TECHNICAL UNIVERSITY - SOFIA
FACULTY OF ENGINEERING AND PEDAGOGY - SLIVEN

ENSI "Key Numbers"
Energy Auditing of Buildings Software

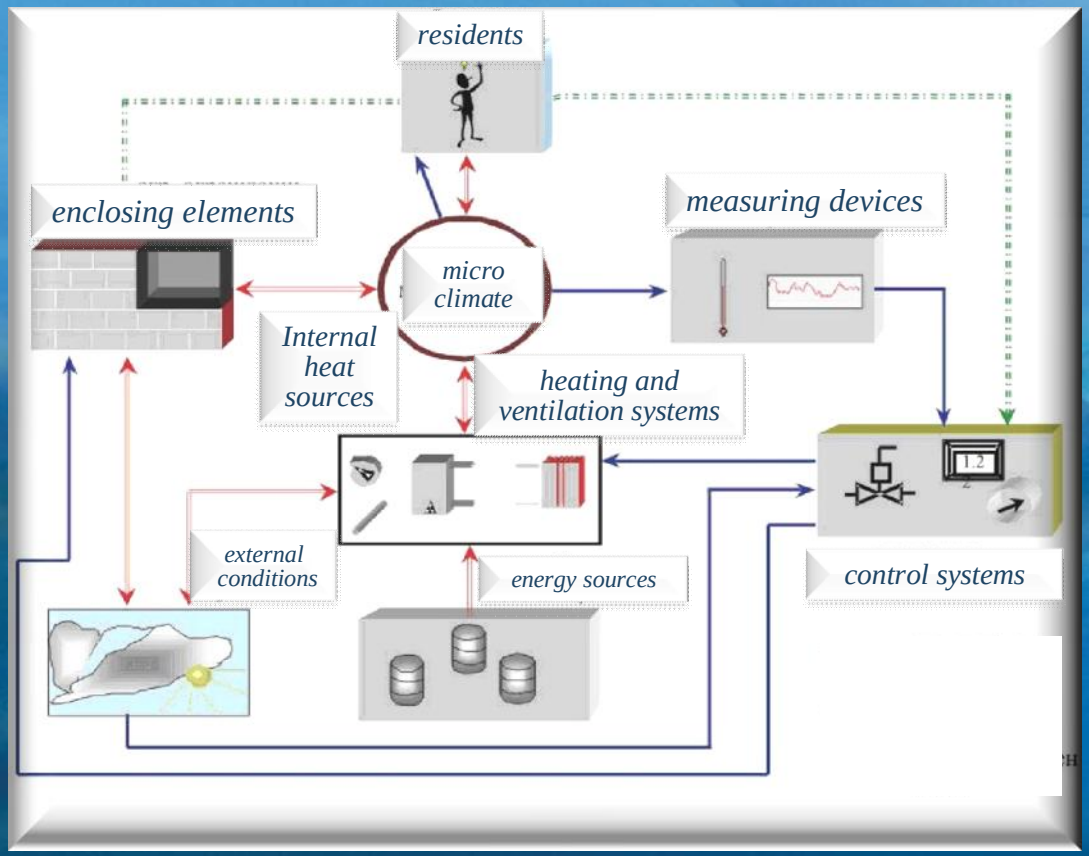
Assoc. prof. K. Atanasov, Assist. prof. N. Krystev

Human Resource Development Centre

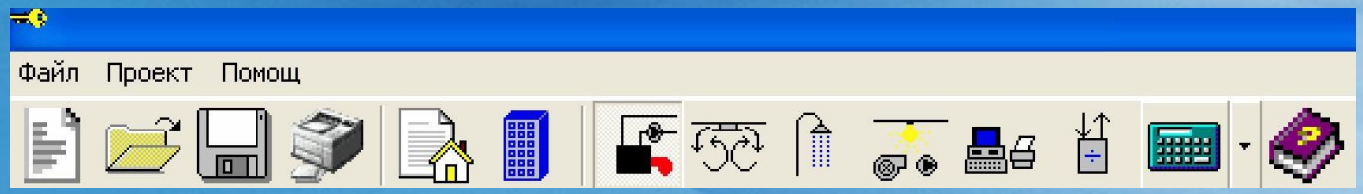
Education and Culture
Lifelong Learning Programme

RESUME

On the basis of method according EN ISO 13790, the company ENSI- **En**ergy **S**aving **I**nternational, Norway, together with TU – Sofia, have developed software to energy consumption modeling and assessment of the potential for reducing energy costs in buildings. The building presents itself as an integrated system, as shown in the figure below.



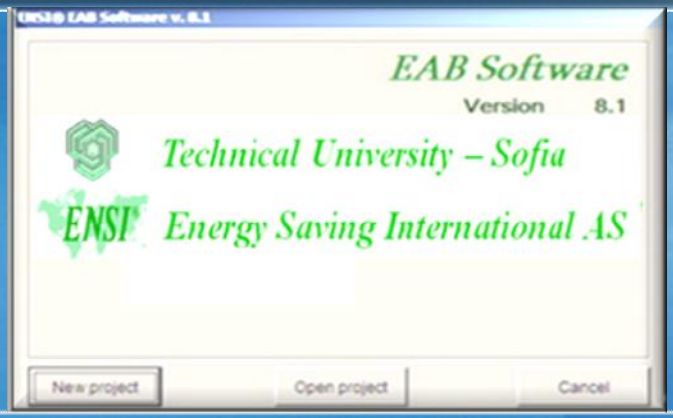
The software allows to work with the following modules:



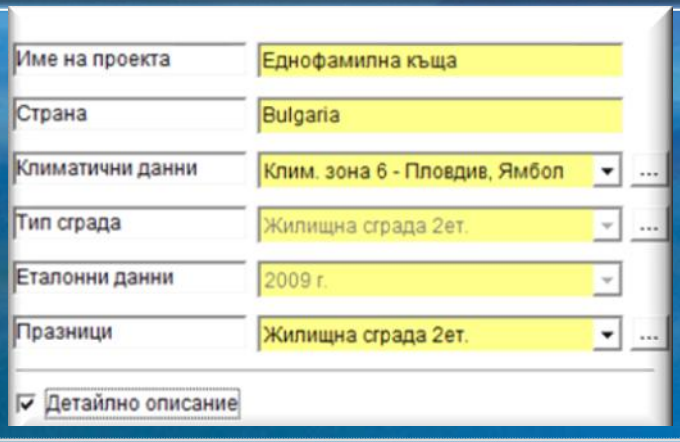
1	2	3	4	5	6	7	8	9	10	11	12	13	14

1	NEW PROJECT - CREATION
2	OPEN ING AN EXISTING PROJECT
3	SAVING OF THE CURRENT PROJECT
4	PRINTING RESULTS
5	INTRODUCTION OF GENERAL DATA OF THE BUILDING
6	INTRODUCTION OF THE GEOMETRIC PARAMETERS OF THE BUILDING
7	MAIN WINDOW – HEATING SYSTEM
8	INTRODUCTION OF VENTILATION SYSTEMS
9	HOT WATER FOR DOMESTIC CONSUMPTION
10	FANS, PUMPS AND LIGHTING – INSTALLED POWER AND OPERATION TIME
11	OTHER VARIOUS ENERGY CONSUMERS
12	MAIN WINDOW - COOLING
13	WINDOW FOR SUMMARY RESULTS
14	HELP – SHORT DESCRIPTION

Once the program starts, the screen appears, which offers two options - start a new project or open an existing project:

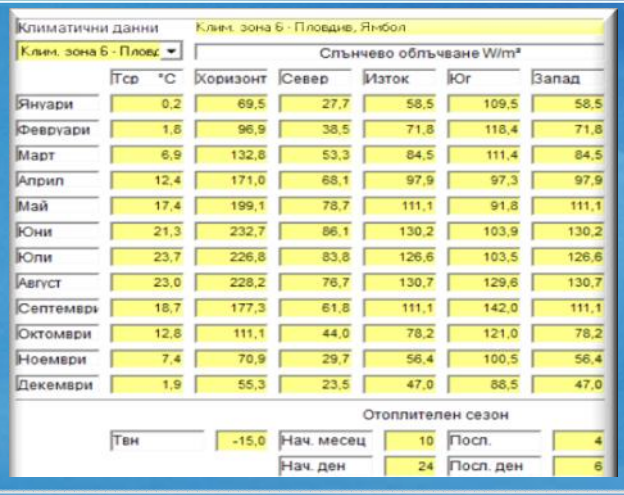


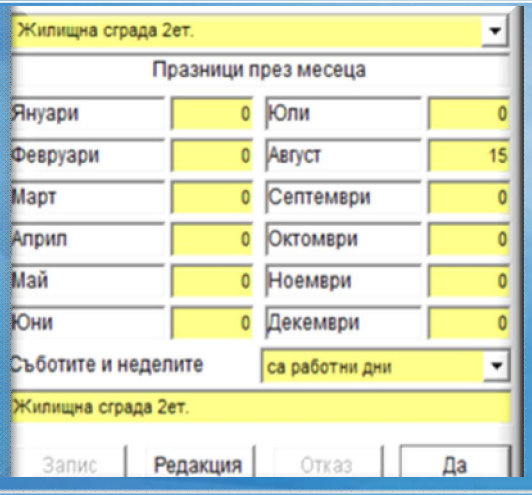
If we choose a new or existing project is a window for initial information appears:



General input data concern the choice of climate area, type of building – apartment, office, kindergarden, hospital and the other kinds, time of the systems use and characteristics of the enclosing elements :

The standard database include 9 climatic zones. In our country they are defined in ORDINANCE № RD-16-296 April 1, 2008 about Energy characteristics of building objects. The climatic database can be expanded through the creation of user data to another area. It can be done by pressing redaction button.





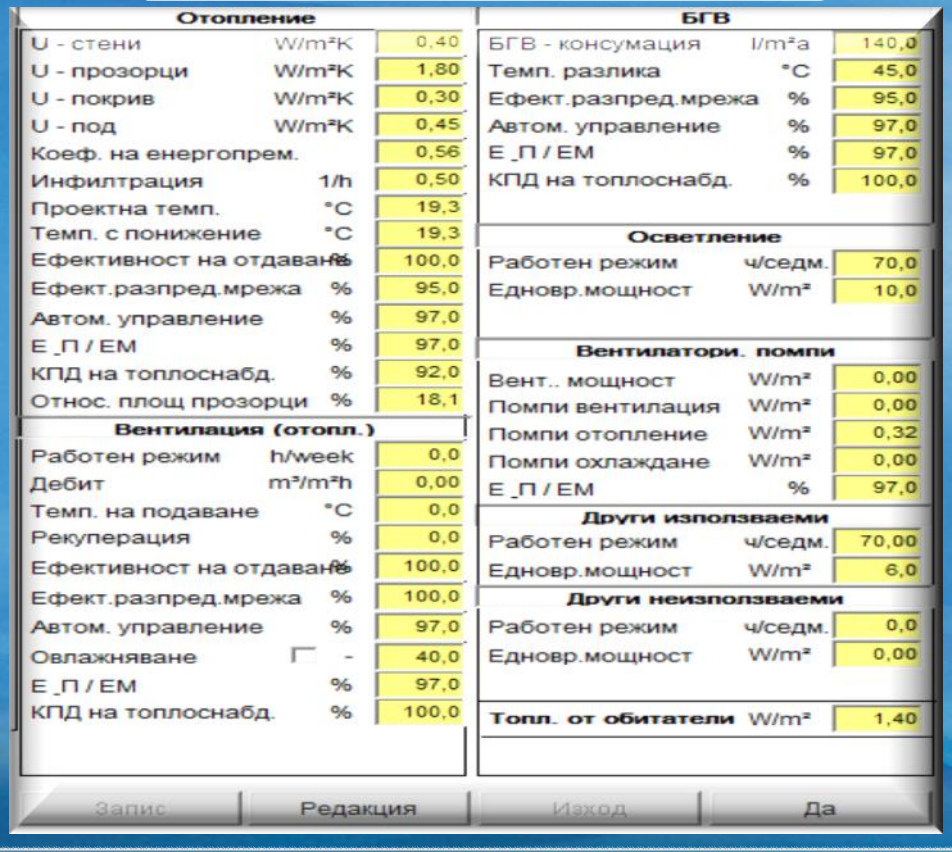
The parameters of the climatic database in accordance with the requirements of the calculation method for determining the energy consumption during the heating season are as follows:

- Average monthly temperature, ° C;
- Average monthly value of the intensity of solar radiation, W/m²;

- *The value of the intensity of solar radiation is obtained by the dividing of the average daily value for the month on 24 hours;*
- External projecting temperature ° C;
- Start and end of the heating season (month and day).

On the next window are shown the number of holidays of the building, when the heating system doesn't work.

Settings - reference data:



Отопление		
U - стени	W/m²K	0,40
U - прозорци	W/m²K	1,80
U - покрив	W/m²K	0,30
U - под	W/m²K	0,45
Коеф. на енергопрем.		0,56
Инфилтрация	1/h	0,50
Проектна темп.	°C	19,3
Темп. с понижение	°C	19,3
Ефективност на отдаване	%	100,0
Ефект.разпред.мрежа	%	95,0
Автом. управление	%	97,0
E_П / EM	%	97,0
КПД на топлоснабд.	%	92,0
Относ. площ прозорци	%	18,1

Вентилация (отопл.)		
Работен режим	h/week	0,0
Дебит	m³/m²h	0,00
Темп. на подаване	°C	0,0
Рекуперация	%	0,0
Ефективност на отдаване	%	100,0
Ефект.разпред.мрежа	%	100,0
Автом. управление	%	97,0
Овлажняване	-	40,0
E_П / EM	%	97,0
КПД на топлоснабд.	%	100,0

БГВ		
БГВ - консумация	l/m²a	140,0
Темп. разлика	°C	45,0
Ефект.разпред.мрежа	%	95,0
Автом. управление	%	97,0
E_П / EM	%	97,0
КПД на топлоснабд.	%	100,0

Осветление		
Работен режим	ч/седм.	70,0
Едновр.мощност	W/m²	10,0

Вентилатори. помпи		
Вент.. мощност	W/m²	0,00
Помпи вентилация	W/m²	0,00
Помпи отопление	W/m²	0,32
Помпи охлаждане	W/m²	0,00
E_П / EM	%	97,0

Други използваеми		
Работен режим	ч/седм.	70,00
Едновр.мощност	W/m²	6,0

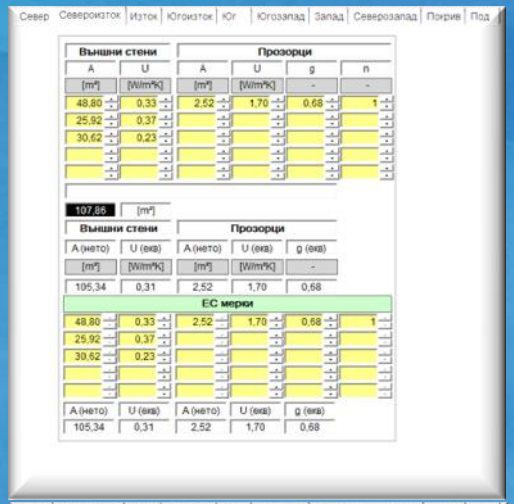
Други неизползваеми		
Работен режим	ч/седм.	0,0
Едновр.мощност	W/m²	0,00

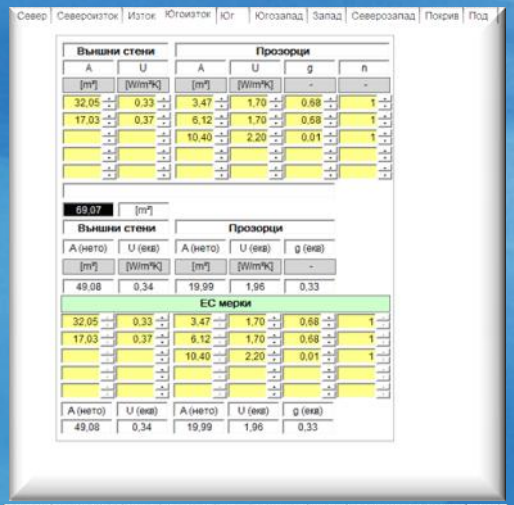
Топл. от обитатели	W/m²	1,40

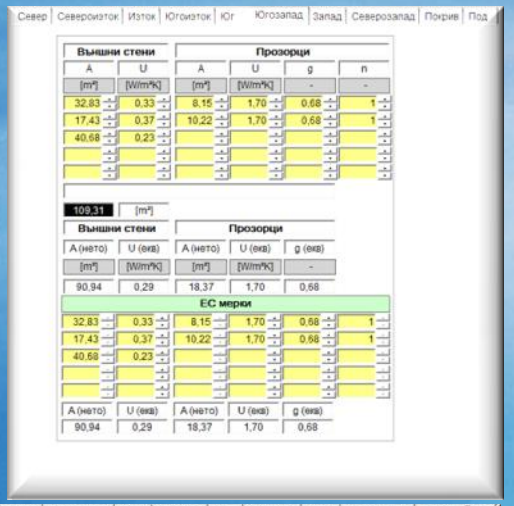
Запис | Редакция | Изход | Да

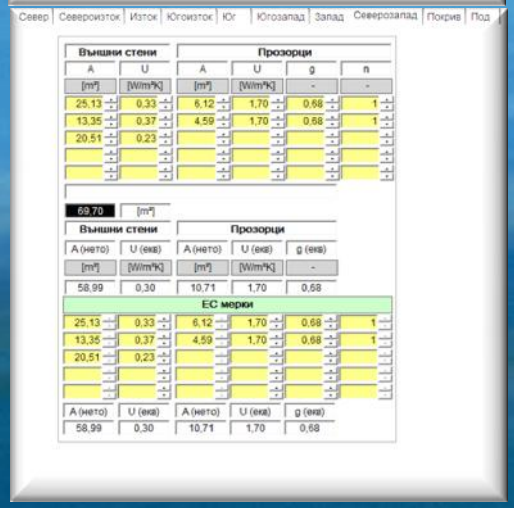
The consumers on this screen have to do choice of building type from 7 included in the standard database kinds - apartment (a block of flats) - 5 floors, apartment - 14 floors, school, kinder garden, university, college, hospital, office building. Data for these types of buildings include the required parameters referred in the relevant ordinance.

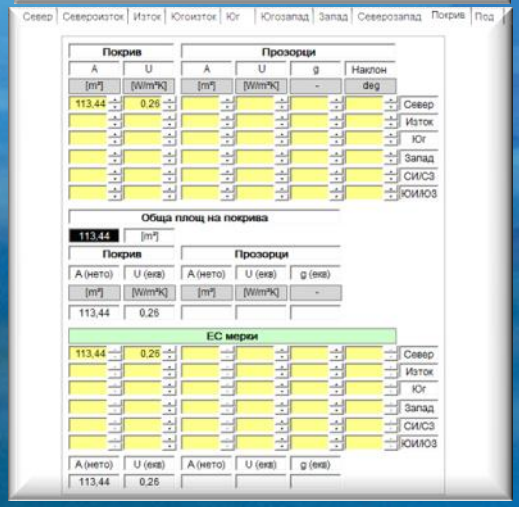
In the current slide are shown the software windows for a detailed description of the family building in depend of the facade azimuth orientation including floor and roof.

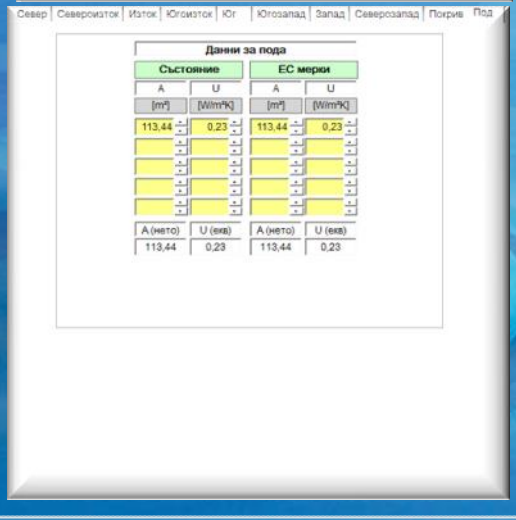






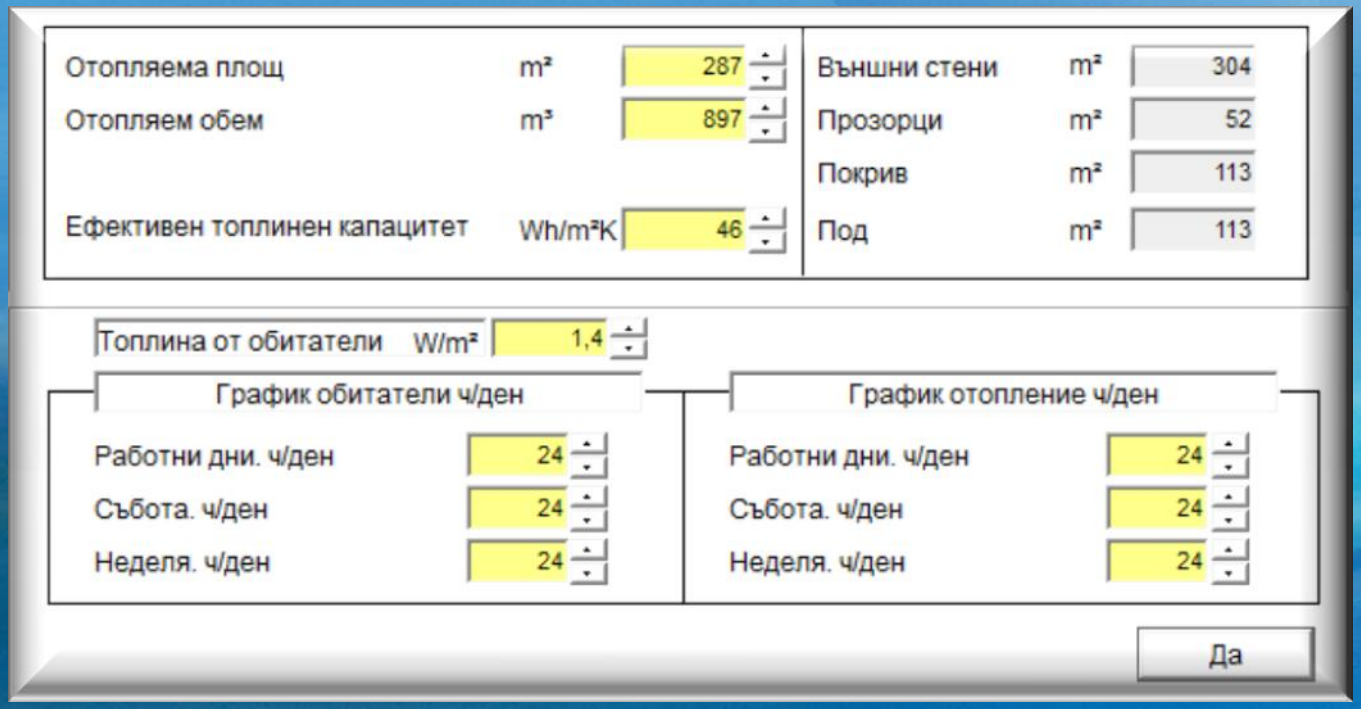






For each facade are provided to five different types of solid elements (walls) and five types of transparent elements (windows). For each type of wall is necessary to introduce area and coefficient of heat transfer, and for each type of window - the area, heat transfer coefficient, the coefficient of total solar gain (full solar radiation) and number of windows of this type.

After summarizing the facade data, the program shows the general geometrical characteristics of the building elements and asks about heating area, gross heating volume, building occupation and heating regime. It is also necessary to introduce the number of people or equivalent amount heat of them in depend of heating area (by square meters) and effective heat capacity of the building. The last parameter determines the type of the building construction – light, middle or heavy construction.



THIS IS THE MAIN WINDOW FOR MODELING AND ENERGY CALCULATIONS OF HEATING IN THE BUILDING.

- The first column is not active. It shows the reference data.
- The second column is active and shows data about actual or existing condition of the building
- The third column is base line of the building.

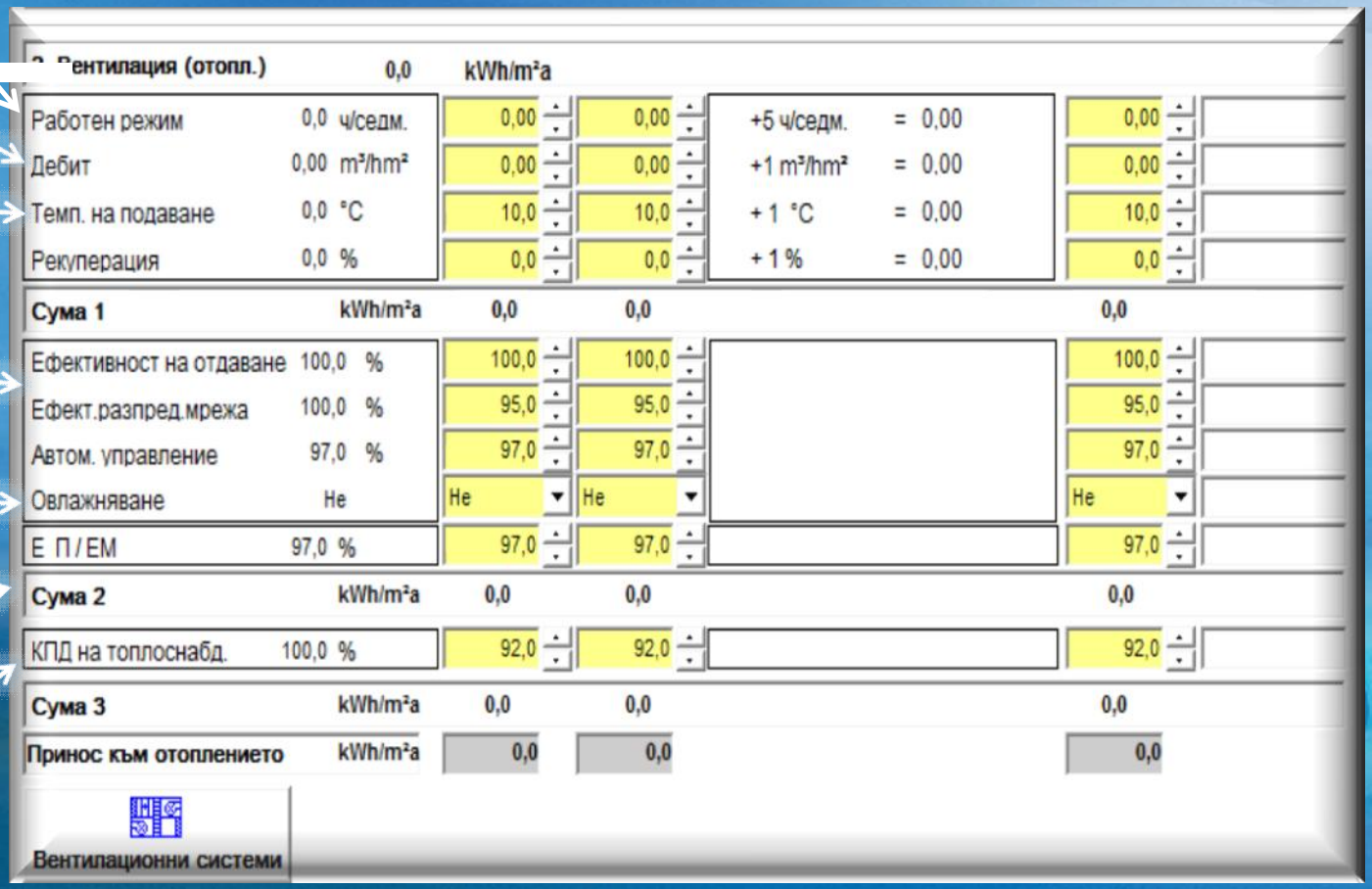
For instance if the indoor temperature during the heating seasons has been too low, the heating system has not been operating fully or surrounding elements has not been effective enough and if we would like to improve the comfort by increasing the heating capacity or building renovation we must to do it at project parameters, but in existing condition. This project parameters– indoor temperature and setback temperature have to be entered in the Baseline column. Then we can make energy-saving measures in the building in the next column.

- The fourth and fifth column show data about energy saving measures and calculations.

Parameter	Standard	Actual	Baseline	Sensitivity kWh/m²a	Measure	Savings
1. Heating	**49,3 kWh/m²a**					
U - wall	0,40 W/m²K	0,31 >	0,31	+ 0,1 W/m²K = 6,63	0,31 >	
U - window	1,80 W/m²K	1,80 >	1,80	+ 0,1 W/m²K = 1,12	1,80 >	
U - roof	0,30 W/m²K	0,26 >	0,26	+ 0,1 W/m²K = 2,45	0,26 >	
U - floor	0,45 W/m²K	0,23 >	0,23	+ 0,1 W/m²K = 2,45	0,23 >	
Compactness ratio	0,65 -	0,65	0,65		0,65	
Window factor	18,1 %	18,1	18,1		18,1	
Total solar gain	0,56 -	0,54 >	0,54		0,54 >	
Infiltration	0,50 1/h	0,50	0,50	+ 0,1 1/h = 6,65	0,50	
Indoor temperature	19,3 °C	19,3	19,3	+ 1 °C = 4,92	19,3	
Setback temperature	19,3 °C	19,3	19,3	+ 1 °C = 0,00	19,3	
Contribution from						
Ventilation (heating)	kWh/m²a	0,00 ...	0,00 ...		0,00 ...	
Lighting	kWh/m²a	14,03 ...	14,03 ...		14,03 ...	
Various equipment	kWh/m²a	8,87 ...	8,87 ...		8,87 ...	
Energy need	**kWh/m²a**	**31,2**	**31,2**		**31,2**	
Emission efficiency	не 100,0 %	100,0	100,0		100,0	
Distribution efficiency	95,0 %	95,0	95,0		95,0	
Automatic control	97,0 %	97,0	97,0		97,0	
TBM/EM	97,0 %	97,0	97,0		97,0	
Sum	**kWh/m²a**	**34,9**	**34,9**		**34,9**	
Generation efficiency	92,0 %	92,0	92,0		92,0	
Energy use	**kWh/m²a**	**38,0**	**38,0**		**38,0**	

Through ventilation (heating) button opens window which allows to input information required modeling of ventilation systems in the building.

- Working regime
- Air specific flow
- Input temperature/ recuperation
- Losses/efficiency distribution system and automatic control
- Air humidity
- Maintenance and system monitoring
- Efficiency of heating system

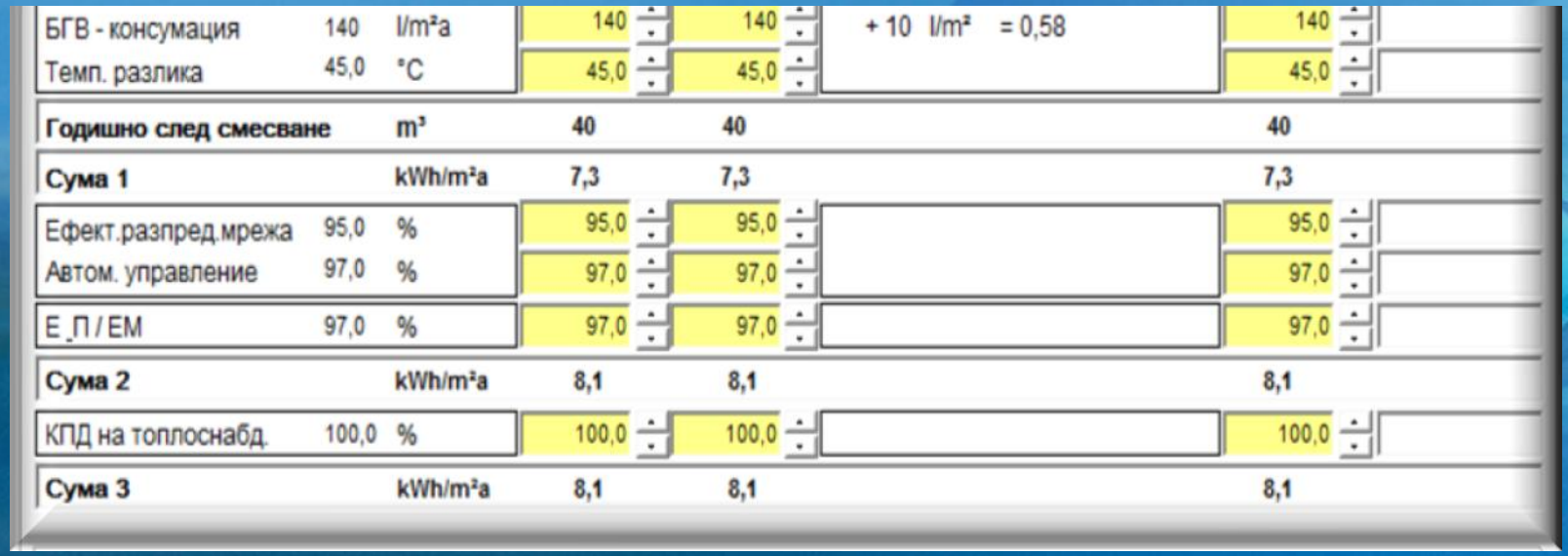


HEAT WATER FOR DOMESTIC NEEDS.

The selection of button "DHW" opens a window in which we have to introduce necessary data for modeling of systems for domestic hot water.

The following data have to introduce:

- Specific hot water consumption l/m² $_{per}$ year.
- Temperature difference /from 7-10 °C to 37-40 °C – after mixing with cold water /
- Losses/efficiency distribution system and automatic control
- Efficiency of heat distribution system



БГВ - консумация	140	l/m²a	140	140	+ 10 l/m² = 0,58	140	
Темп. разлика	45,0	°C	45,0	45,0		45,0	
Годишно след смесване		**m³**	**40**	**40**		**40**	
Сума 1		**kWh/m²a**	**7,3**	**7,3**		**7,3**	
Ефект.разпред.мрежа	95,0	%	95,0	95,0		95,0	
Автом. управление	97,0	%	97,0	97,0		97,0	
Е_П / ЕМ	97,0	%	97,0	97,0		97,0	
Сума 2		**kWh/m²a**	**8,1**	**8,1**		**8,1**	
КПД на топлоснабд.	100,0	%	100,0	100,0		100,0	
Сума 3		**kWh/m²a**	**8,1**	**8,1**		**8,1**	

FANS AND PUMPS / LIGHTING

In this window the consumers have to introduce data about working regime and installed capacity of existing fans, pumps heating and lighting. Installed capacity is necessary to correct to real conditions.
For these devices insert value to 100 % about maintenance and system monitoring.

Вентилатори	0,00	W/m²	0,00	0,00	+1 W/m²	= 0,00	0,00	
Помпи вентилация	0,00	W/m²	0,00	0,00	+1 W/m²	= 0,00	0,00	
Помпи отопление	0,32	W/m²	0,32	0,32	+1 W/m²	= 3,96	0,32	
Е_П / ЕМ	0	%	0,0	0,0			0,0	
Сума 3		**kWh/m²a**	**1,3**	**1,3**			**1,3**	

5. Осветление		**34,5**	**kWh/m²a**					
Работен режим	70	ч/седм.	70	70	+1 ч/седм.	= 0,48	70	
Едновр.мощност	10,00	W/m²	9,80	9,80	+1 W/m²	= 3,45	9,80	
Сума 3		**kWh/m²a**	**33,8**	**33,8**			**33,8**	

VARIOUS EQUIPMENT

These energy consumers are divided in two types:

- *Various equipment with some influence on the heat balance of the building.*

For instance - household equipment - iron, vacuum cleaner, computer, TV, washing machine etc..

- *Various equipment without influence on the heat balance of the building, but with some influence of total energy (electrical) consumption.*

For example in this case - outdoor lighting, building's lift, and other outdoor equipment.

6. Разни

6.1 Разни влияещи на баланса	**20,7**	**kWh/m²a**							
Работен режим	70	ч/седм.	70	70	+5 ч/седм.	=	1,53	70	
Едновр.мощност	6,00	W/m²	6,20	6,20	+1 W/m²	=	3,45	6,20	
Сума 3		**kWh/m²a**	**21,4**	**21,4**				**21,4**	
6.2 Разни невлияещи на баланса	**0,0**	**kWh/m²a**							
Работен режим	0	ч/седм.	0	0	+5 ч/седм.	=	0,00	0	
Едновр.мощност	0,00	W/m²	0,00	0,00	+1 W/m²	=	0,00	0,00	
Сума 3		**kWh/m²a**	**0,0**	**0,0**				**0,0**	

ENERGY BUDGET

The window "Energy Budget " in table form, provides information about energy consumption of building components for the reference and current building before introduction of energy saving measures (existing situation) and after introduction of energy saving measures, allowing easy comparison of the obtained values.

Бюджет "Разход на енергия" | ЕС мерки | Мощностен бюджет | ЕТ крива | Годишно разпределение | Топлинни загуби

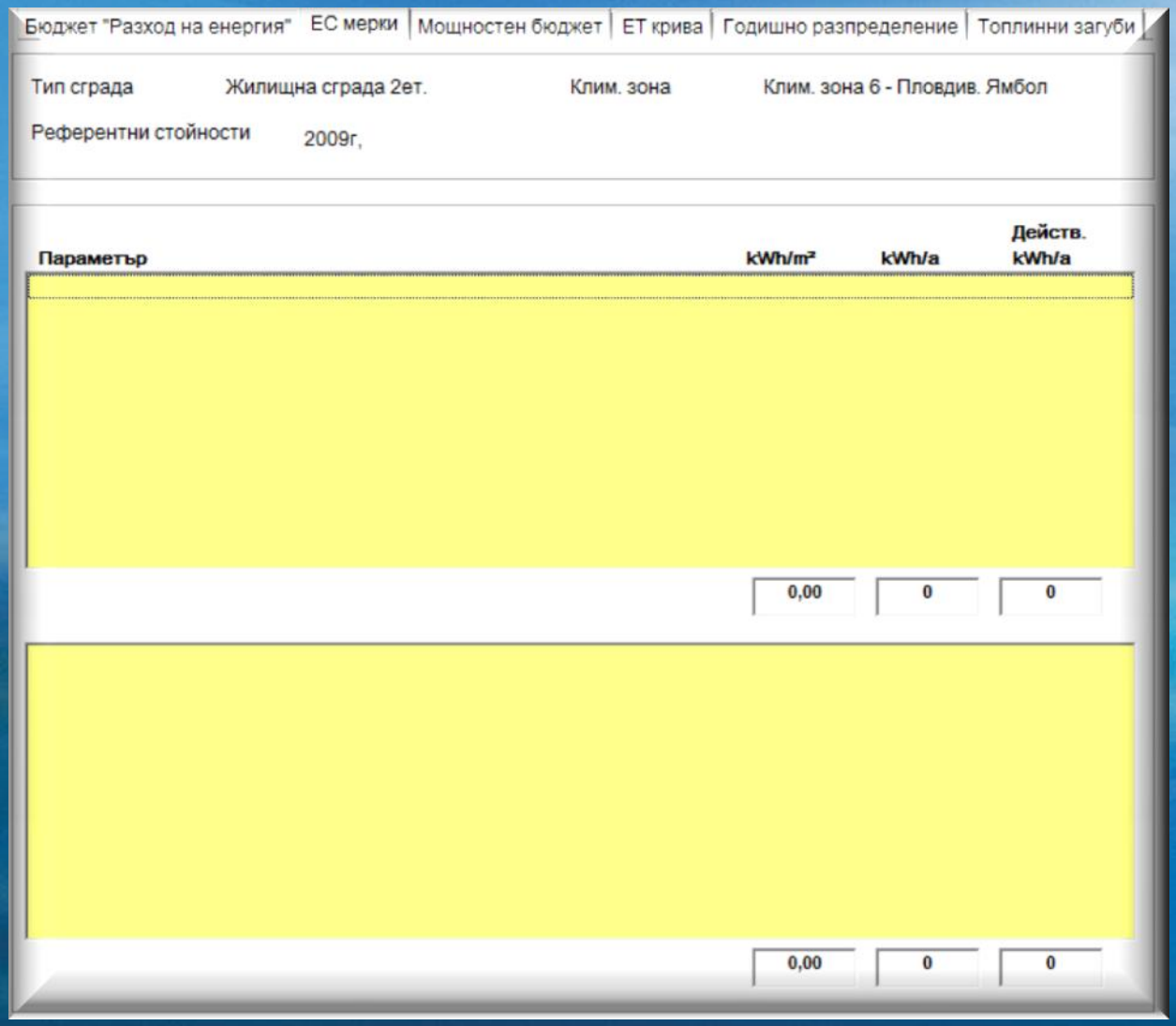
Тип сграда Жилищна сграда 2ет. Клим. зона Клим. зона 6 - Пловдив. Ямбол

Референтни стойности 2009г,

Параметър	Еталон	Състояние		Базова линия		След ECM	
	kWh/m²	kWh/m²	kWh/a	kWh/m²	kWh/a	kWh/m²	kWh/a
1. Отопление	49,3	38,0	10 893	38,0	10 893	38,0	10 893
2. Вентилация (отопл.)	0,0	0,0	0	0,0	0	0,0	0
3. БГВ	8,1	8,1	2 329	8,1	2 329	8,1	2 329
4. Помпи. вент.(отопл.)	1,3	1,3	364	1,3	364	1,3	364
5. Осветление	34,5	33,8	9 703	33,8	9 703	33,8	9 703
6. Разни	20,7	21,4	6 139	21,4	6 139	21,4	6 139
Общо (отопление)	113,8	102,5	29 428	102,5	29 428	102,5	29 428
Обща отопляема площ	287						
7.1 Охлаждане	0,0	0,0	0	0,0	0	0,0	0
7.2 Вентилация(охл.)	0,0	0,0	0	0,0	0	0,0	0
7.3 Вентилатори (охл.)	0,0	0,0	0	0,0	0	0,0	0
7.4 Други (охл.)	0,0	0,0	0	0,0	0	0,0	0
Общо (охлаждане)	0,0	0,0	0	0,0	0	0,0	0
Обща охлаждаема площ	0						
Отопление и охл.	113,8	102,5	29 428	102,5	29 428	102,5	29 428

ENERGY SAVING MEASURES

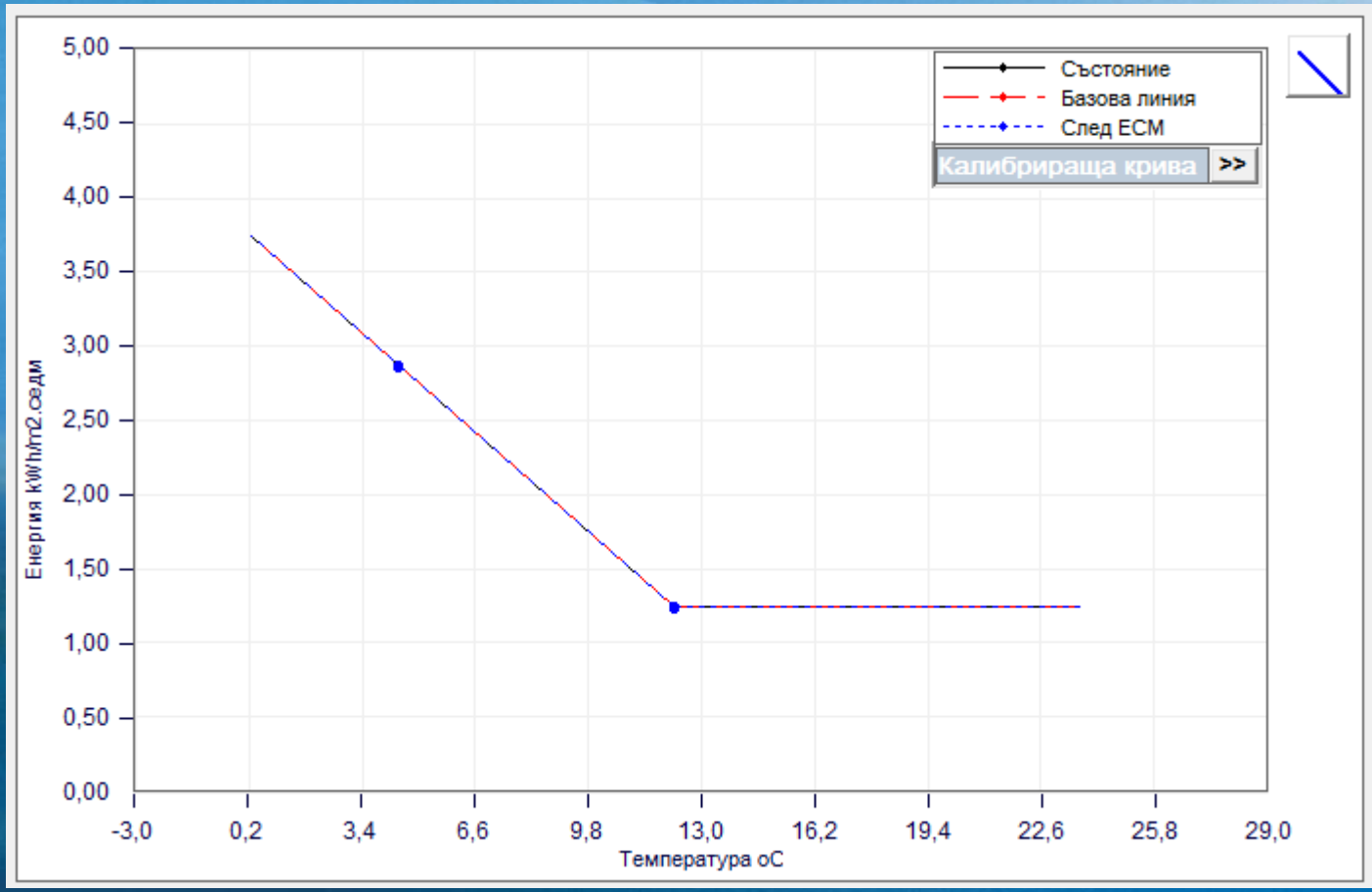
A list of energy saving measures are included here, entered in the project, based on the actual calculations. Each measure reduce in some rate the total energy consumption. In this case the building is new and corresponds with the legal requirements for heat insulation and energy conservation in Bulgaria.



ENERGY MONITORING - ET CURVE

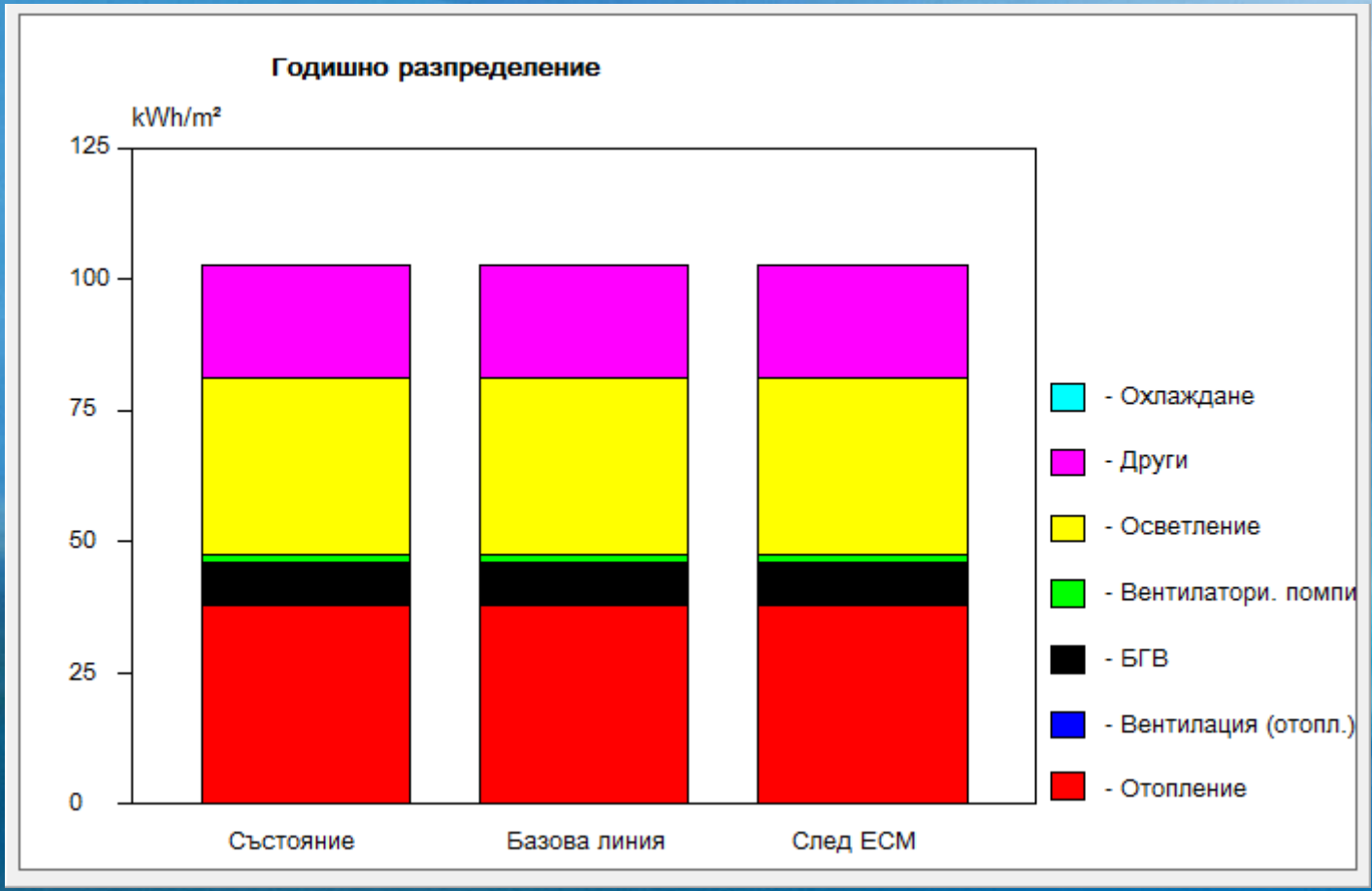
The ENSI software includes calculation of the ET Curve (for Actual, Baseline and After measures situation).

The energy curve and the average outdoor air temperature allow to determine the actual energy consumption and compare this consumption with the expected consumption.
The straight line presents constant energy consumption for hot water throughout the year .



ANNUAL ENERGY DISTRIBUTION

The window "Annual distribution" shows in graphic form the distribution of the components of the building's energy balance.



SCALE OF ENERGY CONSUMPTION

According to carried modeling research of this family building is obtained low value of energy consumption. This value compared with reference values corresponds to the energy performance of Class "B".

Limits (from – to)	Energy consumption class	Values (from – to), kWh/m^2
$EP < 0{,}5\ EP_{max,r}$	A	$EP < 29{,}13$
$0{,}5\ EP_{max,r} < EP \leq EP_{max,r}$	B	$29{,}13 < EP \leq 57{,}4$
$EP_{max,r} < EP \leq 0{,}5\ (EP_{max,r} + EP_{max,s})$	C	-
$0{,}5\ (EP_{max,r} + EP_{max,r}) < EP \leq EP_{max,s}$	D	-
$EP_{max,s} < EP \leq 1{,}25\ EP_{max,s}$	E	-
$1{,}25\ EP_{max,s} < EP \leq 1{,}5\ EP_{max,s}$	F	-
$1{,}5\ EP_{max,s} < EP$	G	-

The **E**nergy **P**erformance of this family building **EP** = 46,10 kWh/m^2 corresponds to high position of energy consumption - Class B.


Thank you!