EVALUATION OF ENERGY SAVING ARRANGEMENTS IN BUILDINGS

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Summary

There are many special technical models and calculation tools for appreciation of energy efficiency and thermal technical characteristics of buildings now. They include technical evaluation of buildings only. Describing approach solve problem of evaluation of buildings complexly. This report describes the energy savings project realization from the systemic approach and for evaluation using a multicriteria evaluation. This method uses technical, economical, ecology and social criteria.

Keywords: decision making, multicriteria evaluation, energy savings, renewable energy sources

1 Introduction

The questions of energy saving in buildings and approaches to their realizations are now in the spotlight. The main reason for their popularity is saving of fossil fuels, in short supply in the EU, lowering of building operating costs and also the Earth climate protection. In the Czech Republic great attention is paid to this area, which is reflected in the current legislation (law No. 406/2000 on energy savings and its implementing regulations such as edict No. 148/2007 about building energy efficiency, as well as the Czech standards such as ČSN 730540).

This report aims to describe the energy savings project realization from the systemic approach that offers a selection of the best option on the basis of a multicriteria evaluation. This approach tries to respect the complexity of the option evaluation, based on the decision making process characterized by one factor and a finite set of options, which are assessed by a number of criteria with the goal to determine the optimal option.

2 Description of the process of project savings evaluation

The decision making process in our model offered here was divided into two steps.

2.1 Object Phase 1

In this step the optimization process is based on a dynamic programming application, which represents one of the methods of mathematical programming. The application here is the function/step of optimal resource allocation. The goal is to generally divide an available source quantity Z into N economy measures so that the final effect will be maximized. The solution is based on the so called Bellman principle of optimization, i.e. that the optimal strategy has the quality that with any opening conditions and any initial decision the remaining decisions must form the optimal strategy with regard to the state that arose as the result of the initial decision.

The result of this method's application is the definition of the set of the project savings evaluation.

Individual projects differ in part in measures structures and in part in its effect.

The measures are for example the method of external cladding insulation, the method of roof cladding insulation, change in aperture filling based on different quality of filling from the point of view of boundary conductance, installation of condensing boilers, use of heat pumps, thermosolar panels etc.

The effect of the project savings evaluation is then understood for example the maximization of savings of energy and greenhouse gasses, minimization of average value of the boundary conductance of the external cladding insulation etc.

2.2 Object Phase 2

The input for the final decision process is the set of project savings that is the result of the model's step 1.

The decision maker/factor then defines decision criteria, which can differ in its factual content and can be divided into economical, technical, ecology and social criteria. It is useful then to choose these criteria from the point of simpler applicability as criteria for decision making and evaluations, and as quality and quantity criteria. At the same time it is necessary to define their exact values. Qualitative criteria can be evaluated only by the extent of their goals fulfillment. For this purpose it is necessary to use the so called ordinary scale, the scale of goal fulfillment.

Suitable criteria for the decision making process about the optimal realization of energy savings of the existing buildings can be taken for example:

- Technical criteria – maximization of energy savings and use of Renewable sources
- Economical criteria – NVP maximization of cash flow, minimization of operating costs
- Ecology criteria – maximization of CO2 savings
- Social criteria – maximization of building comfort and its useful life lifespan

For the criterion of a multicriteria decision making defined in this way, it is necessary to establish the weights of each criterion. This problem can be solved by various methods sufficiently described in literature. A scoring method was used for modeling the user preferences. In principle, to get information about relative importance of each criterion we can use other methods such as a sequence method or the pair comparison method. When we get information about the criteria in this way, or approach is then based on implementation of the scaled sum method. It is a special case of the utility function method, which presupposes only the linear utility function.

After normalizing through a transformation formula and recalculation by the weights of each criterion we then get the “best” option the one that reaches the greatest utility value. If necessary, we can also order the options by their declining utility values.

The result is finding the optimal method of energy savings project realization, or it allows to define option preferences or at least to exclude no effective options.

3 Case study

At the end of our contribution we present a case study of the application of the decision making model.

3.1 Case study

In closing we present a case study of the application of the decision making model.
A decision needs to be made about an optimal method of energy savings in an administrative building.
As a 1st step these partial measures for energy savings were proposed:

Tab. 1 Criteria matrix

Energy saving arrangements
Changing windows and doors
Thermal insulation of walls
Thermal insulation of roof
Complete thermal insulation of the building
Installation of thermosolar panels
Installation of heat regulator valves
Installation of thermal insulations of piping

Options of the energy savings project were defined, based on the best portfolio model; these differ by investment demands as well as energy savings level.
Altogether 4 options A to D were generated. The options are different at energy savings, at economic efficiency, at CO_2 savings and at using of renewable sources.
These options were evaluated using a multicriteria decision model in the 2nd step.
These deciding criteria were chosen:

- The highest energy savings
- The highest use of Renewable sources
- Maximization of CO_2 savings
- Maximization of comfort

The result was setting of basic criteria matrix.

Tab. 2 Criteria matrix

	f1	**f2**	**f3**	**f4**	**f5**
Option A	878	-6160	163	0	9
Option B	475	-92	88	1	6
Option C	289	1140	54	0	5
Option D	695	-2630	129	1	8

There were set of weights for the evaluation criteria currently. Second step result of decision making process was normalized criteria array, which elements formulate utility values of selected options. The best option was made by multicriteria utility value.

$$u(a_i) = \sum_{j=1}^{k} v_j r_{ij} \tag{1}$$

	f1	f2	f3	f4	f5
A	1,00	0,00	1,00	0,00	1,00
B	0,32	0,83	0,31	1,00	0,25
C	0,00	1,00	0,00	0,00	0,00
D	0,69	0,48	0,69	1,00	0,75

u(ai)
0,56
0,55
0,30
0,68

v	0,20	0,30	0,18	0,14	0,18

Fig. 1 Setting of the utility options

The best option was chosen Option D which includes using of renewable sources, thermal insulations of walls, exchange of windows and thermo regulations valves.

4 Conclusions

Current approaches to the problems of energy saving do not respect fully the systemic approach to this area. The decisions made are mainly based on mono-criterion approach, which leads to preferences to a narrower point of view to the detriment of others. Our approach here tries to offer complex solutions, i.e. incorporate into the decision making process differing, even contradictory, points of view. This is what happens in practice anyway. For example, if we want to maximize energy savings, we run into funding problems. Maximization of Renewable sources does not lead to economical effectiveness, very efficient building in the A category leads to a very long period of investment return, and so on.

The approach suggested tries to in the most objective way to include these contrary viewpoints in the decision making process, through the implementation of the multi-criterion decision-making.

We therefore feel that this new approach to solving the real problems will help designers and building owners in their objective decision-making, because it permits the systemic approach based on multi-criterion decision-making.

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