MANUAL

An illustration of all cases would exceed the scope of a user manual. Therefore, in the following, the functionality and application will be described using a few examples.

At the beginning, the user is briefly informed about the functionality of the tool and the validity of the statements and in this context that there is no guarantee for the validity of the statement and that in any case it is recommended to seek professional advice from OSS, architects or contractors for the energy-efficient design and renovation of buildings – Figure 6. A project name must also be entered in the first step. Necessary entries are marked with orange-colored font. Once the entry has been made, it must be confirmed. Afterwards, the button "Next step" in the navigation menu (marked in Figure 7) can be used to proceed to the next tab. Otherwise, this button has no function. Furthermore, there are links to the creation of a new project and to the outPHit project homepage in the navigation area. Both open new tabs in the web browser. The navigation via "Previous Step" (only available from page 2) and "Next Step" serves to give the user the possibility to make changes to the answers afterwards.

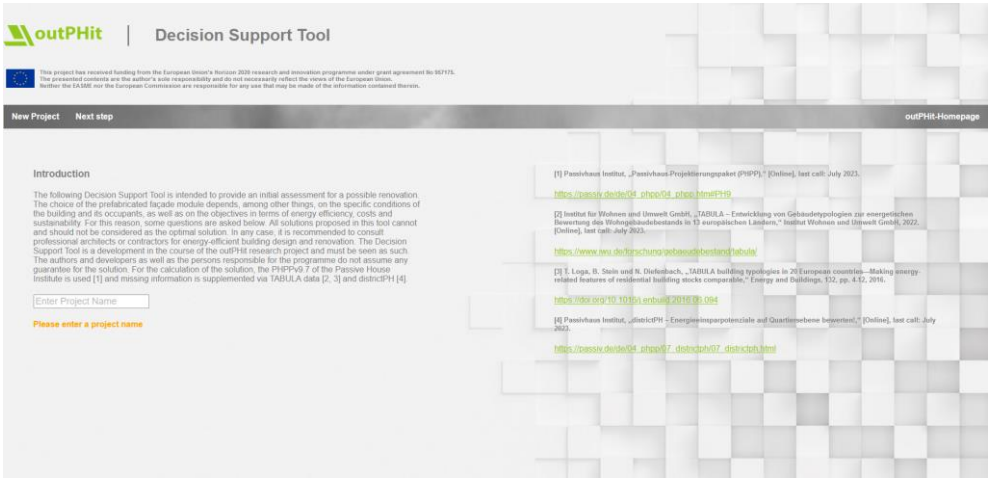

Figure 6: Introduction in deSuTo. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

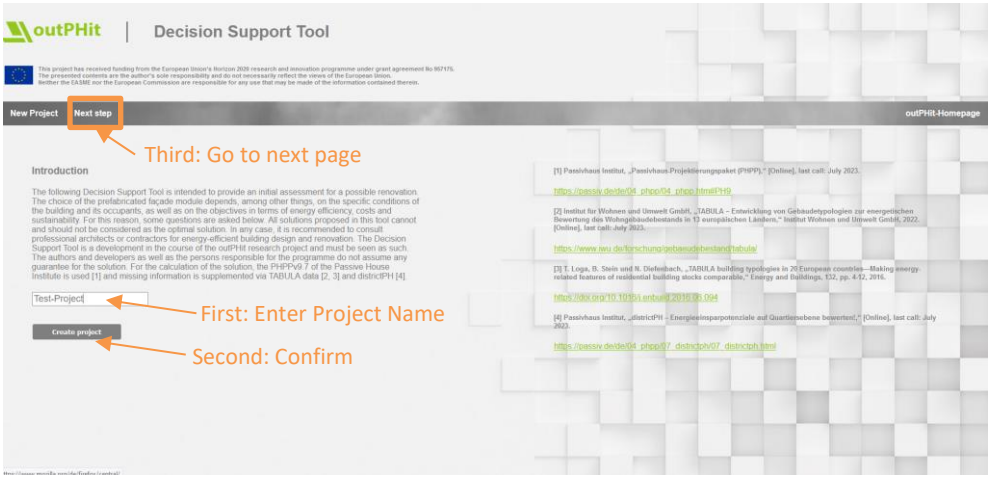

Figure 7: Enter Project-Name in deSuTo. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

The first set of questions asks general questions about the building, e.g., location nation (dropdown list - currently only nations where project partners outPHits are represented), age (dropdown list), presence of a developed roof and basement, number of floors (dropdown list), and average room height (Figure 8). After selecting the location information country, a city still needs to be selected. The location information is used to provide a climate classification. Weather data from PHPPv9.7 is used for this purpose. For individual questions, more detailed questions are displayed depending on the answer. For example, if the user selects that the roof and basement are present, they will also be asked if they are heated. The conceptual building model is then displayed on the right side of the screen and must be confirmed (Figure 9). All questions must be answered and confirmed to proceed to the next question section via the "Next step" button.

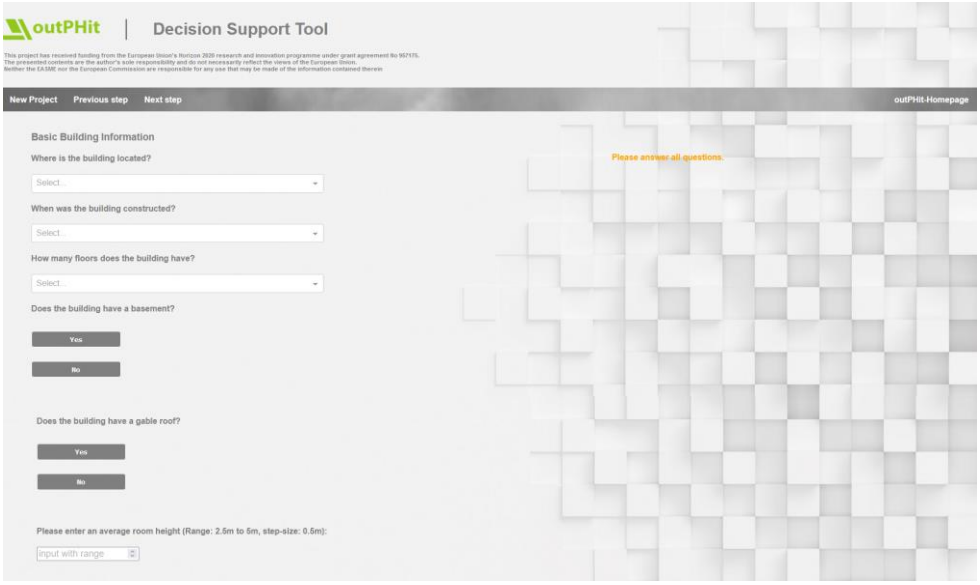

Figure 8: General questions about the building – Part 1. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

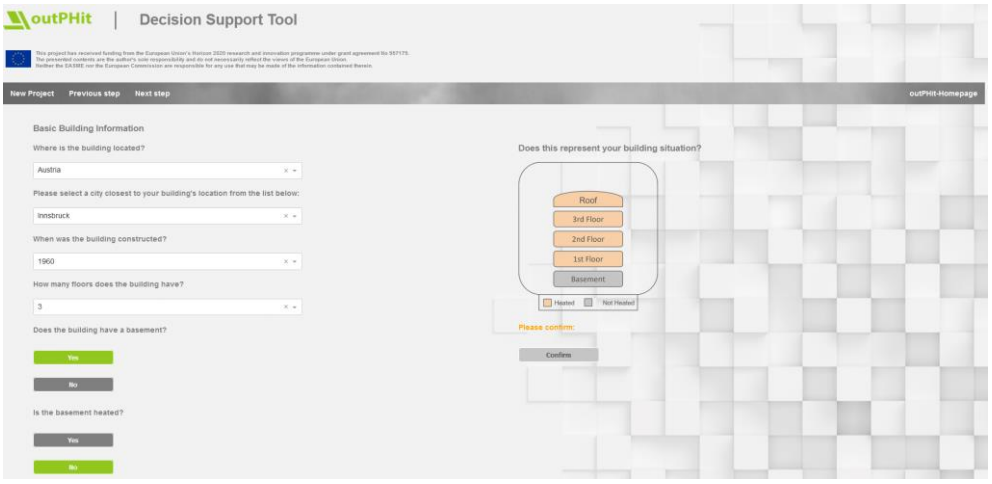

Figure 9: Confirmation of the entry in the field general questions about the building. This example shows a three-story building with an unheated basement and heated roof. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

The next step is to answer further general questions about the building. Again, all questions must be answered and confirmed to proceed to the next step. Geometry, area, and window details are asked here. Two geometries are available for the area, where the user must enter the respective edge lengths (cf. Figure 10, Figure 11). Minimum and maximum values as well as the step size are always displayed for input fields with numbers.

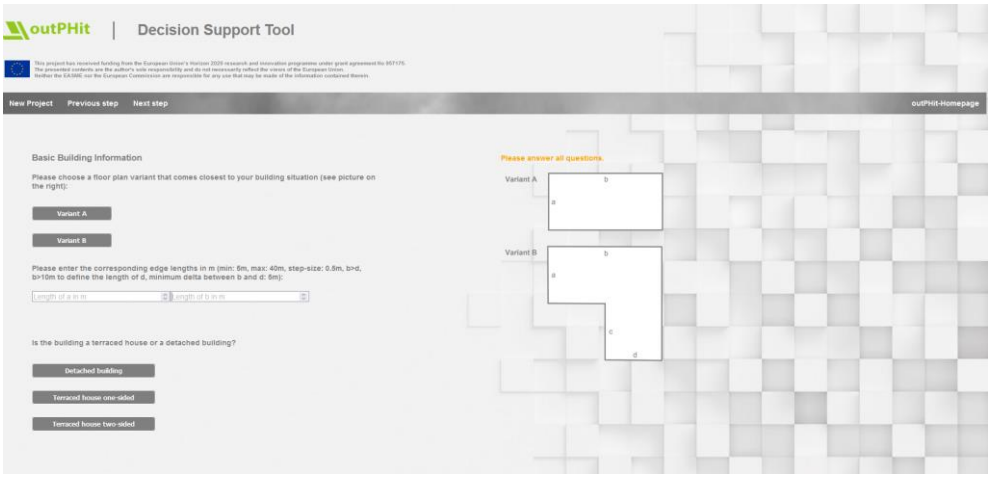

Figure 10: General questions about the building – Part 2. Selection of the building floor plan and dimensions. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

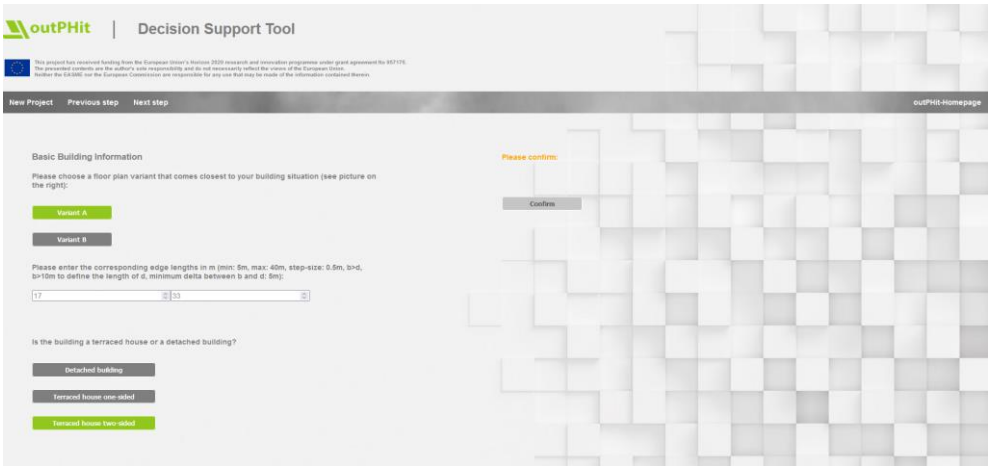

Figure 11: General questions about the building – Part 2. Example user selection: Variant A with defined dimensions and two directly adjacent buildings. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

Since two directly adjacent buildings were selected in the previous step (Figure 11), the next step is to mark the relevant facade sides (see Figure 12, Figure 13). This influences, among other things, the areas to be renovated, as well as the energy demand calculation and the available window areas. Afterwards, the building orientation to the south must be entered via a slider (Figure 14). The building orientation has an influence on the solar thermal yield (questions about windows will be asked later).

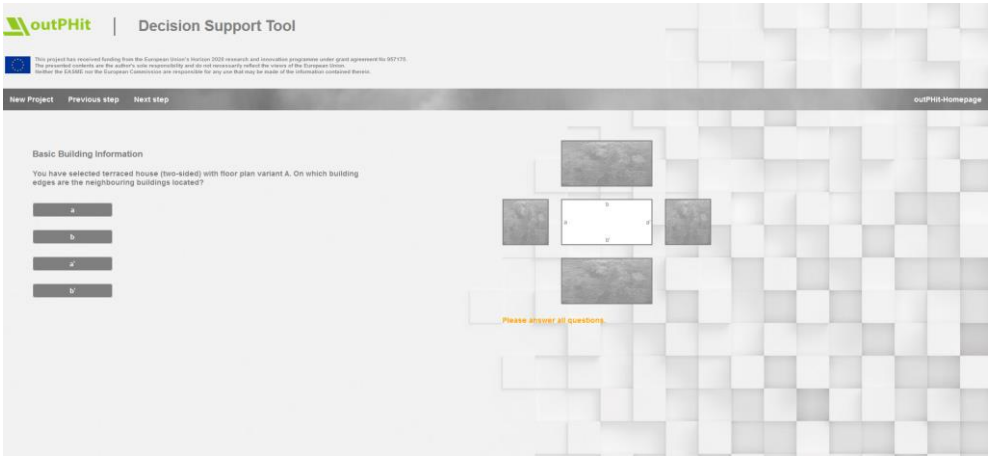

Figure 12: General questions about the building – Selection of directly adjacent buildings. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

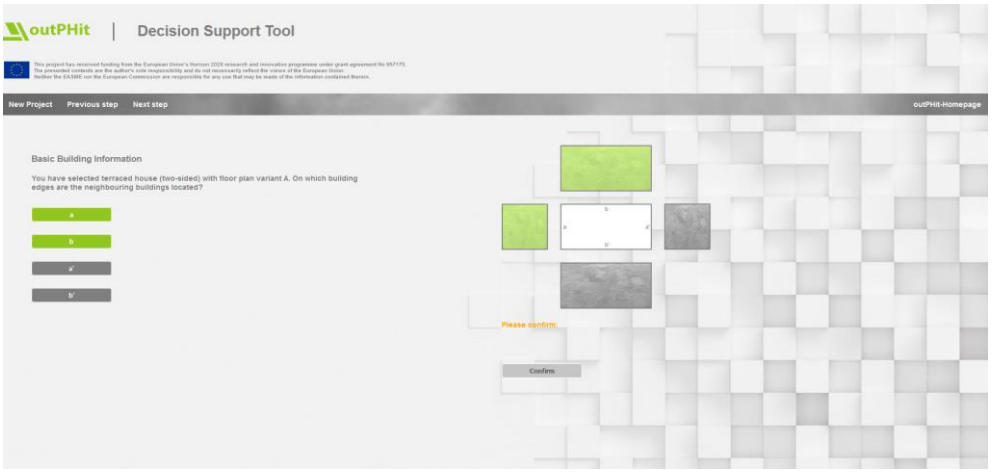

Figure 13: General questions about the building – Selection of directly adjacent buildings. In this example is one directly adjacent neighboring building on each of the facade sides a and b. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

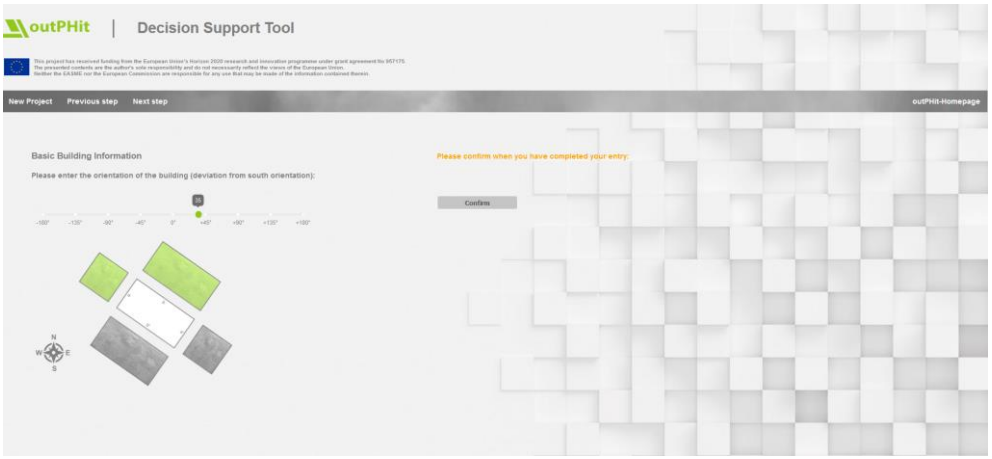

Figure 14: General questions about the building – South orientation selection. In this example is the user input of 35°. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

In the next questionnaire block (Figure 15), details of the building envelope, specifically the walls, roof, and baseplate, must be provided. In general, a choice can be made from an existing system selection of certified components. If this is not known to the user, alternative questions are asked, as shown in the figure below. Here, the user is asked about the building construction, material, and insulation as well as the corresponding thicknesses. Furthermore, it is asked whether the user knows information about u-value and f_{RSI}-value. If this is not known, the question can be answered in the negative. In this case, as in all other cases, missing information is compensated with information from TABULA. Finally, in this question category, the user must provide a self-assessment of the remediation status.

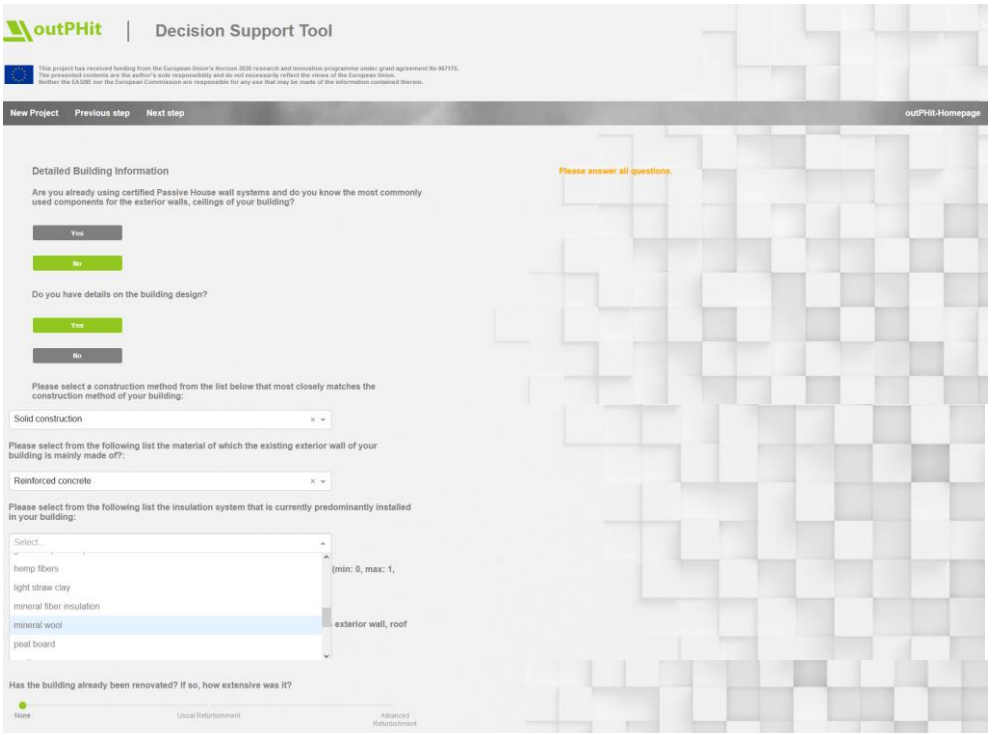

Figure 15: General questions about the building – Part 3 "Wall-Roof-Baseplate". The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

For the windows, the user is first asked whether he has detailed information. If this is the case, a query is made for window frames, window glazing and window areas depending on the compass direction. A component selection is available for glazing and window frames via a drop-down list. This is based on PHPPv9.7. If no detailed information is available, only the total window area is requested (Figure 16). Necessary window details are then obtained from TABULA.

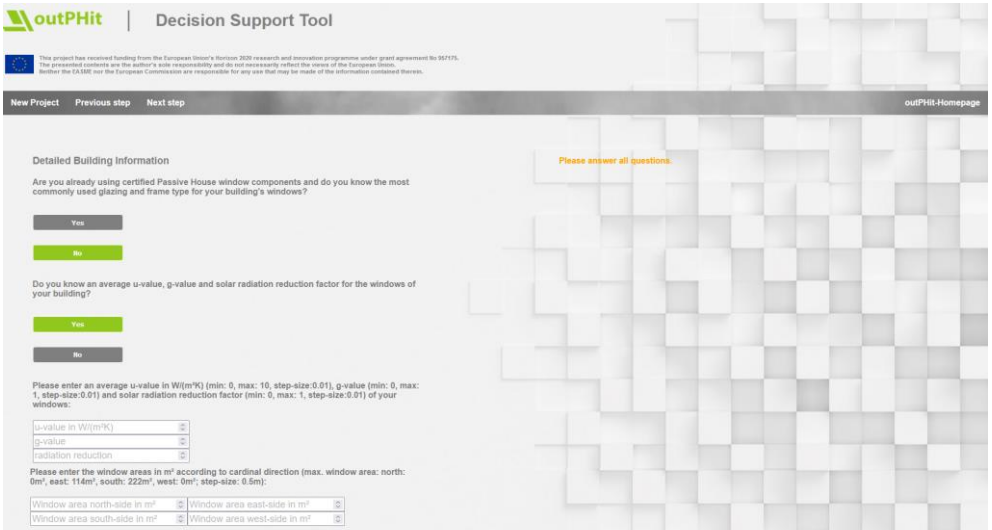

Figure 16: General questions about the building – Part 4 "Window". The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

If the general building information is stored, the user is also asked about the objective of the renovation measure. Here, the user must set the focus on a Likert scale for the categories "energy efficiency standards", "sustainability" and "costs". Details on EnerPHit standards, can be accessed via an info button (cf. Figure 17).

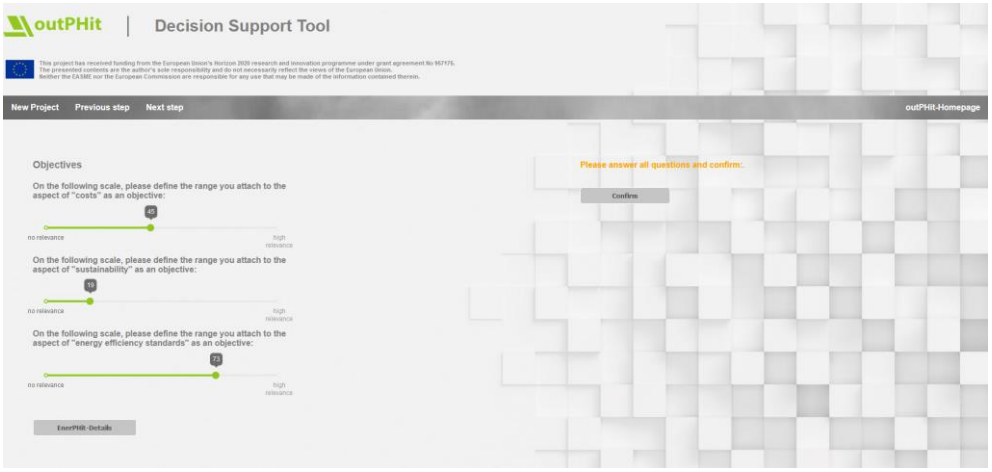

Figure 17: Selection of objectives in deSuTo. The image representation results from the development status and does not represent any guarantee that the final application is worked out in the same way.

After entering the objective, several detailed questions come up, including the construction and possibility of crane installation (defines module size). Once the detailed information has been entered, a conceptual solution proposal appears at the end. The first questions are used to categorize the building to allow comparison with TABULA to cover missing detailed information, the so-called missing pieces (**https://webtool.building-typology.eu/#bm**; last call: 04/2023). The calculation is based on the PHPPv9.7 (**https://passiv.de/de/04_phpp/04_phpp.htm#PH9**; last call: 04/2023). After that, a solution is presented (only as a concept).

CONCLUSION

75% of existing buildings are considered inefficient by standard [51]. Currently, the renovation rate in Europe is about 2% [7]. It is expected that the renovation rate will increase in the coming years to meet climate protection targets. Typically, retrofit projects in the residential sector require consideration of complex administrative structures, legal structures, and other challenges. These aspects can make the selection of a retrofit solution a complex decision-making process. However, the selection of appropriate retrofit solutions for residential buildings is currently still a difficult task, especially due to the diversity of systems and their impact on building performance [32]. Given that most of the housing stock in Europe is multi-family housing, this is where there is the greatest need for support tools. With the ***deSuTo***-outPHits, a contribution was made to support the renovation process and its actors.

The question in work package 4 of outPHit calls for the examination of a possibility to find suitable system solutions for residential buildings. With ***deSuTo*** not only an own development within the outPHit project was presented, but also numerous support tools from the literature were identified, which are designed for different applications and serve different interest groups. Example tools considered in more detail included EPIQR [31], TOBUS [29], PARADIS [22] and the work of Amorocho et al. [32], Lanzarote et al. [39] and Gilani et al. [5], which were taken into account in the project-specific tool development.

There is currently no common consensus on the main criteria, the applicable remediation methods and on support tools to assist the decision-making process [52]. The implementation of ***deSuTo*** as an online application and open transparency should contribute to finding a common consensus.

Mostly, there is no simultaneous consideration of several stakeholders in the weighting of the criteria. Solutions usually focus only on running simulations to quantify the performance of the systems. This is also the case in ***deSuTo***. However, the multi-user problem is to be part of future developments.