Method of automated selection of necessary detailing in energy modeling

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Abstract. One of the issues that should be solved during a building design process is a calculation of heat consumption and energy efficiency of a future building. The technology of energy modeling, BEM, helps designers to automate this process. Already in the first design stage an engineer needs to make important decisions, and it's not always possible to change some of them later therefore reliability of initial data is of great importance. Nevertheless, most of the data is absent in the beginning, but despite it the designer still can evaluate a calculation accuracy. A creation of the system, that automates the process of selection of necessary calculation detailing will allow to significantly increase a quality of heat consumption calculation.

1. Introduction

BEM (Building Energy Modeling) of energy consumption is series of the engineering calculations allowing to predict an energy consumption of a building within year. And, as a result, to predict a payback of design solutions. For Russia this is a new direction, but in Europe and the USA it is known for a long time and well developed. BEM allows to evaluate level of consumption of energy resources and to evaluate a maintenance cost on a design phase.

Energy modeling is carried out for assessment of energy and financial efficiency of each solution. It is possible to understand how implementation of each engineering solution will result, and further - to select optimal of them.

A mathematical model is necessary for energy consumption modeling. It includes an architectural model connected with engineering systems of a building. This interrelation is a basis of algorithm of a specialized software calculation based on physics of processes.

Energy modeling consists of the following stages:

• modeling of annual life cycle of a building in basic configuration (basic model);

• modeling of annual life cycle of a building after application of energy efficient solutions (analytical model)

Level difference of energy consumption of this two models - "basic" and "energy efficient" - allows to talk about the reached percent of energy efficiency of an object and about economy value.

The energy model allows to analyze object resources consumption taking into account peak loads.

BEM in Russia is not obligatory, but if certification of a building on LEED, BREEAM, GREEN ZOOM is required, then calculation of energy model and the certificate of a building are obligatory. Energy modeling significantly supplements the section "Energy efficiency" which is obligatory in

Russia. The energy model is the powerful instrument of control from sketch to maintenance of a building. It allows to evaluate:

- energy consumption and carbon emissions by a building in different period (within year, by months, days and hours);
- thermal characteristics (calculation of heating and refrigerating loadings, analysis of heat release, effects of population density, infiltration and the working equipment);
- water flow in and outside of a building and costs of water;
- insolation. It is possible to visualize insolation of windows and surfaces during the chosen period;
- natural lighting. Calculation of indicators of natural lighting and determination of illumination levels in any points of a building;
- Shadows and flares. Visualization of situation and trajectory of the sun movement in relation to model at any time any place.

Thus, a customer will be able to receive any quantity of basic solutions and to predict expenses on operation of a building.

The analysis of BEM is possible in the dynamic mode with use 3D geometry, hourly weather information and building location. Depending on tasks energy modeling can be carried out in different software (Tas Systems; IES VE, eQuest, EcotectAnalysis) or by using methods of mathematical modeling.

2. Materials and Methods

Methods of energy modeling allow to analyze energy and economic part from consumption of energy resources. The analysis is carried out by results of simulation of annual cycle of building maintenance. As a result – an information of energy efficiency of a building.

Energy efficiency of a building is the important indicator influencing the cost of its operation.

By connection a building to energy resources sometimes there is a question of the choice of this or that rate. Economy by the choice of more difficult differentiated rates is not always obvious. By results of energy modeling of a building influence of rates for the annual cost of energy resources is visible. The choice of the correct rate leads to increase of energy saving of a building.

It is difficult to make reasonable decision on the choice of this or that design solution from the point of view of energy efficiency of a building. For this purpose it is necessary to take into account large number of factors anyway influencing energy consumption of the considered system. Modeling allows to consider set of all factors at assessment of efficiency of actions for increase in energy saving of a building. Energy modeling gives reliable vision about efficiency of each solution. Then it is possible to make reasonably choice aside only of those solutions which really will be energy efficient for the considered building.

Besides, possessing information on economy in terms of money, not difficult adequately to evaluate payback period of the selected solution any more.

BEM helps to solve wide number of problems, to optimize energy consumption and to achieve increase in energy saving, and, therefore, to reduce unreasonable maintenance cost.

The main objective which faces designers is creation of the comfortable habitat for the person provided with architectural and engineering systems of a building. For calculation of required comfort, it is necessary to consider set of processes. Calculation has included all factors and mechanisms of interaction which take place in reality. In fact, during design the certain mathematical model is created, reflecting work of a building in actual practice - model of energy consumption of a building which includes architectural model, connecting it with engineering systems. This communication is described in mathematical algorithms on which a calculation software is constructed. Engineers have no need to enter these algorithms, but especially input of initial data is responsible.

All components of model can be united in the main categories:

Weather data - array of an environment parameters, such as temperature, humidity, pressure, wind speed, value of solar radiation. Detailed modeling of a building requires detailed model of the environment. In world practice arrays of hourly values of each parameter are used.

Geometry of a building and environment. Only the elements participating in processes of heatmass transfer enter geometrical model: the external and internal protecting constructions, the elements of internal thermal inertia shading elements of a building and environment. Basic parameters are obligatory: density, layer thickness, heat conductivity, heat capacity and coefficients of reflection visible and IR-radiations.

"Schedules" of internal parameters: the hourly values of parameters of model replacing stationary values, for example, calculated temperature indoors. Distinguish 2 types of "schedules": the setting internal loadings - electricity consumption by lighting systems and the equipment, water consumption, and internal parameters - microclimate in rooms, parameters of engineering systems work, etc.

Models of systems and the equipment - part of the mathematical algorithms, put in BEM software. In view of big complexity of engineering systems in comparison with the same architectural component, 2 levels of their detailing are provided in the majority of software: sample and step-by-step.

At stage of conceptual design there are few data on future building, but nevertheless it is possible to evaluate heat consumption approximately.

As it is stated above, in calculation the set of parameters is used, and it is possible to consider them all or partially. Thus, to start calculation it is necessary to enter only obligatory parameters and to consider approximate accuracy without other parameters.

Operation principle of the program such:

An engineer can specify the current design stage, then gets in reply the list of parameters providing the corresponding accuracy of calculation, or several lists if combinations of parameters. The engineer can just specify the accuracy requirement, and also get the list of necessary parameters.

The simplified example (table 1).

Table 1. Example, table with parameters for calculation

	Average %	Min %	Max %
Parameter 1	85	80	92
Parameter 2	10	8	12
Parameter 3	5	1	9
SUM	100		

There are three available parameter influencing the calculation. If we consider all from them, the calculation precision is 100%. During the researches we have found out that for the second parameter 10%, and interval of values - 8 … 12% were average influence on precision. For the third - 5%, interval 1 … 9%. As we talk about the accuracy of calculations, it is specified as a percentage.

Table 2. Example, without one of parameters.

	Average %	Min %	Max %
Parameter 1	85	80	92
Parameter 2	10	8	12
Parameter 3		1	9
SUM	95	91	99

If we do not know the third parameter, we don't include it in the calculation (table 2), and the result is 95% (91 … 99%). This record format says to us that heatlosses are counted with a margin error 5% and that there are parameters which we have not considered and which can change the accuracy of heatlosses up to from 91 to 99%.

The phrase "calculation is made with accuracy of 100%" means that the software has error from real values, and for the further calculations it is necessary to take into account a safety factor, but within this research precision of the calculations is accepted to 100%.

Thus, the engineer can evaluate the precision of the calculation on early stages of design process.

3. Conclusion

In the conducted research was made:

development of method of the automated choice of necessary detailing of model;

development of the information system realizing method of the automated choice of necessary detailing of model.

approbation of the proposed solutions in practice;

definition of possible perspectives of application of this direction taking into account the Russian construction norms and realities.

The model detail levels depending on initial conditions are formulated.

The database of influences of each of parameters for calculation at energy modeling is created.

Compliances between the detail levels of model and parameters for calculation at energy modeling are defined.

The algorithm of work of information system is developed for the automated choice of necessary detailing of model.

The information system realizing method of the automated choice of necessary detailing of model is developed. At stage of conceptual design (sketch) the engineer can quickly define the most energy efficient project from several alternatives by determination only some parameters depending on requirements to model in these conditions and the region of a future building. This method allows to considerably reduce expenses on further design and expenses on maintenance of the building.

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