# Multi-criteria evaluation used as a tool taking into account the optimal selection of materials, described on example of selection of thermal insulation materials for wood-based envelope

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**Abstract— Currently, the choice of materials for the construction of buildings should take into account not only their traditional features such as price and quality but also the environmental qualities. The thesis describes the process of multi-criteria evaluation of thermal insulation materials for wood-based envelope with other possible comparing of obtained valuation parameters.**

***Index Terms*— Criteria limits, Decision analysis, Method of order, Multi-criteria evaluation**

## I. INTRODUCTION

The European Union in the documents Standards of the European Parliament and Council 2010/31 / EU [1] knew as The Standards 20-20-20 adopted three major commitments to meet the criteria by 2020. The first one is to reduce the overall greenhouse gas emissions by at least 20% compared to year 1990. The second one is the reduction of energy consumption in the EU countries also by at least 20% and the third one is a commitment to achieve a 20% share of renewable energy in total energy consumption by 2020 [1]. By applying external wood-based cladding there is a presumption to fulfil the first two obligations of the directive. At the same time in order to comply with the objectives of sustainable construction it is necessary to evaluate the selection of materials for the construction still in the design process. The article describes the selection of thermal insulating materials for wood-based cladding by a based on multi-criteria evaluation [2].

## II. METHODOLOGY OF MULTI-CRITERIA EVALUATION

Evaluation of thermal insulation materials is based on a comparison of the materials with a thickness of achieving U-value = 0,15W/(m$^2$.K), which is the target value recommended for exterior walls according the STN 73 0540-2 [3]. It would not be fair to compare the thermal insulation material at the same thickness, because in providing thermal protection of buildings it does not matter on the thickness of the thermal insulation material, but on its ability to conduct heat. In selecting materials for the thermal insulation materials for the wood based envelope the following characteristics were evaluated: technology, economic and environmental. Technological: For the thermal insulation material the weight per unit area was chosen as the technological characteristics, which is based on the 1 m$^2$ of thermal insulation material for a given thickness. It is calculated as the product of the density and thickness of the material. Economical: They represent the price of the thermal insulating material in the thickness based on one 1 m$^2$. Environmental characteristics: To achieve the sustainable development requirements, it is necessary to deal with the environmental aspects, while the three basic of them are [4]: PEI – (Primary energy input) the amount of bounded energy, GWP – (Global warming potential) the potential of global warming, AP – (Acidification potential) the potential of acidification of the environment.

For a materials having approximately the same specific weight the change from PEI, GWP and AP taken into account for 1 kg for PEI, GWP and AP taken into account on it has no great influence on a change of the operation of the materials in the environment. However, for materials with different densities given conversion has a major impact on the change in the ratio of exposure of the materials to the environment. PEI based on 1 kg of material was converted to the PEI based on 1 m$^2$ such that a weight is multiplied by the weight per unit area. In assessing the GWP and AP it is necessary to proceed in the same way.

### *A. Decision analysis*

From multi-criteria evaluation the results are obtained on how the thermal insulation materials are rated in each of the three evaluation criteria. The one basic methods of decision is used for the overall evaluation of the different materials - the decision analysis. First of all, the criteria limits are created and for the importance of each criterion (evaluation criteria) the weighting method according the evaluation order is used.

### *B. Criteria limits*

Assign a point value (0-10 points) for individual values of the assessing criteria of materials. Within the 10 points is the best possible score and the 0 points is the worst score. When converting the values to points the intermediate points are linearly interpolated and normalized points are rounded to 1 decimal place. Subsequently, the scoreboard is created by the weighting criteria. The weight of the individual sub-parameters in one category, as well as the total weight of evaluation criteria shall be determined by using the weighted evaluation with the method of order.

### *C. Method of order*

1st: Determination of the order request by relevance
2nd: Assign points: the most important criterion: the number k, the other k-1 and the last one 1

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3th: In general, the i-criterion a natural number $b_i$ is assigned The weight of criterion is calculated according to the formula:
$v_i=b_i/\sum^{k}_{i=1} b_i$, $/\sum^{k}_{i=1} b_i = k.(k+1)/2$, $i = 1,2,\ldots,k.$ (1)

## III. THE RESULTS

### *A. The results of multi-criteria evaluation*

The first step was to obtain the environmental and building physical properties [5, 6, 7], which are processed and converted to the evaluation parameters according to the methodology of multi criteria evaluation (Fig. 1, 2).

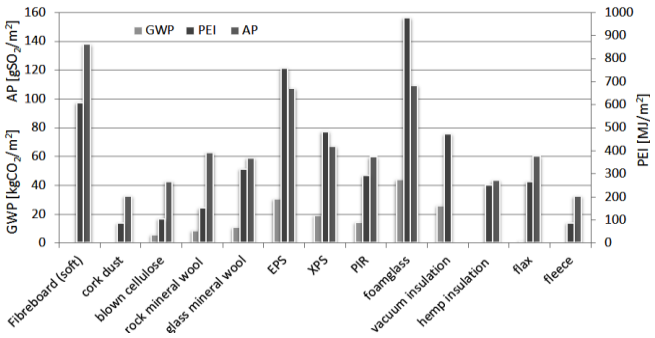


Fig. 1: The required thickness of materials to achieve U-value = 0,15 W/(m$^2$.K) along with technological and economic evaluation parameters

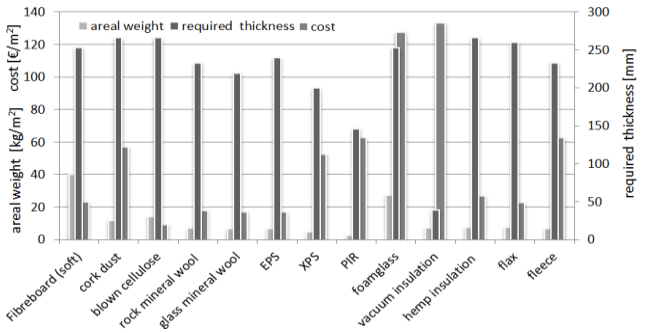


Fig. 2: Environmental evaluation parameters

In the evaluation performance the thermal insulation materials will be compared with a thickness of 4-27 cm (Fig. 1). The prices for the thickness of the individual materials are taken from the price list of materials of construction and economic software Cenkros and form the price list of selected representatives for different types of thermal insulation materials. From an environmental point of view, as expected, just the thermal insulation based on a natural basis: hemp, flax, sheep wool, cork dust and blown cellulose have a minimal negative impact on the environment.

### *B. The results of the overall evaluation of the different materials using the method of weighted sequence evaluation*

For the comparison of the thermal insulation materials the decision-analysis was used. The importance of each parameter has been assigned by the weighting evaluation method according to the order in different variants (Fig. 3, 4). For comparison with an equivalent (Fig. 5) and an extreme high (Fig. 6, 7) assessment was used by given the importance of the evaluation criteria.

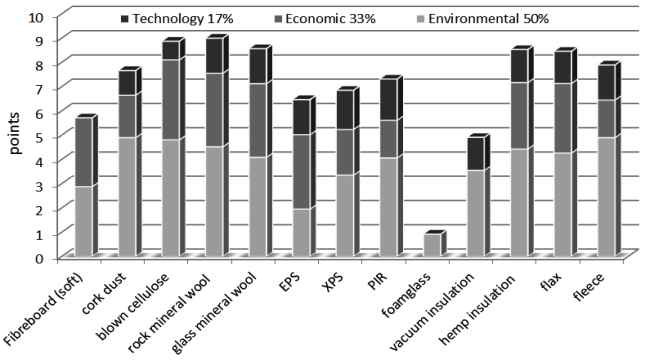


Fig. 3: Overall evaluation of materials with different importance of evaluation criteria: 17% technology, 33% economic, 50% environmental

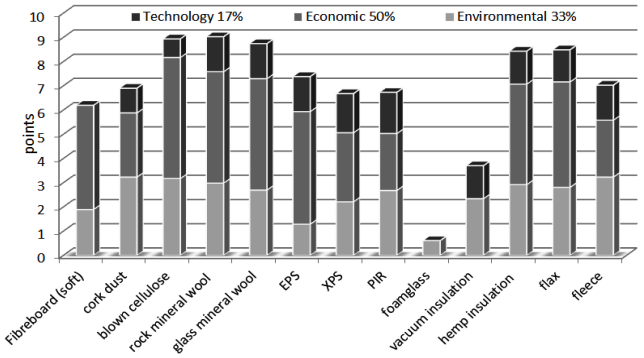


Fig. 4: Overall evaluation of materials with different importance of evaluation criteria: 17% technology, 50% economic, 33% environmental

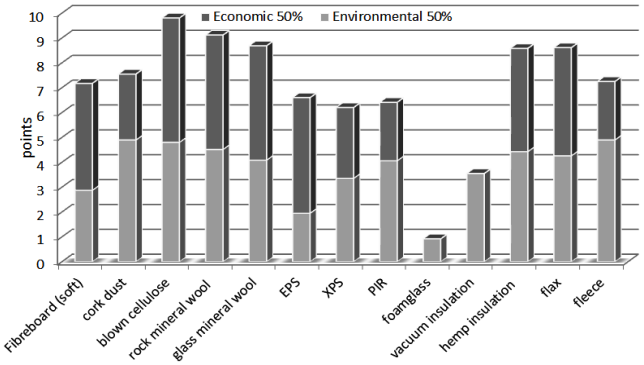


Fig. 5: Overall evaluation of materials with different importance of evaluation criteria: 50% economic and 50% environmental

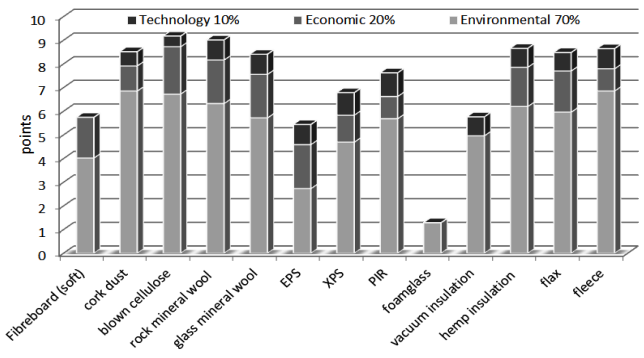


Fig. 6: Overall evaluation of materials with different importance of evaluation criteria: 10% technology, 20% economic, 70% environmental

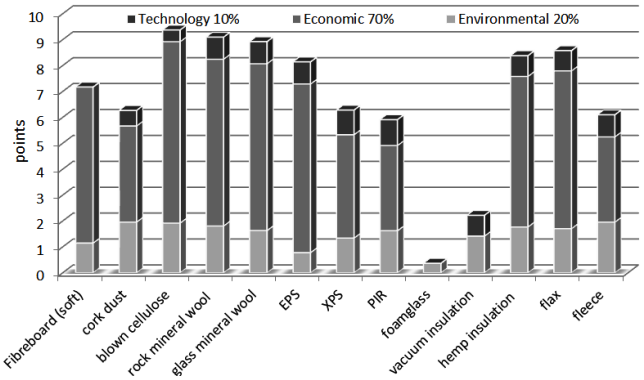


Fig. 7: Overall evaluation of materials with different importance of evaluation criteria: 10% technology, 70% economic, 20% environmental

## IV. Conclusion

From the results of the overall evaluation of the materials was shown that the blown cellulose, mineral wool, hemp and flax insulation boards are the thermal insulation materials with the maximum score of assessment from all variants of multi-criteria evaluation. The evaluation parameters were switched to evaluate the thermal insulation materials for the construction of external cladding. Therefore, the same materials that come out from the evaluation may achieve better results in the evaluation of their use in other structural parts of the building (e.g., when the using of other assessment of strength characteristic, hydrophobicity, etc. enter the assessing process.).

## Acknowledgment

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