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ENERGY ANALYSIS OF 3D MODEL OF BUILDING IN ArchiCAD ENVIRONMENT

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ABSTRACT

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BIM (Building Information Model) is an emerging notion appeared in recent years. Since then a large amount of BIM programs has been released. EcoDesigner is one of such programs, which is dealing with 3D-models. The research in question focuses on the study and analysis of this program. The paper presents a 3D-model of a building and its examination. The main principles of the calculation have been determined. The thesis shows and describes the calculations of the energy consumption of the building. The manual calculation of the heating losses is presented and described. All in all, the objectivity of the data is established and confirmed.

Software of this type is crucial and useful nowadays and has a significant potential in the future. The software of BIM will be further developed in diverse directions. Its improvement will simplify the work process of engineers.

Keywords:
Energy consumption
EcoDesigner
BIM
Heat losses

CONTENT

1 INTRODUCTION

The current era of constant technological development in all spheres of human activities causes environmental concern and provokes the rational use of land resources. In order to cope with the problem, a theory of "Sustainable Development" was developed, which is especially spreading in Europe.

There are three dimensions of sustainable development: environmental, economic and social. Energy is one of the key issues of sustainable development.

Since 1990’s a huge amount of energy consumption is observed, leading to an increasing amount of CO_2 emissions, which is one of the reasons for the climate change. There is a need to develop the energy efficient programs of elimination of energy losses for industry and population sectors. In the building sector huge energy losses are observed due to the heat losses through building structures, that increases the amount of energy consumption. One of the efficient ways to prevent those losses is to improve the thermal insulation properties of the used material and structures.

The goal of the thesis is to apply the EcoDesigner software to 3D modeling of a building for evaluation of the energy balance. Therefore, a study of the program is needs to be done. EcoDesigner is an add-on to ArchiCad that enables the leveraging of data from a building information model for a topic of current interest: evaluation of the energy consumption and energy conservation of a building.

EcoDesigner enables now the architects to assess the energy economy of a building in a feasible way. The program quickly performs an analysis on an ArchiCAD building information model, yielding a variety of valuable data that tells the designer how their design solutions affect the building’s energy consumption, overall costs and carbon footprint. (Putkonen 2010)

The significant benefit of EcoDesigner is how broad its analysis could be. The program perceives the design as a single object which is affected not only by the building components but also by the location of the building, local weather conditions, how the used energy is produced and many other parameters that can be set for the analysis. Rapid testing of a design eases the process of imroving the design in order to make it more ecological; the impact of any change could be instantly viewed in EcoDesigner. (Putkonen 2010)

The program is built on the VIPCore calculation engine developed by a Swedish company, Strusoft. It is based on certified analysis standards in the field. The calculation is quick due to the certain parameters calculated on the basis of default values. Thus, EcoDesigner does not purport to replace or even compete with more detailed analysis programs, which have been used before. For the architect, however, the benefits of this program are clear; its easy use makes it a necessary tool for anyone who needs to evaluate the energy economy of a design. (Putkonen 2010)

In the process of writing the thesis, EcoDesigner is used as a tool to assess the energy balance that is constantly being taken into account during the building modeling. The analysis of energy balance can detect an energy wastage. The implementation of the methods allows to reduce and balance the energy consumption. As a result it can decrease the negative impact on the enviroment. The use of energy program helps architects to work more effectively nowadays, and leads to sustainable development.

2 TOTAL HEAT LOSS CALCULATION

The term “heat loss” commonly refers to the heat transfer of an object to its ambient environment. This means that the object in question (a wall, for example) is at a temperature above the ambient temperature. Mathematically, the heat loss of a system through conduction is described using formula 1:

$$Q_{tot} = \sum H_{tot} (T_{in} - T_{out}) \Delta t / 1000 \qquad 1.$$

where
H_{tot} = characteristic of the total heat loss,
T_{in} = the temperature inside, ^{0}C,
T_{out} = the temperature outside, ^{0}C. (Ympäristöministeriö 2007, 18)

The H_{tot} is calculated using formula 2:

$$H_{tot}=\sum(U_{outside\ wall} A_{outside\ wall}) + \sum(U_{roof} A_{roof}) + \sum(U_{ground\ floor} A_{ground\ floor}) + \sum(U_{window} A_{window}) + \sum(U_{door} A_{door}) \qquad 2.$$

where
Q_{tot} = is the total heat loss of the building (kWh),
H_{tot} = characteristic of the total heat loss (W/K),
U = thermal transmittances (W/m^{2}K),
A = the building surface area (m^2),
Δt = the length of period (h),
1000 = the factor that brings the answer to kWh (Ympäristöministeriö 2007, 18).

Thermal transmittance (U) indicates the heat flow density which permeates a building component in steady-state when the temperature difference between the environment on different sides of the building component is the unit of temperature. (National Building Code of Finland 2002, 4)

Thermal transmittances for building components are calculated using thermal conductivity design values determined for building materials provided with a CE mark in accordance with the EU standards; tabulated design values for thermal conductivity stated in the EU standards; values of normative thermal conductivity (λn) or any other thermal conductivity design values suitable for the building component and determined in an acceptable way. If the same material is provided with several λn-values, the value suitable for the target on the basis of footnotes is selected. (National Building Code of Finland 2002, 5-6)

Thermal transmittances are calculated using formula 3:

$$U = 1 / R_T \qquad 3.$$

where

R_T = total thermal resistance of a building component from one environment to another (National Building Code of Finland 2002, 6).

When the material layers in a building component are of uniform thickness and the heat is transmitted at right angles to the material layers, the total thermal resistance RT of a building component is calculated using formula 4:

$$RT = R_{si} + R_1 + R_2 + ... + R_m + R_g + R_b + R_{q1} + R_{q2} + ... + R_{qn} + R_{se} \qquad 4.$$

where

$R_1 = d_1 / \lambda_1$,

$R_2 = d_2 / \lambda_2$,

$R_m = d_m / \lambda_m$,

d_1, d_2, ... d_m = thickness of material layer 1, 2 (m),

λ_1, λ_2, ... λ_m = design thermal conductivity of material layer 1, 2, (e.g. normative thermal conductivity) (m),

R_g = thermal resistance of an air cavity in the building component,

R_b = thermal resistance of the ground,

R_{q1}, R_{q2}, ... R_{qn} = thermal resistance of thin material layer 1, 2, ... n,

R_{si} + R_{se} = sum of the internal and external surface resistances. (National Building Code of Finland 2002, 7)

If the thickness of a homogeneous material layer varies in the direction of the level of the structure, the mean value may be used as the thickness provided so that the local minimum thickness is not below the mean value by more than 20%. (National Building Code of Finland 2002, 6)

When building components are inhomogeneous so that they have material layers in the direction of the surfaces with parallel sectors of different thermal resistance, the thermal resistance R_j of the inhomogeneous material layer j is calculated using formula 5:

$$1 / R_j = f_a / R_{aj} + f_b / R_{bj} + ... + f_n / R_{nj} \qquad 5.$$

where
fa, fb, ... fn a proportional part of the total area of a material layer of the homogeneous subarea,
a, b, ... n in the inhomogeneous material layer j,
R_{aj}, R_{bj}, ... R_{nj} = thermal resistance of the homogeneous sub-area a, b, ... n in the inhomogeneous material layer j where $R_{aj} = d_j / \lambda_{aj}$, $R_{jb} = d_j / \lambda_{bj}$, ... $R_{jn} = d_j / \lambda_{nj}$,
λ_{aj}, λ_{bj}, ... λ_{nj} = design thermal conductivity of the material layer aj, bj, ... nj, e.g. normative thermal conductivity. (National building code of Finland 2002, 6)

The total thermal resistance RT of building components containing inhomogeneous layers is calculated using formula 6 (thermal transmittance U using formula 3):

$$R_T = R_{si} + R_1 + R_2 + ... + R_n + \Sigma R + R_{se} \qquad 6.$$

where

R_1, R_2, ... R_n = thermal resistance of the inhomogeneous material layer 1, 2, ... n calculated using the formula 5,
ΣR = sum of thermal resistances of homogeneous material layers, air cavity, thin material layers and the ground,
Rsi + Rse = sum of the internal and external surface resistances. (C4 National building code of Finland, 6-7)

Regularly repeated thermal bridges in the structure when they are characteristic to it are taken into account when ascertaining conformity of the thermal transmittances. This concerns, for instance, ties, brackets and supporting struttings and frames which are typical to the structure in the entire area of the envelope represented by it. (National Building Code of Finland 2002, 7)

When calculating thermal transmittances, there is no need to take into account any individual thermal bridges in the building envelope, made for various reasons. An individual thermal bridge may be formed by a junction between the base floor or ceiling and the external wall; a balcony support; a column cutting through the base floor; a component for building service technology and any other such like separately designed and implemented single component in the structure. (National Building Code of Finland 2002, 7)

The temperature of the structure at the point of a thermal bridge is different in respect of the surrounding structure. The result of this could be a local decrease in thermal comfort, the surface getting dirty and, at its worst, moisture condensing on the inside surface of the structure or deeper in the structure. In respect of all thermal bridges, the structures are designed in such a way that there are no moisture problems, referred to, and that the thermal conditions in accordance with Part D2 of the National Building Code is achieved in the occupied zone. (National Building Code of Finland 2002, 7)

When the design thermal conductivity of the thermal bridge material is different from the corresponding design value of the adjacent material over fivefold, the increase $\Delta U\Psi X$ of the thermal transmittance for building components due thermal bridges is calculated using formula (7):

$$\Delta U\Psi X = \Sigma\Psi_k (l_k / A) + \Sigma X_j(n_j / A) \qquad 7.$$

where

Ψ_k - linear additional thermal transmittance of a linear thermal bridge k in the building component, similar with each other, W/(mK),

X_j - point additional thermal transmittance of a point thermal bridge j in the building component, similar with each other, W/K,

l_k - total length of similar linear thermal bridges in the building component, m,

n_j -number of similar point thermal bridges in the building component,

A - area of the building component, m^2.(National Building Code of Finland 2002, 8)

Additional thermal transmittance of linear and point thermal bridges (Ψ_k, X_j) is calculated using a method of calculation appropriate for the purpose or is determined by experiment (C4 National Building Code of Finland, 8).

3 DETERMINATION OF BUILDING INFORMATION MODEL

BIM is an acronym for Building Information Modelling, or Building Information Model. It describes the process of designing a building by one coherent system of computer models rather than by separate sets of drawings. In order to not be misled by the word ‘building’ – BIM is just relevant to the civil engineering sector. (WSP 2013)

In fact, BIM offers enormous gains in cost and time saving, greater accuracy in estimation, and the avoidance of error, alterations and rework due to the information loss. However, the adoption of BIM involves much more than simply changing of the software. In order to achieve all the benefits it could provide, everyone in the architecture, engineering and construction industries would need to learn to work in fundamentally new ways. BIM is a whole new paradigm. (WSP 2013)

A sociotechnical system is the combination of man-made technology as well as the social and institutional consequences of its implementation in society. Like the telephone network, it is not just a collection of wires; it contains associated behaviours, social norms, certain kinds of relationships and cultural institutions.
BIM is a ‘system’ being a unified entity which consists of many interacting tangible and intangible parts. It is ‘sociotechnical’ since it has social components, complementing the technical core like the leaves on a tree. The social parts influence the evolution of the technical core through feedback loops. (WSP 2013)

The technical core of BIM is the software that enables 3D modelling and information management. Extensive use of the software eventually leads to a more complete understanding of the technical core. (WSP 2013)

After technology comes the work practices. Moving beyond the software comes the realisation that there is a lot more to BIM than the technical core. This becomes clearer as the technical core begins to shape social practices by expanding possibilities. At first, this means more intense collaboration between different disciplines. Eventually this leads to the creation of a whole new institutional and cultural environment (WSP 2013)

Building information modelling covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components. BIM data can be used to illustrate the entire building life cycle, from cradle to cradle; quantities and properties of materials can be extracted easily and the scope of works can be easily defined. Furthermore systems, assemblies and sequences can be shown in a relative scale to each other and relative to the entire project. (Thenbs 2011)

BIM goes far beyond simply switching to new software. It requires changes to the definition of traditional architectural phases and far more data sharing than architects and engineers are used to. It is able to achieve these improvements by modelling representations of actual parts and pieces being used in the construction process, representing a major shift from traditional computer aided design. (Thenbs 2011)

The interoperability of the model requires that drawings, master building specifications, standards, regulations, manufacturer product specifications, cost and procurement details, environmental conditions, emissions data and submittal processes all work together. The whole process is about different information resources feeding into the documentation, which then becomes a necessary part of the model. (Thenbs 2011)

BIM is far more than 3D CAD modelling; it is a rich information source containing far more than geometric information. Software is the interface to a building information model; rich information content is its body and soul. (Thenbs 2011)

On February 6, 2013, GRAPHISOFT announced the launch of EcoDesigner STAR Public Beta, the first software that places standard-compliant energy analysis in the heart of the architects' familiar BIM work environment. EcoDesigner STAR enables architects to design the most energy-efficient buildings, without having to rely on input from engineers or specialist consultants. (Graphisoft 2013)

4 ECODESIGNER ANALYSIS

4.1 House description

The object of the analysis is a single-level apartment building with a pent roof, with an area of 236 m^2, considered for the residence of one family. There is no information concerning the situation around the building, i.e. topography, water bodies, vegetation etc. The model is located on a flat and empty surface.

4.2 EcoDesigner

EcoDesigner is a program which allows to make the calculations of energy consumption. First of all, the model of building should be analysed. Based on this model, the program provides with the results and creates a report about the work that has been done.

EcoDesigner is accessible under Design Extras in the Design menu (Fig.1).

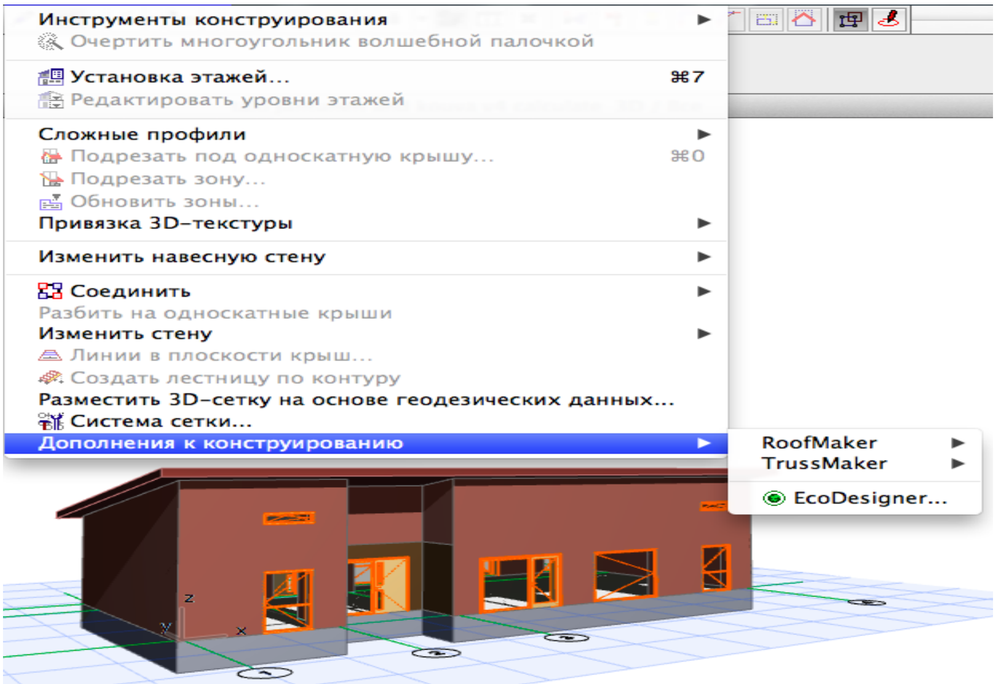

FIGURE 1. EcoDesigner selected

The program automatically presents an analysis of the structures separating them into exterior and interior structures. The next step is to select the Model Review in the Structures tab. The colour coding indicates whether the analysis has been correctly performed (Fig.2). This allows to modify the classification of building components.

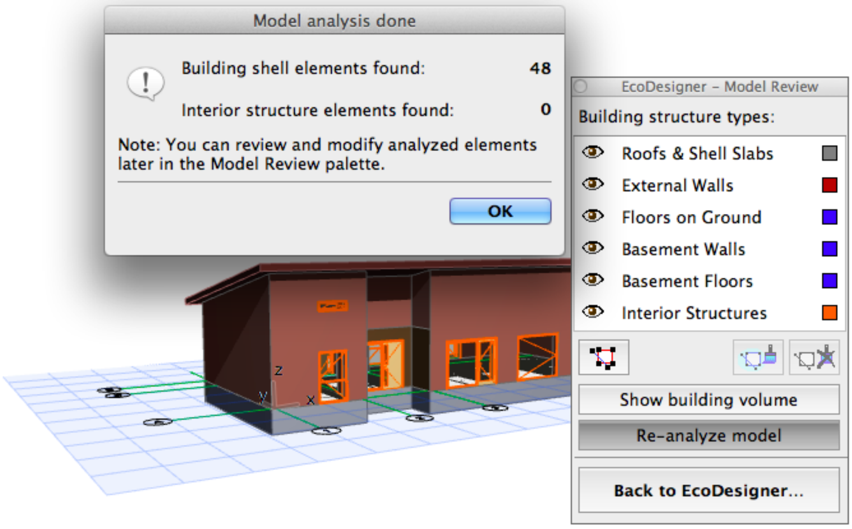

FIGURE 2. Model analysis tab

Then, the model analysis is followed by entering the calculation parameters. The first analysis of the model requires the introduction of a wide data range. The subsequent analysis of the model is easier since the required changes are usually insignificant.

There are a couple of options of entering the location of the city. It can be selected from the list or by addition of the coordinates (longitude and latitude) manually (Fig. 3). The program finds the weather forecast data based on the location.

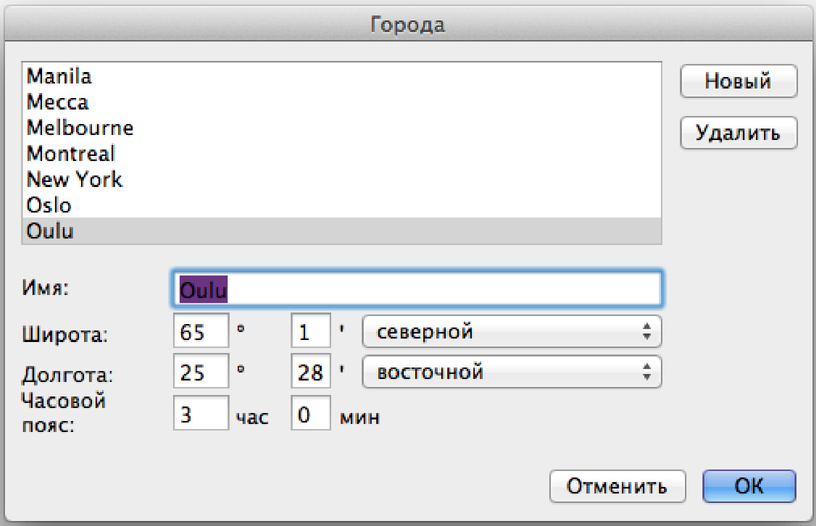

FIGURE 3. EcoDesigner location tab

After that, the purpose of the building needs to be determined. The program allows choosing the profile of the building, that includes: commercial building, public building, industrial building and etc. The heating profile is changed depending on the purpose of the building. Furthermore, the orientation to north, the height of the building, the wind shielding, the surrounding environment and shading against the sun should be defined. Finally, all the mentioned parameters can be added as numbers, or be chosen from the suggested parameters (Fig. 4).

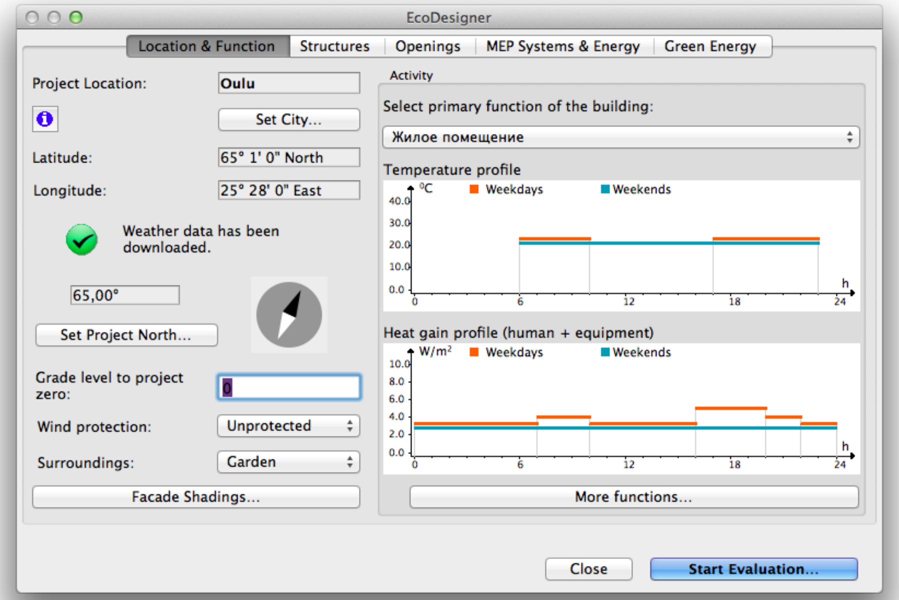

FIGURE 4. EcoDesigner main tab

Figure 5 presents the Structures tab. Building shell elements are divided into groups depending on orientation. Each element has its own U-value, area, surface, structure, thickness and infiltration values. The tempered floor area and building volume are calculated automatically.

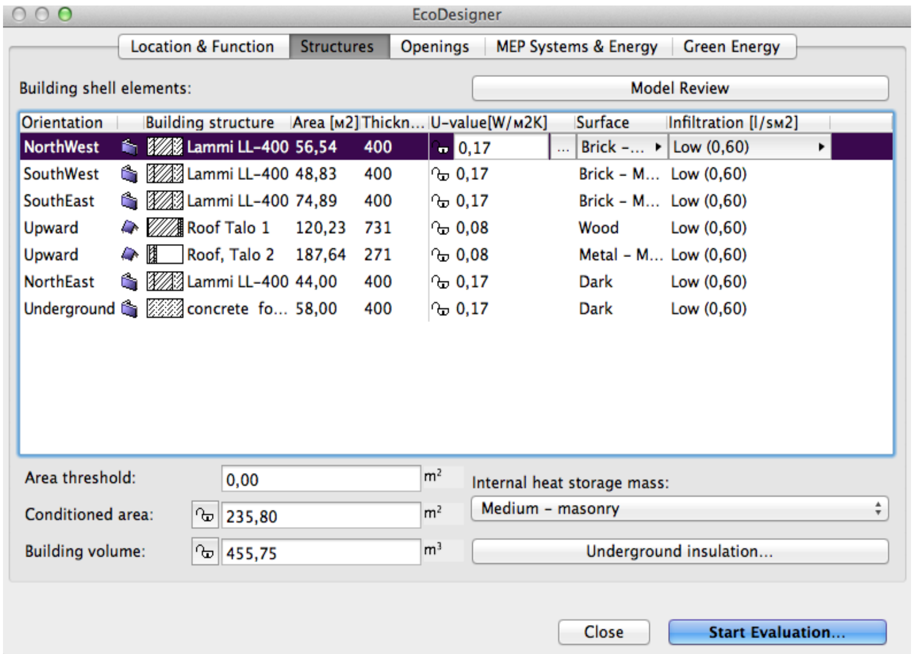

FIGURE 5. EcoDesigner structures tab

The U-values can be changed by a U-value calculator window by adding the thermal conductivity, density and heat capacity of the structure (Fig. 6).

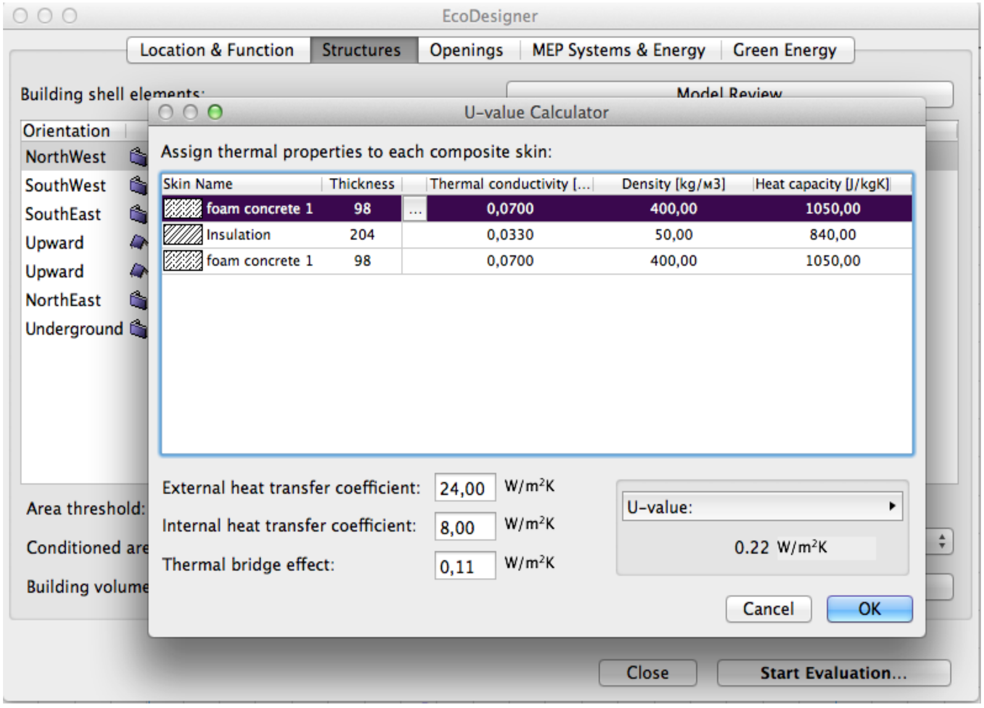

FIGURE 6. EcoDesigner U-value calculator tab

The changing can be done directly or by choosing the defined values from the Material Catalog (Fig. 7).

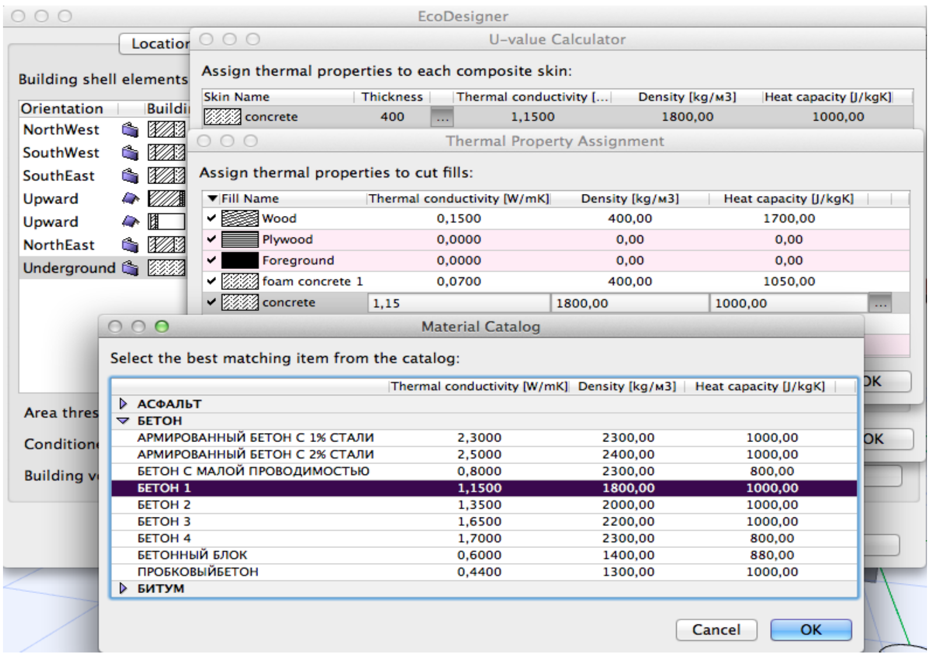

FIGURE 7. *EcoDesigner thermal property assignment tab*

The Material Catalog is an extensive database integrated within EcoDesigner that contains building material information relevant for the energy calculations (Thermal conductivity, Density and Heat capacity). The building materials are grouped in main categories with drop-down detailed lists to enable easy access and quick selection. (Graphisoft, 2013).

These parameters may be found in the technical specs provided by the manufacturer or in generally available tables. In this research the U-values were taken from the project of the building. Furthermore, changes in parameters of surface and infiltration were made. Then, the different options of visual perception like colored plasters, stones, bricks, concrete, metal, wood were chosen for the structure surfaces. In order to define the infiltration, the average value of infiltration in living and public houses was chosen, which is supposed to be around 0,5-075 l/sm^2. In EcoDesigner the low value (0,6 l/sm^2) can be chosen due to the several parameters that are airtight, low, average and high infiltration. The underground insulation properties were assigned, that is styrofoam with a thickness of 50 mm (Fig. 8).

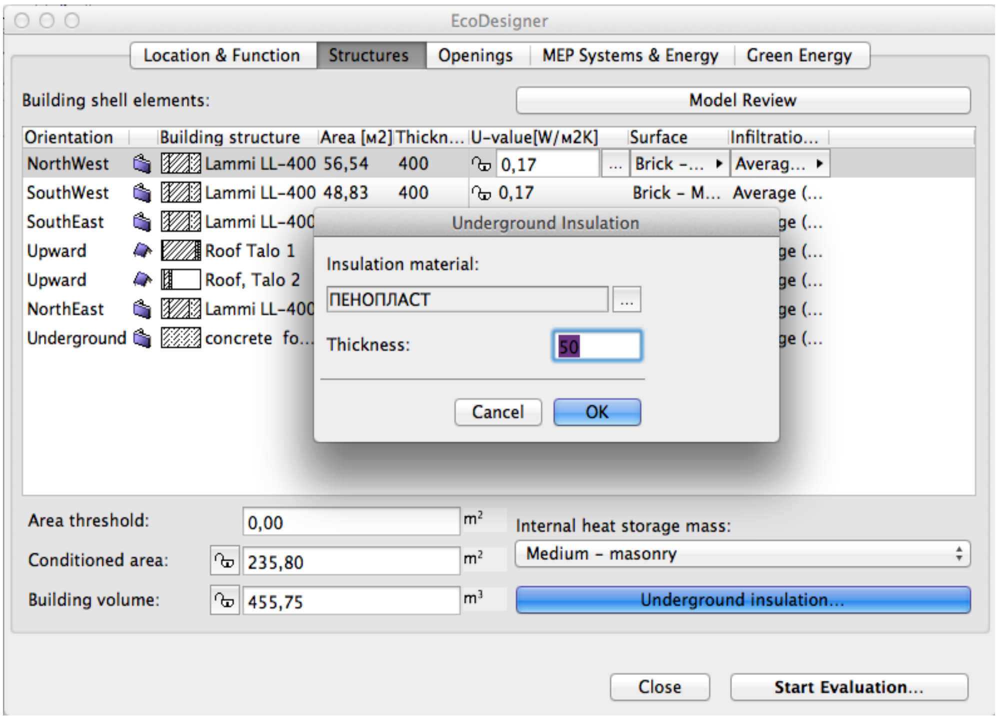

FIGURE 8. EcoDesigner underground Insulation tab

4.3 Calculation algorithm of U-value (R-value)

The U-value Calculator integrated into EcoDesigner calculates the average heat transmission coefficient of materials and composite structures, based on a stationary algorithm that is used by most national standards. Some local conventions prefer to use R-value (Thermal Resistance Coefficient), which is the inverse of U-value. EcoDesigner supports the use of R-value in addition to U-value. U-value can be found using formula 8:

$$U=1/(1/h_i + \sum d/ \lambda+1/h_e) \qquad 8.$$

h_i = internal heat transfer coefficient;

h_e = external heat transfer coefficient;

d = skin thickness;

λ = thermal conductivity (Graphisoft, 2013).

The openings are located according to the orientation of the related structure (Fig. 9). Their parameters can be changed separately and manually. The following types of groups of parameters could be observed: openings type, area of the types (doors or windows), shading device, glass % (percentage of transparent surface compared total surface area), U-value (Heat transmission coefficient), TST % (Total Solar Transmission compared to transparent glass), Infiltration (air permeability of the selet structures).

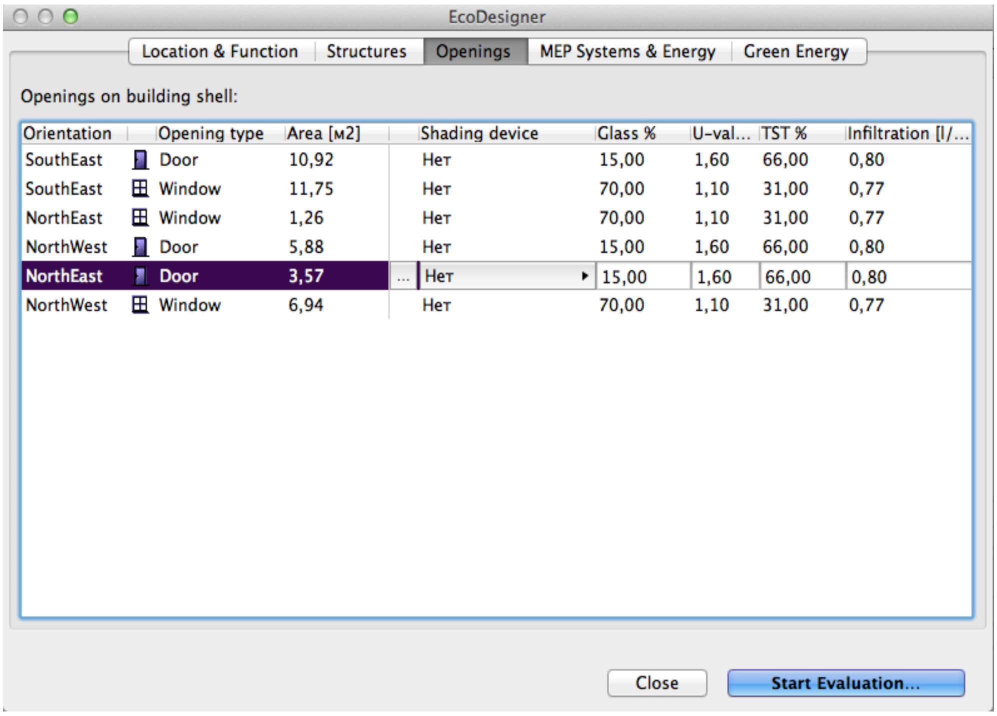

FIGURE 9. EcoDesigner openings tab

The area of windows and doors surfaces is calculated automatically. Using the information about the doors and windows from the openings catalog, all the other fields are filled up automatically, such as glass %, U-value, TST %, infiltration but not shading devices, which are filled manually if it is needed.

The openings catalog is an extensive database of building physics information relevant for the energy calculations: glass %, U-value, TST % and infiltration. The structures that may be built into openings on the building shell are grouped in main categories (windows/glazed doors/curtain wall glazing, air inlet valves, external doors and skylights) that drop down in detailed lists to enable easy access and quick selection (Fig. 10) (GraphiSoft, 2013).

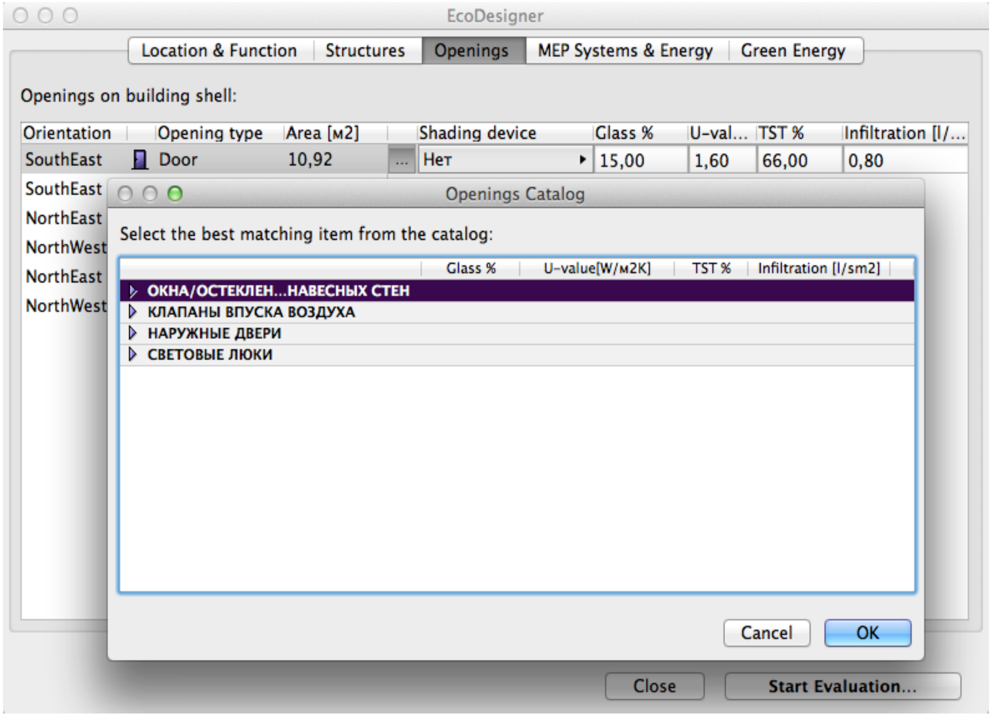

FIGURE 10. EcoDesigner openings tab and openings catalog

In the MEP System and Energy tab (Fig. 11), the energy involved in heating the building is specified. Also type of cooling and ventilation of the building, temperature of hot and cold water, energy source factor and price for the energy must be chosen manually.

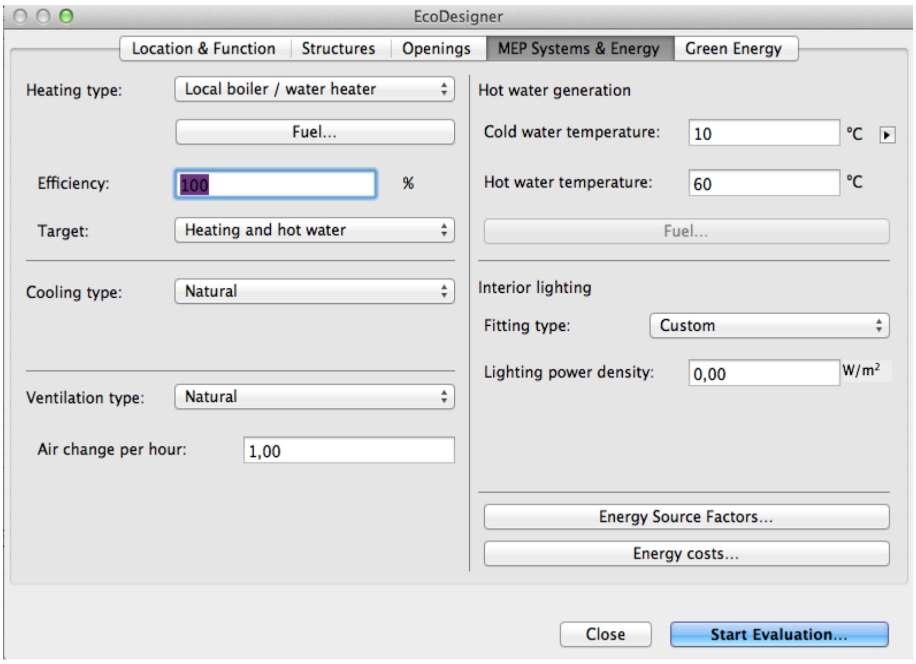

FIGURE 11. EcoDesigner MEP system and energy tab

The price of electricity was defined as 12,5 c/kWh (Fig. 12).

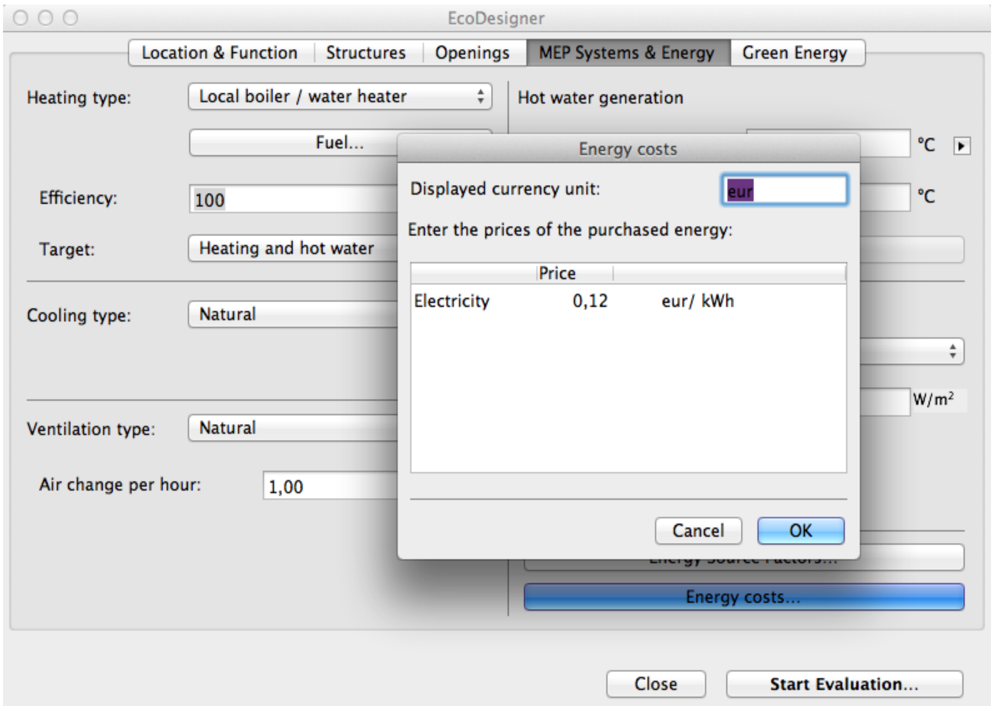

FIGURE 12. EcoDesigner MEP system and energy costs tab

If the building has a heat pump or solar panels, their properties must be separately specified (Fig. 13). These parameters are not used, as the project of the building does not have information about it.

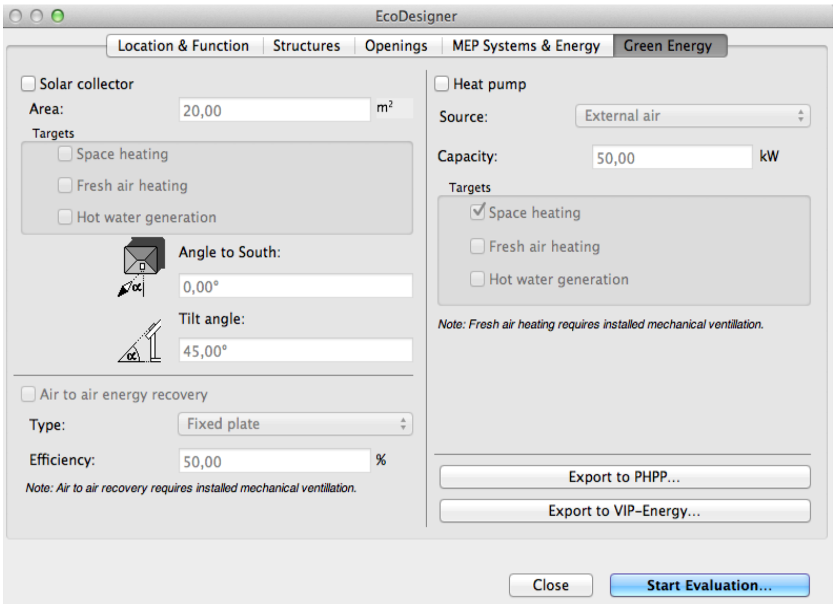

FIGURE 13. EcoDesigner green energy tab

Once all the data has been entered, the Start Evaluation button should be used to receive a report from the program (Fig.14 and Fig. 15).

Energy Balance Evaluation

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ArchiCAD Educational version, not for resale. Courtesy of Graphisoft.

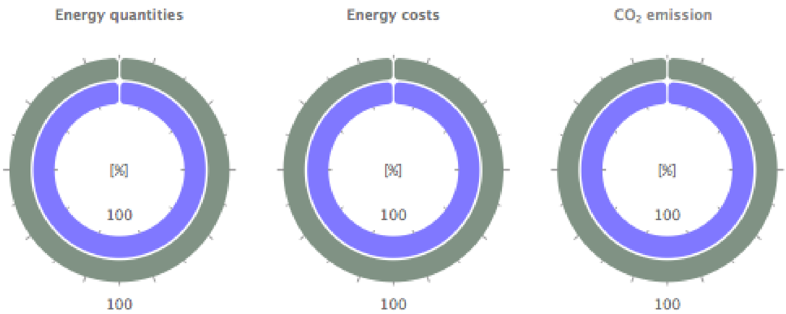
Key Values

General project data		
Location:	Oulu	
Activity Type:	Жилое помещение	
Evaluation Date:	14.05.13, 17:06	
Building geometry data		
Treated floor area:	235,80	m^2
Building shell area:	572,45	m^2
Ventilated volume:	455,75	m^3
Glazing ratio:	3	%
Building shell performance data		
Air leakage:	2.77	ACH
Outer heat capacity:	-	J/m^2K

Heat transfer coefficients	U value	[W/m^2K]
Building shell average:	0.17	
Roofs:	0.08 - 0.08	
External walls:	0.17 - 0.17	
Basement walls:	0.17 - 0.17	
Openings:	0.80 - 0.86	
Specific annual demands		
Net heating energy:	168.48	kWh/m^2a
Net cooling energy:	0.31	kWh/m^2a
Energy consumption:	208.75	kWh/m^2a
Primary energy:	625.32	kWh/m^2a
Operation cost:	25.01	eur/m^2a
CO_2 emission:	49.53	kg/m^2a

Energy Consumption by Sources

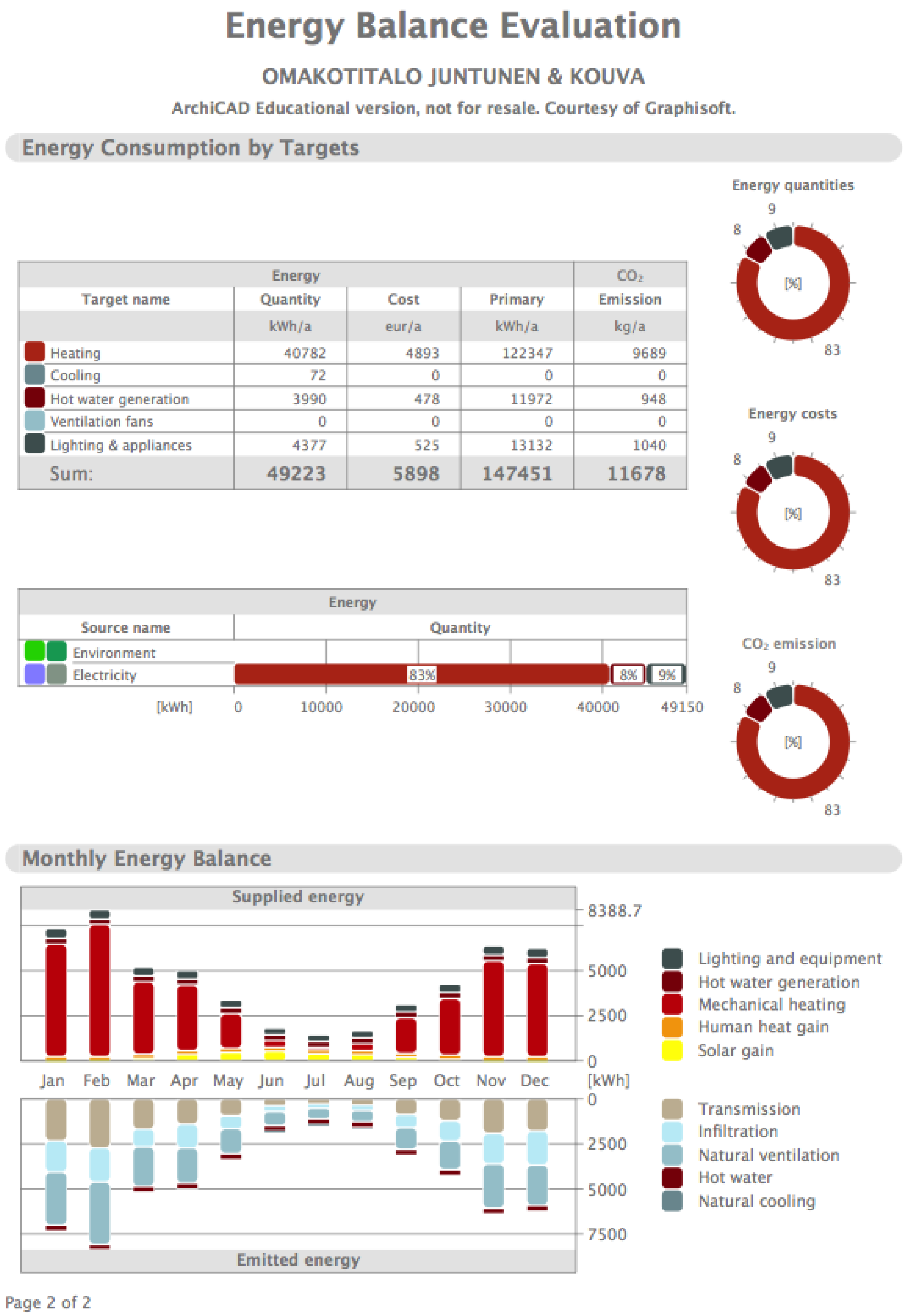
Energy				CO_2 emission
Source type	Source name	Quantity	Cost	
		kWh/a	eur/a	kg/a
Renewable	Environment	72		0
Secondary	Electricity	49150	5898	11678
	Sum:	49223	5898	11678*



* This amount of CO_2 is absorbed in one year by 0.1 hectares (roughly equivalent to 2 tennis-courts) of tropical forest.

Page 1 of 2

FIGURE 14. EcoDesigner report page 1



Energy Balance Evaluation

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ArchiCAD Educational version, not for resale. Courtesy of Graphisoft.

Energy Consumption by Targets

Target name	Energy Quantity	Cost	Primary	CO_2 Emission
	kWh/a	eur/a	kWh/a	kg/a
Heating	40782	4893	122347	9689
Cooling	72	0	0	0
Hot water generation	3990	478	11972	948
Ventilation fans	0	0	0	0
Lighting & appliances	4377	525	13132	1040
Sum:	49223	5898	147451	11678

Source name	Energy Quantity
Environment	
Electricity	83% 8% 9%

Monthly Energy Balance

Page 2 of 2

FIGURE 15. EcoDesigner report of page 2

The Key Values included in the report are the following:

General project data: location, activity type and evaluation date of the report; Building geometry data: treated floor area, building shell area, ventilated volume and glazing ratio;

Building shell performance data: air leakage, outer heat capacity;

Heat transfer coefficients: average U-value and U value for all external shell structures; Specific annual demands: net heating energy, net cooling energy, energy consumption, primary energy, operation cost , CO2 emission (Fig. 16).

Key Values

General project data		
Location:	Oulu	
Activity Type:	Жилое помещение	
Evaluation Date:	14.05.13, 17:06	
Building geometry data		
Treated floor area:	235,80	m^2
Building shell area:	572,45	m^2
Ventilated volume:	455,75	m^3
Glazing ratio:	3	%
Building shell performance data		
Air leakage:	2.77	ACH
Outer heat capacity:	–	J/m^2K

Heat transfer coefficients	U value	[W/m^2K]
Building shell average:	0.17	
Roofs:	0.08 – 0.08	
External walls:	0.17 – 0.17	
Basement walls:	0.17 – 0.17	
Openings:	0.80 – 0.86	
Specific annual demands		
Net heating energy:	168.48	kWh/m^2a
Net cooling energy:	0.31	kWh/m^2a
Energy consumption:	208.75	kWh/m^2a
Primary energy:	625.32	kWh/m^2a
Operation cost:	25.01	eur/m^2a
CO_2 emission:	49.53	kg/m^2a

FIGURE 16. EcoDesigner report of key values

The section of Energy Consumption by Source of the Evaluation Report (Fig. 17) contains one table and three pie charts. The left column in the table introduces the energy sources by type (Renewable, and Secondary) and name; their color codes are used in the pie chart. The Quantity column lists the magnitude [e.g. kWh/a] while the Cost column shows the price [currency/a] of each energy source consumed in one year. The right column in the table shows the carbon footprints associated with the listed energy source magnitudes. (Graphisoft, 2013)

Energy Consumption by Sources

	Energy			CO_2 emission
Source type	Source name	Quantity	Cost	
		kWh/a	eur/a	kg/a
Renewable	Environment	72		0
Secondary	Electricity	49150	5898	11678
	Sum:	49223	5898	11678*

FIGURE 17. EcoDesigner. Report of energy consumption by source

The Figure 18 graphically displays the percentage of the quantities, costs and carbon footprints distribution of the used energy sources. The internal indicator ring shows the energy source type distribution while the external ring displays the actual energy source distribution (Fig. 18). (Graphisoft, 2013)

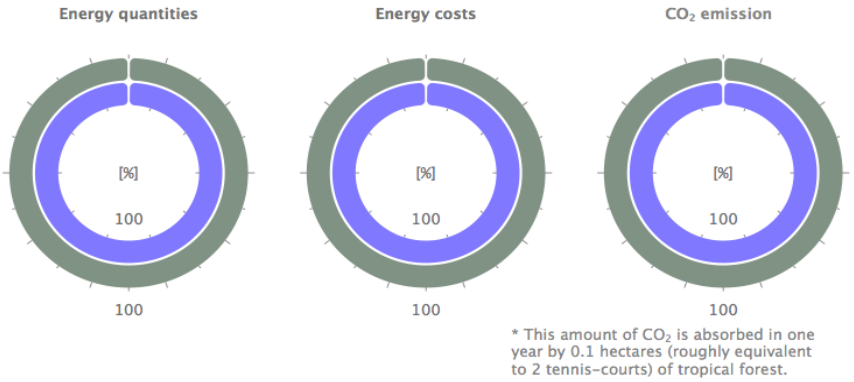
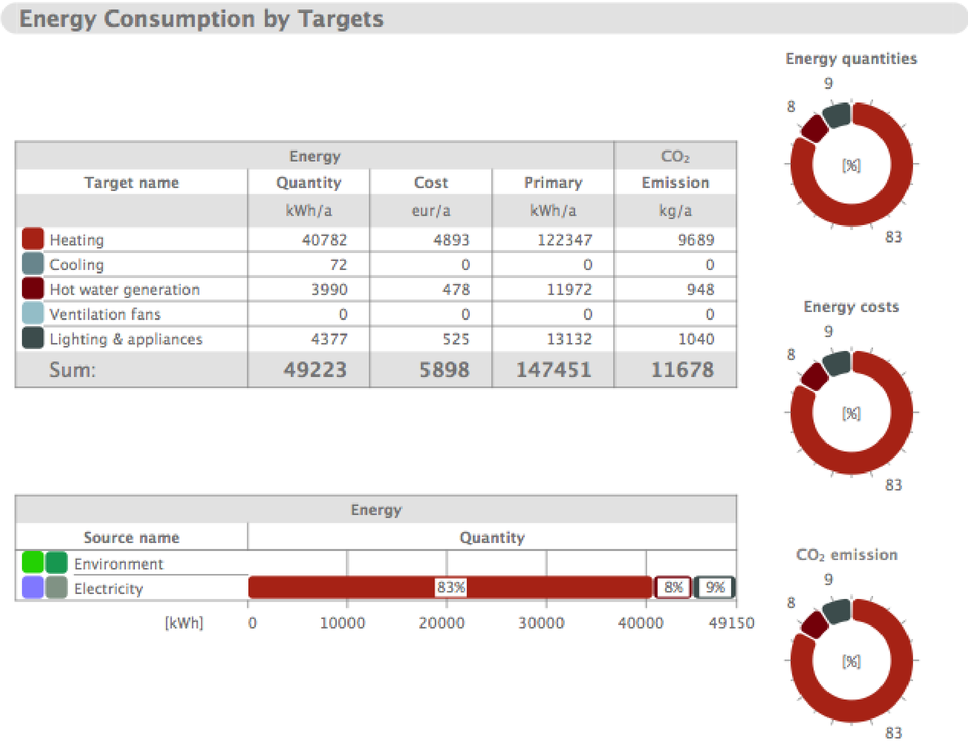


FIGURE 18. EcoDesigner. Report of energy consumption by source

Besides the information on the carbon dioxide emissions resulting from the building's operation over the course of a year, the magnitude of equivalent CO2 absorbent vegetation is also displayed on the Energy Balance Evaluation, under the CO2 Emission by Energy Sources pie chart (Fig. 18).

This section of the Evaluation Report contains two tables and three pie charts. The table's leftmost column lists energy Targets by name, plus their color codes used in the pie chart. The Quantity column lists the magnitude [e.g. kWh/a] while the Cost column shows the price [currency/a] of energy spent on each target in one year. Next to the Primary energy breakdown, the table's rightmost column shows the carbon footprints associated with the listed energy target magnitudes (Fig. 19). (Graphisoft, 2013)



Energy Consumption by Targets

Target name	Energy Quantity	Cost	Primary	CO_2 Emission
	kWh/a	eur/a	kWh/a	kg/a
Heating	40782	4893	122347	9689
Cooling	72	0	0	0
Hot water generation	3990	478	11972	948
Ventilation fans	0	0	0	0
Lighting & appliances	4377	525	13132	1040
Sum:	49223	5898	147451	11678

FIGURE 19. EcoDesigner report of energy consumption by target

The Figure 19 graphically displays the percentages of the quantities, costs and carbon footprints associated with each energy target. The Target Quantities by Energy Sources bar chart links the information found on the Energy Consumption by Sources and on the Energy Consumption by Targets tables together, by displaying the energy target type, magnitude and percentage of each energy source (Fig. 19). (Graphisoft, 2013)

The primary energy value is the ‘common denominator’ among different energy source consumption types, when determining the building’s total energy consumption. Not only does it indicate the net energy source consumed, but it also incorporates the energy needed for the manufacturing, transportation and the raw material processing of the energy source, as well as its transportation to the place of use. Minimizing the specific primary energy demand is a great way to improve the designed buildings’ overall performance. (Graphisoft, 2013)

The Monthly Energy Balance bar chart (Fig. 20) is a graphical display of the amount of energy the building emits (bottom part of chart), as well as the building's supplied energy: the amount of energy it absorbs from the environment and its own internal heat sources (top part of chart), by month. According to the energy balance equation - which is the fundament of building physics - the Emitted energy and Supplied energy bars must be equal every month. The vertical axis of the chart shows an energy scale. Along the horizontal axis, the twelve months of the year are shown. (Graphisoft, 2013)

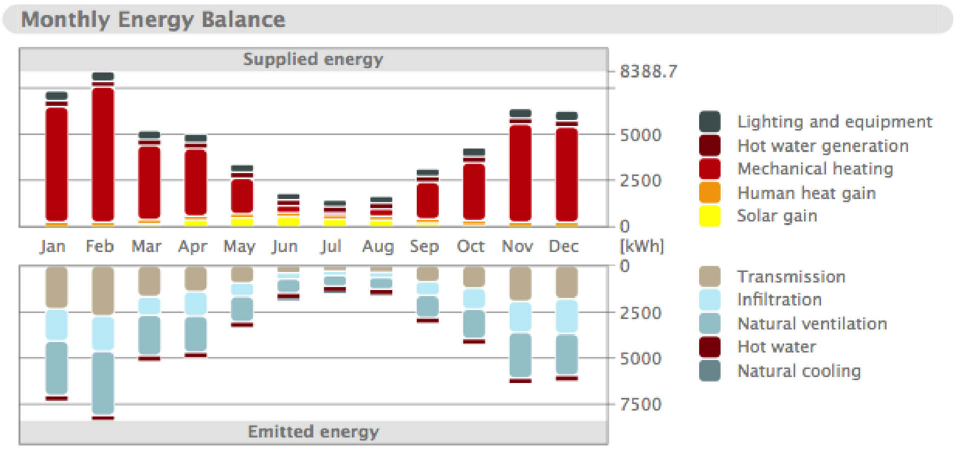


FIGURE 20. EcoDesigner report. monthly energy balance

5 RESULTS

According to the analysis of 3D model the following data were found i.e. the energy consumption of the building, the energy cost and the amounts of CO_2 emissions. The heating of the building is requires the highest amount of energy which is 40782 kWh/a. Due to the fact that the building has its own water heater, it works on electricity. Furthermore, there is a need of energy for hot water generation as well as for lighting and appliances. Therefore, the annual price of electricity is 3440 euros. What is more, the amount of carbon emissions is high.

Additionally, the heat losses of the building passing through its external structures such as roof, walls, windows and doors should be estimated. The energy consumption can be reduced by applying the best thermal properties or the best U-value for the building structures. This feature leads to reduction of the heat loss from the building. Thus, the energy consumption and its costs are decreased. In other words, U-Value is the measure of the rate of heat loss through a material. Hence, low U-values should be the main focus in all aspects of design.

All in all, a manual calculation of energy consumption of the building for estimation of energy losses was performed. The calculations were made by following equations (1) and (2). An example of the calculation of the heat loss for December 2012 is presented in Table 1.

TABLE 1. Calculation of heat loss for December 2012

Outer temperature		-12,4 ^{0}C			
Inlet temperature		+21 ^{0}C			
Type of structures	Area	U value (W/m^{2}K)	Difference temperature (Δt)	H_{tot}	Q_{tot} (W) for each structure
North west	56,54	0,17	33,43	9,61	231,35
South west	48,83	0,17	33,43	8,30	199,80
South west	74,89	1,17	33,43	87,62	2109,01
North east	44	0,17	33,43	7,48	180,04
Upward roof 1	120,2	0,08	33,43	9,61	231,51
Upward roof 2	187,6	0,08	33,43	15,01	361,31
Undegraoud	58	0,17	33,43	9,86	237,33
Summary	3550,357464				
South east door	10,92	0,8	33,43	8,74	210,27
South east window	11,75	0,86	33,43	10,11	243,22
North east window	1,26	0,86	33,43	1,08	26,08
North weast door	5,88	0,8	33,43	4,70	113,22
North east door	3,57	0,8	33,43	2,86	68,74
North west window	6,94	0,86	33,43	5,97	143,66
Summary	805,20				
Floor area (slaps)	226,1	0,16	33,43	36,17	870,55
Total sum Qtot (W) for December					5226,11
Notes: U-thermal transmittance, W/(m2K) Qtot-is the total heat loss of the building kWh Htot -is characteristic of the total heat loss, W/K					

Table 2 presents the energy losses (Qtot) per month for the building for the period from April 2012 to March 2013

TABLE 2. Energy losses per month

Month	Energy losses (Qtot), [kWh]
January	4561,71
February	4253,74
March	4927,52
April	3272,61
May	2124,52
June	1455,43
July	820,73
August	1147,46
September	1872,83
October	2826,44
November	3270,42
December	5226,11
Total heat loss (Q_{tot})	35759,52

The calculation was made for the whole of the outer shell of the building. The weather forecasting data for the year was taken from the same source which was used by EcoDesigner, in order to avoid differences between the temperature data (Appendix 1).

The amount of energy which is required to ensure the inlet temperature 21 ^{0}C is 49223 kWh/a (Figure 19). The amount of energy for heating is 40782 kWh/a. The annual heat loss of a system through conductions is 35759.59 kWh (Table 2). Hence, the energy consumption for the heating should be equal to the heat losses. Therefore, the heat entering into a building should cover the heat which is going away. It could be seen that there is a difference in these amounts

(5022.44 kWh). The reason of this difference is that EcoDesigner takes other parameters into account during the calculation.

In calculating a building's energy consumption, the EcoDesigner utilizes known or measured facts about all parts of the energy flow. The energy flow is calculated taking climate factors such as temperature, sun, humidity and wind into consideration. Other factors in the calculation include the varying room temperature requirements, air exchange, internal heat gains, and the use of solar panels, ventilation units, heat pumps and cooling systems. The program calculates the energy balance of the building by comparing the emitted energy with the supplied energy. (GraphiSoft 2013)

6 DISCUSSION

As it was discussed previously, the program EcoDesigner is easy and efficient to implement. The interface and visual perception of the basic shell are informative and understandable. The basic data is entered without any problems. However, some obstacles were arisen while using the U-value calculator. Thus, the calculation of the U-values can be done using layers of the structures, or the value can be specified directly in the input field U-value. What is more, the listed U-values from the structural layers did not match with the set values.

Actually, no any other difficulties were detached while entering the set values at the various steps of operation in the program. The main advantage of this program is that the process of entering of additional information and modification is simple and effortless. Furthermore, there is no need to enter the same data into program every time. Once entered, the information is automatically saved. That feature facilitates and accelerates the work in the program.

The analysis of the program report and its comparison with a manual calculation shows the difference in the obtained values. The data reached in the manual calculation, in accordance with the Eurocode formulas, was more objective, than the data from EcoDesigner. Although the algorithm of the program takes a lot of other parameters into consideration, the values can also be considered objective.

In addition, the economical factor was considered as well. In this case the heating of the house is provided by electricity. Indeed, in Finland the heating of the house with an area of 120 m^2 by using a boiler and electricity typically costs 1,500 euros per year. Thus, 5900 euros is a standard electricity price per year for a house with an area of 260 m^2 by using a boiler and electric heating. The value of energy consumption for heating in the 40722 kWh per year can be considered real (Findacha 2013).

To conclude, the program is an effective tool for the analysis of energy efficiency of a building. Besides, it is a proper, practical guide for training engineering students. It assists with rapid designing and easily provides alternative versions of the project. The other benefit is that it is time and cost efficient. The research in question has demonstrated that EcoDesigner is an objective and valuable instrument for analysis energy consumption of a building.

At this stage of the product evolution of the company Graphisoft, the EcoDesigner program is a plugin for ArchiCad 12-15 and integrated in interface of the ArchiCad 16. This leads to changes in the interface. As a result, the simplicity and clarity of using are lost in comparison with the previous versions. Thus, there is a need to learn the program from the beginning. Therefore, EcoDesigner program as a plugin for ArchiCad benefits more than the modern version.

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APPENDICES

Weather data from April 2012 to March 2013

Date	Maximum temperature (F)	Minimum temperature (F)	Average temperature (F)	Day average temperature (oC)	Mounth average temperature (oC)
1.4.2013	37,4	6,8	22,1	-5,445	0,066
2.4.2013	32	8,6	20,3	-6,435	
3.4.2013	35,6	15,8	25,7	-3,465	
4.4.2013	32	17,6	24,8	-3,96	
5.4.2013	28,4	10,4	19,4	-6,93	
6.4.2013	30,2	6,8	18,5	-7,425	
7.4.2013	37,4	8,6	23	-4,95	
8.4.2013	32	5	18,5	-7,425	
9.4.2013	35,6	1,4	18,5	-7,425	
10.4.2013	41	19,4	30,2	-0,99	
11.4.2013	41	15,8	28,4	-1,98	
12.4.2013	39,2	23	31,1	-0,495	
13.4.2013	42,8	33,8	38,3	3,465	
14.4.2013	42,8	33,8	38,3	3,465	
15.4.2013	44,6	37,4	41	4,95	
17.4.2012	37,4	28,4	32,9	0,495	
18.4.2012	35,6	28,4	32	0	
19.4.2012	35,6	23	29,3	-1,485	
20.4.2012	41	23	32	0	
21.4.2012	39,2	32	35,6	1,98	
22.4.2012	41	32	36,5	2,475	
23.4.2012	53,6	32	42,8	5,94	
24.4.2012	42,8	35,6	39,2	3,96	
25.4.2012	42,8	30,2	36,5	2,475	
26.4.2012	51,8	30,2	41	4,95	
27.4.2012	46,4	39,2	42,8	5,94	
28.4.2012	50	35,6	42,8	5,94	
29.4.2012	46,4	32	39,2	3,96	
30.4.2012	50	32	41	4,95	
1.5.2012	41	35,6	38,3	3,465	7,40
2.5.2012	44,6	33,8	39,2	3,96	
3.5.2012	44,6	32	38,3	3,465	
4.5.2012	42,8	32	37,4	2,97	
5.5.2012	42,8	35,6	39,2	3,96	
6.5.2012	46,4	33,8	40,1	4,455	
7.5.2012	48,2	30,2	39,2	3,96	

8.5.2012	50	35,6	42,8	5,94	
9.5.2012	60,8	32	46,4	7,92	
10.5.2012	51,8	42,8	47,3	8,415	
11.5.2012	48,2	41	44,6	6,93	
12.5.2012	48,2	35,6	41,9	5,445	
13.5.2012	44,6	32	38,3	3,465	
14.5.2012	53,6	33,8	43,7	6,435	
15.5.2012	59	39,2	49,1	9,405	
16.5.2012	60,8	39,2	50	9,9	
17.5.2012	69,8	46,4	58,1	14,355	
18.5.2012	57,2	44,6	50,9	10,395	
19.5.2012	53,6	42,8	48,2	8,91	
20.5.2012	53,6	39,2	46,4	7,92	
21.5.2012	48,2	35,6	41,9	5,445	
22.5.2012	51,8	35,6	43,7	6,435	
23.5.2012	53,6	39,2	46,4	7,92	
24.5.2012	59	39,2	49,1	9,405	
25.5.2012	64,4	44,6	54,5	12,375	
26.5.2012	62,6	46,4	54,5	12,375	
27.5.2012	68	46,4	57,2	13,86	
28.5.2012	53,6	44,6	49,1	9,405	
29.5.2012	50	41	45,5	7,425	
30.5.2012	50	37,4	43,7	6,435	
31.5.2012	51,8	37,4	44,6	6,93	
1.6.2012	51,8	41	46,4	7,92	
2.6.2012	57,2	44,6	50,9	10,395	
3.6.2012	57,2	48,2	52,7	11,385	
4.6.2012	53,6	46,4	50	9,9	
5.6.2012	51,8	46,4	49,1	9,405	
6.6.2012	55,4	42,8	49,1	9,405	
7.6.2012	51,8	42,8	47,3	8,415	
8.6.2012	55,4	44,6	50	9,9	
9.6.2012	51,8	42,8	47,3	8,415	
10.6.2012	62,6	42,8	52,7	11,385	
11.6.2012	60,8	50	55,4	12,87	
12.6.2012	64,4	48,2	56,3	13,365	
13.6.2012	60,8	46,4	53,6	11,88	
14.6.2012	69,8	46,4	58,1	14,355	
15.6.2012	62,6	44,6	53,6	11,88	
16.6.2012	66,2	44,6	55,4	12,87	
17.6.2012	62,6	57,2	59,9	15,345	
18.6.2012	60,8	53,6	57,2	13,86	

19.6.2012	60,8	53,6	57,2	13,86	
20.6.2012	59	48,2	53,6	11,88	
21.6.2012	59	46,4	52,7	11,385	
22.6.2012	59	42,8	50,9	10,395	
23.6.2012	68	41	54,5	12,375	
24.6.2012	66,2	50	58,1	14,355	
25.6.2012	60,8	51,8	56,3	13,365	
26.6.2012	62,6	55,4	59	14,85	
27.6.2012	57,2	46,4	51,8	10,89	
28.6.2012	51,8	44,6	48,2	8,91	
29.6.2012	60,8	44,6	52,7	11,385	
30.6.2012	64,4	51,8	58,1	14,355	
1.7.2012	66,2	51,8	59	14,85	
2.7.2012	66,2	53,6	59,9	15,345	
3.7.2012	64,4	48,2	56,3	13,365	
4.7.2012	62,6	46,4	54,5	12,375	
5.7.2012	75,2	46,4	60,8	15,84	
6.7.2012	77	57,2	67,1	19,305	
7.7.2012	77	57,2	67,1	19,305	
8.7.2012	68	62,6	65,3	18,315	
9.7.2012	71,6	53,6	62,6	16,83	
10.7.2012	60,8	51,8	56,3	13,365	
11.7.2012	66,2	55,4	60,8	15,84	
12.7.2012	68	55,4	61,7	16,335	
13.7.2012	73,4	55,4	64,4	17,82	
14.7.2012	66,2	53,6	59,9	15,345	
15.7.2012	71,6	51,8	61,7	16,335	
16.7.2012	68,8	53,6	61,2	16,06	
17.7.2012	64,4	55,4	59,9	15,345	
18.7.2012	71,6	53,6	62,6	16,83	
19.7.2012	60,8	53,6	57,2	13,86	
20.7.2012	60,8	51,8	56,3	13,365	
21.7.2012	60,8	48,2	54,5	12,375	
22.7.2012	60,8	46,4	53,6	11,88	
23.7.2012	64,4	50	57,2	13,86	
24.7.2012	69,8	55,4	62,6	16,83	
25.7.2012	66,2	48,2	57,2	13,86	
26.7.2012	64,4	51,8	58,1	14,355	
27.7.2012	66,2	46,4	56,3	13,365	
28.7.2012	77	46,4	61,7	16,335	
29.7.2012	80,6	57,2	68,9	20,295	
30.7.2012	78,8	60,8	69,8	20,79	

31.7.2012	71,6	59	65,3	18,315	
1.8.2012	68	55,4	61,7	16,335	
2.8.2012	68	53,6	60,8	15,84	
3.8.2012	66,2	59	62,6	16,83	
4.8.2012	66,2	55,4	60,8	15,84	
5.8.2012	69,8	53,6	61,7	16,335	
6.8.2012	69,8	51,8	60,8	15,84	
7.8.2012	60,8	51,8	56,3	13,365	
8.8.2012	53,6	48,2	50,9	10,395	
9.8.2012	55,4	46,4	50,9	10,395	
10.8.2012	59	44,6	51,8	10,89	
11.8.2012	66,2	42,8	54,5	12,375	
12.8.2012	66,2	50	58,1	14,355	
13.8.2012	69,8	48,2	59	14,85	
14.8.2012	69,8	48,2	59	14,85	
15.8.2012	75,2	55,4	65,3	18,315	
16.8.2012	75,2	51,8	63,5	17,325	
17.8.2012	73,4	51,8	62,6	16,83	
18.8.2012	68	50	59	14,85	
19.8.2012	59	44,6	51,8	10,89	
20.8.2012	57,2	41	49,1	9,405	
21.8.2012	62,6	44,6	53,6	11,88	
22.8.2012	59	50	54,5	12,375	
23.8.2012	55,4	50	52,7	11,385	
24.8.2012	59	46,4	52,7	11,385	
25.8.2012	62,6	46,4	54,5	12,375	
26.8.2012	66,2	46,4	56,3	13,365	
27.8.2012	68	48,2	58,1	14,355	
28.8.2012	69,8	48,2	59	14,85	
29.8.2012	62,6	48,2	55,4	12,87	
30.8.2012	60,8	44,6	52,7	11,385	
31.8.2012	60,8	44,6	52,7	11,385	
1.9.2012	60,8	48,2	54,5	12,375	
2.9.2012	53,6	42,8	48,2	8,91	
3.9.2012	59	41	50	9,9	
4.9.2012	62,6	39,2	50,9	10,395	
5.9.2012	59	51,8	55,4	12,87	
6.9.2012	57,2	44,6	50,9	10,395	
7.9.2012	55,4	35,6	45,5	7,425	
8.9.2012	55,4	33,8	44,6	6,93	
9.9.2012	53,6	32	42,8	5,94	
10.9.2012	57,2	30,2	43,7	6,435	

11.9.2012	60,8	51,8	56,3	13,365	
12.9.2012	60,8	44,6	52,7	11,385	
13.9.2012	57,2	44,6	50,9	10,395	
14.9.2012	53,6	41	47,3	8,415	
15.9.2012	55,4	46,4	50,9	10,395	
16.9.2012	60,8	44,6	52,7	11,385	
17.9.2012	57,2	46,4	51,8	10,89	
18.9.2012	59	48,2	53,6	11,88	
19.9.2012	57,2	48,2	52,7	11,385	
20.9.2012	50	44,6	47,3	8,415	
21.9.2012	53,6	42,8	48,2	8,91	
22.9.2012	51,8	37,4	44,6	6,93	
23.9.2012	53,6	42,8	48,2	8,91	
24.9.2012	50	39,2	44,6	6,93	
25.9.2012	46,4	35,6	41	4,95	
26.9.2012	46,4	35,6	41	4,95	
27.9.2012	53,6	41	47,3	8,415	
28.9.2012	44,6	41	42,8	5,94	
29.9.2012	46,4	41	43,7	6,435	
30.9.2012	51,8	44,6	48,2	8,91	
1.10.2012	53,6	46,4	50	9,9	
2.10.2012	53,6	48,2	50,9	10,395	
3.10.2012	53,6	39,2	46,4	7,92	
4.10.2012	53,6	41	47,3	8,415	
5.10.2012	51,8	41	46,4	7,92	
6.10.2012	50	44,6	47,3	8,415	
7.10.2012	48,2	42,8	45,5	7,425	
8.10.2012	48,2	41	44,6	6,93	
9.10.2012	46,4	39,2	42,8	5,94	
10.10.2012	46,4	41	43,7	6,435	
11.10.2012	42,8	39,2	41	4,95	
12.10.2012	42,8	39,2	41	4,95	
13.10.2012	41	37,4	39,2	3,96	
14.10.2012	41	32	36,5	2,475	
15.10.2012	41	26,6	33,8	0,99	
16.10.2012	42,8	26,6	34,7	1,485	
17.10.2012	39,2	33,8	36,5	2,475	
18.10.2012	46,4	32	39,2	3,96	
19.10.2012	44,6	32	38,3	3,465	
20.10.2012	41	23	32	0	
21.10.2012	33,8	23	28,4	-1,98	
22.10.2012	35,6	19,4	27,5	-2,475	

23.10.2012	37,4	30,2	33,8	0,99	
24.10.2012	44,6	33,8	39,2	3,96	
25.10.2012	35,6	24,8	30,2	-0,99	
26.10.2012	28,4	23	25,7	-3,465	
27.10.2012	28,4	19,4	23,9	-4,455	
28.10.2012	28,4	19,4	23,9	-4,455	
29.10.2012	30,2	23	26,6	-2,97	
30.10.2012	33,8	30,2	32	0	
31.10.2012	32	24,8	28,4	-1,98	
1.11.2012	39,2	28,4	33,8	0,99	
2.11.2012	37,4	33,8	35,6	1,98	
3.11.2012	39,2	33,8	36,5	2,475	
4.11.2012	37,4	33,8	35,6	1,98	
5.11.2012	37,4	32	34,7	1,485	
6.11.2012	33,8	26,6	30,2	-0,99	
7.11.2012	33,8	30,2	32	0	
8.11.2012	33,8	26,6	30,2	-0,99	
9.11.2012	30,2	17,6	23,9	-4,455	
10.11.2012	39,2	23	31,1	-0,495	
11.11.2012	39,2	35,6	37,4	2,97	
12.11.2012	41	32	36,5	2,475	
13.11.2012	33,8	24,8	29,3	-1,485	
14.11.2012	39,2	23	31,1	-0,495	
15.11.2012	39,2	28,4	33,8	0,99	
16.11.2012	37,4	21,2	29,3	-1,485	
17.11.2012	41	33,8	37,4	2,97	
18.11.2012	41	39,2	40,1	4,455	
19.11.2012	37,4	32	34,7	1,485	
20.11.2012	39,2	32	35,6	1,98	
21.11.2012	46,4	39,2	42,8	5,94	
22.11.2012	44,6	39,2	41,9	5,445	
23.11.2012	41	39,2	40,1	4,455	
24.11.2012	41	37,4	39,2	3,96	
25.11.2012	37,4	35,6	36,5	2,475	
26.11.2012	35,6	30,2	32,9	0,495	
27.11.2012	32	15,8	23,9	-4,455	
28.11.2012	17,6	8,6	13,1	-10,395	
29.11.2012	12,2	8,6	10,4	-11,88	
30.11.2012	17,6	12,2	14,9	-9,405	
1.12.2012	17,6	14	15,8	-8,91	
2.12.2012	14	-5,8	4,1	-15,345	
3.12.2012	-0,4	-11,2	-5,8	-20,79	

4.12.2012	5	-11,2	-3,1	-19,305	
5.12.2012	14	-9,4	2,3	-16,335	
6.12.2012	-4	-11,2	-7,6	-21,78	
7.12.2012	24,8	-4	10,4	-11,88	
8.12.2012	23	19,4	21,2	-5,94	
9.12.2012	21,2	15,8	18,5	-7,425	
10.12.2012	19,4	8,6	14	-9,9	
11.12.2012	23	17,6	20,3	-6,435	
12.12.2012	30,2	19,4	24,8	-3,96	
13.12.2012	30,2	19,4	24,8	-3,96	
14.12.2012	24,8	21,2	23	-4,95	
15.12.2012	23	15,8	19,4	-6,93	
16.12.2012	17,6	14	15,8	-8,91	
17.12.2012	17,6	15,8	16,7	-8,415	
18.12.2012	15,8	3,2	9,5	-12,375	
19.12.2012	3,2	-4	-0,4	-17,82	
20.12.2012	3,2	-5,8	-1,3	-18,315	
21.12.2012	-5,8	-13	-9,4	-22,77	
22.12.2012	-5,8	-13	-9,4	-22,77	
23.12.2012	-4	-13	-8,5	-22,275	
24.12.2012	3,2	-9,4	-3,1	-19,305	
25.12.2012	1,4	-7,6	-3,1	-19,305	
26.12.2012	12,2	-4	4,1	-15,345	
27.12.2012	23	12,2	17,6	-7,92	
28.12.2012	21,2	5	13,1	-10,395	
29.12.2012	21,2	-2,2	9,5	-12,375	
30.12.2012	32	21,2	26,6	-2,97	
31.12.2012	33,8	28,4	31,1	-0,495	
1.1.2013	33,8	32	32,9	0,495	
2.1.2013	33,8	28,4	31,1	-0,495	
3.1.2013	28,4	26,6	27,5	-2,475	
4.1.2013	28,4	5	16,7	-8,415	
5.1.2013	14	3,2	8,6	-12,87	
6.1.2013	8,6	-0,4	4,1	-15,345	
7.1.2013	21,2	8,6	14,9	-9,405	
8.1.2013	26,6	21,2	23,9	-4,455	
9.1.2013	26,6	14	20,3	-6,435	
10.1.2013	24,8	5	14,9	-9,405	
11.1.2013	15,8	-0,4	7,7	-13,365	
12.1.2013	23	6,8	14,9	-9,405	
13.1.2013	23	14	18,5	-7,425	
14.1.2013	24,8	17,6	21,2	-5,94	

15.1.2013	21,2	-0,4	10,4	-11,88	
16.1.2013	1,4	-16,6	-7,6	-21,78	
17.1.2013	5	-13	-4	-19,8	
18.1.2013	24,8	5	14,9	-9,405	
19.1.2013	33,8	12,2	23	-4,95	
20.1.2013	17,6	-0,4	8,6	-12,87	
21.1.2013	24,8	8,6	16,7	-8,415	
22.1.2013	23	12,2	17,6	-7,92	
23.1.2013	23	1,4	12,2	-10,89	
24.1.2013	17,6	-4	6,8	-13,86	
25.1.2013	15,8	-0,4	7,7	-13,365	
26.1.2013	26,6	15,8	21,2	-5,94	
27.1.2013	27,4	21,2	24,3	-4,235	
28.1.2013	30,2	21,2	25,7	-3,465	
29.1.2013	35,6	30,2	32,9	0,495	
30.1.2013	33,8	28,4	31,1	-0,495	
31.1.2013	33,8	30,2	32	0	
1.2.2013	30,2	26,6	28,4	-1,98	
2.2.2013	26,6	23	24,8	-3,96	
3.2.2013	24,8	21,2	23	-4,95	
4.2.2013	26,6	23	24,8	-3,96	
5.2.2013	24,8	8,6	16,7	-8,415	
6.2.2013	12,2	-2,2	5	-14,85	
7.2.2013	8,6	-2,2	3,2	-15,84	
8.2.2013	10,4	-7,6	1,4	-16,83	
9.2.2013	23	-7,6	7,7	-13,365	
10.2.2013	24,8	23	23,9	-4,455	
11.2.2013	23	5	14	-9,9	
12.2.2013	24,8	-2,2	11,3	-11,385	
13.2.2013	32	23	27,5	-2,475	
14.2.2013	30,2	28,4	29,3	-1,485	
15.2.2013	30,2	28,4	29,3	-1,485	
16.2.2013	30,2	27	28,6	-1,87	
17.2.2013	30,2	23	26,6	-2,97	
18.2.2013	24,8	3,2	14	-9,9	
19.2.2013	26,6	-0,4	13,1	-10,395	
20.2.2013	15,8	-9,4	3,2	-15,84	
21.2.2013	32	15,8	23,9	-4,455	
22.2.2013	23	5	14	-9,9	
23.2.2013	30,2	23	26,6	-2,97	
24.2.2013	33,8	28,4	31,1	-0,495	
25.2.2013	33,8	24,8	29,3	-1,485	

26.2.2013	39,2	28,4	33,8	0,99	
27.2.2013	41	28,4	34,7	1,485	
28.2.2013	37,4	23	30,2	-0,99	
1.3.2013	23	1,4	12,2	-10,89	
2.3.2013	17,6	-4	6,8	-13,86	
3.3.2013	19,4	5	12,2	-10,89	
4.3.2013	19,4	3,2	11,3	-11,385	
5.3.2013	30,2	5	17,6	-7,92	
6.3.2013	32	8,6	20,3	-6,435	
7.3.2013	21,2	3,2	12,2	-10,89	
8.3.2013	21,2	3,2	12,2	-10,89	
9.3.2013	10,4	-9,4	0,5	-17,325	
10.3.2013	19,4	3,2	11,3	-11,385	
11.3.2013	15,8	-9,4	3,2	-15,84	
12.3.2013	17,6	-18,4	-0,4	-17,82	
13.3.2013	12,2	-20,2	-4	-19,8	
14.3.2013	14	-14,8	-0,4	-17,82	
15.3.2013	19,4	-11,2	4,1	-15,345	
16.3.2013	21,2	-13	4,1	-15,345	
17.3.2013	23	3,2	13,1	-10,395	
18.3.2013	21,2	-2,2	9,5	-12,375	
19.3.2013	26,6	8,6	17,6	-7,92	
20.3.2013	28,4	10,4	19,4	-6,93	
21.3.2013	23	5	14	-9,9	
22.3.2013	30,2	5	17,6	-7,92	
23.3.2013	30,2	15,8	23	-4,95	
24.3.2013	30,2	14	22,1	-5,445	
25.3.2013	32	6,8	19,4	-6,93	
26.3.2013	30,2	-0,4	14,9	-9,405	
27.3.2013	32	15,8	23,9	-4,455	
28.3.2013	28,4	10,4	19,4	-6,93	
29.3.2013	33,8	5	19,4	-6,93	
30.3.2013	30,2	8,6	19,4	-6,93	
31.3.2013	39,2	6,8	23	-4,95	

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