ANALYSIS OF EU STATE OF THE ART TOOLS FOR DEEP RENOVATION OF BUILDINGS

Deliverable D.T1.2.1

Final version

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The eCentral project summary

Addressing poor energy performances of public buildings is at the core of EU's Energy Efficiency Directive and Energy Performance Building Directive but also one of growing financial issues in Central European countries. To address that eCentral project will support key stakeholders to realize benefits of newly implemented building standard – nearly zero energy building (nZEB). eCentral project will prove that nZEB approach, although innovative, is optimal and cost-effective solution for renovation and construction of public buildings. Project aims to capitalise on results of previous and ongoing EU initiatives. Austria has a proven track record with nZEB renovation projects and will be leading other implementing partners (CRO, SLO, HUN) by example. Transnational cooperation will be used to receive maximum international visibility of selected pilot actions. Main outputs of the project are:

- energy performance certificate (EPC) Tool for public authorities
- deployment and promotion of innovative financing schemes
- training programme and project development assistance for nZEB projects
- building renovation strategies for selected regions
- state of the art pilot nZEB public buildings in selected regions
- established cooperation with scientific institutions and other nZEB initiatives

Transnational Assessment and Support Group, formed from project experts and scientific institutions will act as a support team and provide quality checks of each output. EPC Tool will be developed and used by public sector decision makers and project developers beyond eCentral project lifetime. Trained energy efficiency teams within the regional government will serve as a backbone for conducting future nZEB projects. The European Academy of Bolzano (EURAC), one of the leading centres of expertise on energy efficiency in the Central Europe region, will focus on policy analysis and dissemination of eCentral project results.

About this document

This document is part of activity A.T1.2 of work package T1 and named D.T1.2.1 "Analysis of EU state of the art tools for deep renovation of buildings". The Energy agency of Styria (EAS) is responsible for this deliverable. This deliverable reveals the most appropriate tools for making analyses of public building stocks within the targeted regions for the Living EPC tool. Furthermore tools, which fits the needs of the Living EPC Tool best will be chosen to be analysed within the deliverable D.T1.2.2 in order to develop the methodology for assessment of potential cost-effective nZEB measures and energy consumption forecasting. The report shall give the following output:

- deep renovation tools, which are in use in the project partners' countries,
- possible inputs for the Living EPC tools and
- selection of tools to create suitable methodology for the Living EPC tool.

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A. Report Summary

This report provides an overview of 13 used tools for assessing cost-effective refurbishments of buildings. For the analysation, a survey was created by EAS. The project partners EURAC, ENERGIAKLUB, KSSENA and REGEA evaluated two to four tools according to the survey. The evaluation was done by EAS.

The survey consists of six sections, divided into general information, information about the building, building technology and refurbishment costs, visualisation of results and usability. The questions were designed in order to gain information about the input and output data as well as the calculation methodology.

EURAC analysed two Italian tools, ENERGIAKLUB assessed three tools from Hungary, KSSENA evaluated two tools representing Slovenia, REGEA did four Croatian tools and EAS analysed two tools from Austria.

As a result of the evaluation of 13 tools, recommendations for the design process of the living EPC tool are given. The following main points for designing the EPC tool were found:

- Include a library for making building inputs easy (also free input with real values shall be possible),
- Include a database for refurbishment costs and give the possibility to implement obtained offers as well (if present),
- The tool shall have the ability to set preferences throughout the refurbishment (exclude building parts, focus on primary energy demand, CO_2, …),
- Link real energy prices with the tool
- Make the tool easy to use – also for non-professionals

The main problem turned out to be, that most of the analysed tools are not meant for non-professionals, which is a very important requirement, when it comes to installing the Living EPC-tool. The problem is, that the subject is really complex and it is not always possible to simplify data gathering without losing accuracy within the refurbishment calculations or the status-quo analysis. This means, that the EPC tool must find this balance of usability, necessary input data and adequate output calculations for the cost-optimized nZEB refurbishment of a public building.

B. Introduction and problem definition

The nearly zero energy building standard requires the development of a new design approach that focuses more on the energy flows in buildings and requires a more dynamic and holistic approach in all topics. The nZEB standard becomes mandatory for all public buildings by 2019, which means new buildings must be carried out in a highly efficient way. To reach those targets, the project consortium will mobilize decision makers on a local and regional level and work closely with them on education and development of potential nZEB projects. Besides implementing training programmes, incorporating nZEB principles into long term require political strategies for defining the approach to achieve the goals. As part of work package T2, current national and local renovation strategies will be analysed and new regional and local energy renovation roadmaps 2030 developed. The development of these strategic documents must be based on a comprehensive status quo analysis for identifying necessary fields of actions.

A status quo analysis of buildings shows the general condition of a building, the potentials for improvement and perhaps financial and environmental aspects. For this status quo analysis, different tools are currently available within the three target regions Croatia (Sveta Nedelja), Hungary (18th district of Budapest) and Slovenia (Velenje).

Deliverable D.T1.2.1 is aiming to identify existing nZEB tools within the targeted regions, which are in use and able to analyse deep renovation measures of public buildings. The deliverable will assess existing tools to determine the most appropriate ones for making analysis of the public building stocks within the three target regions (Croatia, Hungary, Slovenia). The results of this analysis will serve as base for the regional renovation roadmaps (D.T2.4.2.) and gives new inputs and recommendations for the currently designed living EPC tool (D.T1.4.2). Additionally, it is closely connected with the follow up deliverable on methodologies for evaluating deep renovation measures for public buildings (D.T1.2.2.). Based on the results of this analysis of tools, an adequate methodology for assessment of potential cost-effective nZEB measures and energy consumption forecasting will be chosen and adapted according to the needs of EPC tool (D.T1.4.2).

Following these beforehand described premises, the survey was designed by EASt in cooperation with REGEA. In the first part of this written report the evaluation methodology of existing nZEB tools will be described. An excel-survey, created by EAS and REGEA, has been chosen as the best way to compare deep refurbishment tools in use. All in all, 13 national tools have been analysed by four project partners (EASt, ENERGIAKLUB, EURAC, REGEA, KSSENA) through this way. The survey includes a brief open description, provides general information and tries to find out in what degree the building gets captured within the tool. The survey also identifies how detailed building technologies (heating, cooling, ventilation, …) are illustrated by the tool. Furthermore, the survey provides questions about to what extent costs are represented by the tool and how results are displayed. In the end the user is able to evaluate the practicability of the tool with a scale from 1 (applies) to 5 (does not apply) and gives a brief overview about strengths and weaknesses of the tools as well as the possibility to add comments.

Based on these surveys, the tools were analysed by EASt. If possible, the tools were also tested by EASt (language barrier, accessibility, etc.) to get the best overview. The goal of this deliverable isn't, that tools are recommended to be used in the partner countries, but to provide a good overview about existing tools and to gain requirements and inspirations for the design of the Living EPC tool and some follow-up deliverables.

After the analysis of the evaluation, which were conducted by all project partners, a few tools are selected for D.T1.2.2 to sharpen the methodology of the Living EPC tool. The selection is based on the most appropriate tools, which are capable of meeting the needs of the Living EPC tool and are able to display public building stocks in the targeted regions.

1. Evaluation Methodology

In order to meet the needs of deliverable D.T1.2.1 (analysis of state of art tools) EAS decided to create a survey to get a better overview of which nZEB tools are existing in the Central European Region. The survey identifies the overall capability of a tool. The goal is to find the best tools to analyse public building stocks in the targeted regions. The selected tools, respectively their methodology will be further analysed within D.T.1.2.2, which aims to define the methodology of assessing the most cost-effective nZEB measures and energy consumption.

1.1. Survey

The main goal with the completed survey is to generate a status quo analysis of common EPC-tools within the target regions, respectively the project partners' countries. In order to get a quick overview, it is the easiest way to create a standardized survey for all tools. The survey, created by EAS and REGEA, was sent out to the knowledge partners in the partner countries (ENERGIAKLUB, EURAC, KSSENA, REGEA) who were responsible to complete the survey for 2-4 tools, which are common in their countries. In advance, it has to be mentioned that not all tools are available in English, but only in the national languages. In this terms EAS was not able to test every tool and relied onto the completed surveys.

As already mentioned, aim of the survey was to analyse national tools with ulterior motive to extract relevant functionalities and methodologies as input for the living EPC tool (D.T1.4.2.). With this objective in mind, the survey was designed to gain maximum information about required input data, calculation methodology, databases behind, calculated outputs and design and usability factors.

The survey includes yes-no questions, multiple choice questions, open evaluations as well as rating scales to identify the usability of the tools. The survey is basically divided into six different sections as follows,

1. General information,
2. Building,
3. Building technology,
4. Refurbishment costs,
5. Results,
6. Usability.

Those sections are accompanied by basic information about the title, application region and the partner, who completed the survey. In the end the evaluator has the chance to express strengths, weaknesses and comments about the tool through an open evaluation box. The blank survey is shown in chapter 1.1.7 Survey. All completed surveys of the partners are attached in the annex.

1.1.1. General information

This section of the survey covers aspects in terms of

- the availability (e.g. self- developed, internal tool or external tool),
- the target group(s) (e.g. professionals, private persons),
- the tool platform (e.g. web based, software, …),

- the costs of the tool,
- tool language,
- CO_2 factors and primary energy demand are provided by the tool,
- preferences can be set throughout the refurbishment (e.g. certain parts of the building should not be included for the refurbishment calculation e.g. insulation of walls is no option).

The above-mentioned bullet points give a quick information about how the evaluated tool is built-up in general.

1.1.2. Building

This section collects information about input data related to the building structure, which need to be feed into the tool. The building section is divided into three sub-sections such as 'General', 'Walls' and 'Windows'. For example: Is the user able to enter the heating demand/select certain building types/select various base shapes and so forth. Secondly, the survey aims to find out how walls are implemented into to the tool in order to calculate the refurbishment. At last, information on how windows are involved in the total refurbishment calculation.

For calculating refurbishments this section is essential because it shows how detailed the refurbishment is calculated and if certain preferences (e.g. ecological aspects) can be defined.

1.1.3. Building technology

The section "Building technology" is divided into two sub-sections, namely "Heating" and "Ventilation and Cooling". The survey works out how the energy demand is included in the tool (e.g. free input or calculated by the system), if it is possible to enter the distribution system, the heating source, and the share of renewables. In the sub-section "Ventilation and Cooling" the survey identifies if and how the energy demand for cooling and ventilation is taken into account in the refurbishment.

1.1.4. Refurbishment costs

Refurbishment costs are mandatory, when it comes to economic decisions throughout refurbishments considerations. Concerning refurbishment costs, it is important to know, if costs are provided by the tool itself or if the user is able to enter values based on real offers from suppliers. However, the survey also identifies which preferences can be set throughout the refurbishment calculation (e.g. set maximum investment costs, …).

1.1.5. Results

This section deals with the illustration of the calculated results. The following questions are asked within this section:

- Are various refurbishment alternatives displayed?
- Is primary energy outlined by the tool?
- Is a CO_2-calculation provided by the tool?

- What methodology is used for the economic efficiency calculation? (e.g. static or dynamic)
- Are follow-up costs integrated within the tools refurbishment calculation? (e.g. energy consumption, maintenance and repair, life cycle costs, etc.)

1.1.6. Usability

The last main section is aiming on the usability of the evaluated tool. The evaluator is required to vote the usability of the tool (intuitive use, visualisation, easy to use, etc.) by evaluating from “1 – applies” to “5 - does not apply”. This displays the personal opinion of the evaluators, whether the EPC-Tool shall be in a similar way or not.

1.1.7. Survey

D.T1.2.1: Analysis of EU state of the art tools for building renovation

Assessment of existing "building" tools in eCentral partner countries

Colour codes: drop-down-menu | open evaluation | rating scale (1-5)

Title of the tool

Subtitle of the tool (if existing)

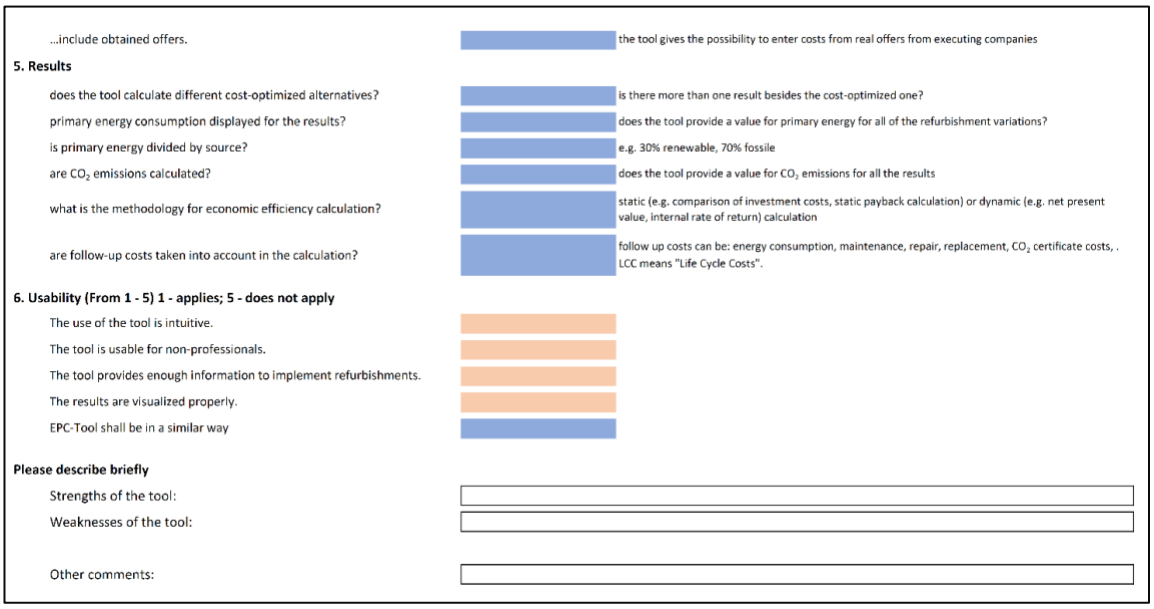
Application region

Form filled out by...

Short description of the tool

	Evaluation	*Information*
1. General		
Availability of the tool?		internal developed tool or buyable tool
Target Group?		who is the end user of the tool
Platform of the tool?		e.g. web-based, software, MS-excel, other
Costs of the tool?		for purchasing
Selection of preferences for the refurbishment available?		e.g. select which parts should be taken into account when calculating the refurbishment
Can you enter primary energy factors or CO_2 factors?		e.g. NO means that they are predefined in the tool
How are energy prices entered?		are there pre-defined energy prices or do you have to enter them on you own?
Language of the tool?		e.g. national language or english or both
2. Building		
2.1 General		
I am able to ...		
...enter the heating and primary energy demand of the building.		e.g. from energy performance certificates, either specific [kWh/m²a] or absolute [kWh(natural gas)/a]
...select certain building types.		e.g. detached; terraced;
...select various base shapes.		e.g. Rectangular; L-Shape; T-Shape; Cross; H-Shape; S-Shape; ...
...incorporate customized floor plans.		e.g draw or upload a floor plan with own measures
...choose certain building types by usage.		single family house; Office building; Hospital; multi-family houses
...set priorities for refurbishment measures.		e.g. priorize ecological materials, primary energy, maximum investment costs
2.1 Walls		
I am able to ...		
...choose wall types provided by the tool.		the tool provides a library/database, where walls can be choosen from
...enter wall areas in m².		enter total area for walls in m²
...enter walls by u-value.		define layer after layer by providing thicknness [mm;cm;m] and thermal conductivity (λ-value) [W/mK]
...enter wall mounting.		the tool offers the ability to define wall structures layer by layer (library-based) in cm
2.2 Windows		
I am able to ...		
...choose window types provided by the tool.		the tool provides a library/database, where windows can be choosen from
...enter window areas in m².		enter total area for windows in m²
...enter dimensions of each window.		height and width of window
...enter windows by u-value or g-value.		set u-value [W/m²K] and/or g-value [-] for status quo analysis as well as refurbishment
3. Building technology		
3.1 Heating		
How does the tool identify the heating energy demand?		energy which is fed into the heating system e.g. liter of heating oil, m³ wood, etc.
I am able to ...		
...enter the heating distribution system.		e.g. heating distribution by radiators or/and surface heating
...enter the heating source.		e.g. natural gas, oil, biomass, ...
...enter percentages of used renewables.		e.g. 30% from renewables, 70% from fossils
...enter gains from excess energy.		e.g. electricity from PV production fed into the grid
3.2 Ventilation & Cooling		
How does the tool identify the energy demand for ventilation?		own value e.g. from calculations for dimensioning the ventilation system. Calculated by the tool by specifying the system
How does the tool identify the energy demand for cooling?		own value e.g. from cooling demand calculations. Calculated by the tool by specifying the system
4. Refurbishment costs		
Refurbishment costs are provided and will be calculated automatically (empiric library).		is a library or database with costs is embedded in the tool
I am able to ...		
...set maximum costs for the refurbishment.		e.g. a value in € that defines the upper limit of renovation costs

Figure 1: Overview blank survey – part 1



...include obtained offers.		the tool gives the possibility to enter costs from real offers from executing companies
5. Results		
does the tool calculate different cost-optimized alternatives?		is there more than one result besides the cost-optimized one?
primary energy consumption displayed for the results?		does the tool provide a value for primary energy for all of the refurbishment variations?
is primary energy divided by source?		e.g. 30% renewable, 70% fossile
are CO_2 emissions calculated?		does the tool provide a value for CO_2 emissions for all the results
what is the methodology for economic efficiency calculation?		static (e.g. comparison of investment costs, static payback calculation) or dynamic (e.g. net present value, internal rate of return) calculation
are follow-up costs taken into account in the calculation?		follow up costs can be: energy consumption, maintenance, repair, replacement, CO_2 certificate costs, . LCC means "Life Cycle Costs".
6. Usability (From 1 - 5) 1 - applies; 5 - does not apply		
The use of the tool is intuitive.		
The tool is usable for non-professionals.		
The tool provides enough information to implement refurbishments.		
The results are visualized properly.		
EPC-Tool shall be in a similar way		
Please describe briefly		
Strengths of the tool:		
Weaknesses of the tool:		
Other comments:		

Figure 2: Overview blank survey – part 2

2. Results of the survey

This chapter provides an overview of the results of the surveys and gives and interpretation of the results.

The completed surveys show different approaches of how refurbishment measures can be implemented in a tool. Most of the evaluated tools are designed to be used only for experts. This results mainly because of the many detailed technical information that is required to be entered in the tool to calculate refurbishment measures and their savings (energy; monetary).

The section ***General information*** in the completed survey provides basic information about the evaluated tools. According to the information collected by the surveys, eleven out of thirteen tools are available for the public, but only one is useable for non-professionals (Baza Mjera evaluated by REGEA). According to REGEA, the tool Baza Mjera is a decision support tool, user-friendly, dynamic (ability to update data) and has the ability to aggregate data.

The result that only one of 13 tools is also usable for non-professionals is justified with the fairly complex subject in terms of building physics, material properties and building technologies. The tools are mainly provided through a programmed software (eight), but also MS Excel (three) or web-based (two) are available throughout the project partners' countries. The language of the tools is mostly the national language (nine) but also four tools provide an English version of the tool. Setting preferred measures within the refurbishment process (e.g. exclude basement ceiling form refurbishment calculation) is possible in nine out of 13 evaluated tools. Entering primary energy factors is also provided by six of the tools.

The way of collecting information about the ***Building*** **structure, physics and other information** varies from tool to tool. The evaluation matters of this section are displayed in the figure below.

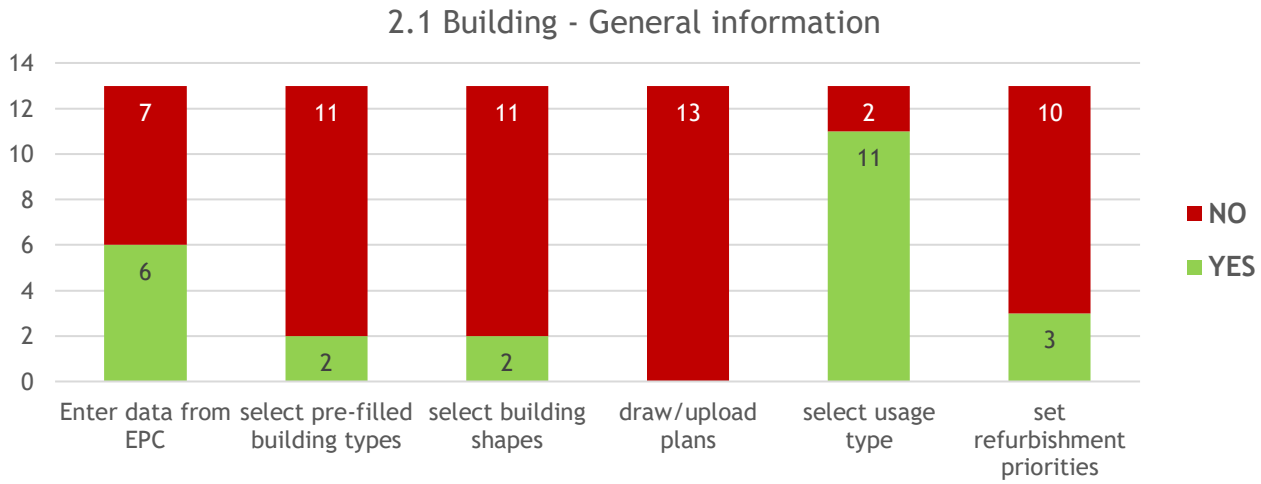


Figure 3: Summary – abilities of tool in section general information

As visible above, the majority of the tools seem to be little automatized; only two are able to select building types and building shapes from database. No tool has the ability to provide an implementation section for plans and only three are able to set refurbishment priorities. This confirms the above-mentioned impression, that these types of tools are currently too complicated to be used by non-professionals, since a lot of input data is required.

Some tools are gathering information with helpful libraries, some give the user the ability to implement data from an energy performance certificate (e.g. energy pass). Data from the energy performance

certificate usually describe the energy demand from the whole building, but don't provide detailed information about certain parts of the building. Another option is that some tools let the user define each wall by entering the wall area and wall mounting – layer by layer. The summary of the tool functionalities regarding entering the building walls are shown in the figure below. The majority of the tools allows to enter wall specifications quite into detail (area, u-value, mounting).

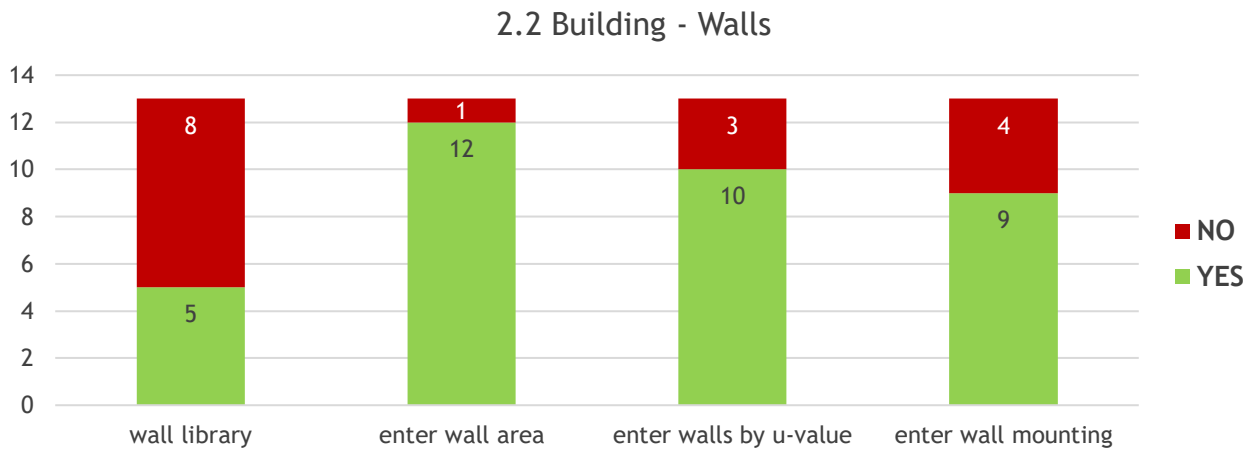


Figure 4: Summary – how to enter information about building walls

Concerning windows, it is also possible that the tool provides a library with various types of common windows and the possibility to enter the size of windows or simply define the total window area of the building. The figure below gives an overview about the different possibilities, which are similar to the wall section.

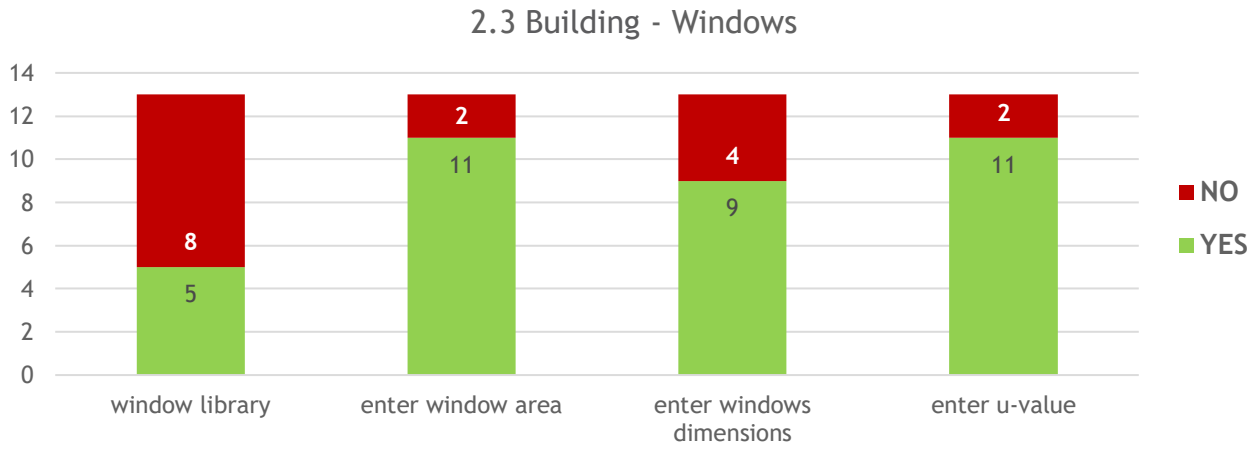


Figure 5: Summary – how to enter information about windows

Collecting data about the ***building technology*** is displayed within the third section of the completed surveys. The heating energy demand is mainly calculated by the tool by using the before entered data. In general, almost all tools provide the option to select "a heating distribution system" as well as the "heating source" of the heating system. 10 from 13 evaluated tools also include the calculation of energy gains produced by photovoltaics or other energy productions such as solar thermal energy (covering heating or hot water demand). In the authors' opinion, capturing the heating demand as well as calculating the

associated primary energy demand is mandatory for gaining processable calculation results from the tool. The figure below shows the functionalities of the tools on how to implement the building's heating system. The majority of the tools allows to enter a heating distribution system, the energy source and energy production. Only five from 13 are able to include the share of renewables.

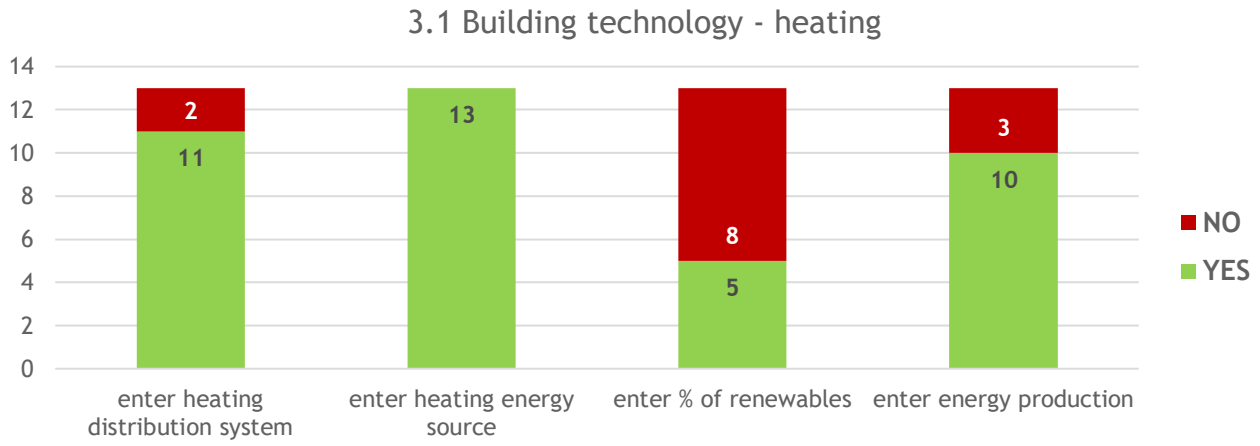


Figure 6: Summary – how to enter information about the heating system

Besides the heating system, the VAC-System (ventilation and air condition) is a main energy consumer with the building system and necessary to be included when it comes to refurbishment measures. This is not only because of the protection of sensitive building stock but also because of the thermal comfort within recreation rooms. As shown in Figure 7, most of the evaluated tools – 11 out of 13 - provide a possibility to include the energy demand for ventilation: either calculated by the tool according to the input data or as input by the user. Cooling, which is especially important for office buildings, is also taken into account by the majority of the evaluated tools. Especially with the coming challenges concerning air exchanger, protecting the building structure and the higher cooling demand it is necessary to take VAC into account when it comes to refurbishment measures within public building stock.

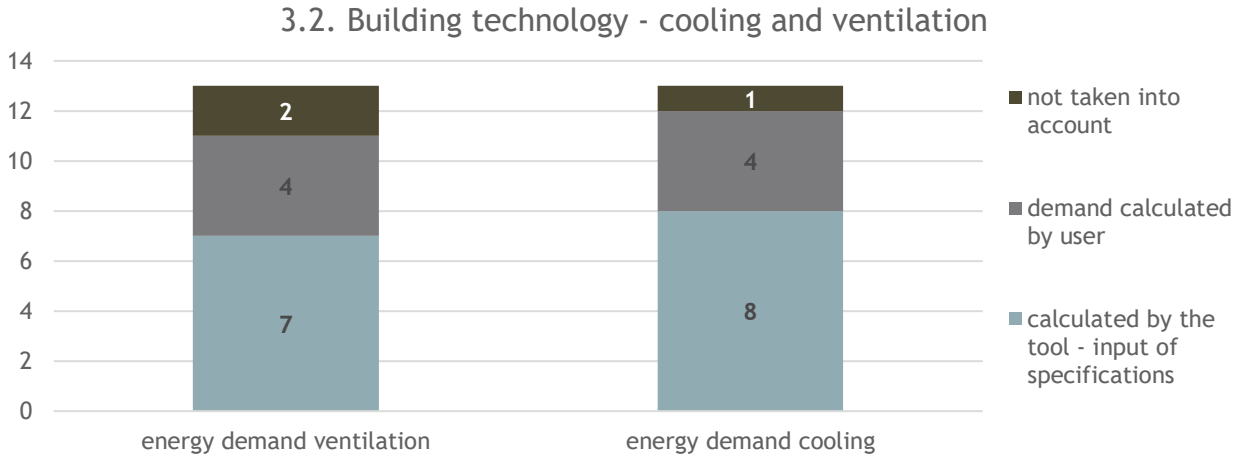


Figure 7: Summary – how to enter energy demand for cooling and ventilation system

In the view of the eCentral project partners, considering the ***refurbishment costs*** are an elementary component of the Living EPC-tool to compare various refurbishment opportunities. The analysis of the surveys shows that only three (CERPLAN (IT); ECOCITIES (AT); BAZA MJERA (HR)) of the evaluated tools include costs in the refurbishment analysis based on a library, which includes average investment costs for single refurbishment measures. In those three tools it is also possible to include the maximum possible investment costs. This function is necessary to find out, which alternative is the most suitable one for the available budget or for the planned (primary) energy reduction. In the tools CERPLAN and BAZA MJERA, one can also implement obtained offers from companies. This function is also available within ECONCALC 3.0 and WINWATT, in which no library is provided by the tool. Including obtained offers gives the user the ability to get information about the amortisation of an investment underpinned with real prices. Comprising it's needless to mention, that refurbishment costs need to be added (e.g. as an updating library in the background) in the Living EPC tool to give public authorities the ability to compare existing alternatives. Therefore, it is useful that the user of the tool is capable to implement real prices by including obtained offers. The figure below summarizes the beforehand description.

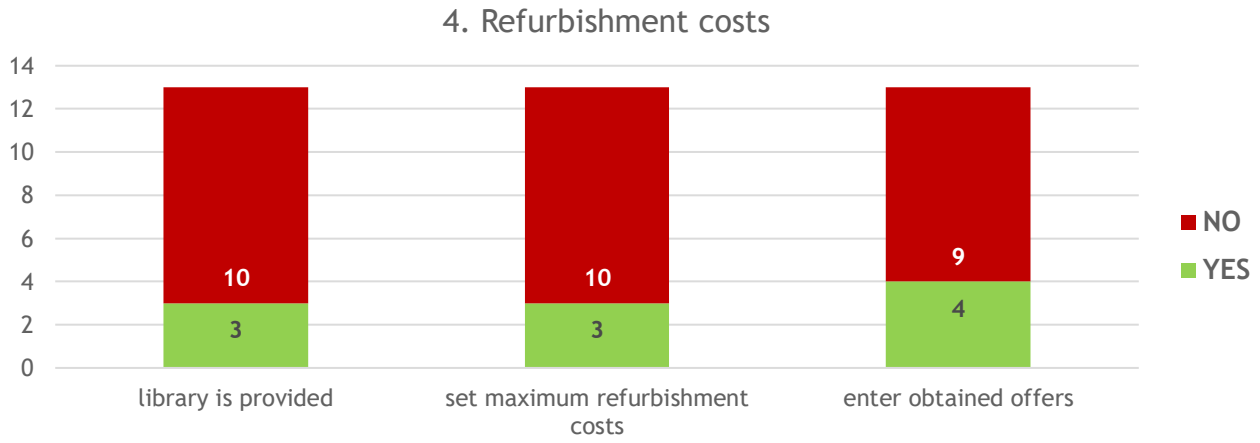


Figure 8: Summary – how to enter refurbishment costs

All tools seem to display ***results*** adequately, but it is not mandatory to include the calculation of the most cost-effective bundle of measure for a potential refurbishment. Almost all tools show the CO_2-emissions, the primary energy demand and the energy consumed divided by source. From all evaluated tools only 3 take follow-up costs into account and provide a suitable LCC analysis for the refurbishment measures that have been calculated (CERPLAN (IT), EconCalc (AT), ECOCITIES (AT)).

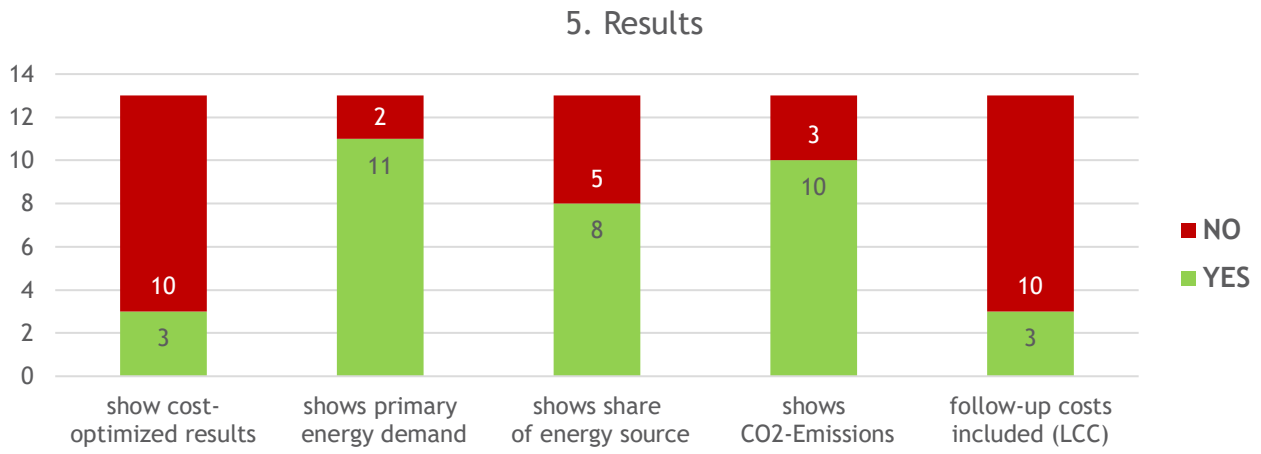


Figure 9: Results of the tools

The ***Usability*** of the evaluated tools vary a lot between the tools. Although all results are visualized properly, most of the tools are not intuitive but complex. Especially the assessment shows, that the evaluated tools are not usable for non-professionals. The tools are mainly designed for professionals with deep knowhow. The evaluation of the surveys also presumes that not enough information is provided by the tools throughout the refurbishment calculation procedure. The figure below shows the average usability of the completed assessment. The tools with the best ratings regarding usability are CERPLAN (Ø1,75), ECOCITIES and Baza mjera (each Ø 2,0) and ProCasaClima (Ø2,25).

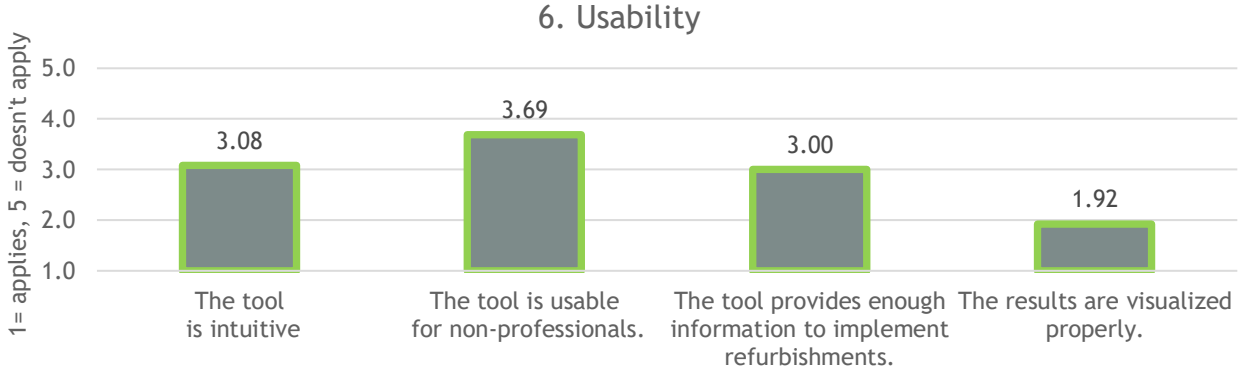


Figure 10: Summary – Rating of usability of the evaluated tools

Especially displaying the calculated results and the usability is a very important component, when it comes to tools, which should be used by non-experts. Tools tend to gather very much information (e.g. about buildings, heating system, ...) but do not provide an adequate form of visualisation, which lead the user (e.g. public authorities) to a decision-making process.

The chart below shows the subjective rating of the tools according to the consortium's opinion. The points were summed up from the last two sections "5. Results" ("Yes" 0 Points; "No" 1 Point) and 6. Usability (1=applies, 5 = doesn't apply). The lower the achieved points, the better the tool got rated to serve as good role model for the Living EPC tool in eCentral.

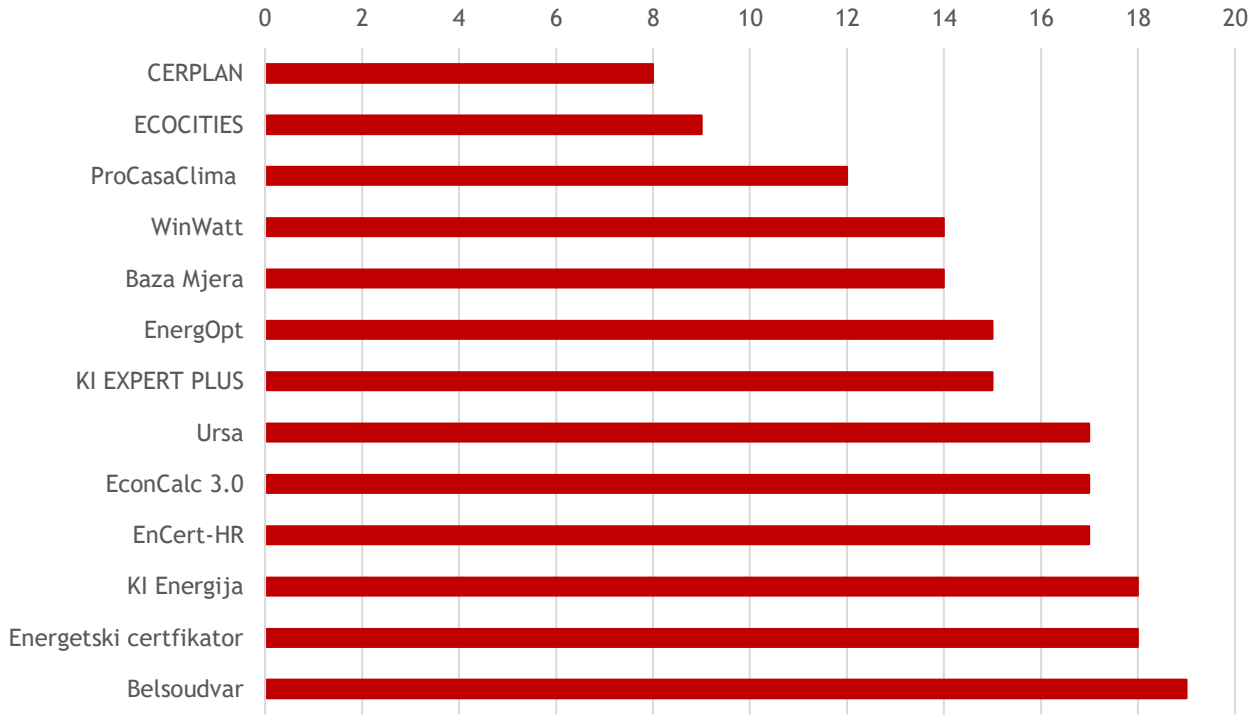


Figure 11: Results of the rating to serve as role model for the Living EPC tool

3. Detailed results - the evaluated tools

Following chapter provides more detailed information about the assessed tools. As already mentioned, the tools were evaluated by the project partners according to the survey created by EAS.

The tools which were evaluated are:

1. ProCasaClima (Italy)
2. CERPLAN (Italy)
3. Belsoudvar (Hungary)
4. EnergOpt (Hungary)
5. WinWatt (Hungary)
6. KI Energija (Slovenia)
7. URSA (Slovenia)
8. EconCalc 3.0 (Austria)
9. ECOCITIES (Austria)
10. Baza mjera (Croatia)
11. EnCert-HR (Croatia)
12. Energetski certifikator (Croatia)
13. KI Expert Plus (Croatia)

In the following sub-sections, every evaluated tool will be introduced and will be analysed in terms of its ability to function as role model for the Living EPC-Tool. The table consists of basic information about the tool such as application region, language and costs. In addition, the table provides information about the way of data gathering, missing elements in the tool and possible inputs for the Living EPC-tool. The goal of the following charts is to introduce the existing tools from the project partners regions and to summarize important findings. The original surveys filled out by the project partners can be find in the annex of this deliverable.

The following table provides a quick overview about all tools and their way of calculating refurbishment measures. Also, it shows how the different tools are gathering data about the building. It is the qualitative analyses of the completed surveys and aims show the different approaches between project partners' countries. The table is sorted according to their relevance for designing the EPC tool.

Title	CERPLAN	EnergOpt	Winwatt	KI Energija
Subtitle			Cinege	Knauf Insulation
Application Region	Italy	Hungary	Hungary	Slovenia
Target group	Experts/official institutions	Experts/official institutions	Experts/official institutions	Experts/official institutions
Costs	chargeable	Free	Chargeable	Free
Language	English; Italian	English; Hungarian	English; Hungarian	Slovenian
The tool has the ability to…	Define: ▪ Heating demand ▪ primary energy demand ▪ CO_2-Emissions (e.g. from energy pass, performance cert., etc.) ▪ base shapes, ▪ usage types ▪ walls, windows (layers, u-value or other) Enter: ▪ max. investment costs ▪ obtained offers Calculate: ▪ cooling demand ▪ Refurbishment costs ▪ Generate most cost-effective alternatives	Define: ▪ Usage type ▪ Wall and window area ▪ Wall mounting (layer by layer from a library) ▪ Windows by u-value, dimensions, etc. ▪ Ventilation and cooling strategy and efficiency Enter: ▪ Type of heating distribution ▪ heating source ▪ mechanical ventilation performance ▪ percentage of renewables Calculate: ▪ Heating demand ▪ CO_2-emissions ▪ Share of renewables	Define: ▪ Usage type ▪ Wall and window area ▪ Wall mounting layer by layer ▪ Windows by u-value, dimensions, etc. ▪ Ventilation and cooling preferences ▪ Heating distribution system ▪ Enter positive energy impacts (pv-production) Enter: ▪ Heating distribution ▪ heating source ▪ ventilation performance ▪ share of renewables ▪ obtained offers Calculate: ▪ Heating, cooling and ventilation demand	Define: ▪ Usage type ▪ Wall and window area ▪ Wall mounting (layer by layer from a library) ▪ Windows by u-value, dimensions, etc. ▪ Ventilation and cooling ▪ Heating distribution system ▪ Enter positive energy impacts Enter: ▪ Energy demand (e.g. from EPC)) ▪ heating source ▪ mechanical ventilation performance ▪ percentage of renewables Calculate: ▪ primary energy demand ▪ CO_2-Emissions ▪ Heating, cooling and ventilation demand
Possible inputs for EPC-Tool	▪ Comparison of energy savings and investment costs ▪ Visualization of results ▪ Usability is also for non-professionals	▪ Very detailed data capturing	▪ Visualization of results (displays primary energy demand) ▪ Obtained offers can be implemented ▪	▪ Library for walls and windows ▪ Wall definition possible (layer by layer with a library)

Title	URSA	EconCalc 3.0	ECOCITIES	Baza Mjera	EnCert-HR
Subtitle		Kosten- und Wirtschaftlichkeits-rechner	Optimizing the energy efficiency of building portfolios		
Application Region	Slovenia	Austria	Austria	Croatia	Croatia
Target group	Experts/official institutions	Experts/official institutions	Experts/official institutions	End-User	Experts/official institutions
Costs	Free	Free	chargeable	Free (MS-excel)	Chargeable
Language	Slovenian	German	English; German	Croatian	Croatian
The tool has the ability to…	<u>Define:</u> ▪ Building type ▪ Wall and window area ▪ Walls provided by library or layer by layer ▪ Windows by u-value, dimensions, etc. ▪ Ventilation and cooling preferences ▪ Heating source and distribution system ▪ CO_2-factors ▪ Enter positive energy impacts <u>Enter:</u> ▪ Energy demand (e.g. EPC) <u>Calculate:</u> ▪ primary energy demand ▪ CO_2-Emissions ▪ Heating, cooling and ventilation demand	<u>Define:</u> ▪ Enter positive energy impacts (e.g. pv-production) <u>Enter:</u> ▪ Energy demand (e.g. from energy performance certificate) ▪ Heating demand ▪ Cooling demand ▪ Ventilation demand ▪ heating source ▪ total area of walls ▪ primary energy factors ▪ CO_2-factors <u>Calculate:</u> ▪ Most cost-effective measures (financially)	<u>Define:</u> ▪ Building type (by usage) ▪ Priorities of the refurbishment ▪ Wall and window area ▪ Wall mounting (layer by layer from a library) ▪ Windows by u-value, ▪ Heating distribution system ▪ Enter positive energy impacts (e.g. pv-production) <u>Enter:</u> ▪ Energy demand (e.g. EPC) ▪ Energy demand for ventilation and cooling ▪ Enter heating source <u>Calculate:</u> ▪ Alternatives for refurbishment ▪ Shows costs and future savings for each refurbishment measures	<u>Define:</u> ▪ Wall and window area ▪ Enter walls and windows by u-value ▪ Heating Distribution system <u>Enter:</u> ▪ Energy demand (e.g. from energy performance certificate) ▪ Enter energy demand for ventilation and cooling ▪ heating source ▪ obtained offers for refurbishment <u>Calculate:</u> ▪ Refurbishment costs ▪ Energy savings	<u>Define:</u> ▪ Usage type ▪ Wall and window area ▪ Walls provided by library ▪ Wall mounting (u-value; layer by layer from a library) ▪ Windows by u-value, dimensions, etc. ▪ Ventilation and cooling preferences ▪ Heating distribution system <u>Enter:</u> ▪ heating source ▪ positive energy impacts (e.g. pv-production) <u>Calculate:</u> ▪ primary energy demand ▪ CO_2-Emissions ▪ Heating, cooling and ventilation demand
Possible inputs for EPC-Tool	▪ Library for walls and windows ▪ Wall definition possible (layer by layer with a library) ▪ Select priorities for the refurbishment	▪ Up to 5 different alternatives are compared in a cost-effective perspective ▪ Obtained offers are included ▪ Subsidies can be displayed by the tool	▪ Displays groups of buildings ▪ Refurbishment costs are provided by the tool (library) ▪ Set maximum costs ▪ Calculates most cost-effective alternative	▪ Individual Wall definition possible (layer by layer) ▪ Refurbishment costs for measures embedded in the tool ▪ Select priorities for the refurbishment	▪ Library for walls and windows ▪ Wall definition possible (layer by layer with a library) ▪ Select priorities for the refurbishment

Title	Energetski certifikator	KI Expert PLUS	Belsoudvar	ProCasaClima
Subtitle				
Application Region	Croatia	Slovenia	Hungary	Italy
Target group	Experts/official institutions	Experts/official institutions	Experts/official institutions	Experts/official institutions
Costs	Free	Chargeable	free	Free
Language	Croatian	Croatian	Hungarian	Italian; German
The tool has the ability to…	<u>Define:</u> ▪ Building type (by usage) ▪ Total wall and window area ▪ Wall mounting (u-value; layer by layer - with a library) ▪ Windows by u-value, dimensions, etc. ▪ Ventilation and cooling preferences ▪ Heating Distribution system <u>Enter:</u> ▪ Heating source ▪ Refurbishment preferences ▪ Positive energy impacts <u>Calculate:</u> ▪ Primary energy demand by source ▪ CO_2-Emissions ▪ Heating, cooling and ventilation demand	<u>Define:</u> ▪ Refurbishment priorities ▪ Building type (by usage) ▪ Wall and window area ▪ Walls and windows are provided by a library ▪ Wall mounting layer by layer from a library possible ▪ Windows by u-value, dimensions, etc. ▪ Ventilation and cooling preferences (specifications) ▪ Heating Distribution system <u>Enter:</u> ▪ Heating source ▪ Positive energy impacts (e.g. Pv-production) <u>Calculate:</u> ▪ Primary energy demand ▪ CO_2-Emissions ▪ Heating, cooling and ventilation demand	<u>Define:</u> ▪ Usage type ▪ CO_2-factors ▪ Wall mounting (layer by layer from a library) ▪ Windows by u-value, dimensions, etc. <u>Enter:</u> ▪ Heating Distribution system <u>Calculate:</u> ▪ Heating demand	<u>Define:</u> ▪ Walls, windows (layers, u-value, …) ▪ Usage types <u>Enter:</u> ▪ Ventilation preferences for mechanical ventilation systems ▪ Cooling preferences for the cooling system (if existing) <u>Calculate:</u> ▪ Primary energy demand, ▪ CO_2-Emissions, ▪ Heating demand ▪ Cooling demand
Possible inputs for EPC-Tool	▪ Library for windows ▪ Wall definition possible (layer by layer with a library) ▪ Select priorities for the refurbishment	▪ Library for walls and windows ▪ Wall definition possible (layer by layer with a library) ▪ Select priorities for the refurbishment	None	None

The overall table shows the differences between the evaluated tools. Especially the way of how data is collected differs between tools. The input can vary from a library-based input to a total open input, which includes the definition of the wall mounting layer by layer. Some tools provide both opportunities. Also, a lot of tools do not take refurbishment costs into account, which is mandatory for a planned refurbishment, because the goal is to find the most cost-effective measure. Within the introduced tools ecological aspects play a minor role when it comes to compare refurbishment measures or are not even taken into account. All tools provide a way to illustrate the heating system in some way. At least the distribution or/and the heating source (biomass, oil, natural gas, …) can be defined. At this point it has to be mentioned, that some tool is able to include external calculations concerning heating, cooling and/or ventilation energy demand. Correspondingly the tool only has to calculate the CO_2-emissions, that are emitted by the selected heating source. Implementing external calculations is an easy way to analyse the energy balance of building, but there are no detailed refurbishment measures possible, because the tool doesn't have any information about the status quo of the building structure (quality of wall, windows, ceilings, roofs…). Therefore, implemented external information can always be an extra-feature, when it comes to refurbishment measures, but a detailed description of components is essential.

The main problem turned out to be, that the tools are not meant for non-professionals, which is a very important requirement, when it comes to installing the Living EPC-tool. The problem is, that the subject is really complex, and it is not always possible to simplify data gathering without losing accuracy within the refurbishment calculations or the status-quo analysis.

As written in the introduction, this deliverable shall give a recommendation for the follow-up deliverable D.T1.2.2 methodology for evaluating deep renovation measures of public buildings. To sharpen the calculation methodology for Living EPC tool the most appropriate tools, which are capable of meeting the needs of the Living EPC tool and are able to display public building stocks in the targeted regions shall be selected and their methodology investigated.

The authors of this deliverables think, that ECOCITIES and CERPlan are the tools of which the methodology fits best to the designated LIVING EPC tool, because it is not only providing a database for refurbishment costs as well as libraries for building input, but also offers to implement several buildings within one municipality.

Both tools are charged with a fee for utilization. CERPlan was developed by EURAC for investigating the refurbishment concepts for the province of Bolzano in Italy.

4. Conclusion

The goal of this deliverable is to assess existing nZEB tools in the project regions in order to determine the most appropriate ones for analysing the public building stocks within the targeted regions. As assessed the tool shall calculate the cost optimal nZEB renovation approach for public buildings. The Living EPC tool shall be simple to use and available in each national language of the target regions (SLO; HR; HU). If possible, the inputs shall be the same in all three countries (e.g. taken from the energy performance certificate), but the output format can differ depending on the countries. This is due to different requirements to meet the nZEB standards within the target regions. The methodology for the calculation will still be the same in all variations. As the completed assessment shows, it is not only mandatory to provide information within the tool but also a detailed planned enrolment with periodic revisions for the (end)-users. It is necessary that the user is able to apply the tool in the designated way. It shall also assist public authorities to adequately interpret the information on EPCs. Another requirement for the tool is to implement existing information from energy performance certificates.

To simplify planned refurbishment process for the public authorities the tool is divided into two levels. One is the user-based simplified version with easy decision support for approaching cost optimized nZEB-refurbishments. The second level is designed for experts to update the database behind the EPC tool. This database should also automatically implement energy prices periodically.

To sum up the following inputs from the 13 tools provide an inspiration for the design of the EPC tool:

- a library for making building inputs easy (also free input with real values shall be possible),
- if not already available, a rough overview on heat demand as well as associated primary energy demand shall be calculated by the tool,
- a database for refurbishment costs (based on average costs of real projects) as well as implementing obtained offers,
- the ability to set preferences throughout the refurbishment process (exclude building parts, focus on primary energy demand, CO_2, …),
- real energy prices (linked to online portal or something similar),
- easy to use – focus on non-professionals since several tools for professionals are available,
- provide overview on several cost-optimised alternatives and compare energy savings and investment costs,
- a result, which shows the most cost-optimized refurbishment,
- including LCA may be a special asset for highlighting the advantages of nZEB renovations.

5. Table of figures