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Mapping the deep renovation possibilities of European buildings

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Abstract. Energy efficiency is priority number one in the EU in the last two years and efforts to achieve it have been made in various ways: through regulations, guidelines, good practice results, education and training. The buildings sector still is the larger consumer of energy, so many policies and national energy strategies have prepared ambitious goals to significantly decrease the sector's energy consumption. An important step for the implementation of these strategies is the detection of the potential to energy renovate the existing building stock. This is the objective of this study; to present the ENERFUND tool which displays the current energy performance of a group of buildings and pinpoints the energy renovation potential for the selected buildings. An extensive study to identify the expectations of the future users was carried out, which provided valuable feedback for the features of the tool. The tool utilizes data from publicly available Energy Performance Certificates in the form of an interactive web map and combines them with other geo-referenced data and general information to allow for a rating of deep renovation opportunities. The paper explains the various features of the tool, and presents typical examples of the tool use for targeted stakeholder interests.

1. Introduction

The reduction of energy consumption in the buildings sector is an ongoing subject for many years. The solutions exist and big efforts are given to provide tailored energy measures to the existing building stock. The new buildings are expected to operate like a nearly zero energy one but the existing buildings have a wide of opportunities to choose from with scalable energy efficiency results. Data are a necessity to identify the magnitude of the energy improvements but equally important, to make well-founded investment decisions. Investment is also needed to make buildings more energy efficient and to achieve the goal of decarbonisation. Open government data enables the public accessibility of geo-referenced information useful for planning large-scale remediation projects. In this context, the Energy Performance Certificate (EPC) is an important data source. This paper presents a web tool which presents energy data of buildings, other important factors that can affect the decision of an energy renovation, and consults on potential energy saving opportunities [1]. The tool makes use of a large number of building EPCs data from 13 European countries and displays them in a user friendly interactive web map. The tool's final goal is to facilitate investment decisions for a large target group which includes financial institutions, real estate, local authorities, and home-owners.

2. User expectations as point of departure for ENERFUND tool development

2.1. Objectives of tool development

In order to achieve the objectives of the Energy Union and to meet the requirements of article 2a of EPBD [2], there is a public interest in information on where spatially localized buildings with low energy efficiency are situated. This information should for example:

- support energy service companies in developing energy efficiency projects;
- enable comparison with neighboring buildings and thus contribute to developing market dynamics;
- sensitize the population to energy efficiency and CO_2 reduction issues.

The ENERFUND tool clearly aims at the development of economic activities in order to achieve the goals of the energy and climate policy, and to strengthen the exemplary role of public buildings, especially at municipal level. Therefore, it was paramount to understand user expectations in order to ensure future tool uptake.

2.2. Identifying user requirements

Four strategic types of users have been identified, namely local authorities, energy services companies (ESCOs), financial institutions, and the general public as the fundamental the target groups. Many activities took place including meetings and workshops in order to acknowledge their preferences [3]. Figure 1 presents the origin of the target groups for a number of conducted meetings while Figure 2 shows the same target groups during workshops.

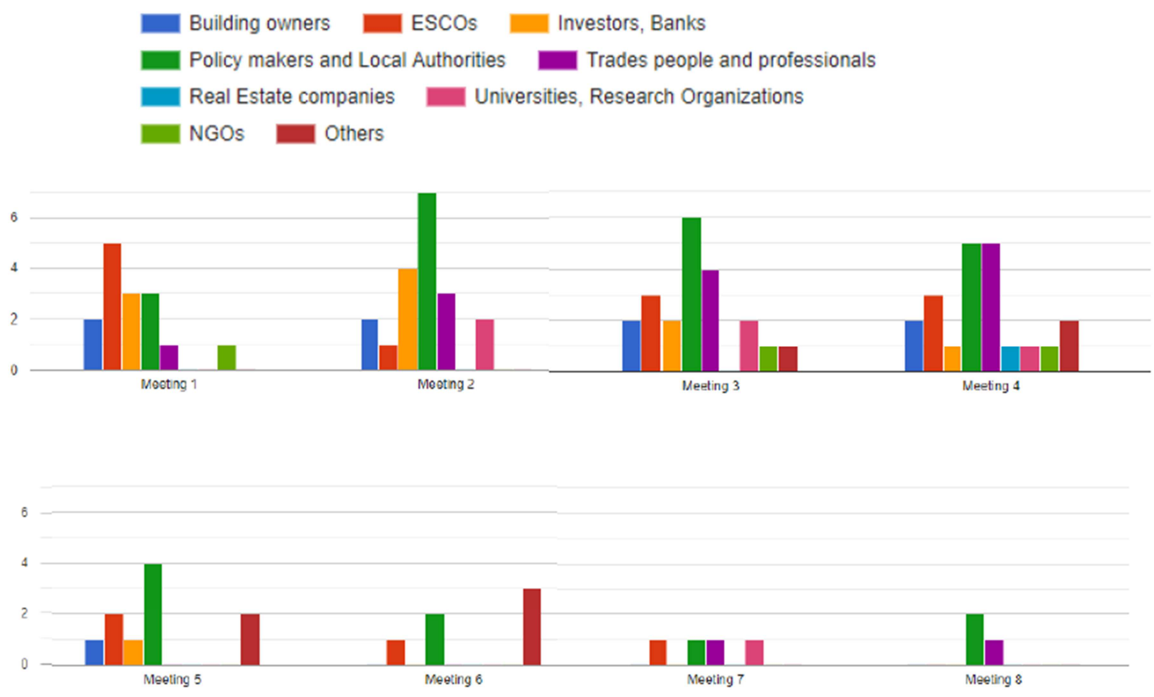

Figure 1. The target groups of the meetings.

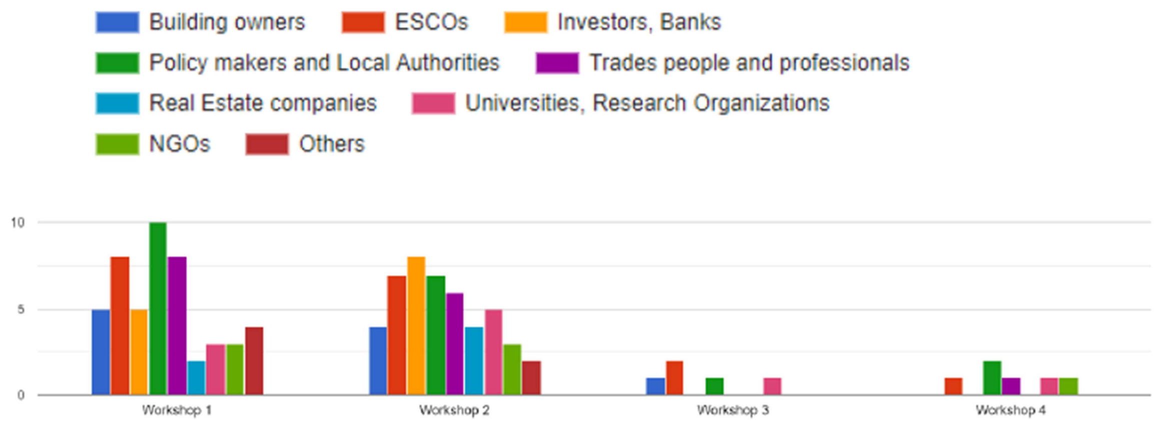

Figure 2. The workshops target groups.

From the early steps of concept development, the ENERFUND team approached potential users in many ways in order to learn about their perception regarding the tool characteristics they would like to see. Opinions were collected via telephone communication, email contact, presentations in various buildings related events, but mainly through meetings and workshops dedicated to the tool as it can be appreciated in the target groups that the meetings and workshops carried out were addressed to [3]. The basic objectives of the meetings are presented in Figure 3.

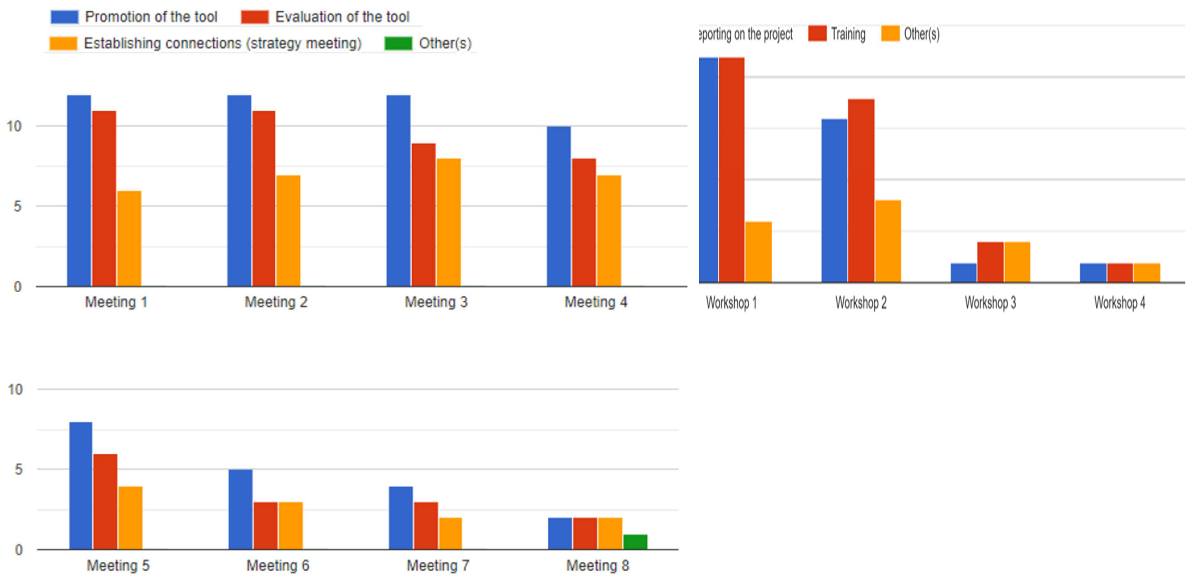

Figure 3. Objectives of meetings (left) and workshops (right).

Questionnaires have also been prepared to record the responses about the layout of the tool, its ease of use, and above all the quantity and quality of data provided. The purpose of the questionnaires was twofold: (1) to gather opinions on the information the tool should present at the beginning of tool development, and (2) to evaluate the usefulness of the tool at the end of the funded project, in order to collect input for future developments.

Among others, the following information was found to be important:

- Type of building use (because it allows for a rough assessment regarding energy demand);
- Year of construction (because it allows for a rough assessment regarding construction typology and possible renovation cost);

- Type of fuel (to be used for planning the decarbonization of the building stock);
- Annual final energy demand [kWh] for space heating and domestic hot water, separately, for residential buildings, and process heat for non-residential buildings (because it will be useful information for energy spatial planning);
- Suitability for installation of solar technologies (solar thermal and photovoltaic systems, needed for planning the decarbonization of the building stock);
- Additional information to be given in order to address energy poverty.
- Especially for the municipalities the following suggestions were recorded:
  - A tool like ENERFUND could be certainly used to motivate municipalities to issue and display EPCs for their own buildings, in order to show how energy performance improves over time.
  - In particular, municipalities could use the tool for preparing their Sustainable Energy Action Plans (SEAP), and to show and compare their performance. It will be also help them to monitor energy renovation targets with actual achievements.

The non-energy benefits of energy efficiency measures must be emphasized, because it is clearly not sufficient to increase energy efficiency alone. This limitation to exclusively energy related performance is considered an important reason why interest in energy performance contracting (ESCO contracts) is still limited.

User requirements on one hand and data availability on the other hand formed the framework for developing the ENERFUND tool.

3. The ENERFUND tool

3.1. Available data source and technical solution

EPC databases were identified as the major source for the ENERFUND tool since they include a variety of important information for the energy performance of the buildings. Additional databases, including significant data for the energy renovation decision making process were also embedded, where available. The level of access on EPC databases depends on the country. In some countries, the access to EPC data is given freely, e.g. in Denmark, the Netherlands, the United Kingdom while in other, only aggregated results or a small sample are made publicly available, e.g. France, Romania, and Greece. However, in most of the countries studied (i.e. Cyprus, Austria), there is no publicly available access to the EPC database. Complete access to the core of the database, meaning access to all raw data, is not provided by most Member States, while in none of the cases were the data geocoded in such a way that the data could be automatically mapped on the tool.

3.2. Overview of country data

In April 2019, more than 8 million EPCs were mapped across 13 countries. In total, more than 73 million unique data entries (such us wall energy efficiency, construction year, etc.) are available from the tool, but this differs from country to country. Figure 4 presents the allocation of the buildings data according to the country. It can be seen that in the Netherlands, 2.864.901 buildings are registered in the ENERFUND tool, while in Cyprus only 53 buildings. This relates not only to the amount of EPC data issued but mainly to the availability of these data. Another important issue for the tool was the building details of the data provided, which are valuable guides to extract the energy saving potential. The main parameters dealt with were: the energy category, the potential energy rating, the produced ENERFUND score, the walls/windows/roof energy efficiency, the main fuel type used for heating purposes, the building area, the building type, and the construction year. Table 1 presents all available data provided by each country. Additionally, the availability of aggregated data is also stated (France and Romania). It can be seen that the parameters vary significantly from country to country. In Slovakia, for example, only the EPC rating and the building type are available in the tool, while for the UK, 10 parameters per EPC are available in the required format.

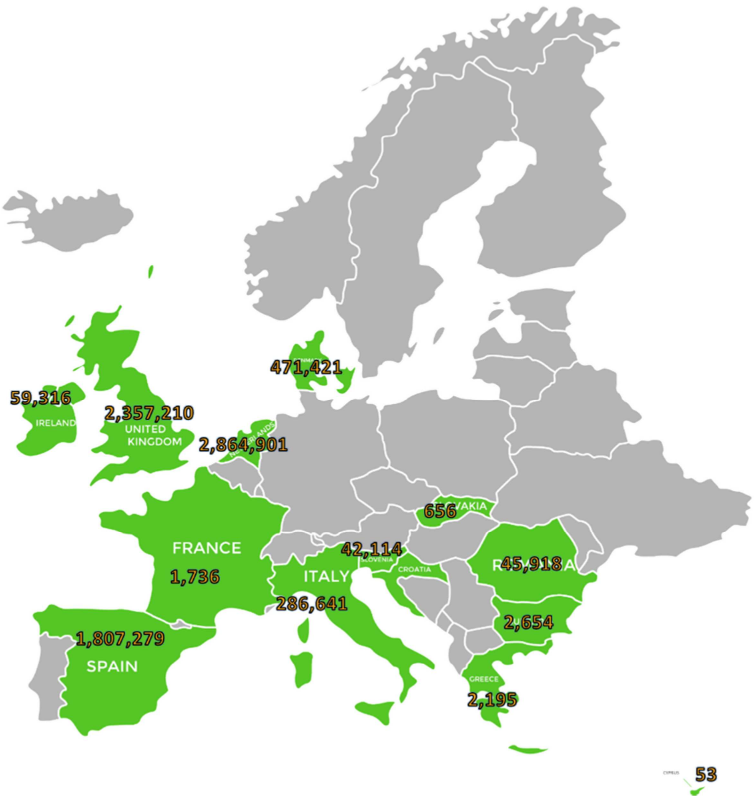

Figure 4. Number of EPCs included in ENERFUND tool per country.

Table 1. Data parameters per building included in ENERFUND tool per country.

Country	Current rating	Potential rating	ENERFUND score	Walls energy eff.	Windows energy eff.	Roof energy eff.	Main fuel type (heating)	Area (m^2)	Buil-ding type	Constru-ction year	Aggregated data
BG	✓	✓	✓	☒	☒	☒	☒	✓	✓	☒	☒
CY	✓	☒	✓	☒	☒	☒	☒	✓	☒	✓	☒
DK	✓	✓	✓	✓	✓	✓	☒	✓	✓	✓	☒
ES	✓	☒	✓	☒	☒	☒	☒	✓	✓	☒	☒
FR	✓	☒	☒	☒	☒	☒	☒	☒	✓	☒	✓
GR	✓	☒	✓	☒	☒	☒	☒	✓	✓	✓	☒
IE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	☒
IT	✓	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
NL	✓	☒	☒	☒	☒	☒	☒	☒	✓	☒	☒
RO	✓	✓	☒	☒	☒	☒	☒	✓	✓	✓	✓
SI	✓	☒	✓	☒	☒	☒	✓	✓	✓	✓	☒
SK	✓	☒	☒	☒	☒	☒	☒	☒	✓	☒	☒
UK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	☒

4. ENERFUND use

The navigation to the tool is quite easy and the user has the ability to refine his or her search in a specific area by directly obtaining information on the number of buildings and their energy category which is color-coded, with deep green for the best (A+ or A) and gradually turns to red for the worst category (e.g. G). The user can easily choose relevant criteria and through filtering, to see the results directly.

Another feature of the tool is the comparison between two or more buildings. The buildings are selected from the map and then, in a separate window, the results of their comparison are displayed. These figures indicate the type of building, its energy category, its floor area, the number of rooms, the energy performance of the envelope materials, etc.

With the above process, information on energy-saving potential can be easily and quickly found in a wide range of interests: from building level, building block, to a district, city, country, and building opportunities for energy renovation of buildings on the basis of economic criteria.

The latest feature of the tool offers the opportunity to compare deep renovation opportunities of single buildings through the ENERFUND score. It is based on a multi criteria analysis methodology and the ratings provided go from 0 (no potential for deep renovation) to 100 (highest potential) and are the result of a relation which takes into account several parameters selected as key drivers for building energy retrofitting, including total floor area, energy saving potential of the building, construction year, average regional building price, occupancy level, own financial contribution to renovation costs, noise levels and ownership status. The formula used was developed so that it could be common and applicable to all countries where open data is available.

Some examples of the tool use are presented below.

Example 1: Residential buildings – Spain

The focus of this example is to identify which residential building should be renovated first according to the ENERFUND score. So, once given a determined area (Barcelona, Spain), the chosen filtering options in order to get a bigger impact on the renovation works were applied (refer to Figure 5):

- Energy rating “G”
- Area bigger than 1,000 m^2
- Building type: residential

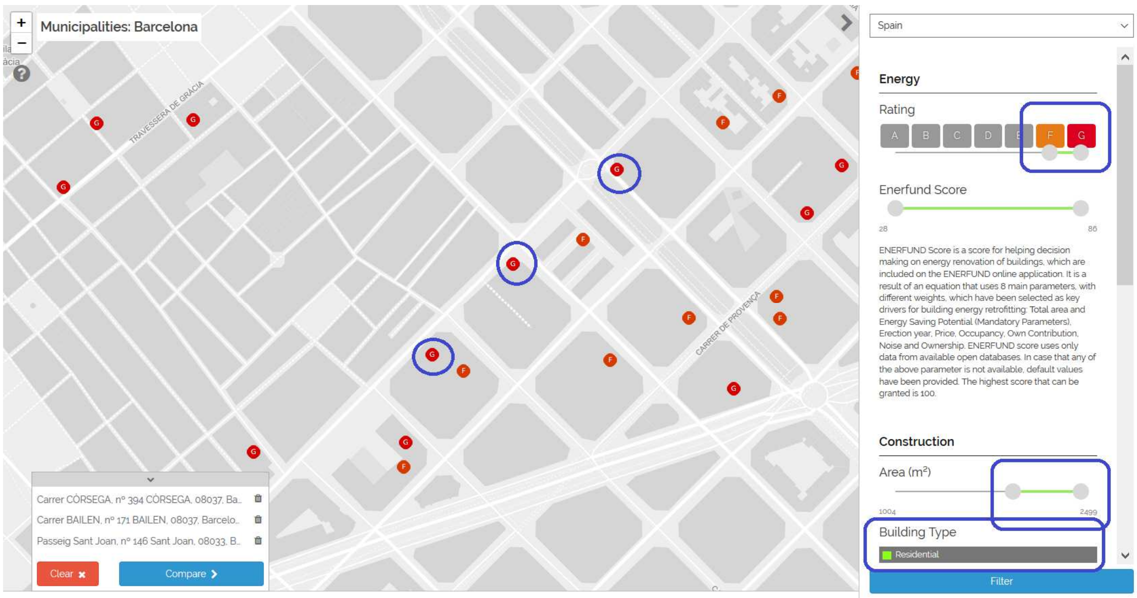

Figure 5. Used filters and selected buildings – Barcelona.

Three buildings with the same EPC rating (G) located in the same area were selected (dots in Figure 5) and the outcome of their comparison is shown in Figure 6.

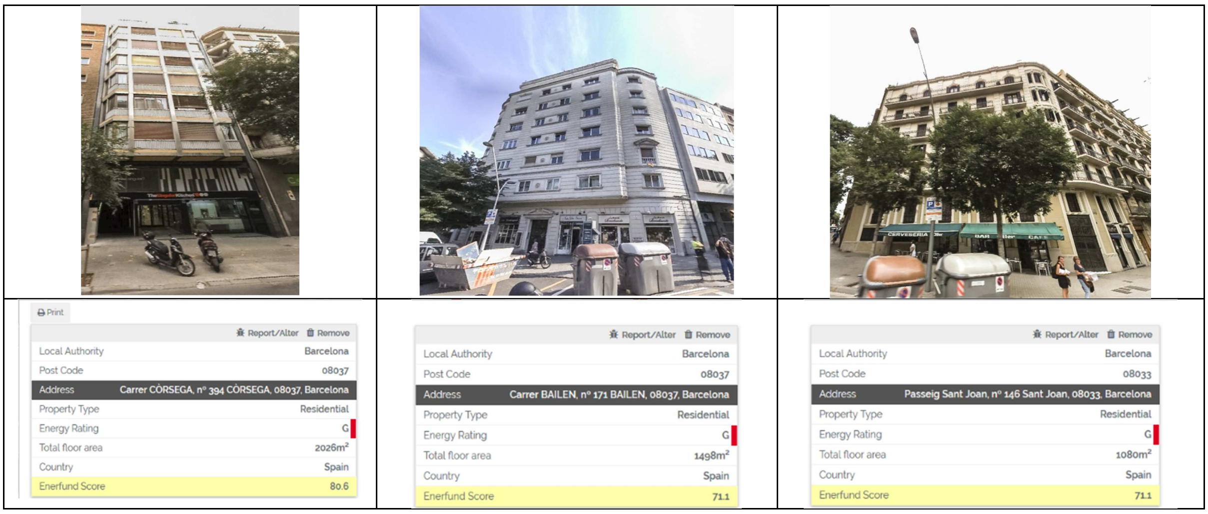

Figure 6. Residential buildings comparison.

It can be seen that two of the buildings have the same Enerfund Score 71.1 and the other one has a higher score of 80.6, therefore this building should be renovated first.

Example 2: Office buildings – UK

The second example is using the filtering options of the tool, and the ENERFUNS score, to identify higher energy renovation opportunities in office buildings in Birmingham, UK. The following filtering options were activated (refer to Figure 7):

- Energy rating "F" to "G"
- Area bigger than 900 m^2
- Building type: Office

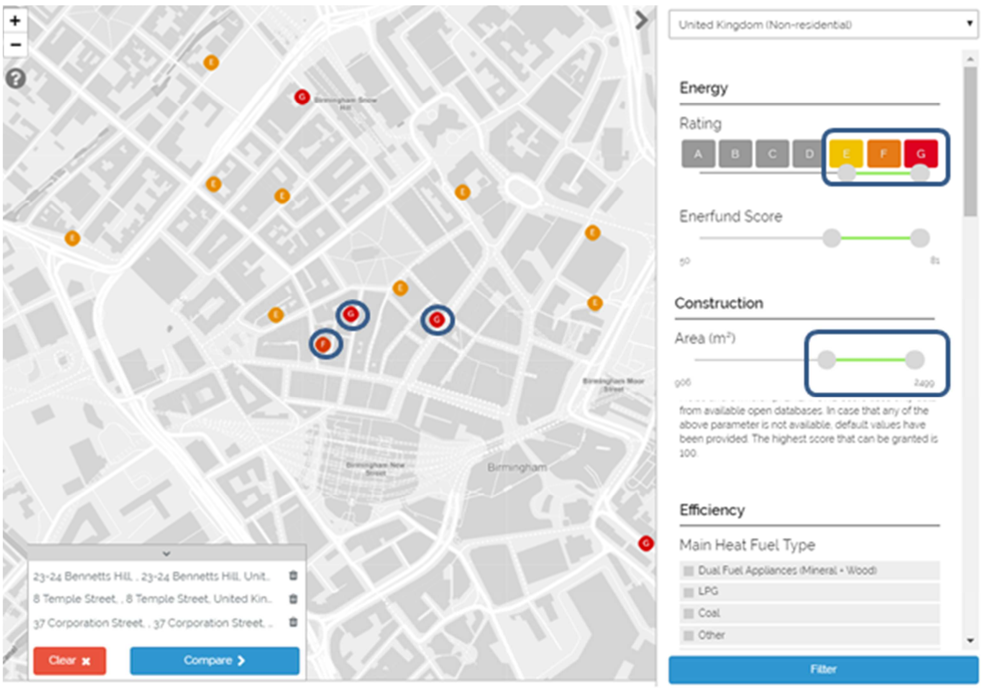

Figure 7. Used filters and selected buildings – Birmingham.

Three buildings located in the nearby area were selected (dots in Figure 7) and the outcome of their comparison is shown in Figure 8.

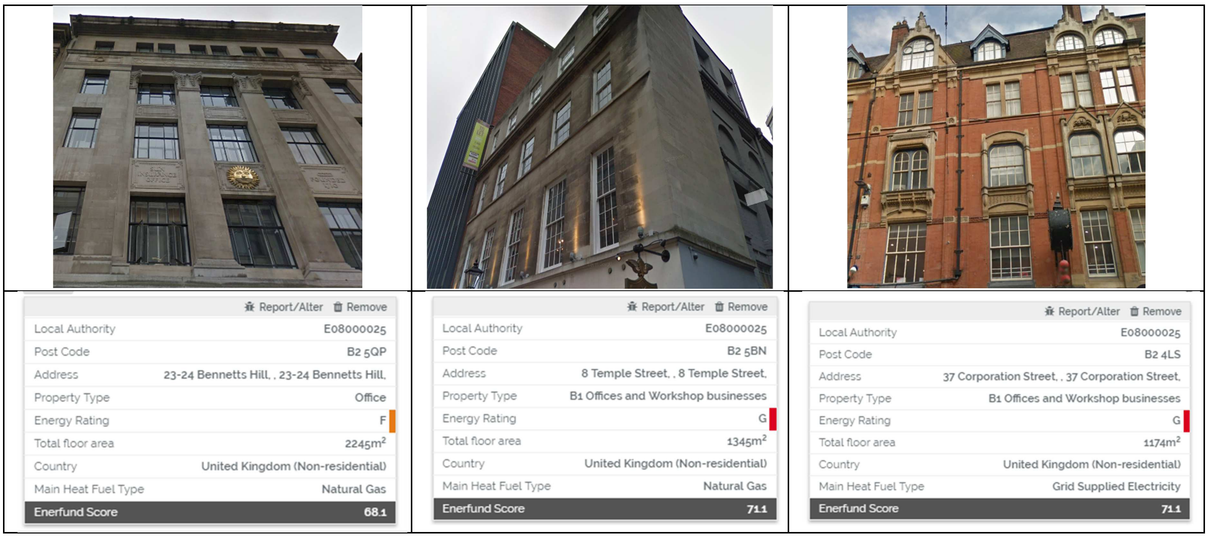

Figure 8. Office buildings comparison.

The Enerfund score prioritised the buildings with EPC rate G to be renovated getting a higher score (71.1).

Example 3: School buildings - Romania

This example is focused on the identification of the educational buildings located in Cluj-Napoca, Romania which need renovation and have the highest potential for energy savings. The municipality is using the tool and the chosen filtering options to identify the buildings are (refer to Figure 9):

- Energy rating – current “F” or “G”
- Energy rating – potential “A” or “B”
- Area bigger than 300 m^2
- Building type: Education

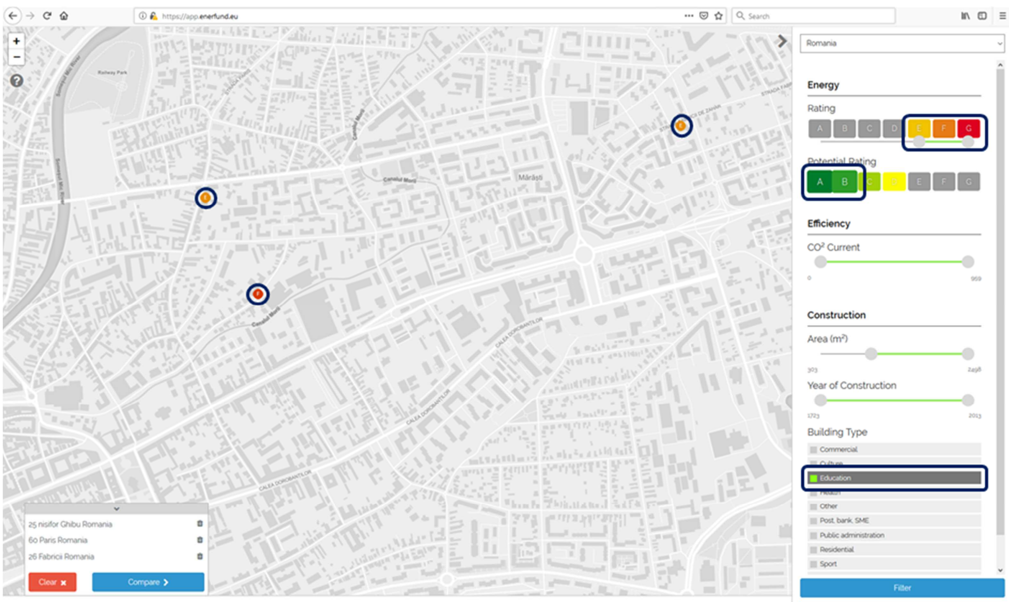

Figure 9. Parameters filtered and selected buildings – Cluj-Napoca.

Three buildings with EPC rating from “E” to “F”, located in the same area, were selected:

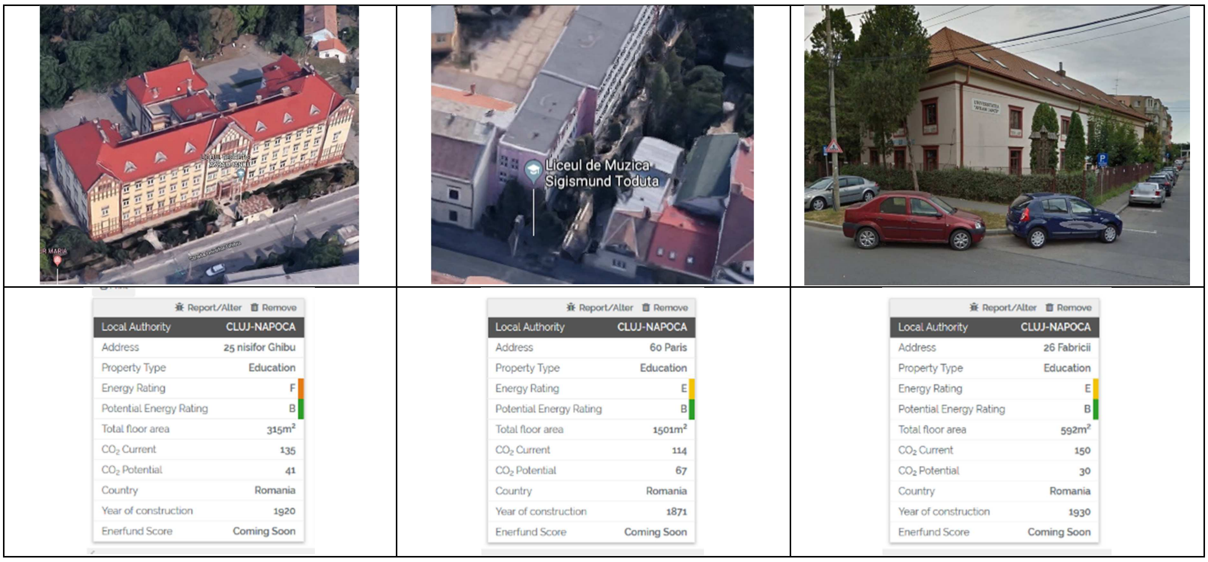

Figure 10. Educational buildings comparison.

The three educational units were identified in less than 2 minutes by the municipality as having the highest potential for renovation, the schools being in the administration and responsibility of the local authority.

5. Conclusions

The interaction with the future stakeholders and users of the tool led to many adjustments, additions, tips and guidance of the latest tool versions taking into account as much as possible the quality of the data provided, the credibility of the data sources, and the restrictions on the data use many countries have set.

The views on the developed tool have been recorded, covering both positive and negative answers, together with the possible reason, e.g. the tool was found useful because of the possibility to compare buildings or because of the graphical representation of the data provided or because of the quantity of the ENERFUND data provided, etc. [4]. A wide distribution of answers shows the existing priorities in the European countries. Figure 11 presents the results from 2 countries, namely Spain and Greece. It can be seen that specific tool features were found principally important, e.g. the graphical representation of the information (21% in Greece), the filtering options (19% in Spain), the function to compare buildings (19% in Greece and 15% in Spain), together with the inspiration to develop other projects/initiatives (19% in Spain, 13% in Greece). The usefulness of the tool reached a high percentage (94% in Greece, 78% in Spain).

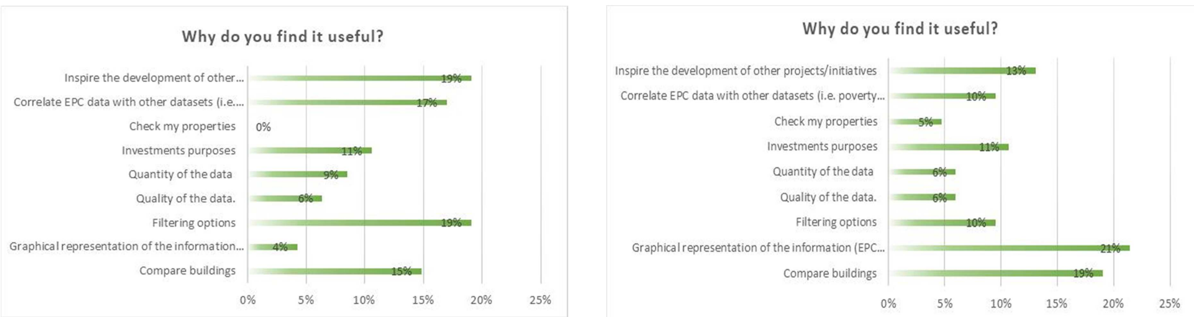

Figure 11. Important features of the tool for Spain (left) and Greece (right).

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The results clearly show that the ENERFUND tool is considered very useful, especially regarding inspiring the development of other project activities. Comparison of buildings is also certainly a feature appreciated by many stakeholders. In this regard, the ENERFUND score was developed as a methodological approach in order to allow for comparison and rating of deep renovation opportunities across European Member States. In practice, it turned out that required data often are not available as part of the Member States' OGD (open government data) data sets and that data quality is quite different. This does not only apply to Member States' level but also to regional level, for example in Spain or Austria, where the resulting EPCs and EPC databases differ depending on the regional specifications. As a conclusion, it is stated that georeferenced utilization of EPC and other relevant data, and the quality of these data, strongly depend on national and regional framework conditions which are different, as a consequence of the European legislation and the way it has been implemented in the Member States. Therefore, additional guidance notes or new ones are necessary for interpreting European Directives in view of digitalization and ambitious energy efficiency and climate targets represented by the provisions of the Energy Union [5].

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