Black Sea Basin Joint Operational Programme 2007-2013

BSBEEP
Black Sea Buildings Energy Efficiency Plan

GA2: Preparation and implementation –
Analysis of internal current situation

Activity GA2.2

Investigation and development of an energy consumption assessment tool (e-tool) for buildings

Draft Version

Table of Contents (indicative proposal)

1. Introduction

[SEE GA2.2_DUTH_FINAL_STUDY_OTHER_TOOLS]

2. E-tool development

2.1 Theoretical background

The numbers of buildings that fall under a municipality's jurisdiction are in the order of thousands and in that aspect the analytical energy assessment of every building is costly in terms of time and effort. Analytical tools are already available in market that can comprehensively assess various aspects regarding energy efficiency and performance of buildings. However these tools require most of the time a noticeable level of expertise to be implemented. In many situations municipal authorities need to decide quickly whereas the evaluation and the results have to be applied by civil servants or other staff with limited scientific knowledge.

The specific e-tool will enhance decision making of municipal authorities and relevant agents by helping them assess the energy consumption of buildings fast but effectively. The proposed e-tool is based on the following concepts:

- The inputs are easily accessible or easily calculated by the e-tool user,
- The e-tool has a qualitative and quantitative output (result),
- The e-tool is easily installed and operated in every PC (with Microsoft Excel or web-based application) by non experts as well,
- The e-tool is upgradable in order for the potential users to develop it further in the future if they wish so.

The Figure below gives a schematic representation of the proposed e-tool.

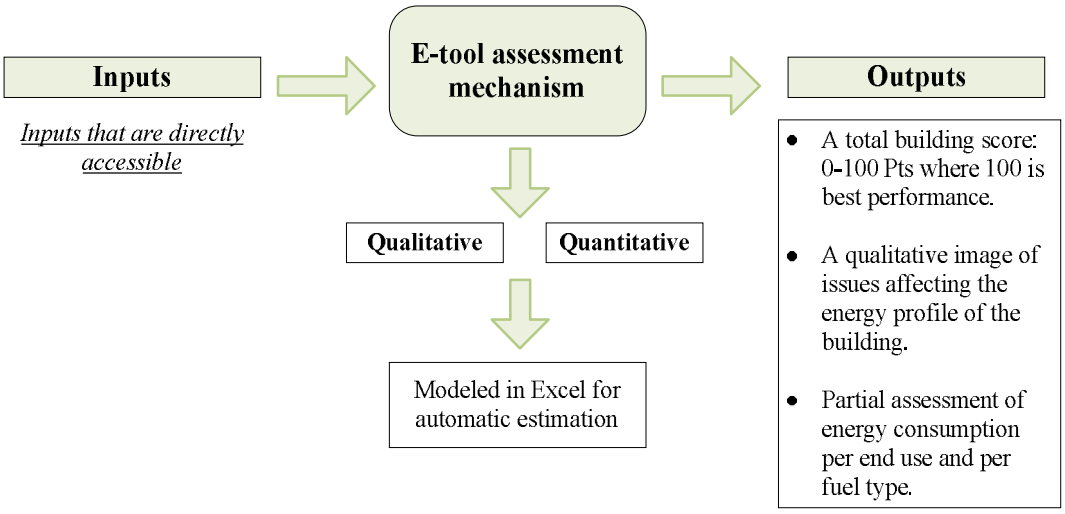


Figure 1. General concept of the proposed e-tool.

The proposed assessment mechanism consists of two levels of assessment:

1. **Qualitative assessment** (0-50 points)

Focus: Energy saving potential (building assessment)

- The specific procedure assesses the current features of the examined building in order to provide a quick qualitative image of the performance of the building based on best available practices.
- The specific method require simple qualitative inputs (questions in multiple choice form) to perform the assessment. In that aspect, if someone is not aware of the energy consumption of the building can also use the tool.
- Buildings with high score are energy efficient and have therefore low potential for energy efficiency interventions. On the other hand, buildings with low score have high potential for energy efficiency interventions.

2. **Quantitative assessment** (0-50 points)
Focus: Building energy demand and building actual consumption

- The specific procedure takes into account European orientation and legislation and provides sound and more technical analysis of the expected energy demands/consumption of the building. More concretely, it compares the annual energy consumption of the building (per end use and per type of energy) with the national average for the specific type of buildings (in KWh/m^2). In that aspect, even if someone is only aware of its energy consumption (not knowing type of insulation, glazing type etc.) can also use the tool.
- Many users despite the fact that they live in relatively energy efficient buildings act irresponsibly in terms of energy saving (e.g. air condition with open windows on municipal offices). In that way the e-tool can also capture in its score energy irresponsible attitudes.

With the categorization of the assessment in two levels, someone is able to use the e-tool even with a small amount of data, whereas those who wish to have a more analytical assessment can also apply it. The compilation of quantitative and qualitative assessment provides the final score ranging from 0-100 Pts where 100 is maximum performance. The analytical development of BSBEEP e-tool is described on the next chapters.

2.2 Qualitative assessment

The qualitative assessment is performed through the evaluation of five generic categories related with the features of the examined building namely:

a) Building envelope (BE)
b) Heating system (HS)
c) Cooling system (CS)
d) Lighting system (LS) and
e) Domestic hot water (DHW)

A number of sub-indicators were chosen for every category in order to cover the most significant issues that are related with the specific category. For example, the category BE is assessed through the analysis of the type of insulation, glazing and frames. Since a level of simplicity had to be retained at this point, the sub-indicators were chosen according to the following criteria:

- They should be easily understood by non experts.
- They should not require analytical estimations and can be assessed using a multiple choice form.
- They efficiently cover key issues that affect the energy performance of the building.

The sub-indicators chosen for the assessment and their description are summarized in Table 1. In total 15 sub-indicators were chosen. For every category a score of 0-10 is given, where 0 indicates the worst performance and 10 the best. The overall rating is derived from the partial rating of every sub-indicator. The evaluation is performed based on the best available practices available in each category. Best available practices for buildings were analytically assessed and are presented in the final study of GA1.3 of BSBEEP project available on BSBEEP website. The higher the level of integration of best available practices on the examined building, the higher its score. The reasoning behind the evaluation of every category is summarized in Table 2.

The types of HS, CS and DHW were ranked according to their combined energy efficiency and respective emissions from their use. Consequently systems with relatively high energy performance are assessed lower if they exhibit high levels of emissions (especially CO_2, CO, PM_{10}, SO_x and NO_x). The presence of automation systems and regular maintenance can further increase the energy consumption performance of the examined building.

In order to promote the utilization of renewable energy systems (RES) for satisfying the energy needs of the building, a bonus score of +10 Pts is given to those buildings that integrate them. The bonus score is applied to buildings that:

- Have photovoltaic systems installed (on roof or walls).
- Have small scale wind energy turbines installed.
- Utilize geothermal energy.

The bonus score is added on the final score of the five categories. For example if the score of a building is 32 and has PV panels installed on its roof, its final score will be 42. The bonus applies until the maximum score reaches 50 and cannot exceed this limit.

Table 1. Sub-indicators for assessing the energy performance of the building.

Category	Sub-indicators	Description
BE	Thermal insulation	Thermal insulation in buildings is an important factor for achieving thermal comfort for their occupants. Insulation reduces unwanted heat loss or gain and can decrease the energy demands of heating and cooling systems.
	Glazing	Glass and glazing selection play a key role in determining the overall building's thermal performance.
	Frames	The material used to manufacture the frame of the windows/doors has a significant impact on the thermal characteristics of the building.
HS	Type	Various types of heating systems exhibit different levels of energy and cost efficiency and impact on environment and human health.
	Automation	The presence of automation and management systems for controlling the heating system can significantly increase the building's energy efficiency.
	Maintenance	Frequent maintenance according to HS manufacturer can increase the efficiency of the respective HS.
CS	Type	Various types of heating systems exhibit different levels of energy and cost efficiency and impact on environment and human health.
	Automation	The presence of automation and management systems for controlling the cooling system can significantly increase the building's energy efficiency.
	Maintenance	Frequent maintenance according to CS manufacturer can increase the efficiency of the respective CS.
LS	Type	Different type of bulbs can provide higher lighting comfort with less consumption of electrical energy.
	Automation	The presence of automation and management systems for controlling the lighting system can significantly increase the building's energy efficiency.
	Day lighting	The need of consuming energy for lighting during daylight is an indicator of ineffective lighting installation.
DHW	Type	Various types of DHW systems exhibit different levels of energy and cost efficiency and impact on environment and human health.
	Automation	The presence of automation and management systems for controlling the DHW can significantly increase the building's energy efficiency.
	Maintenance	Frequent maintenance according to DHW system manufacturer can increase the efficiency of the respective DHW system.

Table 2. Reasoning behind the evaluation of every category.

Category	Sub-indicators	Assessment logic (select one per sub-indicator)	Evaluation	Max score
BE	Thermal insulation	None/unknown	0	+10
		Only in roof/terrace	+1	
		Only in building frame	+2	
		Only in walls	+3	
		In walls and frame/roof	+5	
	Glazing	Single regular	0	
		Single with heat-absorbing tint	+1	
		Double insulated	+1.5	
		Double low-e/reflective coating	+2	
		Triple glass	+2.5	
	Frames	Aluminum/steel	0	
		Aluminum/steel (thermal brake)	+1	
		Wood/PVC (vinyl)	+2	
		Fiberglass	+2.5	
HS	Type	Fireplace (open type)	0	+10
		Air condition (regular)	+1	
		Electric heaters/boilers/AC (inverter)	+2	
		Fireplace (energy efficient)	+3	
		Oil boiler	+4	
		Gas boiler (regular)	+5	
		Biomass boiler	+5.5	
		Gas boiler (condensation)	+6	
		Heat pump	+7	
	Automation	None	0	
		Temp. Sensors/Thermostats (central)	+1	
		Temp. Sensors/Thermostats (room)	+1.5	
		Energy management system	+2	
	Maintenance	No/Unknown	0	
		Yes	+1	
CS	Type	AC (regular)/Floor fans	0	+10
		AC (inverter)/Ceiling fans	+2	
		Heat pump	+5	
		None (passive cooling)	+7	
	Automation	None	0	
		Temp. Sensors/Thermostats (central)	+1	
		Temp. Sensors/Thermostats (room)	+1.5	
		Energy management system	+2	
	Maintenance	No/Unknown	0	
		Yes	+1	

Table 2 (continue). Reasoning behind the evaluation of every category.

Category	Sub-indicators	Assessment logic (select one per sub-indicator)	Evaluation	Max score
LS	Type	Incandescent lamps	0	+10
		Energy saving incandescent lamps	+2	
		Fluorescent lamps	+5	
		LEDs	+7	
	Automation	None	0	
		Motion sensors	+1	
		Luminosity sensors	+1.5	
		Energy management system	+2	
	Day lighting	Required	0	
		Not required	+1	
DHW	Type	Electrical boiler	0	+10
		Oil boiler (regular)	+1	
		Gas boiler (regular)	+2.5	
		Oil boiler (condensing)	+3	
		Gas boiler (condensing)	+4.5	
		Solar water heater	+6	
		Heat pump	+7	
	Automation	None	0	
		Thermostats/timers	+1	
		Energy management system	+2	
	Maintenance	No/Unknown	0	
		Yes	+1	
			Maximum Score	**50**
			RES Bonus	**+10**

So far all categories were considered to be of equal importance (10 pts per category). However this would increase the level of uncertainty of the results since different use profiles and spatial characteristics of a building result in different energy requirements and performance. Not all countries and types of buildings are expected to equally focus on the same categories to improve their energy efficiency. For example countries with a warmer climate (e.g. Greece) should be more concerned in improving the cooling systems of their buildings in comparison with countries with colder climate (e.g. Ukraine). Respectively, heating is more important than cooling for educational buildings, since schools are not occupied during summer.

Weights must be assigned for every category based on the specific characteristics and needs of the examined building. Weighting expresses the importance of each indicator relative to the others in a quantitative way. There are several methods that can be applied to determine the weights of indicators (Yang et al., 2010). In this case, the analytical hierarchy process (AHP) will be applied to extract specific weights. AHP was chosen due to its wide acceptability and its ability to be easily applied in a wide range of criteria (Singh et al., 2007).

The AHP is a multicriteria decision making tool that allows developing weights for selected criteria with the application of a series of pair-wise comparisons (Hermann et al., 2007). At first hierarchies have to be established indicating the relative importance of an examined category

over another. The intensity of importance is expressed on a scale of preference from 1 to 9 where 1 indicates equal importance and 9 extremely importance (Table 3).

Table 3. Scale of preference to express importance with the AHP method.

Scale	Importance level
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extreme importance

The next step is to develop a pair-wise comparison matrix for various dimensions of assessment. The comparison process is repeated for every pair of the categories to be assessed until a matrix with relative weights is filled. In this case since the building efficiency is assessed through five categories (BE, HS, CS, LS and DHW), a 5×5 matrix will be developed.

In total fourteen (14) matrixes were developed, seven (7) for every country participating in BSBEEP (Greece, Romania, Armenia, Moldova, Ukraine, Turkey, Black Sea Region) and seven (7) for every type of building to be assessed (Residential Apartment, Residential Single House, Office, Hospital, Hotel, Educational, Other). In order to increase the applicability of the e-tool, two more generic choices were included in the analysis (Black Sea Region and Other) that will be based on the average values of other categories. This will enable other countries of Black Sea Region to assess their buildings (of any type) with the proposed e-tool. A typical example of pair-wise comparison matrix for Greece is provided in Table 4. For instance, in this case BE is considered to have a strong importance (5) over LS whereas CS and DHW are of equal importance (1).

Table 4. An example of pair-wise comparison for Greece.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1.00	2.00	4.00	5.00	4.00
Heating System (HS)	0.50	1.00	3.00	4.00	3.00
Cooling System (CS)	0.25	0.33	1.00	2.00	1.00
Lighting System (LS)	0.20	0.25	0.50	1.00	0.50
Domestic Hot Water (DHW)	0.25	0.33	1.00	2.00	1.00

The hierarchies and pair-wise comparison matrixes were developed by BSBEEP experts according to their experience and analysis of the external current situation (see also GA1 results of BSBEEP Project). It should be noted that country data and respective evaluation are mostly representative for areas that fall within Black Sea regional boundaries, since the prevailing weather conditions and spatial data for different national regions may vary vastly. The comparison matrixes for every category are presented in Tables 5-16. The results presented in the specific Tables were based on the following assumptions:

Countries: The order of importance for the five categories examined per country is (higher number of ">" indicate higher level of significance):

- Greece: BE>HS>>DHW=CS>LS
- Romania: BE>HS>>>DHW>CS>LS
- Armenia: BE>HS>>DHW=CS>LS
- Moldova: BE>HS>>>DHW>CS>LS
- Ukraine: BE>HS>>>DHW>CS>LS
- Turkey: BE>HS>>DHW=CS>LS
- Black Sea Region: BE>HS>>DHW>CS>LS

For all countries, building envelope was considered to be the most significant category in terms of building energy efficiency, since a poor energy performance of the envelope will result in inefficient heating and cooling of the building. Heating systems consume higher amounts of energy in comparison with other systems examined and are of major significance. Countries with significant higher annual average temperatures, number of heatwave episodes and days with sunshine such as Greece, Turkey and Armenia present higher cooling needs in comparison with Northern countries (Romania, Moldova, and Ukraine). Lighting systems are of lower significance since they consume less energy in comparison with cooling and hot water systems.

Type of building: The order of importance for the five categories examined per building type is (higher number of ">" indicate higher level of significance):

- Residential – Apartment: BE>HS>>>CS=DHW>LS
- Residential – Single house: BE>HS>>>CS=DHW>LS
- Office: BE>HS>>CS>LS>DHW
- Hospital: BE>HS>>CS=DHW=LS
- Hotel: BE>HS>>DHW=CS>LS
- Educational: BE>HS>>LS>CS>DHW
- Other: BE>HS>>DHW>CS>LS

Apartments and single houses present similar hierarchy of the systems, with the exception that BE in single houses is slightly more significant. Offices present higher lighting needs and lower hot water needs in comparison with other types of buildings. Hospitals and hotels need to achieve the best possible comfort level for their occupants and consequently all categories need to be highly taken into account. Educational buildings focus mostly on the heating systems and lighting since cooling and hot water is rarely been applied.

Table 5. Pair-wise comparison matrix for Greece.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	3,00	4,00	3,00
Heating System (HS)	0,67	1,00	2,50	3,50	2,50
Cooling System (CS)	0,33	0,40	1,00	2,00	1,00
Lighting System (LS)	0,25	0,29	0,50	1,00	0,50
Domestic Hot Water (DHW)	0,33	0,40	1,00	2,00	1,00

Table 6. Pair-wise comparison matrix for Romania.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	4,50	5,00	4,00
Heating System (HS)	0,67	1,00	4,00	4,50	3,50
Cooling System (CS)	0,22	0,25	1,00	2,00	0,50
Lighting System (LS)	0,20	0,22	0,50	1,00	0,40
Domestic Hot Water (DHW)	0,25	0,29	2,00	2,50	1,00

Table 7. Pair-wise comparison matrix for Armenia.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	3,50	4,50	3,50
Heating System (HS)	0,67	1,00	3,00	4,00	3,00
Cooling System (CS)	0,29	0,33	1,00	2,00	1,00
Lighting System (LS)	0,22	0,25	0,50	1,00	0,50
Domestic Hot Water (DHW)	0,29	0,33	1,00	2,00	1,00

Table 8. Pair-wise comparison matrix for Moldova.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	5,00	5,50	4,50
Heating System (HS)	0,67	1,00	4,50	5,00	4,00
Cooling System (CS)	0,20	0,22	1,00	1,50	0,50
Lighting System (LS)	0,18	0,20	0,67	1,00	0,33
Domestic Hot Water (DHW)	0,22	0,25	2,00	3,00	1,00

Table 9. Pair-wise comparison matrix for Ukraine.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	5,00	5,50	4,50
Heating System (HS)	0,67	1,00	4,50	5,00	4,00
Cooling System (CS)	0,20	0,22	1,00	1,50	0,50
Lighting System (LS)	0,18	0,20	0,67	1,00	0,33
Domestic Hot Water (DHW)	0,22	0,25	2,00	3,00	1,00

Table 10. Pair-wise comparison matrix for Turkey.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	3,00	4,00	3,00
Heating System (HS)	0,67	1,00	2,50	3,50	2,50
Cooling System (CS)	0,33	0,40	1,00	2,00	1,00
Lighting System (LS)	0,25	0,29	0,50	1,00	0,50
Domestic Hot Water (DHW)	0,33	0,40	1,00	2,00	1,00

Table 11. Pair-wise comparison matrix for apartment.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	5,00	6,00	5,00
Heating System (HS)	0,67	1,00	4,50	5,50	4,50
Cooling System (CS)	0,20	0,22	1,00	2,00	1,00
Lighting System (LS)	0,17	0,18	0,50	1,00	0,50
Domestic Hot Water (DHW)	0,20	0,22	1,00	2,00	1,00

Table 12. Pair-wise comparison matrix for single house.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	2,00	5,00	6,00	5,00
Heating System (HS)	0,50	1,00	4,00	5,00	4,00
Cooling System (CS)	0,20	0,25	1,00	2,00	1,00
Lighting System (LS)	0,17	0,20	0,50	1,00	0,50
Domestic Hot Water (DHW)	0,20	0,25	1,00	2,00	1,00

Table 13. Pair-wise comparison matrix for office.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	3,00	3,50	6,00
Heating System (HS)	0,67	1,00	2,50	3,00	5,50
Cooling System (CS)	0,33	0,40	1,00	1,50	2,50
Lighting System (LS)	0,29	0,33	0,67	1,00	3,00
Domestic Hot Water (DHW)	0,17	0,18	0,40	0,33	1,00

Table 14. Pair-wise comparison matrix for hospital.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	3,00	3,00	3,00
Heating System (HS)	0,67	1,00	2,50	2,50	2,50
Cooling System (CS)	0,33	0,40	1,00	1,00	1,00
Lighting System (LS)	0,33	0,40	1,00	1,00	1,00
Domestic Hot Water (DHW)	0,33	0,40	1,00	1,00	1,00

Table 15. Pair-wise comparison matrix for hotel.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	3,00	3,50	3,00
Heating System (HS)	0,67	1,00	2,50	3,00	2,50
Cooling System (CS)	0,33	0,40	1,00	1,50	1,00
Lighting System (LS)	0,29	0,33	0,67	1,00	0,67
Domestic Hot Water (DHW)	0,33	0,40	1,00	1,50	1,00

Table 16. Pair-wise comparison matrix for educational buildings.

Category	BE	HS	CS	LS	DHW
Building Envelope (BE)	1,00	1,50	5,00	4,00	6,00
Heating System (HS)	0,67	1,00	4,50	3,50	5,50
Cooling System (CS)	0,20	0,22	1,00	0,33	4,00
Lighting System (LS)	0,25	0,29	3,00	1,00	5,00
Domestic Hot Water (DHW)	0,17	0,18	0,25	0,20	1,00

The next step is to find the normalized weight of every category by normalizing each column in Tables 5-16 (weights for categories Black Sea Region and Other will be extracted from the average weights of all countries and building types respectively). This can be achieved by dividing the category relative weight by the sum of relative weights in column and then averaging the values across the rows. Every column of the matrix is then normalized by dividing the sum of the elements in the specific column. The average of each row is the final weight of the examined category. The specific procedure was followed for all comparison matrixes in order to extract the weights presented in Tables 17 and 18.

The consistency of each judgment was assessed with the application of the Consistency Ratio (CR). More specifically the 5×5 normalized matrix was multiplied with the 5×1 weight matrix. Then the estimated 5×1 matrix was divided by the 5×1 weights matrix in order to extract a final consistency 5×1 matrix. The consistency index (CI) of n criteria (in this case n=5) is CI = (λmax – n)/n – 1 where λmax is the largest eigen value of the n×n pair wise comparison matrix. The consistency ratio is estimated using the formula CR = CI/RI where RI is 1.12 for 5×5 matrixes. The acceptable CR for n=5 is 0.1. If the value of CR is below this value then the evaluation is considered to be consistent and acceptable.

Table 17. Relative weights of categories per country.

Category	Greece	Romania	Armenia	Moldova	Ukraine	Turkey	Black Sea
Building Envelope (BE)	0,375	0,404	0,391	0,414	0,415	0,375	0,396
Heating System (HS)	0,288	0,320	0,305	0,330	0,330	0,288	0,310
Cooling System (CS)	0,130	0,088	0,117	0,075	0,075	0,130	0,103
Lighting System (LS)	0,076	0,061	0,070	0,058	0,058	0,076	0,066
Domestic Hot Water (DHW)	0,130	0,127	0,117	0,123	0,123	0,130	0,125

Table 18. Relative weights of categories per building type.

Category	Apartment	Single House	Office	Hospital	Hotel	Educational	Other
Building Envelope (BE)	0,425	0,454	0,390	0,368	0,373	0,399	0,401
Heating System (HS)	0,340	0,304	0,304	0,281	0,286	0,315	0,305
Cooling System (CS)	0,090	0,093	0,137	0,117	0,125	0,091	0,109
Lighting System (LS)	0,055	0,057	0,115	0,117	0,092	0,152	0,098
Domestic Hot Water (DHW)	0,090	0,093	0,053	0,117	0,125	0,043	0,087

The combination of relative country weights and building type weights resulted in forty nine (49) different sets of final weights for every situation (one per combination of country-type of building) (Table [ ]). The specific weights are automatically utilized by the e-tool to assess the examined building. The final score of qualitative assessment is calculated using the formula:

$$Score = 5 \times \sum Wi \times SCi$$

Where i = BE, HS, CS, LS and DHW, W_i = the category final weight according to Tables 19-25 ($0 \leq W_i \leq 1$), SC_i = the initial score of the category according to Table 2 ($0 \leq SC_i \leq 10$). In Figure 2, three examples of qualitative assessment are presented for three different buildings.

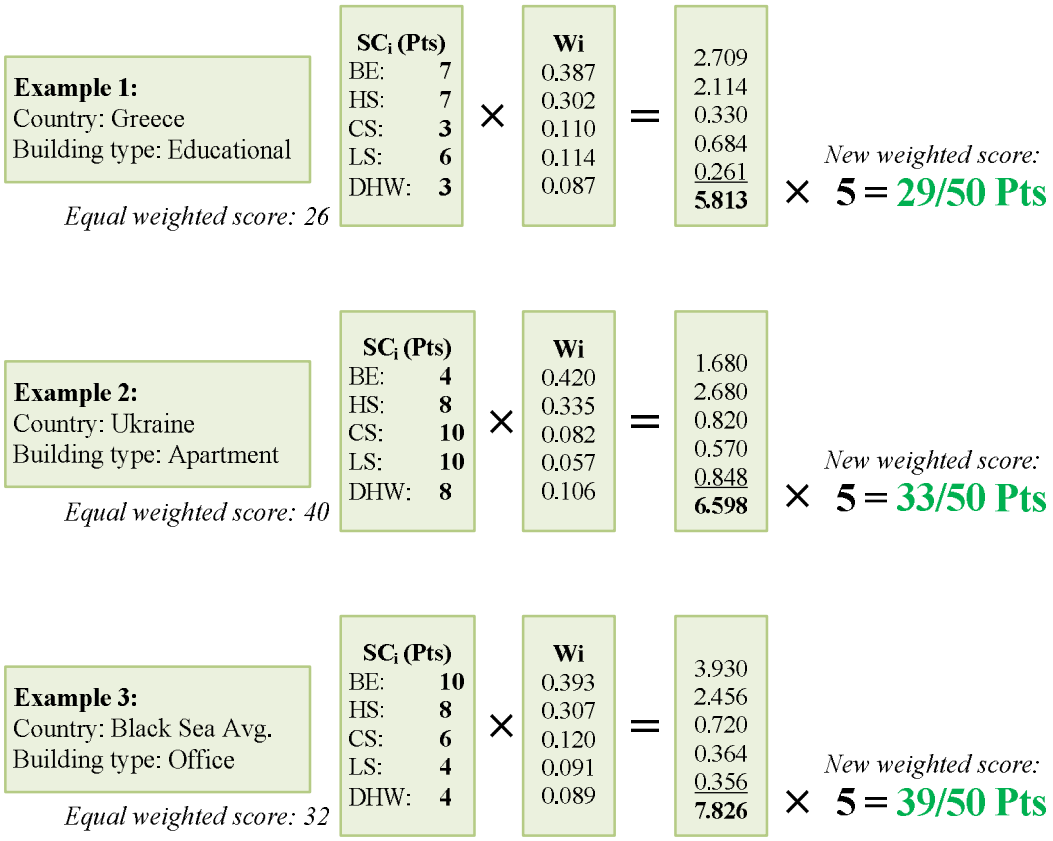


Figure 2. Indicative examples of the proposed qualitative assessment scoring system.

Table 19. Final weights per category for Greece.

Category	Apartment	Single House	Office	Hospital	Hotel	Educational	Other
Building Envelope (BE)	0,400	0,414	0,383	0,371	0,374	0,387	0,388
Heating System (HS)	0,314	0,296	0,296	0,284	0,287	0,302	0,297
Cooling System (CS)	0,110	0,111	0,134	0,124	0,128	0,110	0,119
Lighting System (LS)	0,066	0,067	0,096	0,097	0,084	0,114	0,087
Domestic Hot Water (DHW)	0,110	0,111	0,092	0,124	0,128	0,087	0,108

Table 20. Final weights per category for Romania.

Category	Apartment	Single House	Office	Hospital	Hotel	Educational	Other
Building Envelope (BE)	0,415	0,429	0,397	0,386	0,388	0,402	0,403
Heating System (HS)	0,330	0,312	0,312	0,300	0,303	0,317	0,312
Cooling System (CS)	0,089	0,090	0,113	0,103	0,107	0,089	0,099
Lighting System (LS)	0,058	0,059	0,088	0,089	0,076	0,107	0,080
Domestic Hot Water (DHW)	0,108	0,110	0,090	0,122	0,126	0,085	0,107

Table 21. Final weights per category for Armenia.

Category	Apartment	Single House	Office	Hospital	Hotel	Educational	Other
Building Envelope (BE)	0,408	0,423	0,391	0,380	0,382	0,395	0,396
Heating System (HS)	0,323	0,305	0,305	0,293	0,295	0,310	0,305
Cooling System (CS)	0,103	0,105	0,127	0,117	0,121	0,104	0,113
Lighting System (LS)	0,063	0,063	0,092	0,093	0,081	0,111	0,084
Domestic Hot Water (DHW)	0,103	0,105	0,085	0,117	0,121	0,080	0,102

Table 22. Final weights per category for Moldova.

Category	Apartment	Single House	Office	Hospital	Hotel	Educational	Other
Building Envelope (BE)	0,420	0,434	0,402	0,391	0,393	0,407	0,408
Heating System (HS)	0,335	0,317	0,317	0,305	0,308	0,323	0,318
Cooling System (CS)	0,082	0,084	0,106	0,096	0,100	0,083	0,092
Lighting System (LS)	0,057	0,057	0,086	0,087	0,075	0,105	0,078
Domestic Hot Water (DHW)	0,106	0,108	0,088	0,120	0,124	0,083	0,105

Table 23. Final weights per category for Ukraine.

Category	Apartment	Single House	Office	Hospital	Hotel	Educational	Other
Building Envelope (BE)	0,420	0,434	0,402	0,391	0,394	0,407	0,408
Heating System (HS)	0,335	0,317	0,317	0,305	0,308	0,323	0,318
Cooling System (CS)	0,082	0,084	0,106	0,096	0,100	0,083	0,092
Lighting System (LS)	0,057	0,057	0,086	0,087	0,075	0,105	0,078
Domestic Hot Water (DHW)	0,106	0,108	0,088	0,120	0,124	0,083	0,105

Table 24. Final weights per category for Turkey.

Category	Apartment	Single House	Office	Hospital	Hotel	Educational	Other
Building Envelope (BE)	0,400	0,414	0,383	0,371	0,374	0,387	0,388
Heating System (HS)	0,314	0,296	0,296	0,284	0,287	0,302	0,297
Cooling System (CS)	0,110	0,111	0,134	0,124	0,128	0,110	0,119
Lighting System (LS)	0,066	0,067	0,096	0,097	0,084	0,114	0,087
Domestic Hot Water (DHW)	0,110	0,111	0,092	0,124	0,128	0,087	0,108

Table 25. Final weights per category for Black Sea Region (Average).

Category	Apartment	Single House	Office	Hospital	Hotel	Educational	Other
Building Envelope (BE)	0,410	0,425	0,393	0,382	0,384	0,397	0,399
Heating System (HS)	0,325	0,307	0,307	0,295	0,298	0,313	0,308
Cooling System (CS)	0,096	0,098	0,120	0,110	0,114	0,097	0,106
Lighting System (LS)	0,061	0,062	0,091	0,092	0,079	0,109	0,082
Domestic Hot Water (DHW)	0,107	0,109	0,089	0,121	0,125	0,084	0,106

2.3 Quantitative assessment

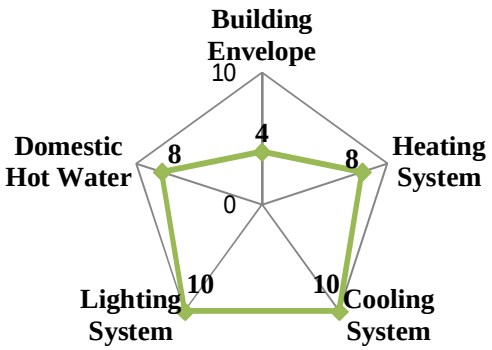
To be performed by DUNAREA (energy per use) and AUA (energy per type)

2.4 E-tool summary

2.5 Presentation of the results

In order to enhance the comprehension and communication of the results, e-tool provides a final assessment sheet including the partial and final evaluation-scores of the examined buildings.

Building Assessment	Your Score
Building Envelope	4
Heating System	8
Cooling System	10
Lighting System	10
Domestic Hot Water	8
Initial Score	40
Weighted Score	33
RES Bonus	n/a
Final Score	**33**



To be finalized after all partners have send their main contributions.

2.6 Software development

To be performed by SAMSUN

3. E-tool application

3.1 Application in municipal buildings

3.1.1 Municipality of Kavala

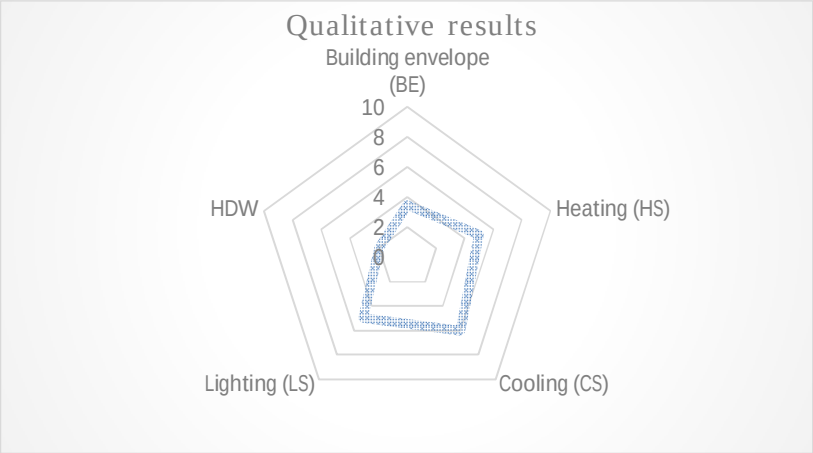
Five (5) municipal buildings were assessed with the application of the BSBEEP E-tool for the municipality of Kavala. The specific buildings were selected based on the screening energy audits that were performed during GA2.1 (for more information see Activity GA2.1 study – www.bsbeep.com) and after communication with municipal authorities that indicated the buildings of high interest. More specifically the municipal buildings that were assessed were:

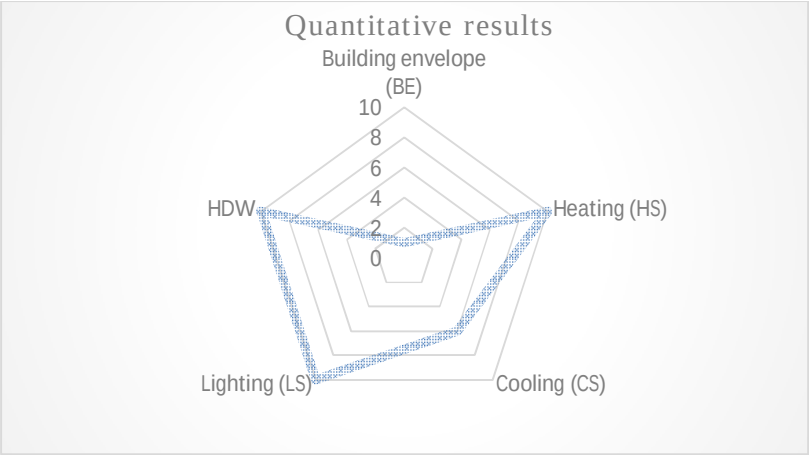
- Municipal Library of Kavala
- Indoor Swimming Pool of Kavala
- 1st / 4th High School of Kavala
- 5th / 6th Primary School, 5th Kindergarten of Kavala
- 19th Primary School, 16th / 19th Kindergarten of Kavala

The results of the implementation of the e-tool are presented below, providing a generic image of the energy performance of the examined building and indicating the areas of high interest where amelioration actions should be performed.

Results from the implementation of BSBEEP e-tool in **Municipal Library of Kavala**.

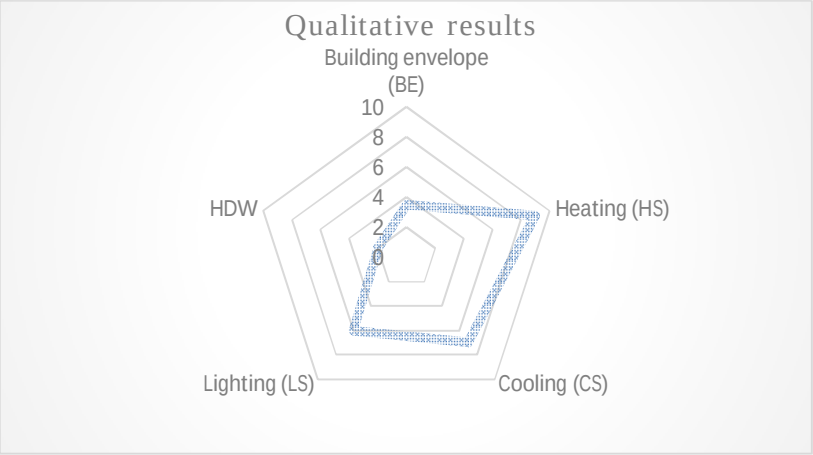
Building Characteristics	QUALITATIVE		QUANTITATIVE		TOTAL	
	Score	Weighted score	Score	Weighted score	Score	Weighted score
Building Envelope (BE)	3,5	6,79	1	1,94	4,5	8,73
Heating System (HS)	5	7,43	10	14,85	15	22,28
Cooling System (CS)	6	3,57	6	3,57	12	7,14
Lighting System (LS)	5	2,18	10	4,35	15	6,53
Domestic Hot Water (DHW)	2	0,87	10	5,40	12	6,27
Renewable source	0	0,00	-	-	0	0,00
TOTAL	**21,50**	**20,83**	**37,00**	**30,11**	**58,50**	**50,94**

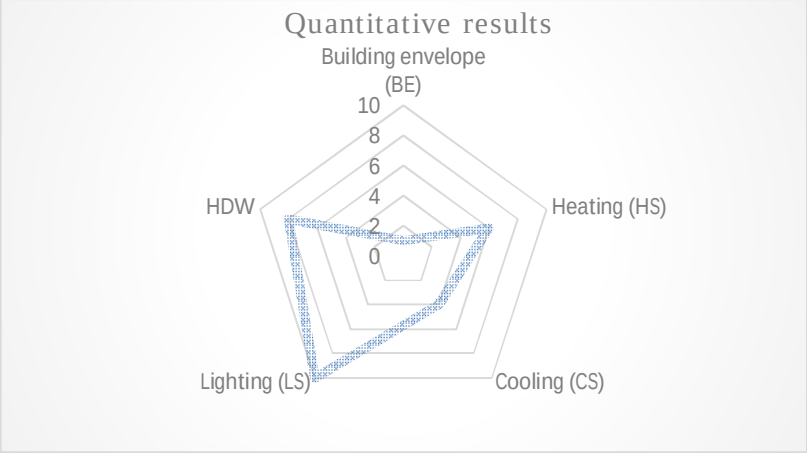




Results from the implementation of BSBEEP e-tool in **Indoor Swimming Pool of Kavala**

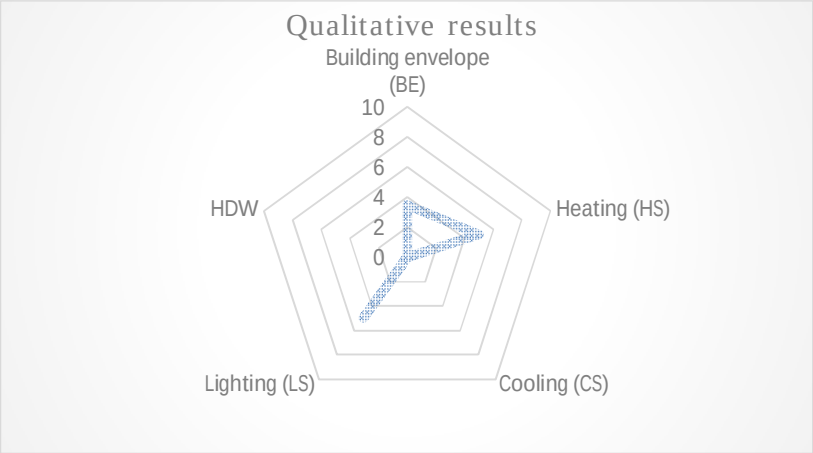
Building Characteristics	QUALITATIVE		QUANTITATIVE		TOTAL	
	Score	Weighted score	Score	Weighted score	Score	Weighted score
Building Envelope (BE)	3,5	6,79	1	1,94	4,5	8,73
Heating System (HS)	9	13,37	6	8,91	15	22,28
Cooling System (CS)	7	4,17	4	2,38	11	6,55
Lighting System (LS)	6	2,61	10	4,35	16	6,96
Domestic Hot Water (DHW)	2	0,87	8	4,32	10	5,19
Renewable source	0	0,00	-	-	0	0,00
TOTAL	**27,50**	**27,80**	**29,00**	**21,90**	**56,50**	**49,70**

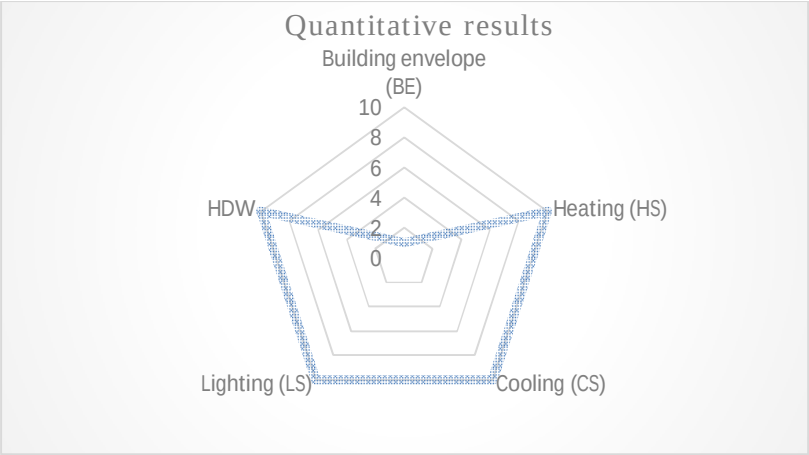




Results from the implementation of BSBEEP e-tool in **1st / 4th High School of Kavala**

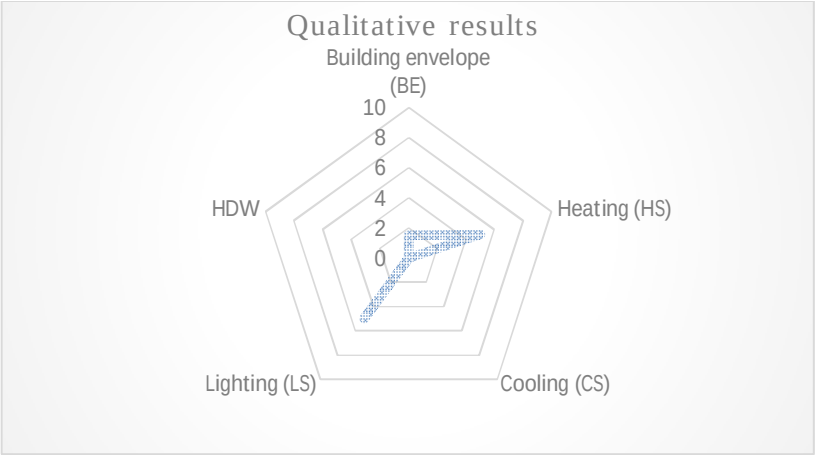
Building Characteristics	QUALITATIVE		QUANTITATIVE		TOTAL	
	Score	Weighted score	Score	Weighted score	Score	Weighted score
Building Envelope (BE)	3,5	6,77	1	1,94	4,5	8,71
Heating System (HS)	5	7,55	10	15,10	15	22,65
Cooling System (CS)	0	0,00	10	5,50	10	5,50
Lighting System (LS)	5	2,85	10	5,70	15	8,55
Domestic Hot Water (DHW)	0	0,00	10	4,35	10	4,35
Renewable source	0	0,00	-	-	0	0,00
TOTAL	**13,50**	**17,17**	**41,00**	**32,59**	**54,50**	**49,76**

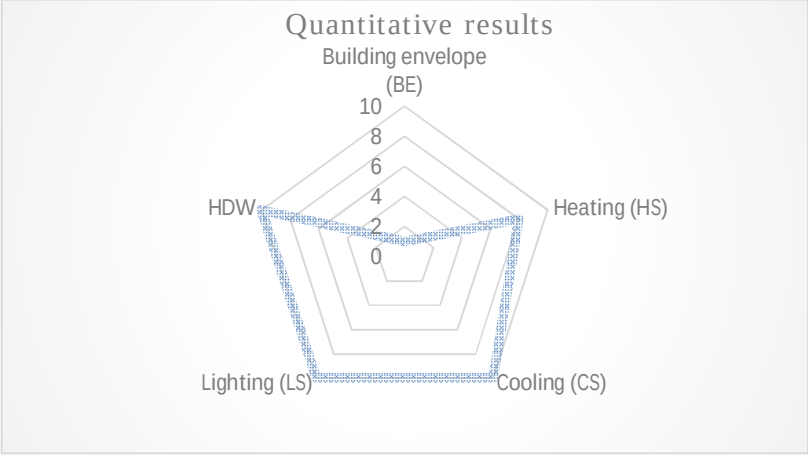




Results from the implementation of BSBEEP e-tool in **5th / 6th Primary School, 5th Kindergarten of Kavala**

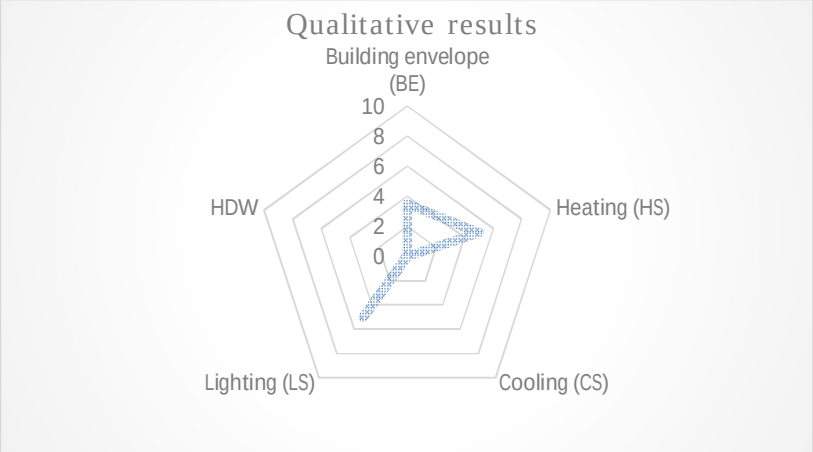
Building Characteristics	QUALITATIVE		QUANTITATIVE		TOTAL	
	Score	Weighted score	Score	Weighted score	Score	Weighted score
Building Envelope (BE)	1,5	2,90	1	1,94	2,5	4,84
Heating System (HS)	5	7,55	8	12,08	13	19,63
Cooling System (CS)	0	0,00	10	5,50	10	5,50
Lighting System (LS)	5	2,85	10	5,70	15	8,55
Domestic Hot Water (DHW)	0	0,00	10	4,35	10	4,35
Renewable source	0	0,00	-	-	0	0,00
TOTAL	**11,50**	**13,30**	**39,00**	**29,57**	**50,50**	**42,87**

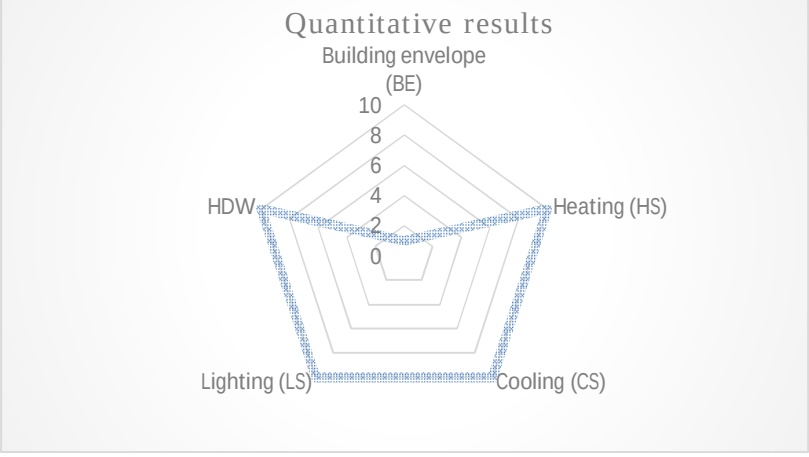




Results from the implementation of BSBEEP e-tool in **19th Primary School, 16th / 19th Kindergarten of Kavala**

Building Characteristics	QUALITATIVE		QUANTITATIVE		TOTAL	
	Score	Weighted score	Score	Weighted score	Score	Weighted score
Building Envelope (BE)	3,5	6,77	1	1,94	4,5	8,71
Heating System (HS)	5	7,55	10	15,10	15	22,65
Cooling System (CS)	0	0,00	10	5,50	10	5,50
Lighting System (LS)	5	2,85	10	5,70	15	8,55
Domestic Hot Water (DHW)	0	0,00	10	4,35	10	4,35
Renewable source	0	0,00	-	-	0	0,00
TOTAL	**13,50**	**17,17**	**41,00**	**32,59**	**54,50**	**49,76**





3. Conclusions

To be written by Galati

References

Annex A: E-tool manual

To be written by e-tool developer (SAMSUN)