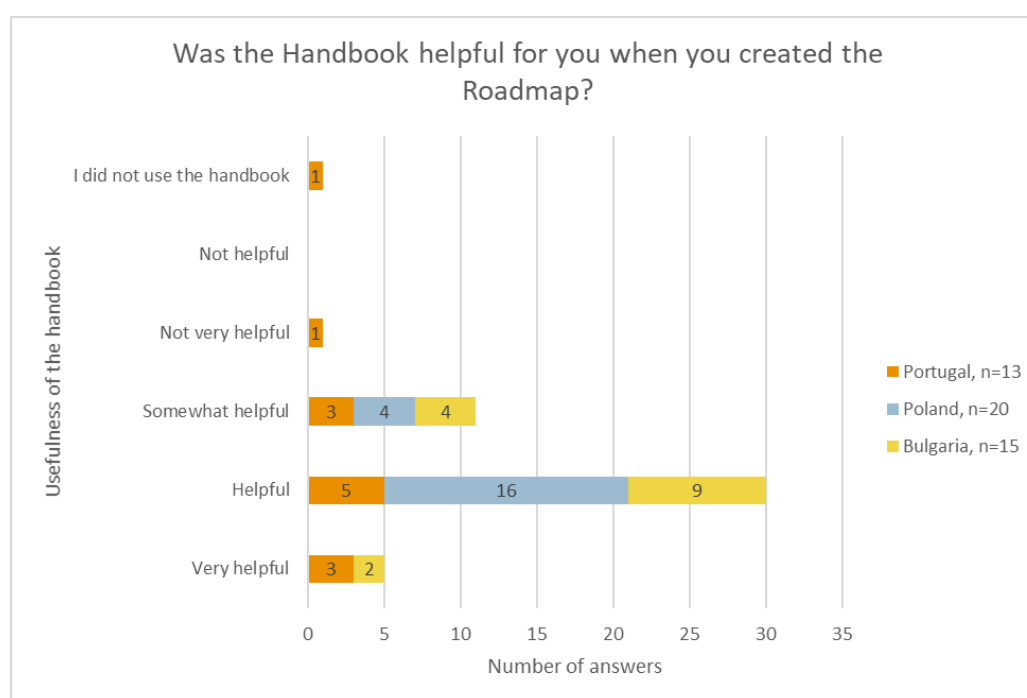


Figure 70: Usefulness of the handbook

Energy auditors were asked for their suggestions to improve the handbook. The most frequent proposals were:

- The handbook should give more detailed information for each item of the Logbook.
- The handbook should present an example building.

The auditors were asked what other tools or information they thought to be helpful in order to create a high quality iBRoad Renovation Roadmap. They suggested to:

- add more technical details and measures to the handbook;
- provide information regarding renovation cost;
- provide more information on technical equipment and renovation practices;
- provide an instructional video, e.g. on YouTube;
- give specific examples for different cases;
- provide a tool for a techno-economic analysis.

iBRoad Logbook

Manageability of Logbook features

At first, energy auditors were requested to indicate how easy or complicated they found individual Logbook features to use (see Figure 71, Figure 72 and Figure 73).

The evaluations of the Portuguese energy auditors regarding the operability of the Logbook differ. Many auditors rate some functions of the Logbook as "very easy"; this is valid for the features "link to the Renovation Roadmap" and "upload documents". The functions "enter and find data in the data storage", in particular, were described as "very complicated". It is noteworthy that a variety of functions have not been used at all, e.g. "create a new building state in the future or in the past" and "upload energy bills".

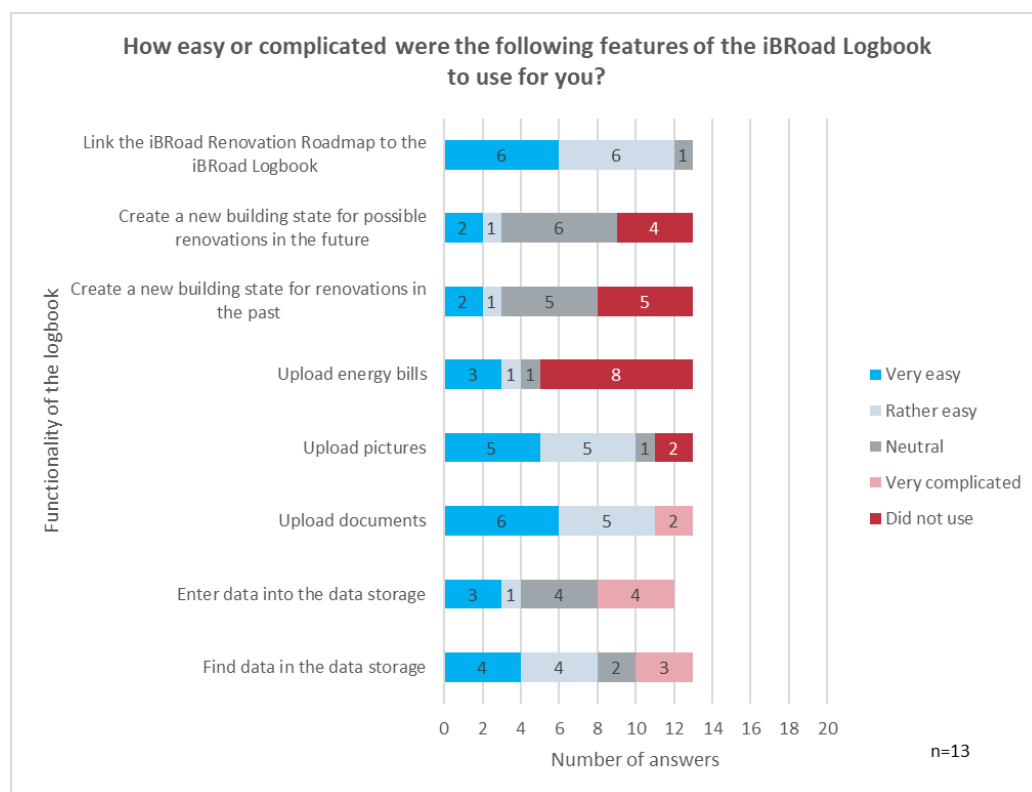


Figure 71: Manageability of Logbook features (Portugal)

The Polish energy auditors evaluated the operability of the Logbook a bit more moderate (see Figure 72). The majority of Polish energy auditors rated the function “enter and find data in the data storage” as “very easy” and “rather easy”. On the other hand, the auditors found the “upload” functions to be “very complicated”. Furthermore, some auditors did not use the functions “upload of energy bills” and “upload of documents”.

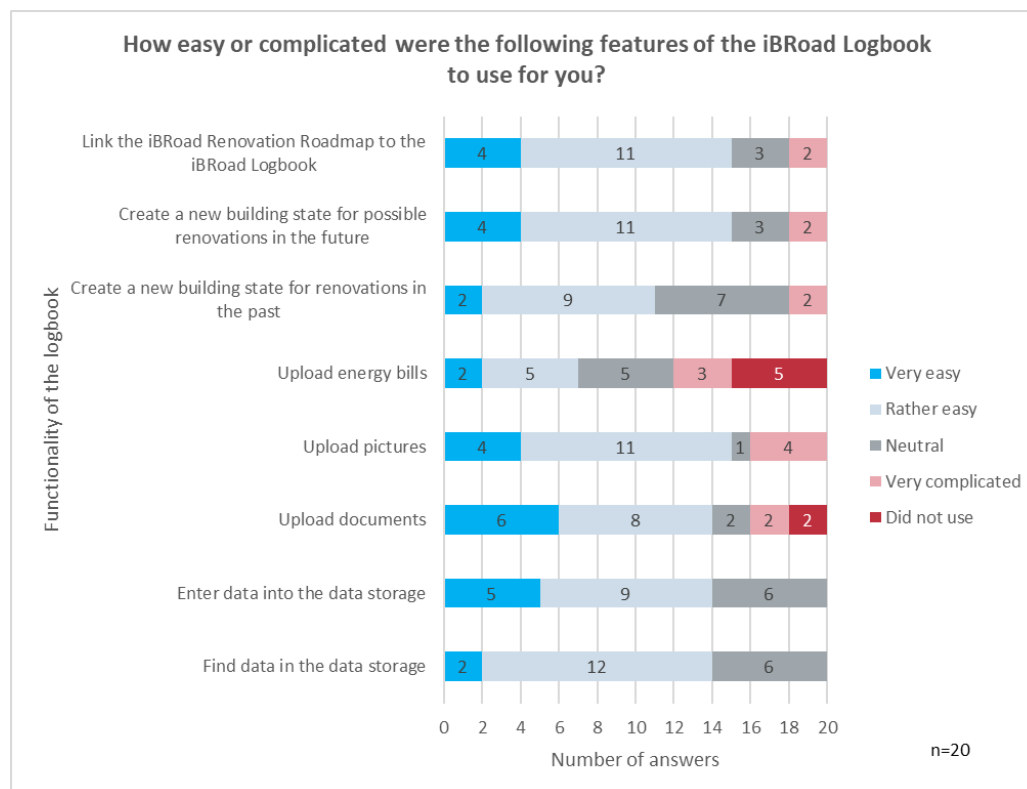


Figure 72: Manageability of Logbook features (Poland)

The Bulgarian energy auditors rated most of the functions as “very easy” or “rather easy” to use. They rated the functions “create new building states” worst compared to the others.

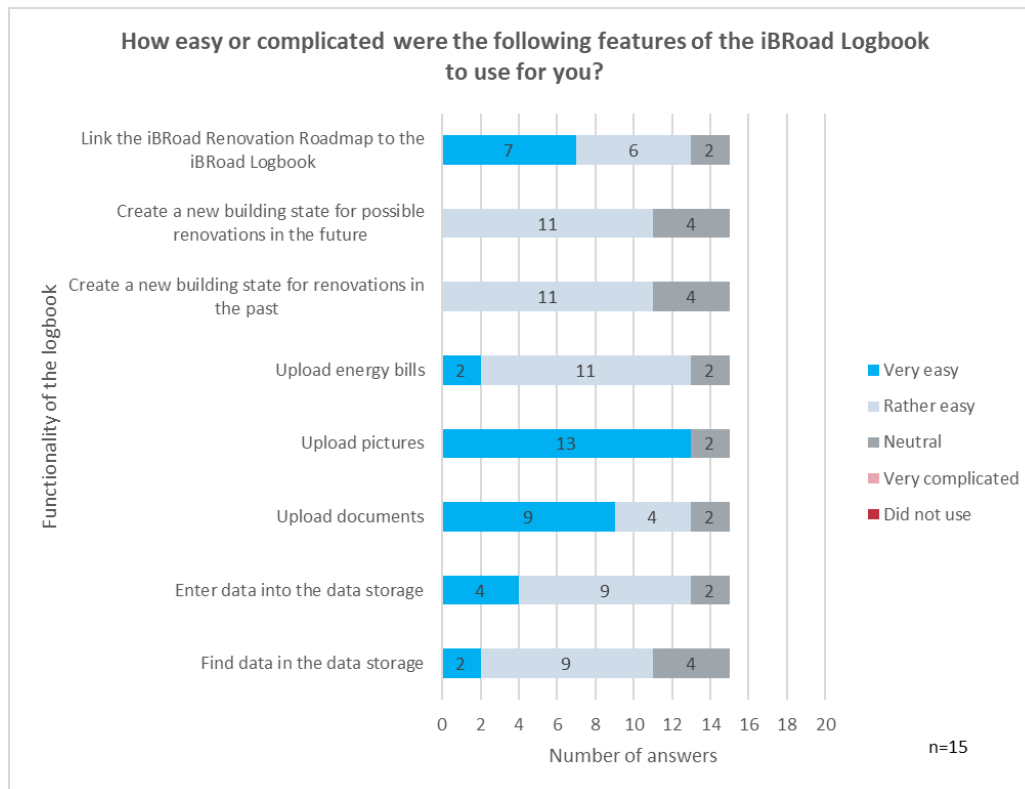


Figure 73: Manageability of Logbook features (Bulgaria)

On average, Portuguese energy auditors needed more time to create the Logbook. In particular, they needed on average about 4.2 hours, whereas Polish auditors completed the Logbook in 2.8 and Bulgarian auditors in 2.0 hours, average.

Usefulness of Logbook features

Also, energy auditors were asked about their opinion on the usefulness of individual iBRoad Logbook features (see Figure 74, Figure 75 and Figure 76). Overall, respondents' feedback was positive.

Portuguese auditors especially appreciated the "building diagnosis" and the "storage of general and administrative information" (see Figure 74). The functions "storage of building energy performance" and "smart information" were rated as less useful. However, the function "storage of smart information" has not yet been developed.

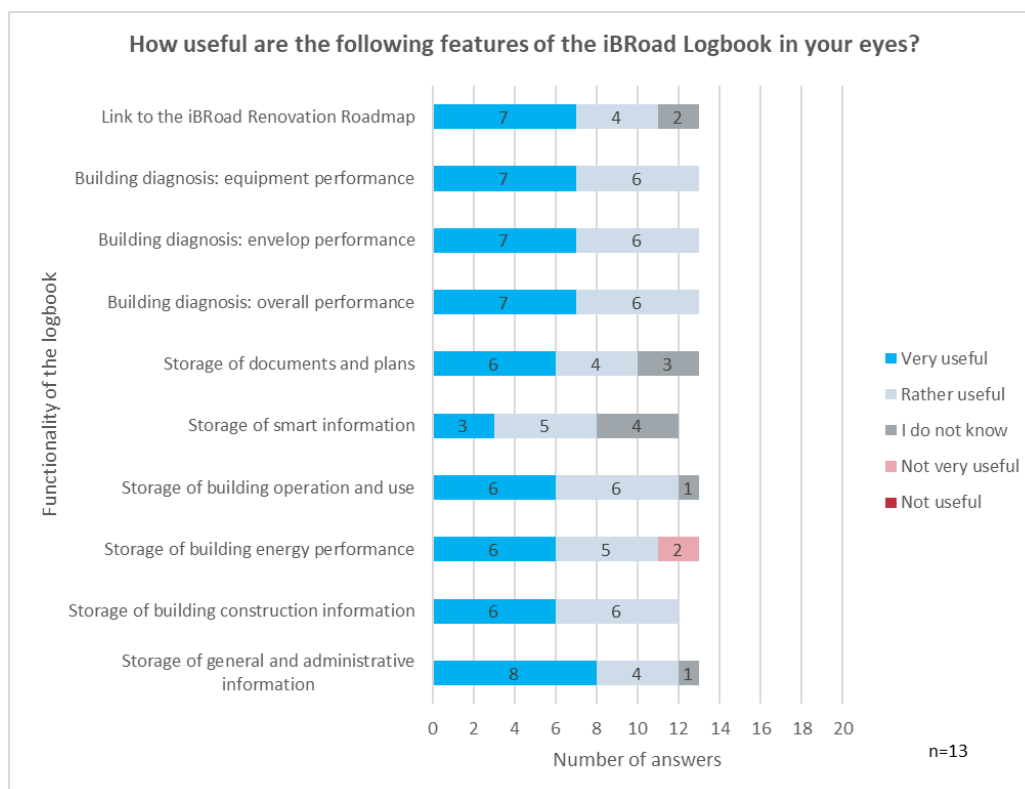


Figure 74: Usefulness of Logbook features (Portugal)

Again, the Polish respondents assessed the Logbook features a bit more reserved (see Figure 75). They considered the functions “storage of document and plans” and “link to the renovation Roadmap” rather not useful.

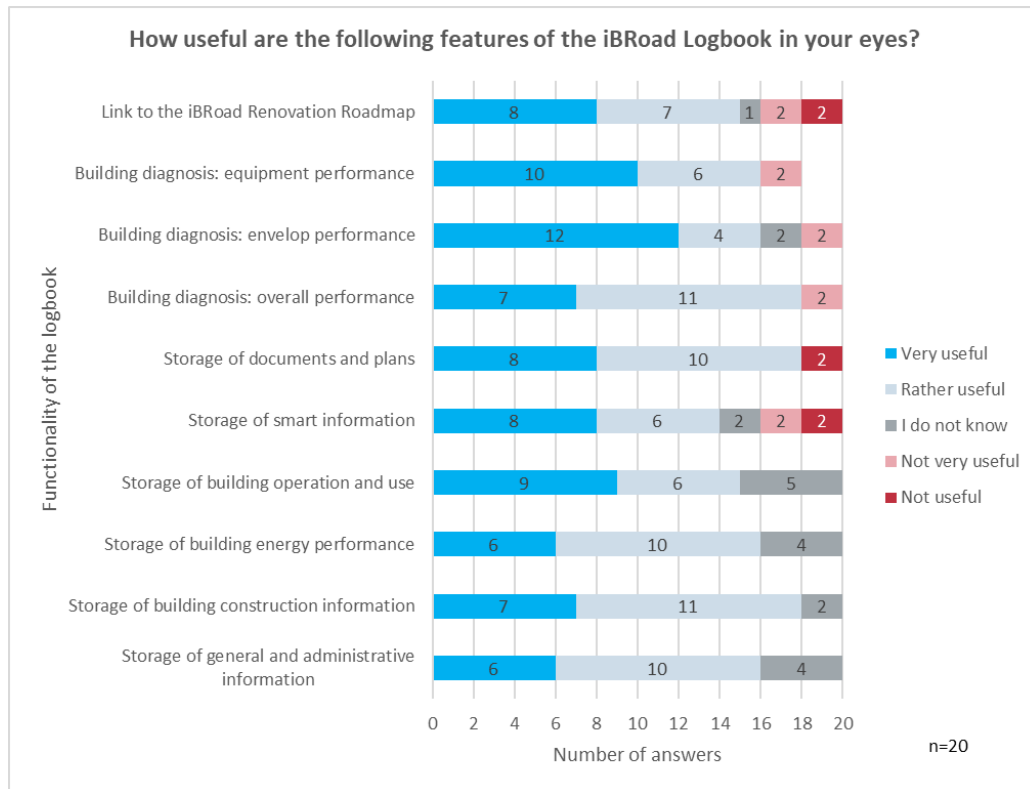


Figure 75: Usefulness of Logbook features (Poland)

Bulgarian auditors, in general, appreciated the Logbook functions and rated them as “very useful”. The functions “storage of documents and plans” and “general and administrative information” received many very positive votes and a couple of negative ones at the same time.

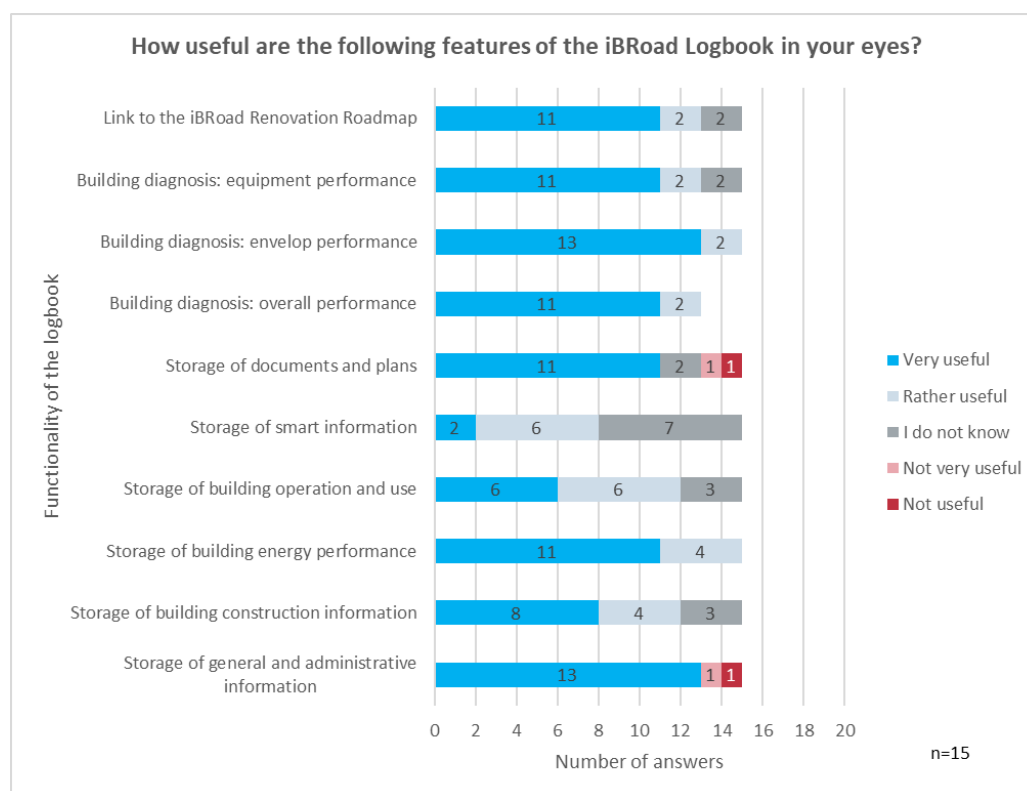


Figure 76: Usefulness of Logbook features (Bulgaria)

Completeness of Logbook features

Energy auditors were asked whether the Logbook is missing certain functions. The majority of auditors stated that current Logbook functions are sufficient (see Figure 77).

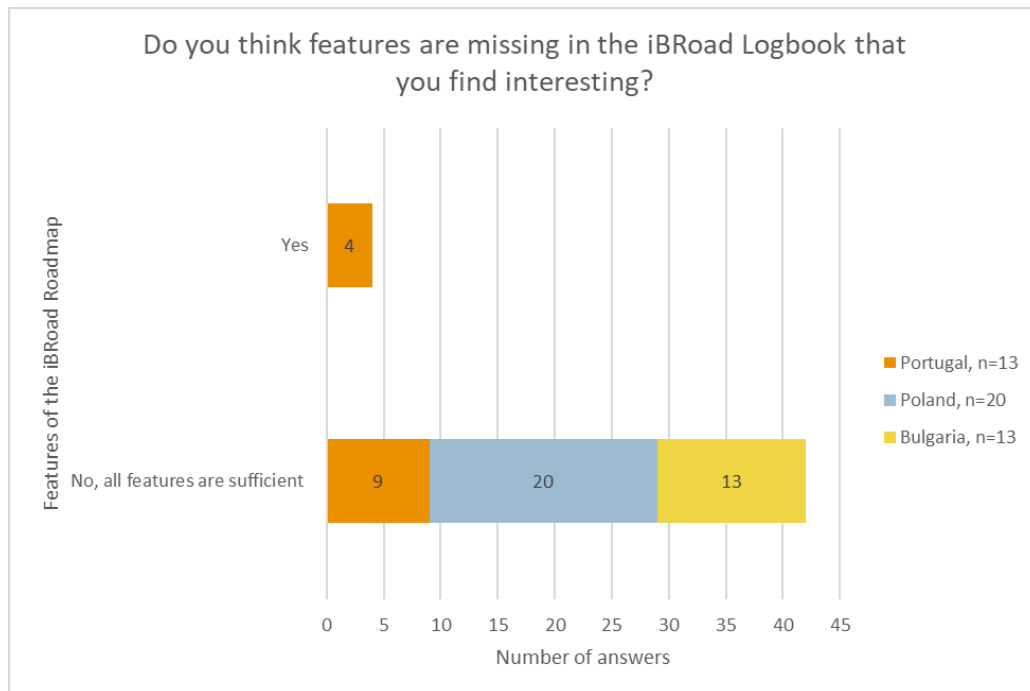


Figure 77: Completeness of Logbook features

Nevertheless, the energy auditors had some ideas to develop the iBRoad Logbook further:

- PDF-version of the Logbook with comparative tables and graphs to simplify the understanding.
- The entered data may be too theoretical for the building owner. This data could only be available in an energy auditor version.
- Add more technical descriptions in the Logbook.
- Automatic data import from the Logbook to the Roadmap.
- The Logbook should be available in different languages.

Statements on the Logbook

Auditors were asked for a general assessment of the iBRoad Logbook (see Figure 78, Figure 79 and Figure 80). Overall, the feedback was rather positive.

Portuguese energy auditors affirmed that the presentation of the equipment and the envelope efficiency with colour classes is easy to understand. More moderate was the Portuguese feedback as concerns the understanding of the icons and whether “the iBRoad Logbook is providing the homeowner with a long-term possibility to track all building-related information”. Notably also, nearly half of the Portuguese field test participants “rather disagree” or “completely disagree” with the statement “It was easy to navigate through the iBRoad Logbook” (see Figure 78).

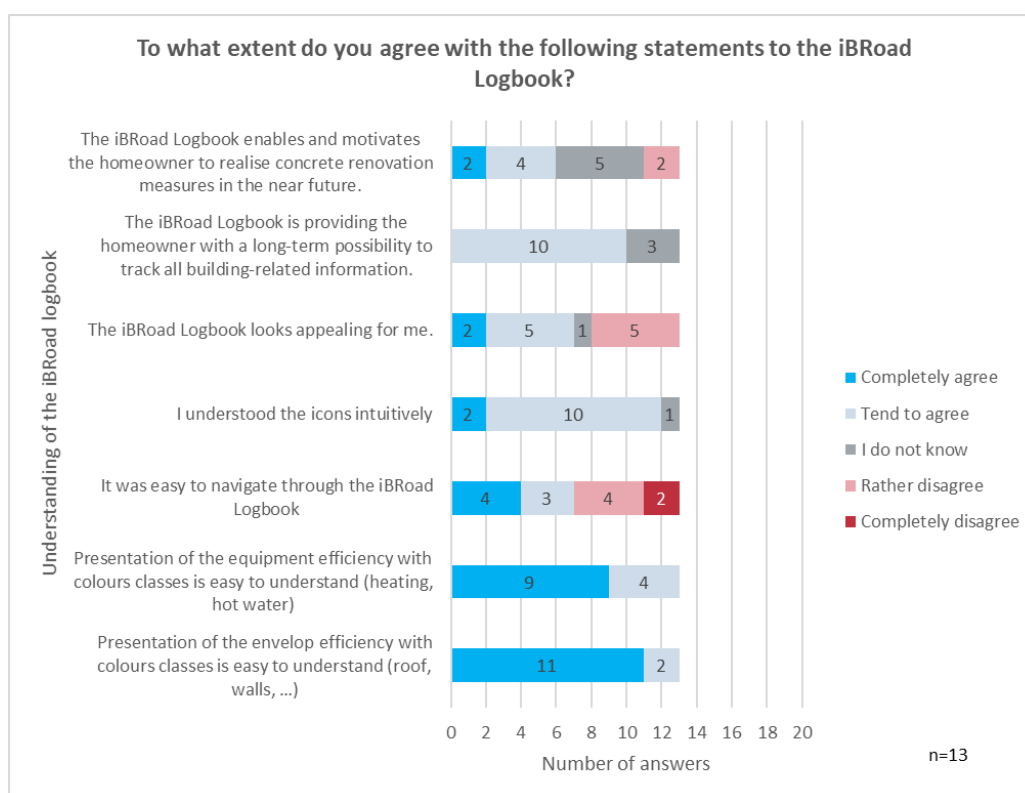


Figure 78: Statements on the Logbook (Portugal)

The Polish auditors considered the presentation of the equipment and the envelope efficiency with colour classes more difficult to understand. The statement “the iBRoad Logbook enables and motivates the homeowner to realise concrete renovation measures in the near future” and “the iBRoad Logbook looks appealing for me” found consent, but not full.

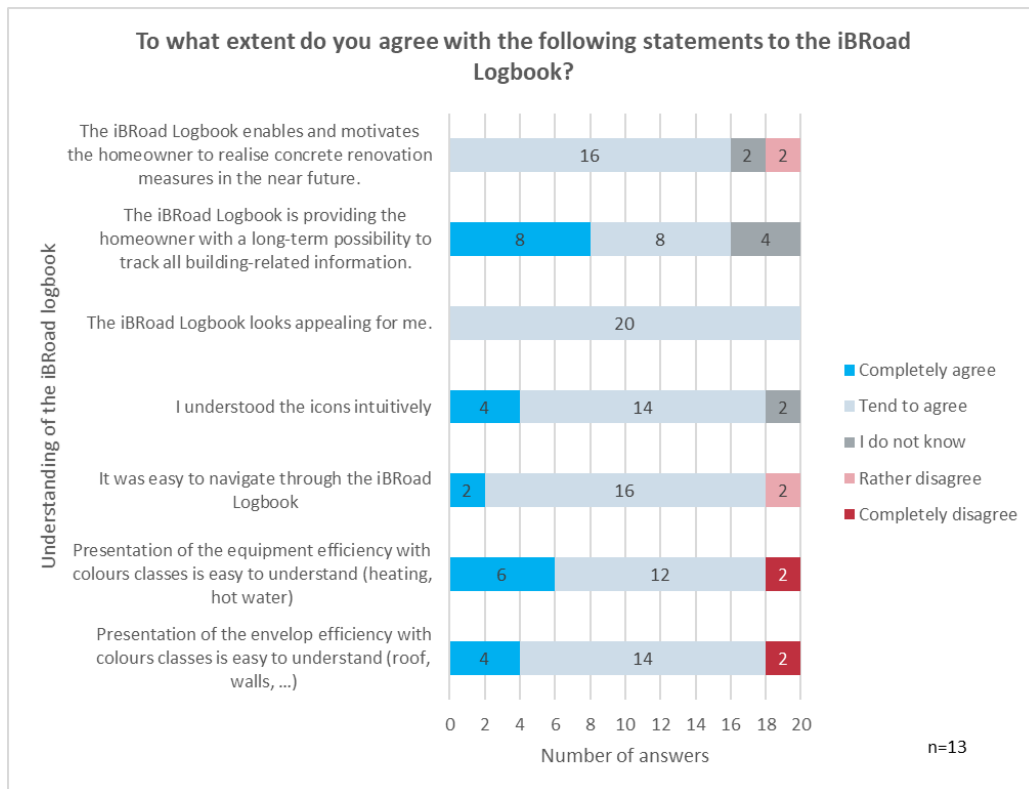


Figure 79: Statements on the Logbook (Poland)

Also, the majority of Bulgarian energy auditors affirmed that the presentation of the equipment and the envelope efficiency with colour classes is easy to understand. Also here, the statement “the iBRoad Logbook enables and motivates the homeowner to realise concrete renovation measures in the near future” and “the iBRoad Logbook looks appealing for me” found consent, but not full.

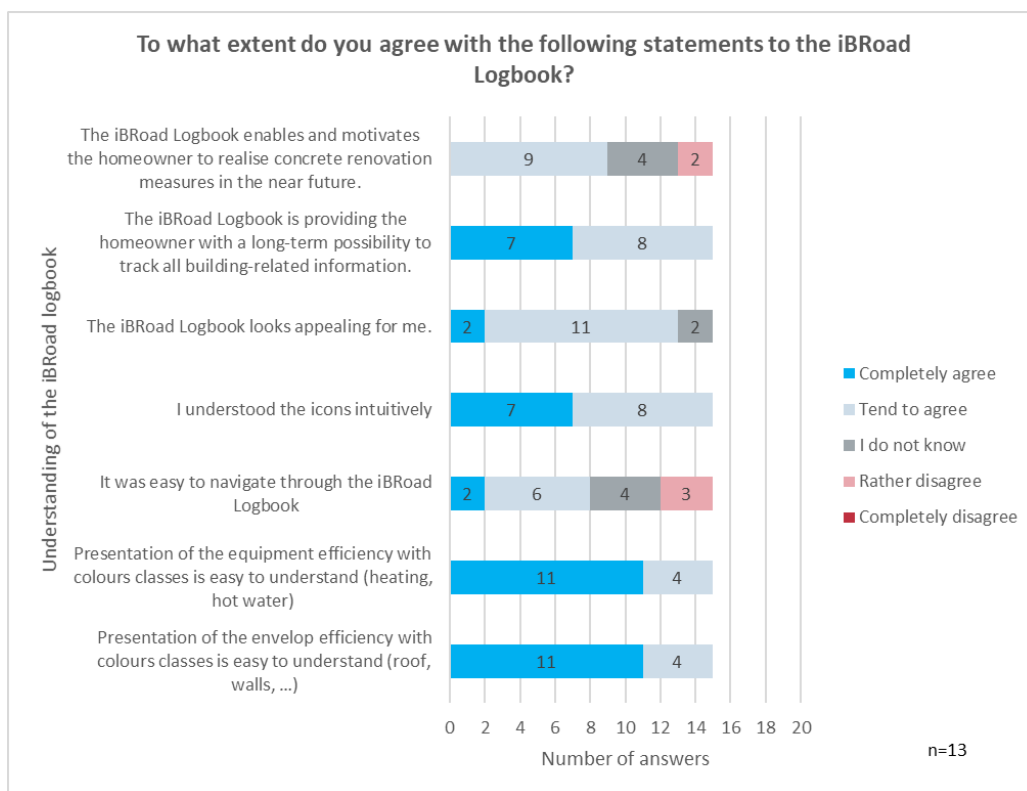


Figure 80: Statements on the Logbook (Bulgaria)

Logbook recommendation rate

Finally, auditors were asked if they would recommend the iBRoad Logbook to their colleagues. Here, the results were very positive (see Figure 81).

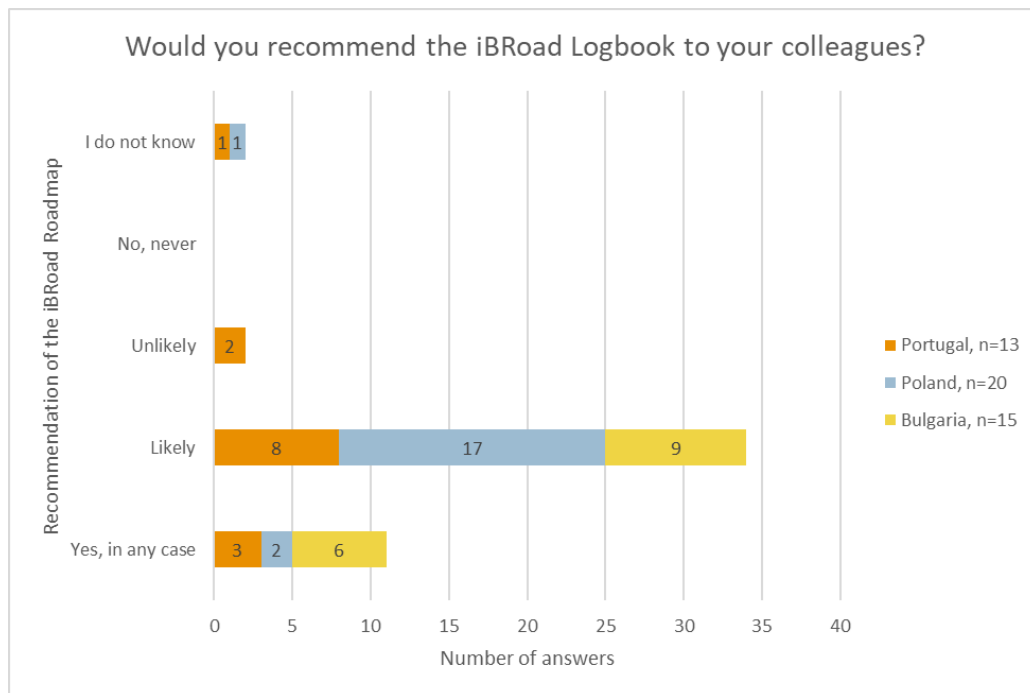


Figure 81: Logbook recommendation rate

Ideas for further development of the Logbook

Auditors were also asked for their ideas for a further development of the iBRoad Logbook. The main issues stated are:

- The Logbook was, for many auditors, difficult to navigate.
- The Logbook should be made more user friendly, e.g., by adding more graphics and tables.
- Entered data should be more visible for the users.
- The Logbook could be adapted to the national EPC databases and data should be transferred automatically.
- The Logbook could be adapted to the national calculation software and data should be transferred automatically.
- Different units should be offered to meet the specific requirements (e.g. kWh, GJ).
- The Logbook should be translated to the respective language.
- There should be more calculations and evaluations of the entered data, i.e., to suggest renovation measures.

iii. Compliance with the iBRoad Roadmap principles

In addition to the evaluation of the questionnaires amongst auditors and homeowners, all Roadmaps and Logbooks that were produced during the field test were reviewed concerning technical content and compliance with the iBRoad principles. The following principles build the basis for the creation of an iBRoad Roadmap (see Figure 82). The principles were introduced to the auditors that participated in the field test during the training.

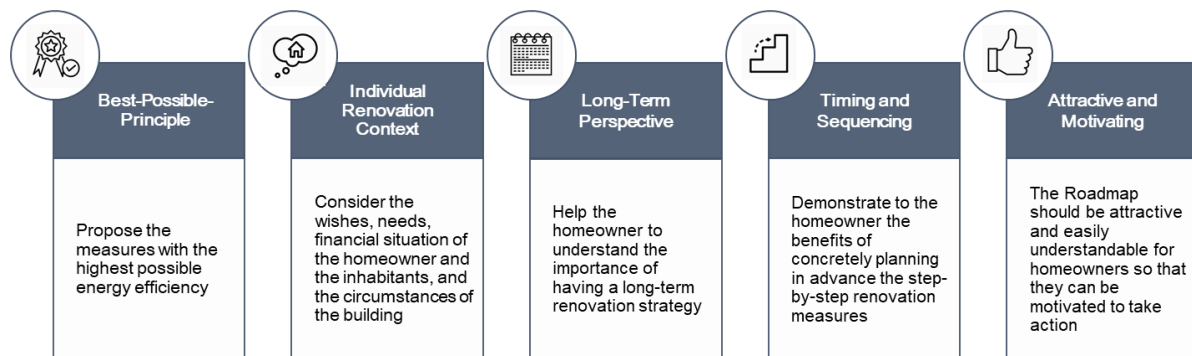


Figure 82: iBRoad Roadmap principles

Best-possible-principle

Every building is unique. Therefore, it is not possible to formulate a universal target that applies to all buildings. However, all existing buildings in total must fulfil the target of a nearly climate-neutral building stock. Thus, the energy auditor should pursue and propose the measures with the highest possible energy efficiency, taking into account the technical circumstances of the individual building and the preferences or financial capabilities of the homeowner – importantly, "best possible" does not mean "no matter how expensive". However, a renovation that is pending anyway is the best occasion to make a building fit for the future. A guiding approach should be, once a building component needs refurbishment to do it not only halfway, but future proof.

Individual renovation Context

Assessing the homeowner's and building inhabitant's situation today and how it is expected in the future is essential: this includes, for instance, financial opportunities, comfort requirements, living space changes, or family planning (e. g. having a baby, children moving out or grandparents moving in).

Also, when creating the iBRoad Roadmap, the energy auditor needs to consider the circumstances of the respective building, e. g.: Are there weaknesses in the building requiring immediate or rapid action? Are there measures that lead with little effort to major improvements? The Roadmap should be based upon the homeowner's perspective. It is intended to support the homeowner, not oblige him.

Long-term perspective

It is important to pursue a long-term renovation plan in order to avoid lock-in effects: Building components have a life span of 40 years or more. If the opportunity for the targeted standard is missed an additional renovation is needed later at extra cost.

Lock-in effects can occur in a step-by-step renovation when the interlinkage of components is not planned ahead: e. g., if you renovate a roof think of a sufficient overhang for a future wall insulation. To avoid unwanted lock-in effects, energy auditors were provided with a list of typical renovation situations to pay attention to in the energy auditors' handbook.

Timing and sequencing

Oftentimes, renovations cannot be carried out in a single operation so that many buildings are only renovated partially. In many cases, the financial situation of the homeowner does not allow comprehensive refurbishment at once. However, a step-by-step renovation does not mean that it is not as good as a renovation at once. In contrast, early replacement of components can also lead to economic losses. A step-by-step renovation, however, is also possible with limited budget. Summarising, also a step-by-step modernisation leads to the final goal, if each renovation step is well planned and takes into account every next step.

Attractive and motivating

The iBRoad Renovation Roadmap needs to be attractive and easily understandable for homeowners in order to motivate them to take action. Therefore, energy auditors were urged to make sure that they use, for instance, pictures whenever appropriate to illustrate specific situations and pay attention to comprehensibility. Building owners have to be guided throughout the Roadmap process and receive clear indications so that they can take action without feeling lost. The homeowner should be able to recognise his own wishes, needs and future plans back in the Roadmap.

iBRoad principles in practice: compliance check

Roadmap

In addition to the analysis of the questionnaires, the iBRoad renovation Roadmaps and the iBRoad Logbooks were checked to assess whether the energy auditors understood the iBRoad principles and the proposed renovation steps are technically plausible. The examination of the documents showed that the auditors' processing was very committed and conscientious.

Most roadmaps show a clear way to the homeowners to improve the energy efficiency of their building. The renovation steps correspond to the long-term perspective and most measures are suitable to motivate the building owner for deep renovation measures.

The Portuguese energy auditors had to deal with a wide variety of buildings (see Figure 83). The years of construction ranged from the 16th century to 2002. Several buildings showed a very high energy demand. With a varying number of steps, the energy auditors succeeded in raising the buildings to ambitious energy classes. After the last step, the majority of the buildings will reach the best energy level A+. The time horizon, from the first to the final renovation step, ranges from 2025 to 2035 in most cases. For many last renovation steps, however, there is no specific year. The auditors did not propose a specific year for the final renovation step, but a technical trigger such as "when windows need to be exchanged". The number of renovation steps ranges from two to five. In cases with many renovation steps in a short time horizon, the periods between each renovation steps tend to be rather short (e.g., just one year between the renovation steps or 5 years between the first and the last renovation step). This might overstrain some homeowners in case it was not agreed as such in advance.

As far as one can judge without knowing the buildings in detail, all measures and renovation steps fit together in a logical and comprehensive way. The context of renovation measures and steps, however, is not always clear. Sometimes, several renovation steps are recommended for the same year. It might be more effective and realistic to either combine these into a single renovation step or to spread the separate steps further apart.

From a technical point of view, energy auditors described the measures extensively. For the comfort improvements, many auditors used the prefabricated text blocks. The renovation steps are complex and plausible. The renovation costs are indicated for all measures. The maintenance costs, however, are sometimes missing.


Pilot country	No.	Year of construction	Number of renovation steps	Current energy level	Final / future energy level	Current primary energy demand [kWh/m ²]	Future primary energy demand [kWh/m ²]	Estimated date for final renovation step	Completeness
 Portugal	1	1986	5	C	A+	183	74	2035-2040	complete
	2	1500	5	D	A+	155	48	2035-2040	complete
	3	1971	4	E	A+	183	0	When plaster needs renovation	complete
	4	1937	3	F	A+	600	27	2030-2035	complete
	5	2001	3	A	A+	30	0	When boiler is exchanged	complete
	6	1937	4	F	A+	600	19	2030-2035	complete
	7	1919	5	D	A+	356	120	2025-2030	complete
	8	1998	4	C	A+	116	0	When plaster needs renovation	complete
	9	1994	2	A+	A	145	112	2025-2030	parts missing
	10	2002	3	C	A	278	104	2030-2035	complete
	11	1575	4	D	A	319	42	2025-2030	complete
	12	1988	4	F	A+	423	117	When windows are exchanged	complete
	13	1998	5	E	B-	203	0	2025-2030	complete
	14	1972	4	D	B-	387	250	2025-2030	complete
	15	1995	3	C	A	176	19	2030-2035	parts missing
	16	1966	2	E	A	326	27	2025-2030	complete
	17	1946	4	F	A	350	92	2030-2035	-
	18	1989	5	D	A+	116	20	When plaster needs renovation	complete
	19	2001	5	E	A	192	19	When plaster needs renovation	complete
	20	1981	4	C	A	211	34	2025-2030	complete

Figure 83: iBRoad Renovation Roadmap results overview (Portugal)

Figure 84 and Figure 85 show parts of an iBRoad renovation Roadmap produced by a Portuguese energy auditor as part of the pilot testing.

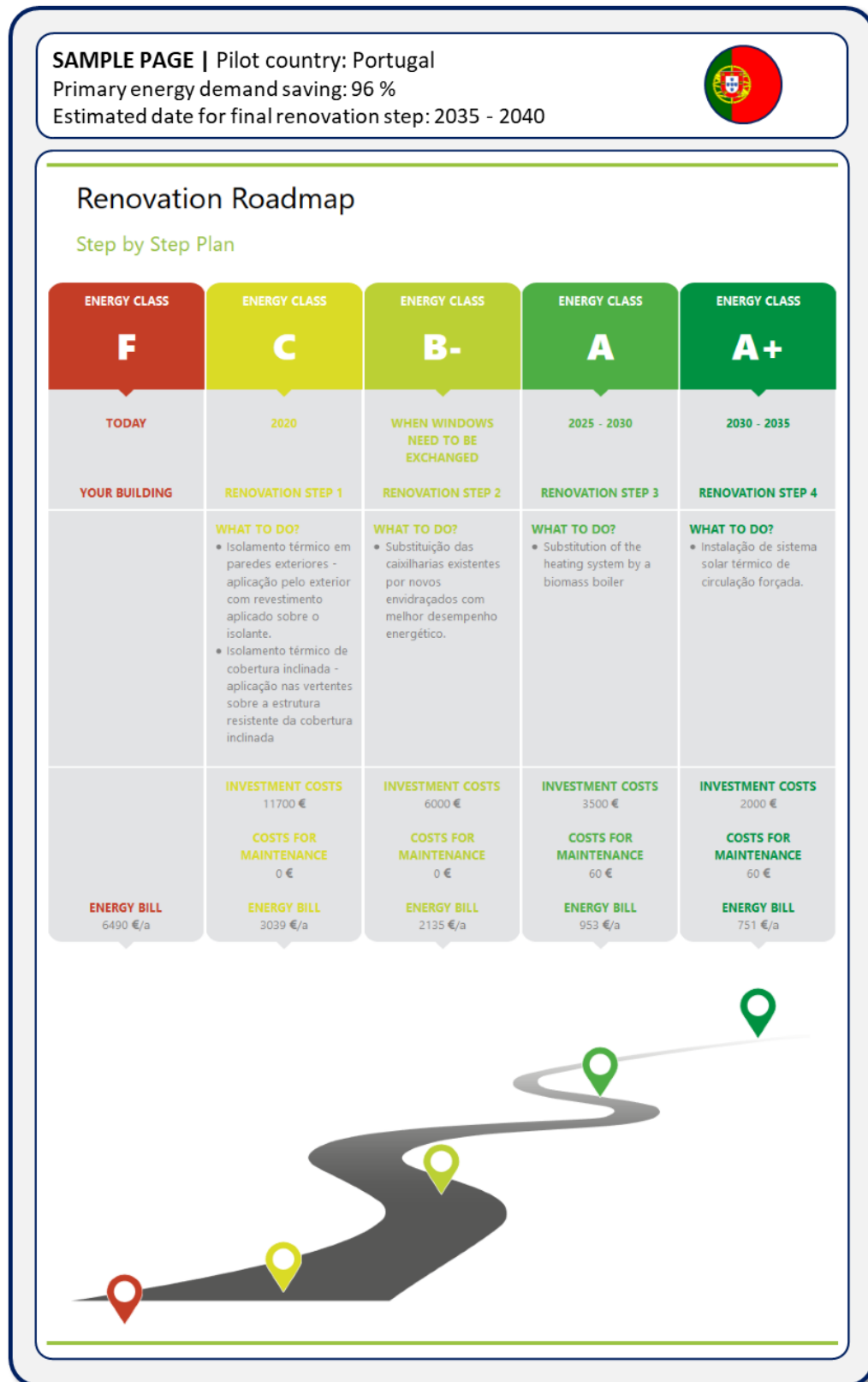


Figure 84: Portuguese example of an iBRoad Renovation Roadmap – renovation roadmap

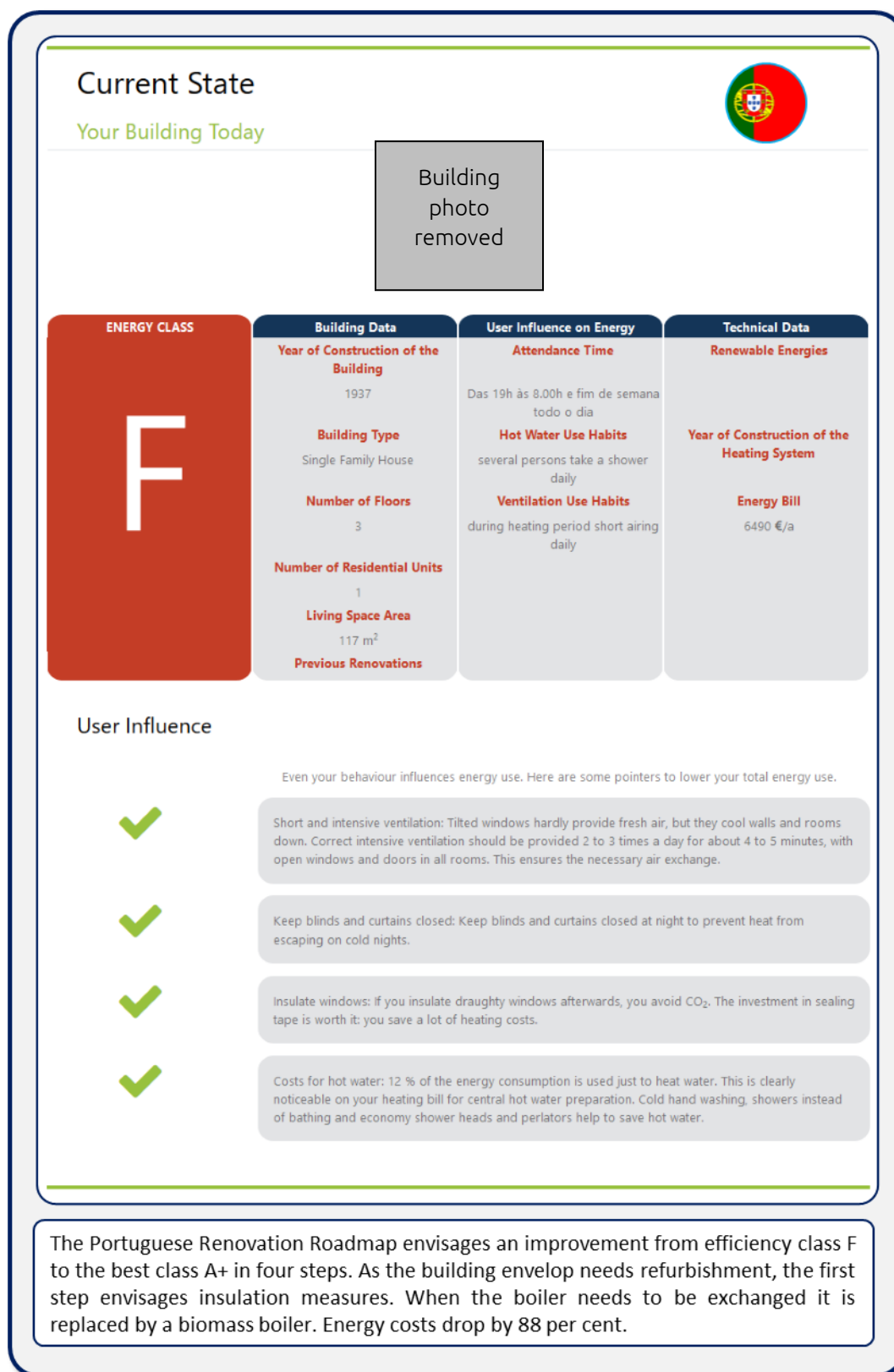


Figure 85: Portuguese example of an iBRoad Renovation Roadmap – current building state

The buildings that were examined in Poland were built between 1936 and 2006. In the present state, most buildings have a high primary energy demand. The Polish energy auditors developed Renovation Roadmaps that foresee significant improvements of the efficiency standards. The best and second-best energy class, however, is foreseen only in four Roadmaps. It is, in the present context, not possible to estimate why the other Roadmaps target lower energy classes.

The proposed dates for the last renovation step lie between 2019 and 2040. However, only four Roadmaps look further than 2030. The proposed number of renovation steps in this period accounts from one to five. Proposing only one renovation step is a contradiction to the idea of a long-term Renovation Roadmap². In this particular case, the auditor explained that a stepwise approach would not have met the specific requirements. The number of renovation steps does not necessarily correlate with the length of the considered period. There are two Roadmaps that suggest three, respectively four renovation steps before 2021. It is obvious that the single measures were meant to be combined into one renovation step. The difference between renovation measure and step should be explained clearer in the training material to better guide the auditors through this process.

Energy auditors described the measures from a technical point of view. Furthermore, they stressed the comfort improvements by entering free text. The renovation steps are complex and plausible. The renovation costs are indicated for all measures as are the incentives.

² It is important to pursue a long-term renovation strategy in order to avoid lock-in effects: Building components have a life span of 40 years or more. If the opportunity for the targeted standard is missed, an additional renovation is needed later at extra cost. Lock-in effects can occur in a step-by-step renovation when the interlinkage of components is not planned ahead: e. g., if you renovate a roof think of a sufficient overhang for a future wall insulation.

Pilot country	No.	Year of construction	Number of renovation steps	Current energy level	Final / future energy level	Current primary energy demand [kWh/m ²]	Future primary energy demand [kWh/m ²]	Estimated date for final renovation step	Completeness
	1	1975	3	medium orange	light green	474	134	Substitution of the old windows	complete
	2	1978	3	dark orange	light green	382	123	2030-2035	complete
Poland	3	1987	4	dark orange	yellow	400	172	2019	complete
	4	1950	3	dark orange	light orange	570	326	2020	complete
	5	1978	1	red	yellow	600	159	As soon as possible	complete
	6	1975	3	medium orange	yellow	321	160	When windows are exchanged	complete
	7	1981	3	dark orange	light green	435	185	2025-2030	complete
	8	2000	3	dark orange	light green	233	185	2035-2040	complete
	9	1978	3	light green	dark green	138	31	2025-2030	complete
	10	1990	3	light orange	light green	335	193	2025-2030	complete
	11	1991	4	medium green	dark green	70	78	2025-2030	complete
	12	1936	5	red	light green	422	134	When plaster needs renovation	parts missing
	13	1978	3	medium orange	light green	276	133	2025-2030	complete
	14	1980	3	dark red	yellow	600	189	2025-2030	parts missing
	15	1999	5	medium green	light green	165	197	2035-2040	complete
	16	2000	5	dark orange	yellow	374	152	During the attic renovation...	complete
	17	2006	5	medium orange	light green	143	86	2030-2035	complete
	18	1981	5	red	medium green	181	46	2025-2030	complete
	19	1980	4	light orange	yellow	600	316	2025-2030	complete
	20	1982	2	yellow	medium green	198	161	When plaster needs renovation	complete

Figure 86: iBRoad Renovation Roadmap results overview (Poland)

Figure 87 and Figure 88 show parts of an iBRoad renovation Roadmap produced by a Polish energy auditor as part of the pilot testing.

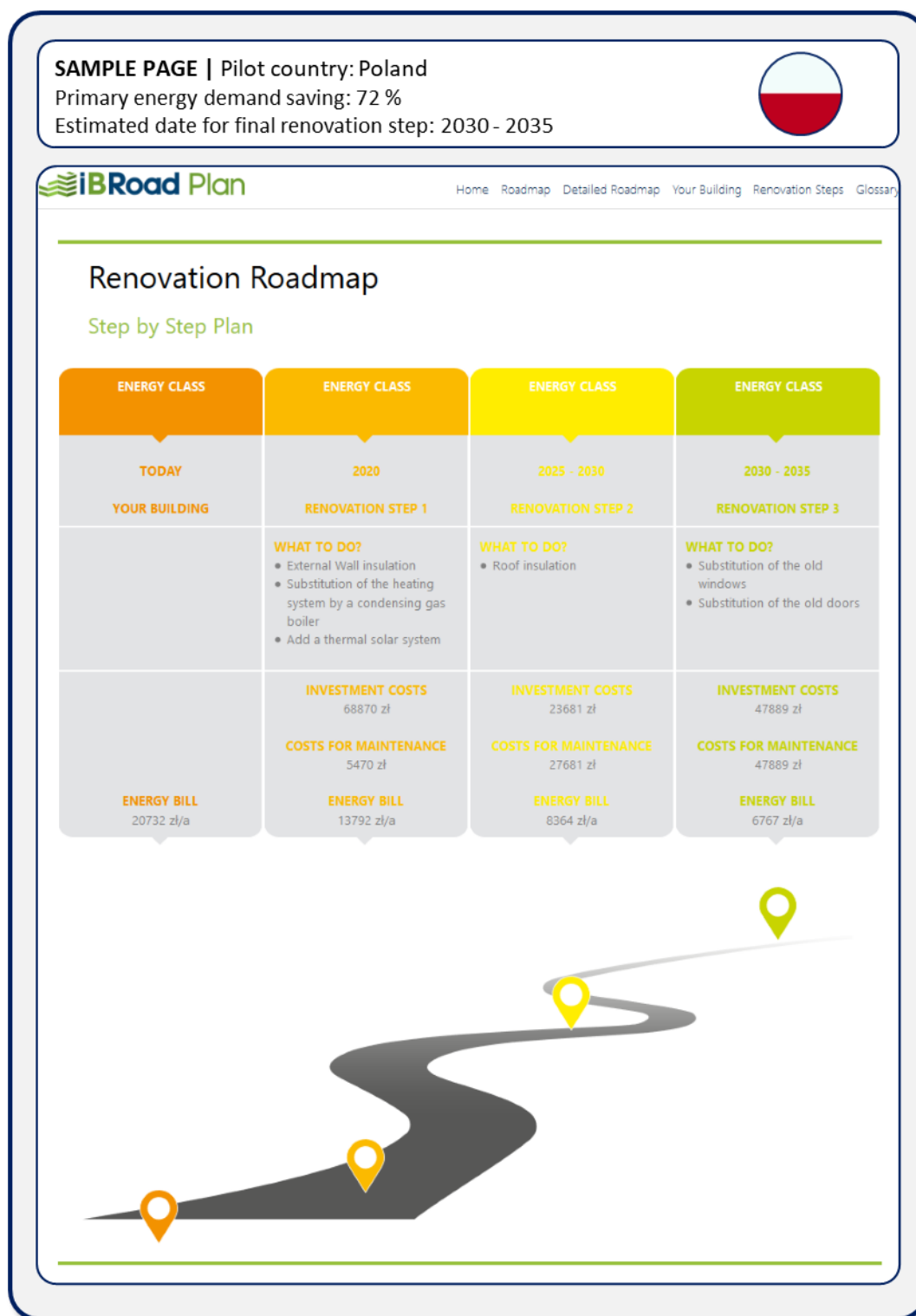


Figure 87: Polish example of an iBRoad Renovation Roadmap – renovation roadmap

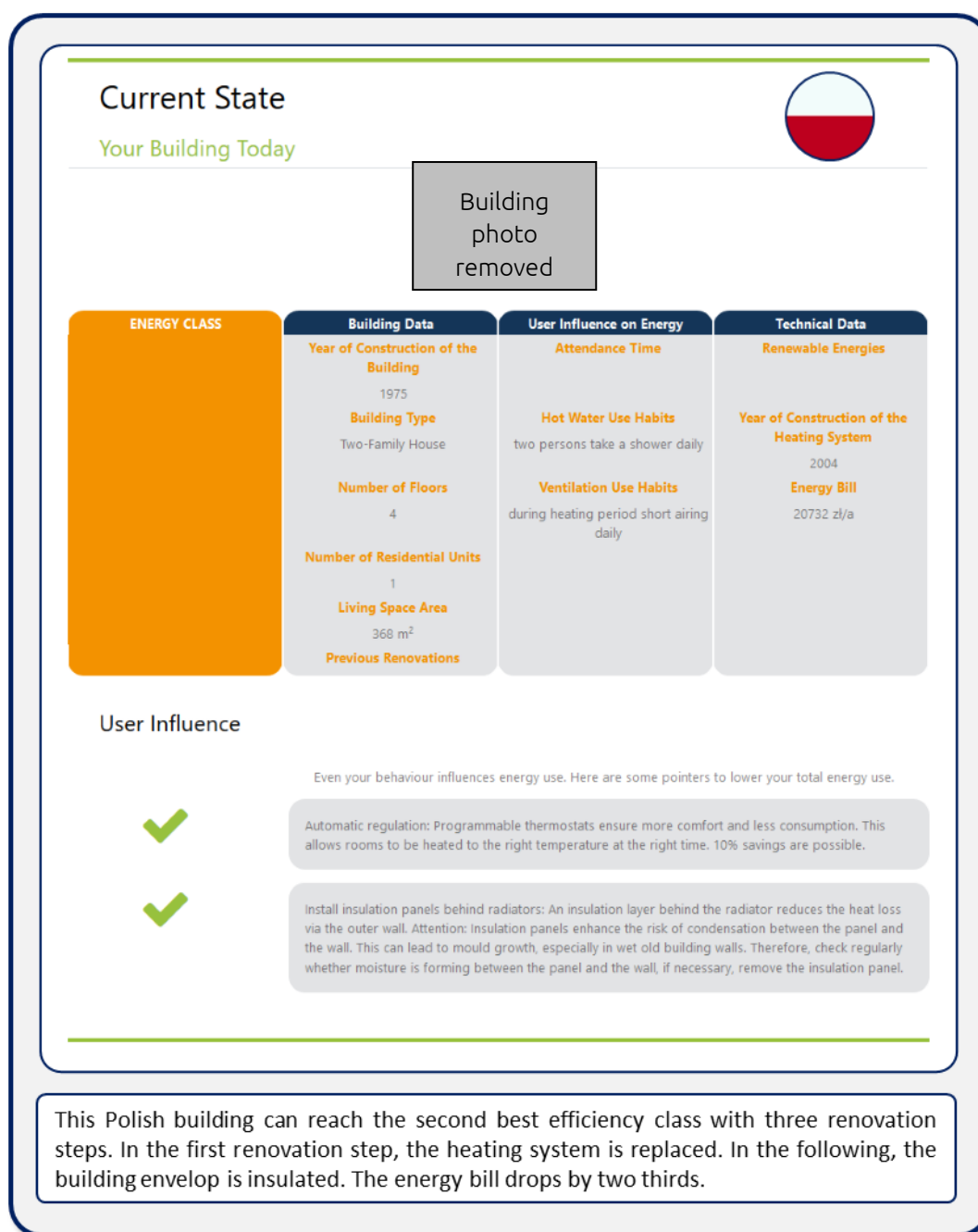


Figure 88: Polish example of an iBRoad Renovation Roadmap – current building state

In Bulgaria, the field test buildings were built between 1929 and 2008. In the present state, nearly half of the buildings are rated the worst energy class. The Bulgarian energy auditors developed Renovation Roadmaps that foresee mainly the third-best energy class “B” after completion of the last renovation step. Three Roadmaps target for the second-best class “A” and one for “A+”.

The proposed dates for the last renovation step lie between 2019 and 2040. Only one Roadmap proposes to carry out all renovation measures in 2019. For the others, the considered periods are distributed almost equally to 2030 and 2040. The proposed number of renovation steps in this period accounts from two to five. The Roadmaps with two steps consider the period until 2030, which seems like a sensible density of renovation work. However, another Roadmap proposes four renovation steps

until 2030. There is one Roadmap suggesting to carry out three renovation steps in 2019. Again, it seems that the single measures here were meant to be combined into one renovation step.

From a technical point of view, energy auditors described the measures extensively. In addition, comfort improvements are explained in detail. The renovation steps are complex and plausible. Renovation costs are shown for all measures, however without mentioning the anyway pending maintenance costs.

Pilot country	No.	Year of construction	Number of renovation steps	Current energy level	Final / future energy level	Current primary energy demand [kWh/m ²]	Future primary energy demand [kWh/m ²]	Estimated date for final renovation step	Completeness
	1	1970	3	G	B	600	362	When plaster needs renovation	complete
	2	-	4	D	B	269	36	2035-2040	complete
Bulgaria	3	1950	3	G	B	600	119	New heating system	complete
	4	1994	3	G	B	504	176	2019	parts missing
	5	1970	4	G	B	479	126	When boiler is exchanged	complete
	6	1980	4	F	A	390	73	2030-2035	complete
	7	1950	3	F	B	600	112	New heating system	-
	8	1968	5	E	A+	411	27	2035-2040	complete
	9	1982	4	G	B	500	111	2030-2035	complete
	10	1947	4	G	A	600	95	2025-2030	complete
	11	1911	2	D	B	362	142	2025-2030	parts missing
	12	2008	2	C	B	203	158	2025-2030	complete
	13	1929	5	G	A	505	109	2035 - 2040	complete
	14	1962	4	D	B	262	108	2035-2040	complete
	15	-	3	D	B	280	136	When windows are exchanged	parts missing

Figure 89: iBRoad Renovation Roadmap results overview (Bulgaria)

Figure 90 and Figure 91 show parts of an iBRoad renovation Roadmap produced by a Bulgarian energy auditor as part of the pilot testing.

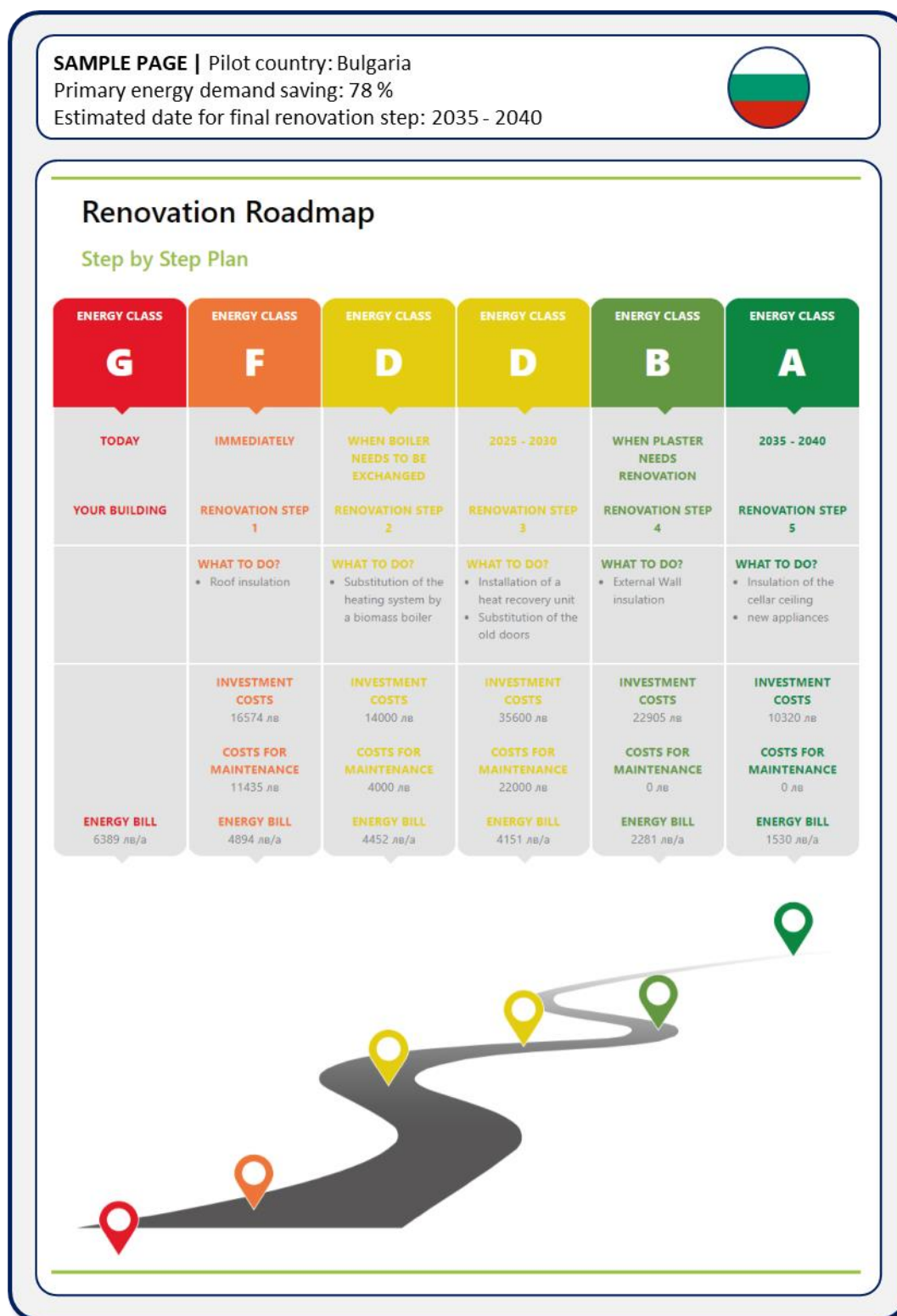


Figure 90: Bulgarian example of an iBRoad Renovation Roadmap – renovation roadmap



Figure 91: Bulgarian example of an iBRoad Renovation Roadmap – current building state

In general, the iBRoad Renovation Roadmaps that were produced during the field tests are compliant with the iBRoad Roadmap principles. The best-possible-principle depends on various issues. A renovation measure should always be best-possible with regard to the technical conditions of the specific building or with regard to the financial frame of the owners. As a result, the best-possible-principle cannot be evaluated with a “fulfilled/not fulfilled” checkbox. The best hint to approach

whether auditors were able to implement the best-possible-principle is the overall improvement in energy demand that is foreseen in the Roadmaps. In this respect, the majority of the auditors took the best-possible-principle very seriously.

The individual renovation context of the Roadmaps may best be indicated by the technical improvement measures on the one hand, and by the description of the user influence in the present building state and the comfort improvements on the other. The technical description of the measures, their order of appearance and the relation to given building requirements seem very well defined. For the non-technical descriptions of the user influence and comfort improvements, the standard text blocks were used more frequently. Overall, all Roadmaps were issued individually for the respective buildings.

All Renovation Roadmaps consider a long-term perspective. They consider periods beyond the pending renovation measures and prepare future measures in order to avoid lock-in effects and reach deep renovation targets. Auditors chose the considered periods individually, depending on the specific needs. They considered both principles, long-term perspective as well as timing and sequencing correctly. This is also supported by the homeowners' answers in the questionnaire where they agreed to a high degree that the Roadmap provided them with a long-term plan.

The fifth principle states that the Renovation Roadmap needs to be attractive, easily understandable and motivating for homeowners. Auditors and homeowners gave positive feedback about the layout of the Roadmap. Homeowners agreed to a high extent that it motivates them to realise concrete measures.

Logbook

The majority of the energy auditors participating in the field test entered building data into the iBRoad Logbook. After the field test, they submitted the specific log-in data to ifeu for an evaluation and plausibility check. Most auditors entered the data for the present building state very extensively. They had to enter all data manually because an interface to national calculation software programmes does not exist at this state of the project. This is also an important issue in the auditors' feedback to the Logbook. Moreover, the Logbooks were evaluated by ifeu in order to specify how the auditors worked with the Logbook, which parts cause problems or which ones are favourable. The results are shown in Figure 92, Figure 93 and Figure 94.


Pilot countries	Number of building	Number of building states	General & admin. info.	Completeness			Comfort levels	My documents & plans	Building diagnosis		
				Building construction info.	Building energy performance	Building operation and use			Overall Energie label	Envelope	Equipment
 Portugal	2	2	complete	complete	complete	complete	-	upload	D	complete	partially
	3	1	complete	complete	complete	complete	-	upload	C	complete	complete
	4	1	complete	complete	complete	complete	-	-	F	complete	complete
	5	2	complete	complete	complete	complete	-	upload	A	complete	complete
	6	1	complete	complete	complete	complete	-	upload	F	complete	complete
	7	-	-	-	-	-	-	-	-	-	-
	8	-	-	-	-	-	-	-	-	-	-
	9	1	complete	complete	complete	complete	-	upload	A+	complete	complete
	10	1	complete	complete	complete	complete	partially	upload	C	complete	complete
	11	1	complete	partially	complete	complete	complete	-	D	complete	complete
	12	2	complete	complete	complete	-	complete	upload	F	complete	complete
	13	1	complete	complete	complete	complete	complete	upload	E	complete	complete
	14	1	complete	complete	complete	complete	complete	upload	D	complete	complete
	15	-	-	-	-	-	-	-	-	-	-
	16	-	-	-	-	-	-	-	-	-	-
	17	1	complete	complete	complete	-	-	-	F	complete	partially
	18	1	complete	complete	complete	complete	-	-	D	complete	complete
	19	1	complete	complete	complete	-	-	-	E	complete	complete
	20	1	complete	complete	complete	-	-	-	C	complete	complete

Figure 92: iBRoad Logbook results overview (Portugal)

Pilot countries	Number of building	Number of building states	Completeness					Building diagnosis			
			General & admin. info.	Building construction info.	Building energy performance	Building operation and use	Comfort levels	My documents & plans	Overall Energie label	Envelope	Equipment
<div><div></div><div></div></div> <div>Poland</div>	2	4	complete	complete	complete	complete	complete	-	-	complete	-
	3	2	partially	complete	complete	-	-	-	yellow	complete	-
	4	2	partially	complete	partially	-	-	-	medium orange	complete	-
	5	1	partially	complete	complete	partially	-	-	dark red	complete	complete
	6	1	partially	complete	complete	complete	-	-	dark red	complete	complete
	7	2	partially	complete	partially	partially	-	-	light green	complete	-
	8	2	partially	complete	partially	-	-	-	light green	complete	-
	9	2	partially	partially	partially	complete	-	upload	light green	complete	-
	10	4	partially	partially	partially	partially	-	-	-	complete	-
	11	1	complete	complete	complete	-	-	upload	light green	complete	partially
	12	1	complete	complete	-	-	-	upload	-	complete	-
	13	1	partially	partially	partially	complete	-	-	-	complete	-
	14	1	partially	complete	partially	complete	-	-	-	complete	-
	15	6	complete	complete	complete	complete	complete	upload	-	complete	partially
	16	7	complete	complete	complete	complete	complete	upload	-	complete	complete
	17	1	-	-	complete	-	complete	-	yellow	complete	-
	18	1	-	-	partially	-	complete	-	red	complete	-
	19	1	partially	complete	partially	complete	complete	upload	-	complete	complete
	20	1	partially	complete	partially	complete	complete	-	-	complete	complete

Figure 93: iBRoad Logbook results overview (Poland)




Pilot countries	Number of building	Number of building states	Completeness					Building diagnosis			
			General & admin. info.	Building construction info.	Building energy performance	Building operation and use	Comfort levels	My documents & plans	Overall Energie label	Envelope	Equipment
	1	1	complete	complete	complete	complete	complete	-	G	complete	complete
	2	1	complete	complete	complete	-	complete	-	D	complete	complete
	3	1	complete	complete	complete	-	-	-	G	complete	-
Bulgaria	4	1	complete	complete	complete	complete	complete	upload	G	complete	-
	5	1	complete	complete	complete	-	complete	-	G	complete	complete
	6	2	complete	complete	complete	complete	partially	-	F	complete	complete
	7	1	complete	complete	complete	-	-	-	F	complete	-
	8	1	-	-	-	-	-	-	E	complete	complete
	9	-	-	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-	-	-
	11	1	complete	complete	complete	complete	complete	-	D	complete	complete
	12	1	complete	complete	complete	complete	complete	-	B	complete	complete
	13	-	-	-	-	-	-	-	-	-	-
	14	-	-	-	-	-	-	-	-	-	-
	15	1	complete	complete	-	-	-	-	-	-	-

Figure 94: iBRoad Logbook results overview (Bulgaria)

Overall, the auditors entered general and very detailed administrative information as well as construction information and energy performance. They made less use of the non-technical issues, e.g., building operation and use, or comfort levels. Portuguese auditors, in particular used the upload functionality to save documents and building plans. The diagnosis of the envelope and equipment is based on a minimum amount of entered data. For the building envelope, auditors provided detailed data. For the technical equipment, however, the entered data was not always sufficient to support the automated diagnosis.

Most auditors entered only one building state in the Logbook. Several auditors, however, entered numerous building states to show past or future renovations.

Field test Logbook in Germany

In Germany, 24 energy auditors participated in the field test of the iBRoad Logbook. They reported on their experiences via email or telephone. Their statements cannot be quantified precisely, therefore, this part of the report only describes, in a quantitative way, tendencies, indisputable facts and topics on which opinions varied significantly.

Most auditors agreed that entering data into the Logbook and uploading files, pictures and heating bills was very easy and intuitive. Finding the entered data and navigating through the Logbook, however, was found one of the most critical issues. Comments said navigation was too unclear and a general overview was missing. Also, the icons that symbolise building components, heating, domestic hot water and cooling were not understood intuitively by a majority. One auditor mentioned that an example building in the Logbook would be very helpful. The graphical layout of the Logbook did not convince many participants. On the other hand, the functionalities – like the colour coding of the components' efficiency and the opportunity to create individual building states – were highly appreciated. Some auditors acknowledged that the iBRoad Logbook would complement other audit products, e.g., saving data from the German Renovation Roadmap (iSFP) to the Logbook, very well.

VI. SUMMARY OF FINDINGS, LESSONS LEARNT AND OUTLOOK

i. Summary of findings

Homeowners' feedback

Overall, the **homeowners' feedback regarding the iBRoad Renovation Roadmap was very positive**. The vast majority of homeowners reported that they quite learned from it. Field test participants particularly appreciated that the Roadmap provides a long-term building renovation plan. Respondent homeowners assessed the Roadmap features as useful and would therefore recommend the iBRoad Roadmap to their family and friends.

Particularly noteworthy is the willingness of most field test participants to implement renovation measures in the near future due to the Renovation Roadmap. The most common measures to be implemented are insulation of the roof, insulation of outer walls and installation of a more efficient heating system.

In addition, **homeowners' feedback regarding the iBRoad Logbook was positive**, albeit a little more moderate compared to the iBRoad Renovation Roadmap. Homeowners who participated in the field test liked the idea of a central repository for all building-related information. Generally, respondent homeowners rated the Logbook features as useful. Consequently, the vast majority of homeowners would recommend the iBRoad Logbook to their family and friends. More than half of the field test participants "tend to agree" or "completely agree" with the statement "The iBRoad Logbook enables and motivates me to realise concrete renovation measures in the near future".

Energy auditors' feedback

All **energy auditors** were able to work well with the **iBRoad Renovation Roadmap Assistant**. Most of them approached the tool intuitively or needed a short time to get used to it. The majority of auditors agreed that the Renovation Roadmap enables and motivates the homeowner to realise concrete renovation measures in the near future. Most auditors also think that the Roadmap contains all relevant indicators. Accordingly, a broad majority of the auditors would recommend the Renovation Roadmap to their colleagues.

Furthermore, most of the attending auditors evaluated the **iBRoad Logbook** as "very useful" or "rather useful". They state that the existing features were sufficient and there was no need for additional features. According to that, a vast majority of auditors said it was likely or very likely that they recommended the Logbook to their colleagues.

ii. Lessons learnt and outlook

The focus for further potential development of the iBRoad software tools can be derived and specified from the field test results. The tasks can be divided into two basic categories: manageability and content.

Outlook to improve manageability of the software

The language barrier seems to have affected the manageability for both auditors and homeowners. Although participants were familiar with the English language and energy agencies translated wide parts of the documents, many participants stated that the language barrier was a major hindrance for understanding. It became very clear that later versions of the iBRoad tools and documents would necessarily have to be translated to the respective languages.

The second important issue mentioned to improve the manageability of the tools for the energy auditors is an automated data transfer between national EPC software and the iBRoad renovation Roadmap and Logbook. The vast amount of required data entries takes a substantial share of the

auditors' processing time. This could be significantly simplified by a data transfer interface. Due to the amount of different national software products, there is no simple solution with a standardised data interface. However, the iBRoad consortium will develop a sketch for possible future solutions.

Furthermore, it proved that the navigation within the tools need to be improved. Some auditors asked for more guidance or felt a bit "lost", especially when entering the data in the Logbook. The consortium will check whether the navigation can be improved and a sample file can be made available.

For the Renovation Roadmap, the consortium will develop a solution to format and print a paper copy.

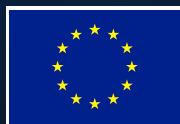
Outlook to improve the content of the software

In terms of content, some auditors required more flexibility. Accordingly, the iBRoad consortium will offer more space for comments and descriptions in free text. This also allows entering non-energetic topics that might nevertheless be interesting for the homeowner. Furthermore, the consortium will check whether dropdown menus are sufficiently flexible or require revision.

The majority of homeowners and auditors in the field test regarded a comparison of different variants in the Roadmap as useful. The iBRoad consortium will therefore develop a systematic solution to include variants and check which changes in the Roadmap Assistant are suitable to support this process. One option which is being considered, is the development of the possibility to make a copy of the roadmap in the assistant, with which, the energy auditor will be able to easily create several roadmaps, to serve as variants.

A number of other minor format- or software- bugs and improvements that became obvious or occurred during the field test will be fixed shortly.

These actions will help to develop the iBRoad tools further into suitable instruments that support homeowners in their buildings' renovation.



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