HeatMod6 – Web-Based Application for Building Heat Balance Calculation

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Abstract
HeatMod6 is web-based user friendly application that allows calculating and analyzing building total heat balance, taking into account such essential thermo physical processes as heat transfer by transmission through building structures, ventilation, diverse internal source of heat gains, solar heat gains and other factors.
Web-based approach offers such benefits:

- *make calculations on-line without need of saving any data to local storage;*
- *access to your calculations from any computer with internet access;*
- *no need to install any application;*
- *always up-to-date mathematical model and classifiers;*
- *operation system independent;*
- *standard form certificate (PDF printout).*

Heatmod6 is adapted to Latvian climatic conditions and complies with the Latvian legal documents [1] (based on EN ISO 13790).
There has been made practical probation of the application and its mathematical model by comparing the results with:

- *measurement data and determining the specific buildings energy efficiency;*
- *such popular applications as EFA, EFA2, HeatMod5, PHPP.*

Keywords - energy efficiency; heat energy balance calculation; heat transfer

1. INTRODUCTION

Analysis of situation in Latvia showed that there are several applications for heat balance calculation, but all of them have its disadvantages and restrictions. Applications used in Latvia are:

- EFA, EFA2, HeatMod5 – developed in Latvia;

- PHPP – developed in German, internationally recognized application.

Our goal was to develop advanced, new fashioned and user friendly application for heat balance calculation taking into account all the disadvantages of existing applications; this application can be used by energy auditors and other specialists, who are interested in analysis of building energy balance.

To verify application mathematical method, we compared it to other applications used in Latvia (EFA, EFA2, HeatMod5 and PHPP) and approbated at existing building and its measurements. According to Latvian national documents [1] (which are based on EN ISO 13790), the accuracy demand of the heat energy balance calculation model is less than 10% and less or equal to 10 kWh/m^2 per year, but in case of heat balance calculation for low-energy consumption or passive houses, there should be used more detailed and accurate method (monthly, simple hourly or even simulation methods) in accordance with standards EN ISO 13790 and related, which is international standard and widely used in the European Union.

For energy auditors and other specialists in most cases there is sufficient to use seasonal or monthly method. In cases, where there is a need for more detailed analysis of building and its situation, there can be used simple hourly or simulation methods, but these methods are more of a scientific nature and not widely used by energy auditors and other specialists.

2. METHODS

To achieve the goal, we investigated and identified disadvantages of existing applications used in Latvia, analyzed Latvian national documents [1] (which are based on EN ISO 13790 etc.) and relevant methodological materials [2, 3], explored evolution of modern applications and chose appropriate development to accomplish that task. Our priorities during the development process were:

- avoiding disadvantages of existing applications;
- creating new fashioned user friendly interface;
- allowing users to perform advanced tasks with simple operations;
- supporting Latvian climatic conditions;
- developing modular and easily extensible application (multi-language support, different countries climatic conditions etc);

2.1. DISADVANTAGES of EXISTING APPLICATIONS

There are summarized applications used in Latvia and its disadvantages:

- PHPP (Passive House Planning Package) – international Excel based and hence not user friendly application, which allows using seasonal or monthly methods for calculating heat balance,

but it does not meet conditions of current Latvian national documents [1] and it has limitations, for example, number of objects etc.;

- EFA – Excel based and hence not user friendly application, which allows using seasonal method for calculating heat balance according to Latvian national documents [1] with limited abilities and restrictions on calculations, number of objects etc.;
- EFA2 – new version of EFA application with bug fixes, some new calculations, but still limited abilities and restrictions because of its Excel based implementation;
- HeatMod5 – desktop application, which allows using seasonal or monthly methods for calculating heat balance, but it was developed in 2002 and based on DIN (Deutsches Institut für Normung) standards, hence it does not meet current Latvian national documents [1].

Excel based applications require to be installed MS Office or similar application on user computer to run them, while HeatMod5 desktop application is limited to Windows XP and older. Nowadays applications must be operation system independent, easy to use, available from any device (desktop computer, notepad, iPad, mobile phone, etc) any time.

Another disadvantage of existing applications is that they are decentralized, there for each of application can have several versions (every time there is a bug fix patches or some changes made). This leads to situations, when user always must follow the application versions otherwise he will be using old one. As a result, each user gets different results because of different versions of applications and there for it becomes very messy to identify the correct result, in the end user gets multiple files each for each building and any of them can be with different versions.

In addition, Excel based applications does not provide any security according to certificate printout; so every user has ability to cheat on certificate data.

2.2. WEB-BASED APPLICATION ADVANTAGES

The trend of nowadays is that applications become web-based (cloud technology), which provides several advantages:

- making calculations online without need of saving any data to local storage, no worry about data losing;
- keeping all the calculations at one place, no need to save every calculation in its own file;
- accessing to your calculations from any device any time with internet access;
- no need to install any application on specific devices;
- always up-to-date mathematical model and classifiers data;

- operation system independent (Windows, Linux, Android, iOS, CromeOS, etc. – you just need web browser);
- standardized and more secure certificate (PDF printout, see Fig.1);
- centralized solution with abilities to extend it providing additional web services etc.

Such approach addresses many of the disadvantages of existing applications and provides even more.

2.3. DEVELOPMENT TOOL

As development tool, there were chosen Microsoft technologies, which are reliable and advanced.

Microsoft .NET framework is used for application server side and its advantages are:

- modern and very powerful development tool with a wide range of libraries;
- native JSON web service support for asynchronous JavaScript call, thus providing more convenient user interface;
- Web application debugging facilities.

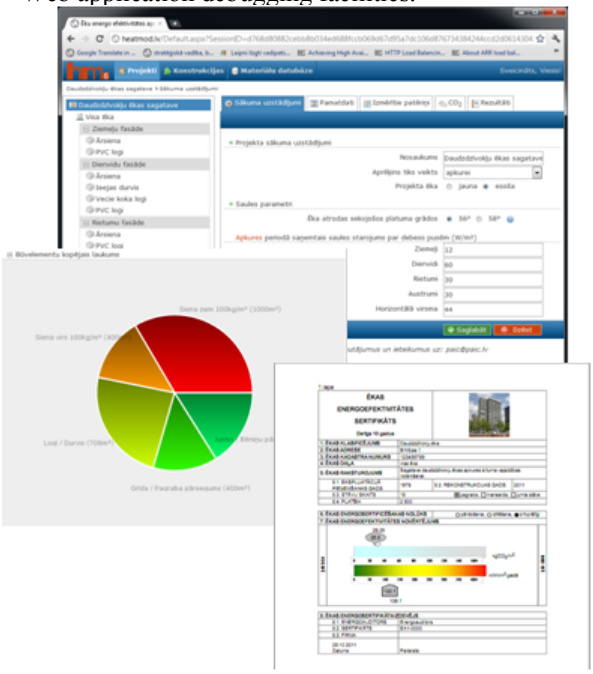

Fig. 1 Different features of HeatMod6 application (data input and visualization, certificate printout, etc)

Microsoft SQL Server is used as application database and its advantages are:

- modern, fast and very powerful database with native XML support;
- built-in support for user and role management;
- built-in reporting development tool;
- a lot more functionality.

2.4. APPLICATION MATHEMATICAL MODEL AND FEATURES

HeatMod6 mathematical model of calculations is based on Latvian national documents [1], which supports on EN ISO 13790, it means that it is multi-country solution, which is ready for multi-language and different country climatic conditions support. It allows calculating and analyzing building total heat balance, taking into account such essential thermo physical processes as heat transfer by transmission through building structures, ventilation, diverse internal source of heat gains, solar heat gains and other factors.

HeatMod6 mathematical model provides annual and monthly based heat balance calculations depending on Latvian climatic conditions. In addition, there are several tools for make calculation easier, for example: definition of homogeneous and heterogeneous constructions (see Fig.2); material database (see Fig.3); calculation of roof, basement and unheated nearby rooms thermal transmittance; heating and cooling breaks etc.

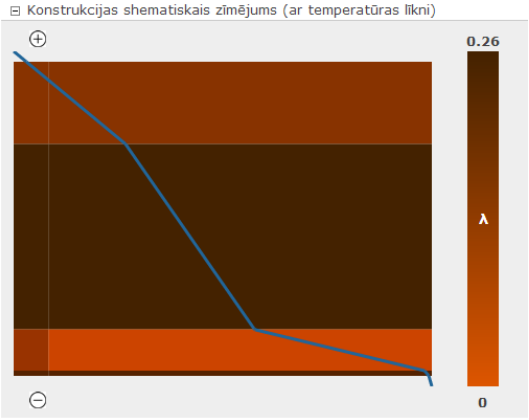

Fig. 2 Heterogeneous constructions and temperature fall in it

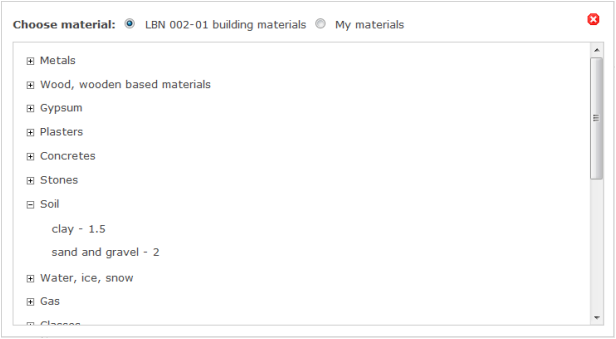

Fig. 3 Database of built-in and user defined materials

HeatMod6 application provides easy definition of building geometry, including multiple zones without thermal coupling between them, construction elements, shadings and thermal bridges (see Fig.4); visualization of results (for example: different cross-sections of calculation results; temperature curve in construction; shading examples etc); ability to add several images and attachments to each of building etc. In addition, user can manage any number of buildings (so called projects) all in one place with no worry about saving them anywhere and copying between devices.

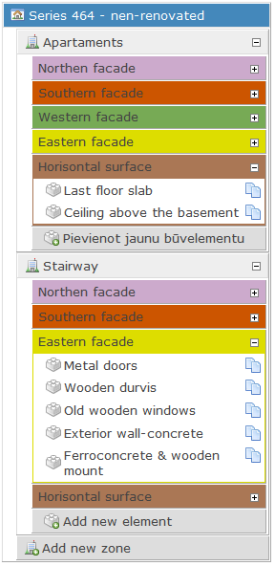

Fig. 4 Tree structure used in building geometry definition

For every building (or so called project) there is ability to manage project main data, multiple building zones without thermal coupling between them and its data, zones construction elements with its thermal bridges and shadings etc.

By managing project main data, user can choose calculation of heating, cooling or both energies; define solar radiation on different directions; choose nearest main city and its climatic data or fill in your own data; fill project and auditor information, measure or design data, fuel and emissions data; add images and attachment files; view result and graphics in different cross-sections; generate print-out certificate.

For every zone in building, user can fill its main data such as inner temperature, zone type, main construction material (type), floor area, height and volume; define ventilation data including natural and mechanical ventilation, recuperation (HRV, MHRV); define internal sources of heat gains from residents and devices, lighting, non-conditioned spaces; water and circulation system; processes and objects; heating system; air condition system; ventilation system; set the heating or cooling breaks and holidays. In addition, for every zone user can view its summary about heat transfer by transmission through zone structures, solar gains by orientations and heat energy balance calculation parameters.

As each of zones consists of construction elements, for every of element user can fill its main data defining type of element (doors, windows, wall, floor, roof, etc), its orientation (north, south, east, west, horizontal); fill in transmission data, including linear and point thermal bridges, its outer temperature, area, heat transfer coefficient etc. There are abilities to calculate heat transfer coefficient for such special cases as roof, floors and basements and influence of nearby unheated space.

For solar gain, user can fill appropriate data for every construction element; in addition user can define one or more shadings for each of construction element with its data.

2.5. MODEL APPROBATION BUILDING

For approbation of HeatMod6 application mathematical model, there was chosen typical dwelling house (Series 464 – see Fig.5.) before and after renovation [4, 5].

Fig. 5 Typical dwelling house in Latvia (Series 464) – before and after renovation

3. RESULTS AND ANALYSIS

For verification of HeatMod6 application and its mathematical model, in all the applications to compare to (see chapter 2.1.) and HeatMod6 application there were fulfilled approbation building data. HeatMod6 application calculation results were compared to other applications calculation results and identified that:

- comparing to PHPP calculations differs for about 3-5%;
- comparing to EFA and EFA2 calculations differs minimally because of rounding error;
- comparing to HeatMod5 calculations differs very much because of HeatMod5 elder calculation model.

Approbation of HeatMod6 application on building measurements data shows that it is suitable and acceptable according to Latvian national documents [1].

During the fulfillment of data, there was observed users ease of use for every application and identified, that HeatMod6 application is more intuitive and easy to use application thanks to its user interface, visual tool etc.

As a result, there were developed advanced and easy to use application for calculating annual (seasonal) and monthly based heat balance according to Latvian climatic conditions, including many useful additional tools, which can be used by energy auditors.

4. CONCLUSION

HeatMod6 application provides seasonal and monthly quasi-steady-state methods according to EN ISO 13790; it is based on Latvian national documents [1] and Latvian climatic conditions.

HeatMod6 application is continually evolving product, we keep on developing new features and additional tools. In the near future there will be implemented such features in HeatMod6 application:

- ability to make cooling calculations by hour (simple hourly method);
- assist tools for calculations;
- additional data visualizations;
- taking into account moisture in constructions;
- other features according to users recommendations.

5. ACKNOWLEDGMENT

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