ENVIRONMENTAL ASSESSMENT OF PUBLIC BUILDINGS – EXAMPLE CASE

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Summary

There are many building assessment methods on the market, many of these methods, e.g. BREEAM, LEED, CASBEE, are designed for a wide use. Most of them are complex, often require data that is locally unavailable, adaptation to local context, and are difficult to use. In this paper an example of public building's evaluation using simplified methods of building environmental impact assessment is presented. These methods are spinoffs of the SBTool and were elaborated under the project STEP at the Warsaw University of Technology (qualitative – quantitative Q^2 analysis) and NEW-EXPERT (quantitative - Q) executed by Energy Conservation Foundation. According to the European policy, public buildings should provide a leading example of energy-efficient and environmentally friendly objects. The aim of this work was to assess a public building that has undergone thermomodenisation using two simplified methods. Towards the end, conclusions drawn from the assessment of results are presented. The results of the evaluation can be used for the purpose of preparing an environmental certificate for the building, which is voluntary. Such documents will show whether buildings are environmentally friendly and whether there is a need for improvement, and will prepare the market for the official certification process in the future.

Keywords: environmental assessment, simplified methods, public building

1 Introduction

The issues of building assessment have been the subject of research, standardization and development process for many years. In common understanding, the word "assessment" (evaluation) is often associated negatively, and the world "sustainability" (sometimes replaced by integrated) draws attention to a wide range of such assessments, and deepens this association. Irrespective of different kinds of bias, assessment methods and the evidence of their application are widespread today. For example, to obtain the CE label required for the product to enter the European market, it has to be assessed using the relevant European standard. Results of evaluations are confirmed by certificates, which inform that the object meets the requirements.

International efforts to reduce greenhouse gas emissions and resource use stimulated development of environmental impact assessment of buildings methods [1] [2], and further the assessment methods taking into account buildings' impact on economic and social issues reflecting buildings' contribution to sustainable development. In recent years, the increase of interest in environmentally friendly and sustainable buildings was noticed and resulted in large design and research activities.

In the paper a public building evaluation using two simplified methods of building sustainability assessment based on quantitative and qualitative analyses [3] is presented. The methods are spinoffs of the SBTool [1]. The first one was elaborated under the STEP project [2] at the Warsaw University of Technology, and the second one under the project NEW EXPERT [4] executed by the Energy Conservation Foundation. The quantitative assessment (NEW EXPERT - Q) is based on characteristic parameters for comparison between values for existing buildings and reference ones. The concept is somehow similar to building resources footprint. Five factors are taken into account: energy use for heating, integrated air pollution emissions, water use, waste production, and building lighting. The second method, qualitative assessment, is based on rating of areas and criteria for the environmental impact of a building (STEP Q^2). The evaluation is done for five main areas: effect on the environment and environmental aspects, both based on LCA, outdoor and indoor environment, and building economy based on assessor's subjective opinion. Both simplified methods can be easily used by designers, architects and energy consultants for checking the adapted solutions, and further, for voluntary labelling of buildings in order to stimulate the market demand for such services and to improve their competitiveness.

2 Building assessment methods' description

2.1 The Q - quantitative assessment of building's impact on the environment

The quantitative assessment is based on characteristic parameters of comparison between values for existing buildings and reference ones and was prepared under a task of the NEW-EXPERT project. Five factors were taken into account: energy use, cost of emissions connected with energy production (integrated emissions are taken into account), water use, waste production, and building lighting. By comparison of values for real and reference buildings each parameter gets a grade from G to A (where G means very bad and A very good environmental performance). The established scale is based on the same idea of best performance as Energy Star or EPBD energy certificate for building and is very easy to be understood.

It was assumed that each of the five specific indicators has the same weight – importance, so the total building grade is the average of grades for every parameter. Thus, the final result of the evaluation can take values from A to G, where grade A defines a very environmentally friendly building and grade G a building unfriendly to the environment.

2.2 The Q^2 quantitative and qualitative assessment method of building's influence on the environment

A qualitative method developed into the curricula of STEP project in contrast to the above mentioned quantitative method is not limited to a few indicators characterizing the building's influence on the environment. It also includes other impacts of the building in the cycle of its existence, such as degradation of the surrounding environment, the impact on the flora around the building, thermal comfort, lighting and acoustics, and others [3]. The qualitative method can be used to assess different stages of building's life-cycle, such as construction, operation, renovation or demolition. It is obvious that not all of the parameters are used at each stage, i.e. the comfort of inhabitants cannot be assessed at the stage of construction. In Fig. 2 the scheme of all categories and sub-categories taken into account in building evaluation are presented.

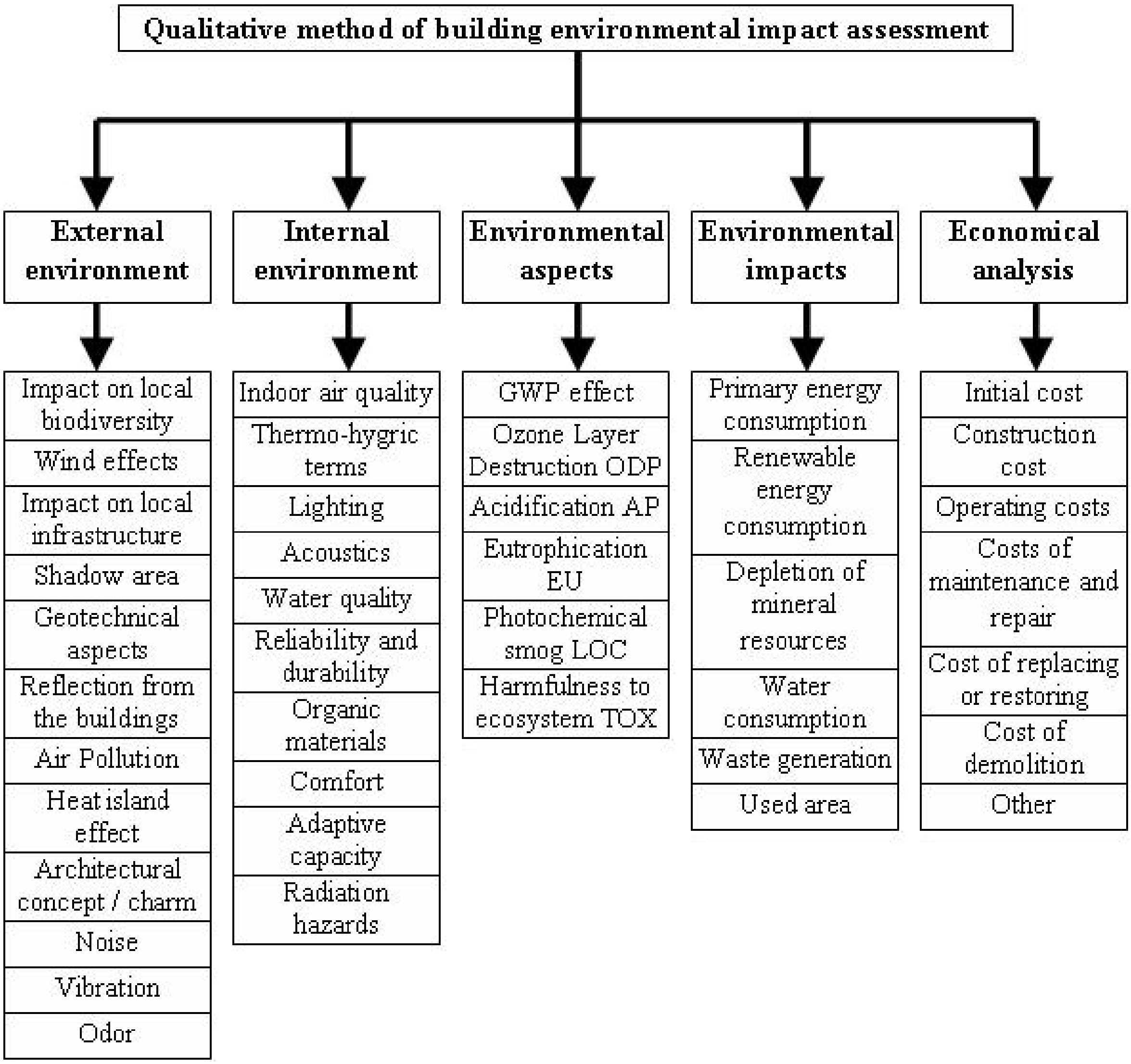

Fig. 1 The categories and sub-categories used in the qualitative assessment method

The evaluation is done for five main areas: environmental aspects, environmental impacts, external and internal environment, and economical analysis. The first two and the last one are based on the live-cycle analysis (LCA) and the two others on objective opinions of the assessor.

The external environment consists of criteria that describe the building impact on the surrounding environment. It includes information on building's impact on natural environment, e.g. on local biodiversity, impact on other buildings, e.g. shadow area or heat island effect, but also on people who might pass next to the evaluated building (criteria such as noise, odour or architectural/aesthetic comfort).

The internal environment refers to indoor spaces. This criterion describes building impact on health and comfort of inhabitants (indoor air quality, water quality or comfort) but the issues of internal spaces reliability and durability or possibility to adapt spaces are also taken into consideration.

The environmental aspects and impacts are based on the LCA and describe the impact of a building on the natural environment [4]. The calculation of LCA takes into account the built-in materials but also resources use. This area has been divided into two categories, as one considers the influence of a building on the environment in global scale (i.e. ODP, GWP, AP, prEN 15978 based) and the second category refers to the use of resources like energy or water.

Finally, some economical analysis LCC is given. This evaluation is based on the building materials used and the resources used. Such evaluation gives information about the total cost of the building use.

Each area of defined criteria (see Fig. 2) has to be rated in the scale from 1 to 5, where 1 means very bad, 3 standard (as required by regulation or standard practice) and 5 very good performance. Finally, the table with grades for every criterion gives a picture of building environmental impact.

3 Sample case description

Public buildings should provide a leading example and should be environmentally conscious, therefore an environmental evaluation of such buildings is required. In this paper the Municipal Authority Building in Zabludow (in Poland) has been assessed. Zabludow is a small city located in the eastern part of Poland.

The assessed building is located in the city center, near an asphalt road and about 100 m away from the main road (national road No. 19). It is a three-storey building, with a basement and non-usable attic. Characteristic dimensions of the building are: height – 12.00 m, length – 24.00 m, and width – 10.60 m, and the storey height is 3.0 m. The basic data for the object can be found in Tab. 1. and in Tab. 2 the heat transfer coefficients for external envelopes of the building are given.

Tab. 1 Volume and area of the assessed building

Parameter	**Value**	
Built-up area	m^2	258,00
Building volume	m^3	2699,00
Volume of the heated parts of the building	m^3	2699,00
Net area of building	m^2	910,90
Surface of the heated parts of the building	m^2	910,90

Tab. 2 Heat transfer coefficients of the assessed building

Heat transfer coefficient [W/m^{2}K]	
External wall on basement level	0,25
External wall	0,23
Roof	0,21
Windows	1,7
Doors	2,0

There are 43 office rooms whose area is smaller than 50 m^2 and one staircase. The building is surrounded by trees and in front of the building there is a small parking lot with a place for bicycles. Surrounding buildings are of similar height and they do not reduce direct

sunlight. Office facades are painted in different shades of green what harmonizes perfectly with the location of the building. The surroundings of the building seems to be quiet and there are not too many noise sources.
The central heating installation has been changed in 2007. The heat source for the installation is a gas boiler. Domestic hot water is produced in electrical storage heaters.

4 Qualitative assessment results

Assessment of the building requires scores to be assigned for all criteria. Hereafter some of the parameters influencing scores are given for each category and criteria (score scale from 1 to 5).

Tab. 3 Scores for category: external environment

Category: External environment		
Sub-category	**Influencing Parameter (examples)**	**Score**
Impact on local biodiversity	▪ Protection of existing ecosystems (trees and green plants surrounding the building have been retained)	3
Wind effects	▪ Due to small volume, the building does not affect the wind conditions in the near surroundings	3
Impact on local infrastructure	▪ Adequate car-parking and easy access to the road network ▪ Bike parking	3
Shadow area	▪ The building does not overshadow any object	3
Geotechnical aspects	▪ The building shows no signs of cracking of the facade and walls	3
Reflection from the buildings	▪ There is no phenomenon of negative reflection of light from a building or the negative artificial light from a building	3
Air pollution	▪ A gas boiler with low emission of NO_x and SO_x has been used	4
Heat island effect	▪ The building does not influence the air flow ▪ The use of materials with a low sunlight absorption coefficient	3
Architectural concept / charm	▪ The height and form of the building is adequate to the surroundings and landscape. ▪ Elements, materials and colours correspond to the surrounding environment and are esthetical	3
Noise	▪ Noise generated by the exterior (street) is minimal and not noticeable inside. ▪ There are no other sources of noise inside or outside the building	3
Vibration	▪ The vibration generated by the exterior is minimal	3
Odour	▪ Appropriate location of the building reduces exposure to odours ▪ Waste from the building is stored in waste containers and does not generate odours	3
	Average score for the category	**3,08**

Tab. 4 Scores for category: internal environment

Category: Internal environment		
Sub-category	**Influencing Parameter (examples)**	**Score**
Indoor air quality	▪ Asbestos materials have not been used in the building ▪ Inside the building materials that can emit mineral fibre have not been used ▪ Smoking is prohibited inside the building ▪ Users do not have any objections	4
Thermo-hygric terms	▪ The thermal insulation is sufficient and relevant, meets all legal requirements after thermo-modernization ▪ There is no biological corrosion ▪ Temperature control is possible	3
Lighting	▪ High ratio of daylight for the whole building ▪ Proper allocation of inside lighting ▪ Use of efficient lighting that ensures adequate amount of light	4
Acoustics	▪ Fulfilment of legal requirements for buildings ▪ External noise is not noticeable, conversation can be carried out freely	3
Water quality	▪ Fulfilment of legal requirements of water quality, good quality of water	3
Reliability and durability	▪ The building does not have any features that can indicate low durability of construction and finishes	3
Organic materials	▪ The use of local and natural materials ▪ Materials used for thermal insulation have CE label	3
Comfort	▪ High comfort, more than 50 m^2 per person ▪ 3 m high floors enhance the feeling of comfort	3
Adaptive capacity	▪ Floors load buffer of more than 2000 N/m2 ▪ Provided additional space for new installations	3
Radiation hazards	▪ There is no radiation threat	3
	Average score for the category	**3,20**

Tab. 5 Scores for category: environmental aspects

Category: Environmental aspects	
Sub-category	**Score**
GWP effect	4
Ozone Layer Destruction ODP	4
Acidification AP	2
Eutrophication EU	4
Photochemical smog LOC	4
Harmfulness to ecosystem TOX	5
Average score for the category	**3,83**

The assessment of sub-categories of the environmental aspect category has been done according to LCA calculation for the considered building. In the calculation material, energy and other resources have been taken into consideration in order to calculate the building impact on the environment in global scale.

Tab. 6 Scores for category: environmental impacts

Category: Environmental impacts		
Sub-category	**Influencing Parameter (examples)**	**Score**
Primary energy consumption	▪ Consumption of energy for obtaining building materials and of energy for building does not exceed 1.5 GJ per ton of product or 5 GJ/m^2 of building surface ▪ The use of highly efficient gas boiler	3
Renewable energy consumption	▪ The majority of the windows are on the south wall. ▪ The building has no renewable energy systems	3
Depletion of mineral resources	▪ The materials in the building are commonly used. ▪ There is a high rate of reuse of materials and components	3
Water consumption	▪ Taps and flushing have a water-saving function	3
Waste generation	▪ The building has a simple system of waste management. ▪ There is a possibility of waste segregation	4
Used area	▪ Land area around the building allows for maintenance or creation of an ecosystem ▪ The building does not reduce recreational or green areas	3
	Average score for the category	**3,17**

Tab. 7 Scores for category: economical analysis

Category: Economical analysis		
Sub-category	**Influencing Parameter (examples)**	**Score**
Operating costs	▪ Low operating costs after thermo-modernization. ▪ Building management costs are lower than the average cost of public building maintenance elsewhere in the country	4
	Average score for the category	**4,00**

As the evaluation was done for an existing building, only the cost of maintenance was taken into consideration.

In Tab. 8. the summary of building assessment carried out according to qualitative assessment method is presented.

Tab. 8 Summary of qualitative building assessment

Category	**Score**
External environment	3,08
Internal environment	3,20
Environmental aspects	3,83
Environmental impacts	3,17
Economical analysis	4,00
Average score of the building	**3,46**

The average score of the qualitative assessment of the building is equal to 3.46. This note is appropriate for a building that is a bit better than a standard building with the same shape and function. It can be concluded that the thermo-modernization brought the building to a good standard.

5 Quantitative assessment results

The quantitative assessment is based on comparison between five parameters: energy use, cost of emissions connected with energy production, water use, waste production and building lighting for the evaluated and the reference building. For each parameter a note is given according to criteria from Tab. 9.

Tab. 9 The principles of grading in the quantitative assessment method

A	Value of the characteristic parameter is better than the value for the reference building by more than 40%
B	Value of the characteristic parameter is better than the value for the reference building by 25% to 40%
C	Value of the characteristic parameter is better than the value for the reference building by 5% to 25%
D	Value of the characteristic parameter differs from the value for the reference building by less than 5%
E	Value of the characteristic parameter is worse than the value for the reference building by 5% to 25%
F	Value of the characteristic parameter is worse than the value for the reference building by 25% to 40%
G	Value of the characteristic parameter is worse than the value for the reference building by more than 40%

In Tab. 10 the value of the parameters for the assessed and the reference building is presented. The score for each of the criteria is also given.

Tab. 10 Summary of quantitative building assessment

Criteria	Evaluated building	Reference building	Score
Energy use [kWh/m^2 year]	108,5	190,6	A
Emission costs [PLN/year]	24,5	24,4	D
Water use [m^3/person year]	12,2	14,6	C
Waste generation [m^3/person year]	2,4	2,0	E
Building lighting [W/m^2]	19,8	20,0	D
Average score of the building			**C**

It can be noticed that even if there is a big difference in energy use of the evaluated and reference building, the cost of emissions is the same. Such situation can occur if the heat sources are different. In the case of assessed building the heat source for heating is a gas boiler and for hot water electricity is used. For the reference building a gas boiler was assumed to be the heat source for both systems.

The average score of the quantitative assessment of the building is equal to C. This note is appropriate for the building that is one class better than a standard building with the same shape, function and with reference parameters of energy use, water consumption and waste generation. It can be concluded that the thermo-modernization of the building allowed to bring the building to a good sustainable standard.

6 Conclusion

In this paper, evaluation of a public building after thermo-modernization was done according to two methods of building environmental assessment: quantitative and qualitative developed as part of polish scientific research. The results from both methods are similar and show that the thermo-modernization allowed to decrease the negative impact of building on the environment. The energy use is much lower than for the reference building, and the other parameters are close to the standard. The final score of the qualitative assessment equal to 3,46 (scale 1-5) and of the quantitative assessment equal to C shows that the evaluated public building has a good environmental standard. It can be also noticed that thermo-modernization of public buildings is also very important from the economical point of view.

Both simplified methods can be easily used by designers, architects and energy consultants for performance labelling. The results of the evaluation can serve as a basis for future optional environmental certificate programs, when they become acceptable on the market or required by regulations. Reports from assessments are documenting buildings' environmental quality or indicate areas for improvement. Both methods are consistent in a sense that a building assessed as good in the quantitative assessment gets a good grade in a part of the qualitative assessment.

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