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METHOD OF AUTOMATIC CHOICE OF REQUIRED DETAILING IN BEM MODEL

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ABSTRACT

In the paper author provides a classification of majority of BEM software, mentions some features linked with them - problems with the building 3D-geometry, weather files, schedules. BEM software contains many parameters for calculation, but at early design phases an engineer does not know many of their values. The proposed method describes an obtaining of an approximate calculation accuracy in the absence of these parameters. Based on this method, software has been created that allows you to get the calculation accuracy in the automatic mode.

Keywords: energy and environmental modeling, BIM, energy efficient buildings and structures, BEM, building energy modeling, energy interrelations, software, CAD.

INTRODUCTION

In our days most of design engineers use BIM modeling software, advantages are widely known - a significantly reduced time of design process, a minimized quantity of mistakes and others.

Besides in many western countries a building energy modeling (BEM) is developed already more than half a century. The section of a building project with energy consumption calculation confirms that all chosen solutions correspond to the most energy efficiency. In Russia it is, unfortunately, not presented neither in design practice, nor in the software, nor in building codes. BEM is obviously the perspective technology that allows to make most precisely calculations of building energy consumption, and to make decisions on early project phases, which are positively influence on energy efficiency.

There is a lot of software for energy modeling, but only some of them are certified by international organizations. To have a certificate - means, that the software has calculation accuracy with an allowable measuring error (Table-1).

Some features of BEM software should be considered:

a) Because BEM appeared long before BIM, and their developing is continuing apart from each other, there is a problem with model geometry transfer from one software to another since in BIM model there are many "extra" data preventing correct import in BEM software. Today this problem can be solved in several ways, for example, by simplification of initial model: surfaces which are not influencing a heat exchange are excluded; all inaccuracies in geometry are eliminated. Also some of software have an ability to create 3D-model from the beginning, because in most cases this way is quicker and simpler than fixing a BIM model.

b) There is a need of a file with climatic data including weather conditions (temperature, humidity, air pressure, speed and direction of wind, solar radiation, etc.) for start a calculation (Figure-1).

A result of modeling depends on quality of weather files. Usually in each software there is a default set of climatic data for many cities, but for Russia a choice is unfortunately few. It's possible to buy weather files for large cities (75-100$/file), but for small settlements they are absent. It ought to be remarked a Meteonorm software [2], that creates the files for any point on Earth, based on a triangulation of data from thousands of its own weather stations around the world.

c) Schedules of occupancy time and engineering systems allow making energy calculation more accurate. A majority of software contains basic schedules for standard buildings and work patterns (Figure-2).

MATERIALS AND METHODS

Successful development of the industry in Russian Federation requires an implementation of energy modeling to real objects. First of all, we need a creation of the Russian BEM software considering a local building codes, but for now in the absence of it we have to use developments of the western colleagues.

The main problem at the first stage of BEM-modeling - a lack of data for a whole model at the design beginning, but also in this case it is possible to evaluate heat losses.

In BEM-modeling there is an opportunity to include in calculation and to exclude from it certain features, for example, a number of people, processes that generate heat, mechanical ventilation, etc. Thus, at the very beginning of design it is required to get only necessary data and to take into account an inaccuracy without all these excluded parameters.

Table-1. Classification of BEM software [1]

3D model is necessary		**Tabular data inputs**	**Mathematical model and programming are necessary**
As an output - fully information about energy consumption and building's life cycle cost	As an output - quantitative and visual information about energy supplies, but you need to analyze a result by yourself	As an output - fully information about energy consumption and building's life cycle cost; colsultant	As an output - quantitative and visual information about energy supplies, but you need to analyze a result by yourself
▪ AECOsim Energy Simulator V8i ▪ AEPS System Planning ▪ ArchiCAD, Energy Analysis ▪ Autodesk Ecotect Analysis ▪ Autodesk Revit ▪ Bsim (Building Simulation) ▪ Building Design Advisor (BDA) ▪ Czech National Calculation Tool ▪ Design Builder, Energy Plus Simulation ▪ EDSL Tas ▪ EnergyCAP Enterprise ▪ ESP-r ▪ gEnergyEPC ▪ IDA Indoor Climate and Energy ▪ IES VE ▪ Polysun ▪ Pvcad ▪ RaumGEO, Mh-software GmbH ▪ Right-Suite Universal ▪ TRNSYS ▪ VisualDOE 4.0	▪ Ansys CFD ▪ AnTherm (Thermal Heat Bridges) ▪ AutoCAD Simulation ▪ COMSOL Multiphysics ▪ CRADLE HEAT Designer ▪ DarTWin Mold Simulator ▪ Delphin ▪ Dymola simulation tools ▪ Flex PDE Solution Inc ▪ Green Building Information System (GBIS) ▪ HEAT 2,3 ▪ Mc4Suite2010 ▪ OpenFOAM ▪ Physibel Software ▪ Siemens NX8 ▪ Solidworks CFD ▪ Star-CD CFD ▪ Usai	▪ ARUP Energy 2 ▪ Autodesk Green Building Studio ▪ OE2 eQUEST ▪ OPAQUE ▪ Energy + ▪ Building Energy Analyzer PRO ▪ Chvac Rhvac ▪ Climate consultant ▪ Earth Energy Designer (EED) ▪ Energy-10 ▪ EnergyPro ▪ EnergySavvy ▪ HEED: Home Energy Efficient Design ▪ MIT Design Advisor ▪ OPTIMISER ▪ OptoMizer ▪ Package PHPP ▪ Passive House Planning (Design) ▪ Recurve ▪ REM/Rate REM/Design ▪ SOLAR-2,5 ▪ TREAT	▪ HAMLAB HAMBASE ▪ LabView National Instruments ▪ MapleSim Model ▪ MathCAD ▪ MatLAB/Simulink ▪ Modelica ▪ Wolfram Mathematica

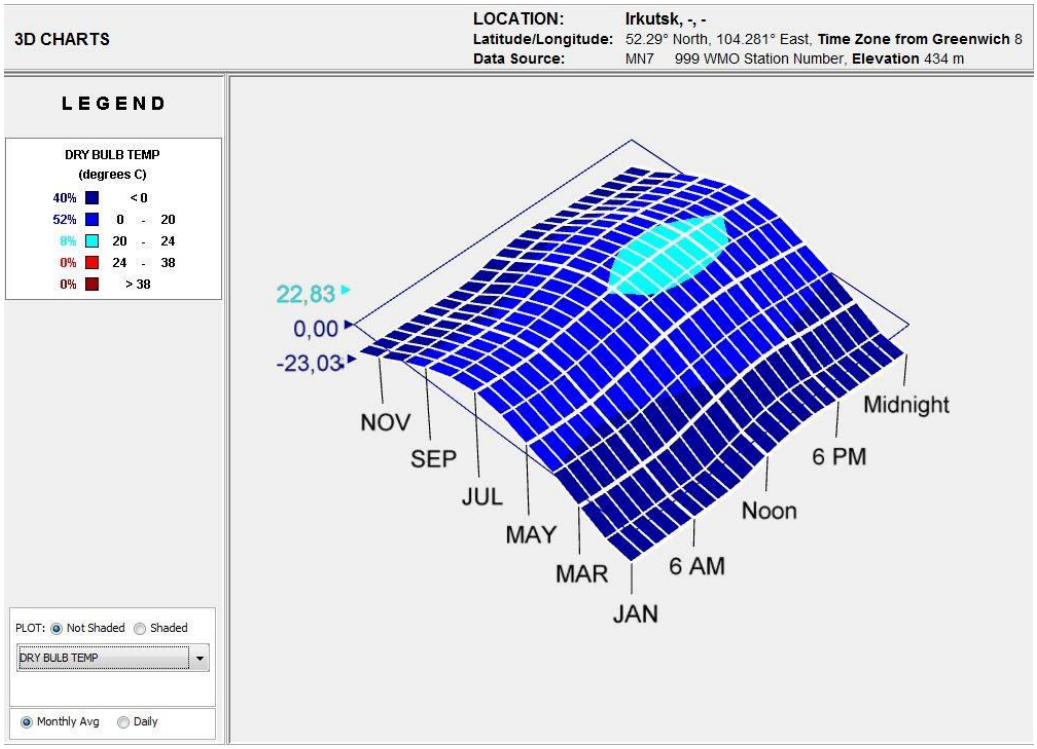

Figure-1. 3D chart of dry bulb temperature, climate consultant software.

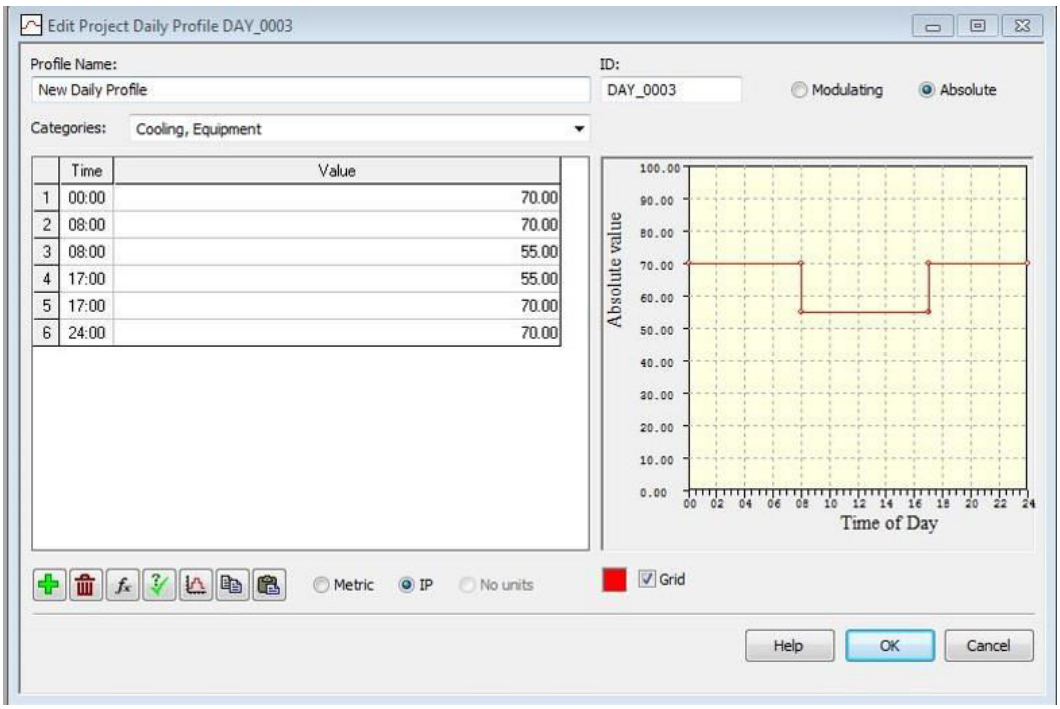

Figure-2. Equipment schedule.

In the research:

a) a list of parameters was compiled, that are taken into account in calculation;

b) influence of each optional parameter was defined. Influence is expressed by the value of accuracy percent which is added by each corresponding parameter. Different combinations of these

parameters correspond to a certain calculation accuracy;

c) a database was created, including all the calculation parameters and the influences corresponding to them;

d) on the basis of this database a specific software was developed;

e) recommendations were provided for future building codes in the field of energy modeling, namely - a list of parameters which an engineer should have on each design stage, and the calculation accuracy of energy consumption corresponding to them.

The functionality of the specific software is:
A design engineer can choose a current design stage, then he receives a list of necessary parameters providing the corresponding calculation accuracy, or several lists if a quantity of combinations of parameters for this accuracy is more than one. In addition, the engineer can just choose, on the contrary, the required calculation accuracy, and he also receives a list of necessary parameters (or several lists).

Parameters are divided on functional groups; therefore there is also an opportunity, for example, to forcibly include an artificial lighting in the calculation and to receive as a result corresponding calculation accuracy.
As a simplified example of this would be the following (Table-2).

Table-2. An example, accounting of all parameters.

	Average %	Min %	Max %
Parameter 1 is mandatory	95	90	97
Parameter 2 (+)	10	8	12
Parameter 3 (-)	-5	-9	-1
SUM	100		

There are three parameters that affect the calculation. First one is mandatory, it is impossible to run the calculation without it. The second signed "plus" - increases value of consumed kW energy, the third signed "minus" - reduces kW. If we consider all of them, final calculation accuracy equals 100%. During the study we found out that an average influence on accuracy for the second parameter is 10% with range of values 8…12%. For the third parameter: -5% with range -9…-1%. Due to the fact that there are parameters with negative influence, we have to use ranges of the influence values for all parameters.

Table-3. An example, without one of parameters.

	Average %	Min %	Max %
Parameter 1 is mandatory	95	90	97
Parameter 2 (+)	10	8	12
Parameter 3 (-)			
SUM	105	101	109

If the value of third parameter is unknown, we do not include it in the calculation (table 3), and get 105% (101…109%). This means that heat losses are calculated with a safety factor and that there are some not considered parameters which can reduce heat losses up to 9%.

Of course, when we say "the calculation was made with 100% accuracy", we mean that the software has its own measuring error, but for convenience within this research the software accuracy is accepted to 100%.

CONCLUSIONS

Thus, an engineer can estimate the accuracy of the calculation, taking into account possible changes of further calculations, when new data will be received from architects and other design engineers. In this study the software was developed, considering average values of accuracy which is added by each parameter during the calculation.

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