TECHNICAL UNIVERSITY - SOFIA
FACULTY OF ENGINEERING AND PEDAGOGY - SLIVEN

Energy Performance Diagnosis of Individual Building with ENSI "Key Numbers" software

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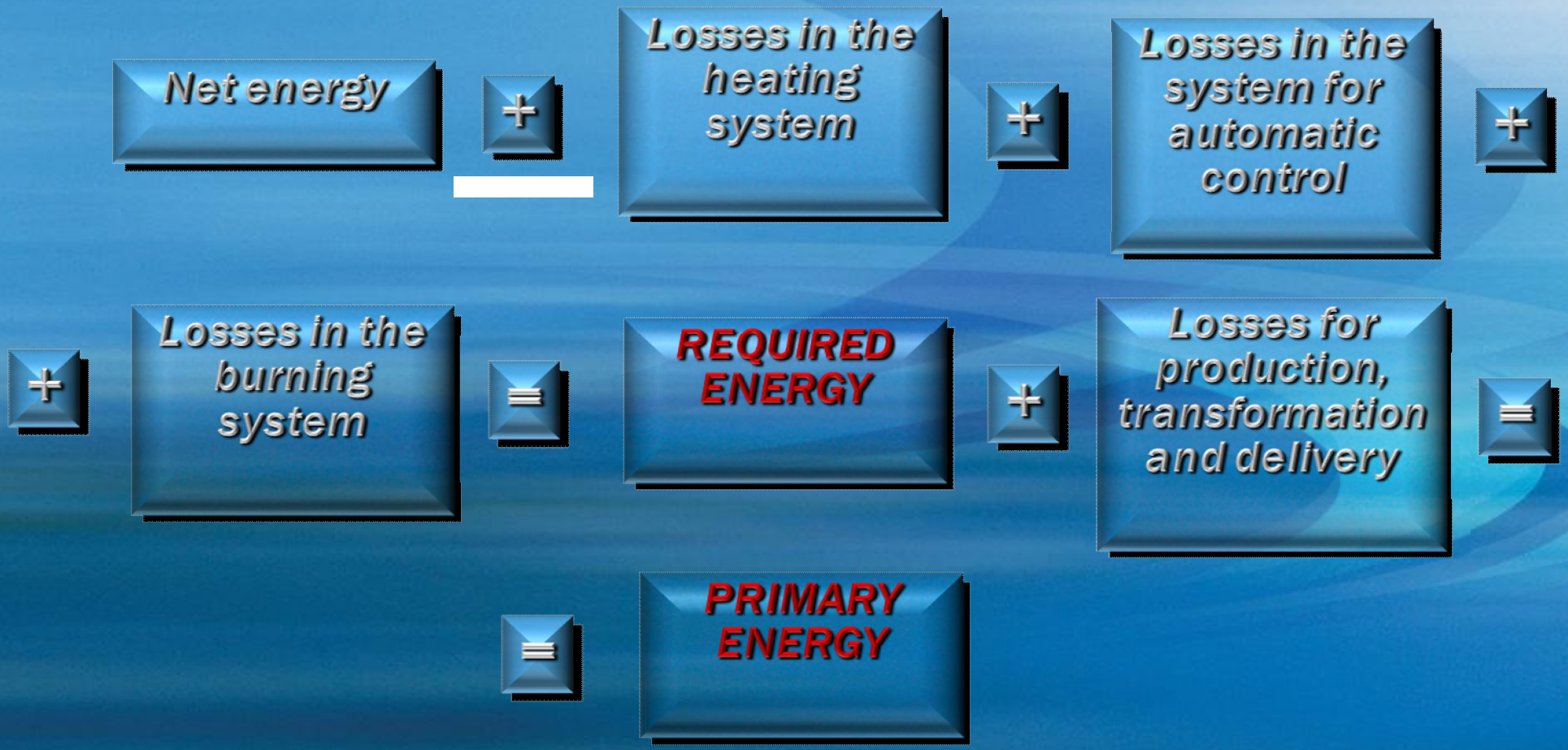
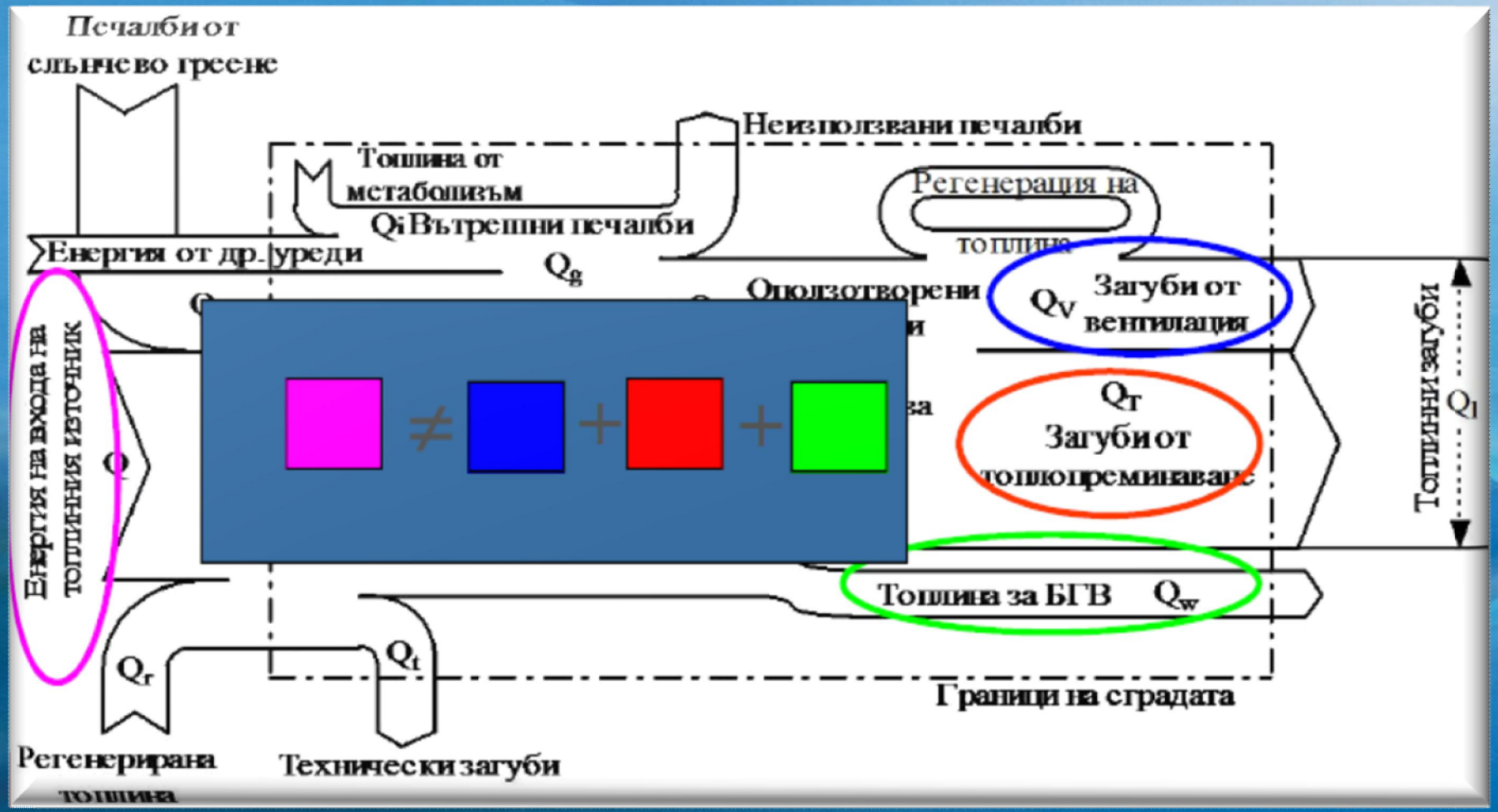
Education and Culture DG

Annual energy consumption by the method BS EN ISO 13790



Energy balance for winter conditions according BS EN ISO 13790



Energy balance for heating, ventilation, cooling and domestic hot water

$$Q = Q_H + Q_V + Q_W + Q_t - Q_r$$

Where:

- Q - Delivered energy to the building;
- $Q_H = Q_{Ht} - \eta_{H,gn} . Q_{H,gn}$ - annually energy consumption for heating;
- QV - annually energy consumption for ventilation;
- Qw - annually energy consumption for DHW;
- Qt – technical losses;
- Qr - annually regenerative energy in the building.

Energy for heating

$$Q_H = Q_{Ht} - \eta_{H,gn} . Q_{H,gn}$$

Where:

- Q_{Ht} – Thermal losses;
- $Q_{H,gn}$ - annually energy gains of heat;
- $\eta_{H,gn}$ – coefficient of heat gains.

$$Q_{H,gn} = Q_{int} + Q_{sol}$$

Where:

- Q_{int} – internal heat gains ;
- $Q_{H,gn}$ – solar radiation gains;

$$Q_{\text{int}} = \frac{1}{1000} \cdot \left(\sum_{\kappa} \Phi_{\text{int},k} \right) . t + \left(\sum_{l} \left(1 - b_{tr,l}\right) \Phi_{\text{int},u,l} \right) . t$$

Where:

- $\Phi_{int,k}$ – average value of the heat flow from the internal source;
- $\Phi_{int,u,l}$ - average value of the heat flow from the internal source in neighboring unheated zone, W;
- $b_{tr,l}$ - Reduction factor for neighboring unheated area ;

Energy for heating

$$Q_{sol} = \frac{1}{1000}.\left(\sum_{\kappa} \Phi_{sol,k}\right).t + \left(\sum_{l} \left(1 - b_{tr,l}\right)\Phi_{sol,u,l}\right).t$$

Where:

- $\Phi_{sol,k}$ - average heat value from sunlight streaming through the elements, W;
- $\Phi_{sol,u,l}$ - average heat value of the flow of solar radiation from the neighboring unheated zone, W;
- $b_{tr,l}$ - Reduction factor for neighboring unheated area ;
- t– time in hours;

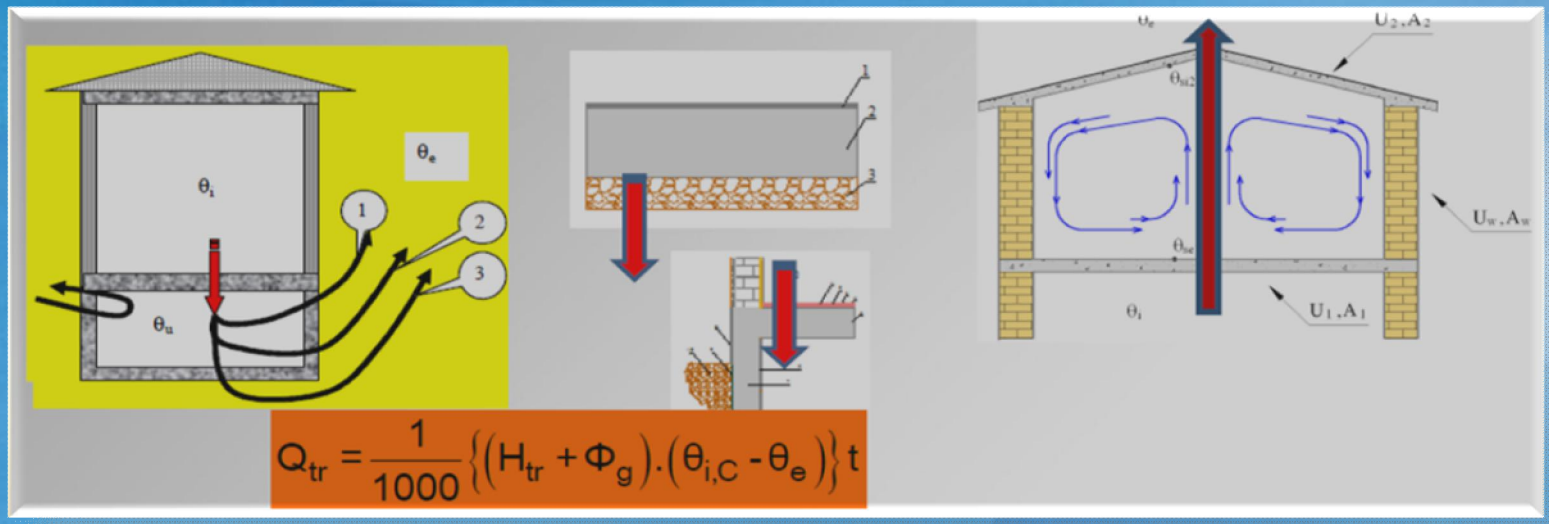
$$Q_{Ht} = Q_{tr} + Q_{ve}$$

$$Q_{ve} = \frac{1}{1000}.\left\{H_{ve}\left(\theta_{i,H} - \theta_{e}\right)\right\}.t$$

Where:

- Q_{ve} - heat loss by ventilation , kWh;
- H_{ve} - coefficient of heat transfer in a ventilation air temperature difference, W/K;
- $\Delta\Theta$ – temperature difference, K;

Energy for heating

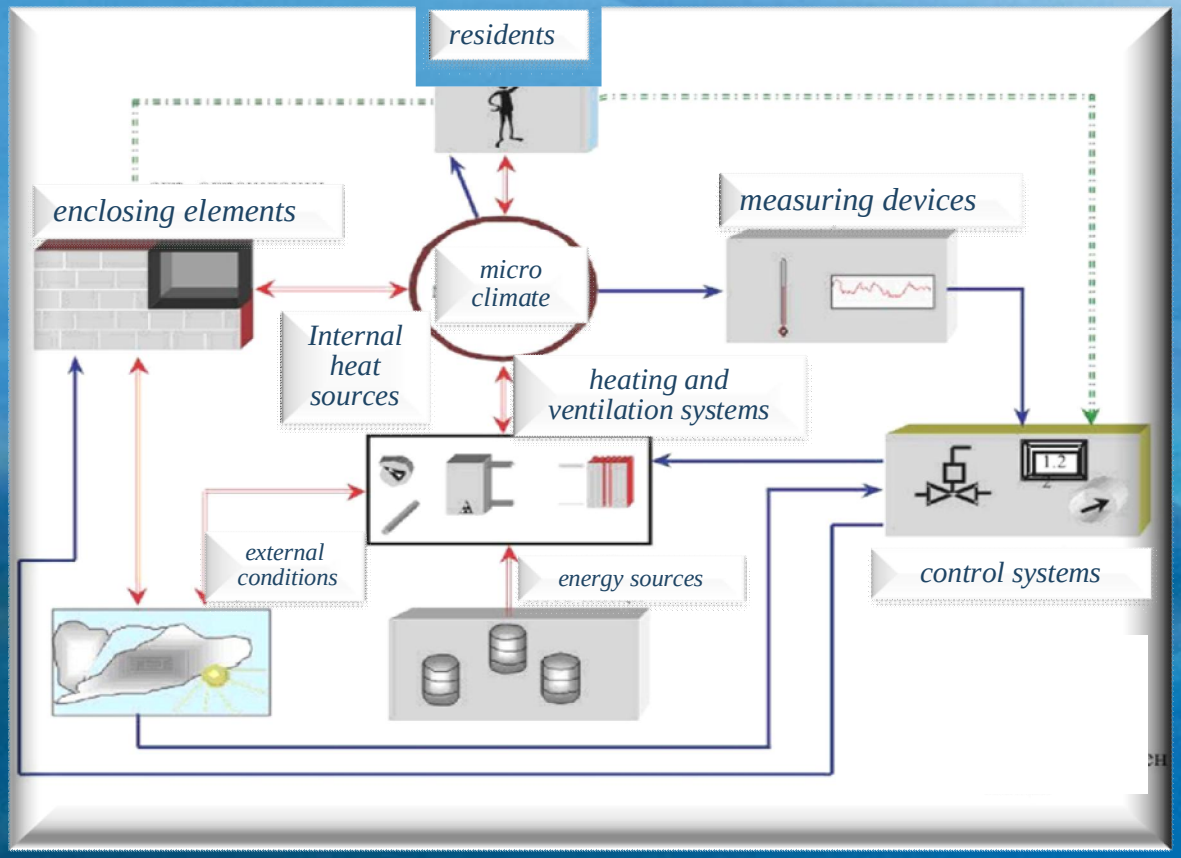


$$Q_{tr} = \frac{1}{1000}.\{(H_{tr} + \Phi_g)(\theta_{i,H} - \theta_e)\}.t$$

Where:

- Q_{tr} - heat loss as heat transfer through the elements, kWh;
- Q_{ve} - heat loss by ventilation , kWh;
- H_{tr} - coefficient of thermal or heat transfer, W/K;
- Φ_g- coefficient of heat transfer through the surrounding elements bordering to the land ,W/K;
- $\Delta\Theta$ – temperature difference, K;

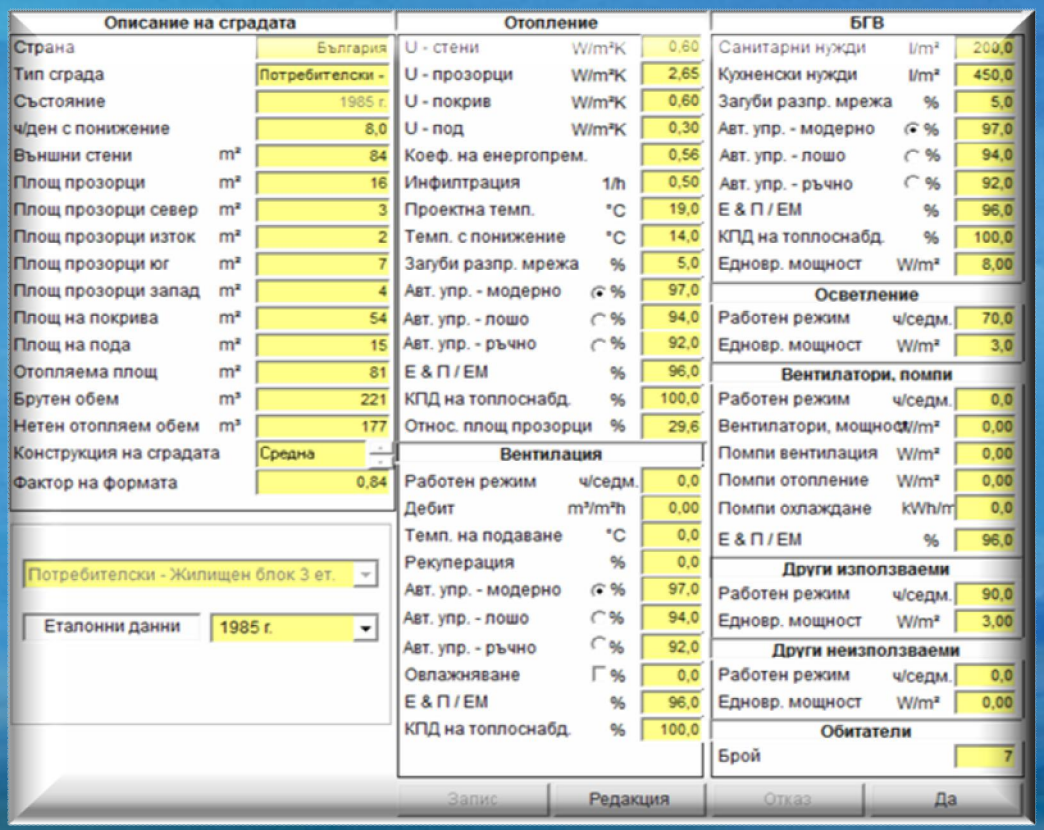
On the basis of method according EN ISO 13790, the company ENSI- **En**ergy **S**aving **I**nternational, Norway, together with TU – Sofia, have developed software to energy consumption modeling and assessment of the potential for reducing energy costs in buildings. The building presents itself as an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



When we choose a new project 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 :

Settings - reference data:



Описание на сградата		
Страна		България
Тип сграда		Потребителски -
Състояние		1985 г.
ч/ден с понижение		8,0
Външни стени	m²	84
Площ прозорци	m²	16
Площ прозорци север	m²	3
Площ прозорци изток	m²	2
Площ прозорци юг	m²	7
Площ прозорци запад	m²	4
Площ на покрива	m²	54
Площ на пода	m²	15
Отопляема площ	m²	81
Брутен обем	m³	221
Нетен отопляем обем	m³	177
Конструкция на сградата		Средна
Фактор на формата		0,84

Потребителски - Жилищен блок 3 ет.

Еталонни данни 1985 г.

Отопление		
U - стени	W/m²K	0,60
U - прозорци	W/m²K	2,65
U - покрив	W/m²K	0,60
U - под	W/m²K	0,30
Коеф. на енергопрем.		0,56
Инфилтрация	1/h	0,50
Проектна темп.	°C	19,0
Темп. с понижение	°C	14,0
Загуби разпр. мрежа	%	5,0
Авт. упр. - модерно	%	97,0
Авт. упр. - лошо	%	94,0
Авт. упр. - ръчно	%	92,0
Е & П / ЕМ	%	96,0
КПД на топлоснабд.	%	100,0
Относ. площ прозорци	%	29,6

Вентилация		
Работен режим	ч/седм.	0,0
Дебит	m³/m²h	0,00
Темп. на подаване	°C	0,0
Рекуперация	%	0,0
Авт. упр. - модерно	%	97,0
Авт. упр. - лошо	%	94,0
Авт. упр. - ръчно	%	92,0
Овлажняване	%	0,0
Е & П / ЕМ	%	96,0
КПД на топлоснабд.	%	100,0

БГВ		
Санитарни нужди	l/m²	200,0
Кухненски нужди	l/m²	450,0
Загуби разпр. мрежа	%	5,0
Авт. упр. - модерно	%	97,0
Авт. упр. - лошо	%	94,0
Авт. упр. - ръчно	%	92,0
Е & П / ЕМ	%	96,0
КПД на топлоснабд.	%	100,0
Едновр. мощност	W/m²	8,00

Осветление		
Работен режим	ч/седм.	70,0
Едновр. мощност	W/m²	3,0

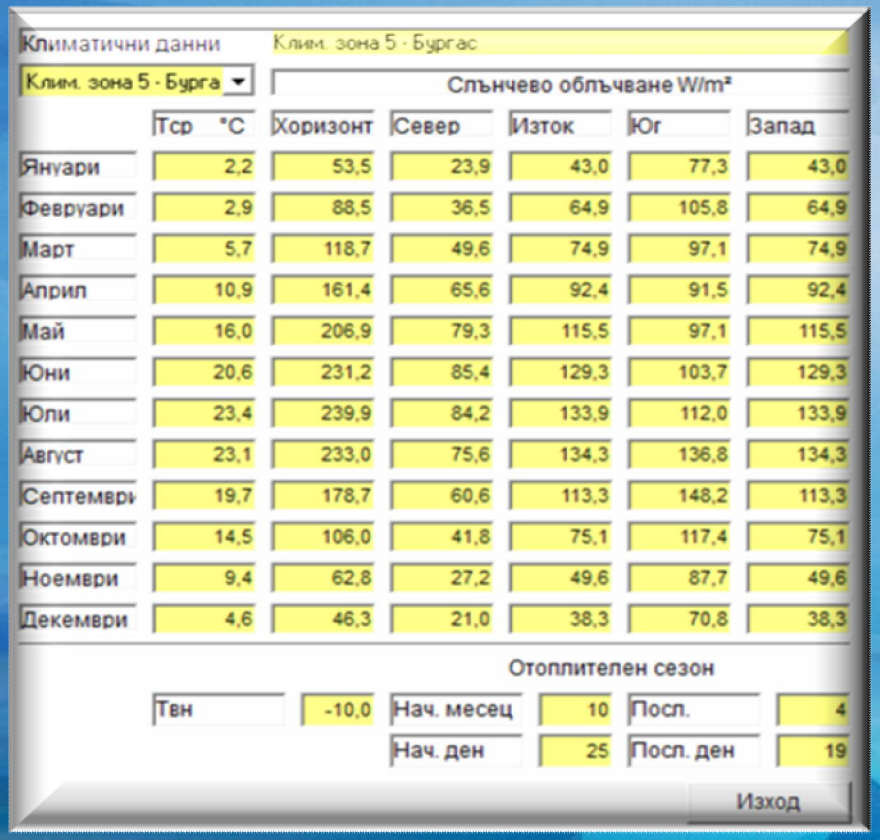
Вентилатори, помпи		
Работен режим	ч/седм.	0,0
Вентилатори, мощност	W/m²	0,00
Помпи вентилация	W/m²	0,00
Помпи отопление	W/m²	0,00
Помпи охлаждане	kWh/m	0,0
Е & П / ЕМ	%	96,0

Други използваеми		
Работен режим	ч/седм.	90,0
Едновр. мощност	W/m²	3,00

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

Обитатели	
Брой	7

Запис | Редакция | Отказ | Да



Климатични данни — Клим. зона 5 - Бургас

Клим. зона 5 - Бурга

	Тср °C	Слънчево облъчване W/m² Хоризонт	Север	Изток	Юг	Запад
Януари	2,2	53,5	23,9	43,0	77,3	43,0
Февруари	2,9	88,5	36,5	64,9	105,8	64,9
Март	5,7	118,7	49,6	74,9	97,1	74,9
Април	10,9	161,4	65,6	92,4	91,5	92,4
Май	16,0	206,9	79,3	115,5	97,1	115,5
Юни	20,6	231,2	85,4	129,3	103,7	129,3
Юли	23,4	239,9	84,2	133,9	112,0	133,9
Август	23,1	233,0	75,6	134,3	136,8	134,3
Септември	19,7	178,7	60,6	113,3	148,2	113,3
Октомври	14,5	106,0	41,8	75,1	117,4	75,1
Ноември	9,4	62,8	27,2	49,6	87,7	49,6
Декември	4,6	46,3	21,0	38,3	70,8	38,3

Отоплителен сезон

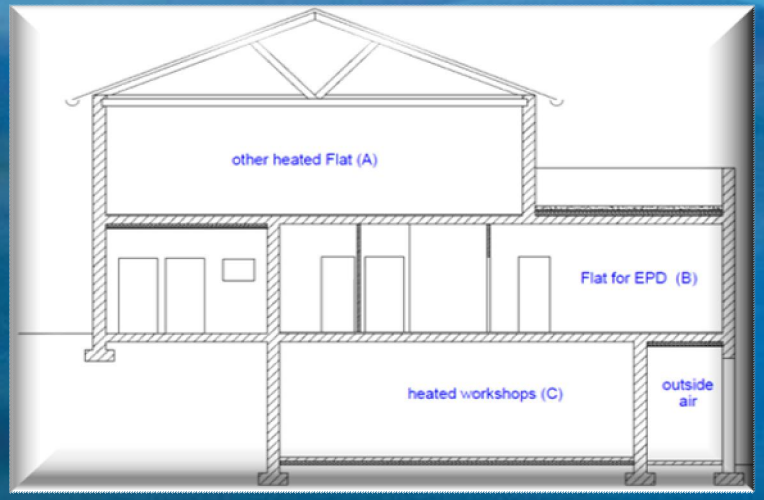
Твн	-10,0	Нач. месец	10	Посл.	4
		Нач. ден	25	Посл. ден	19

Изход

On this screen we have to do choice of building type from 7 included in the standard database kinds - apartment (a block of flats) – 1-5 floors, apartment – 6-14 floors, school, kinder garden, university, college, hospital, office building. Data for these types of buildings include the required parameters referred in the relevant ordinance.

After summarizing the facade data, the program shows the general geometrical characteristics of the building elements, heating area, gross heating volume and effective heat capacity of the building. The last parameter determines the type of the building construction – light, middle or heavy construction.

Отопляема площ	m²	81	Външни стени	m²	84
Брутен обем	m³	221	Площ прозорци	m²	16
Нетен отопляем обем	m³	177	Площ на покрива	m²	54
Конструкция на сградата		Средна	Площ на пода	m²	15



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 when the heating system has not been operate fully or surrounding elements has not been effective enough then the indoor temperature during the heating seasons has been too low, and if we would like to improve the comfort in the building, 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	48,7 kWh/m²y					
U - wall	0,60 W/m²K	0,47	0,47	+ 0,1 W/m²K = 4,98	0,47	
U - window	2,65 W/m²K	3,06	3,06	+ 0,1 W/m²K = 0,94	3,06	
U - roof	0,60 W/m²K	0,33	0,33	+ 0,1 W/m²K = 3,19	0,33	
U - floor	0,30 W/m²K	0,33	0,33	+ 0,1 W/m²K = 0,88	0,33	
Compactness ratio	0,84 -	0,76	0,76		0,76	
Window factor	29,6 %	19,8	19,8		19,8	
Total solar gain	0,56 -	0,52	0,52		0,52	
Infiltration	0,50 1/h	0,50	0,50	+ 0,1 1/h = 3,56	0,50	
Indoor temperature	19,0 °C	19,0	19,0	+ 1 °C = 4,23	19,0	
Setback temperature	14,0 °C	14,0	14,0	+ 1 °C = 2,10	14,0	
Contribution from						
Ventilation (heating)	kWh/m²y	0,00 ...	0,00 ...		0,00 ...	
Lighting	kWh/m²y	4,89 ...	4,89 ...		4,89 ...	
Various equipment	kWh/m²y	6,29 ...	6,29 ...		6,29 ...	
Energy need		34,5	34,5		34,5	
Emission efficiency	5,0 %	3,0	3,0		3,0	
Distribution efficiency	97,0 %	Автомат.	Автомат.	Лошо +3 %, Ръчно +5%	Автомат.	
Automatic control		36,7	36,7		36,7	
TBM/EM	96,0 %	96,0	96,0		96,0	
Sum		38,2	38,2		38,2	
Generation efficiency	100,0 %	100,0	100,0		100,0	
Energy use	kWh/m²y	38,2	38,2		38,2	

ENERGY BUDGET

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

Проект
EPD FRANCE

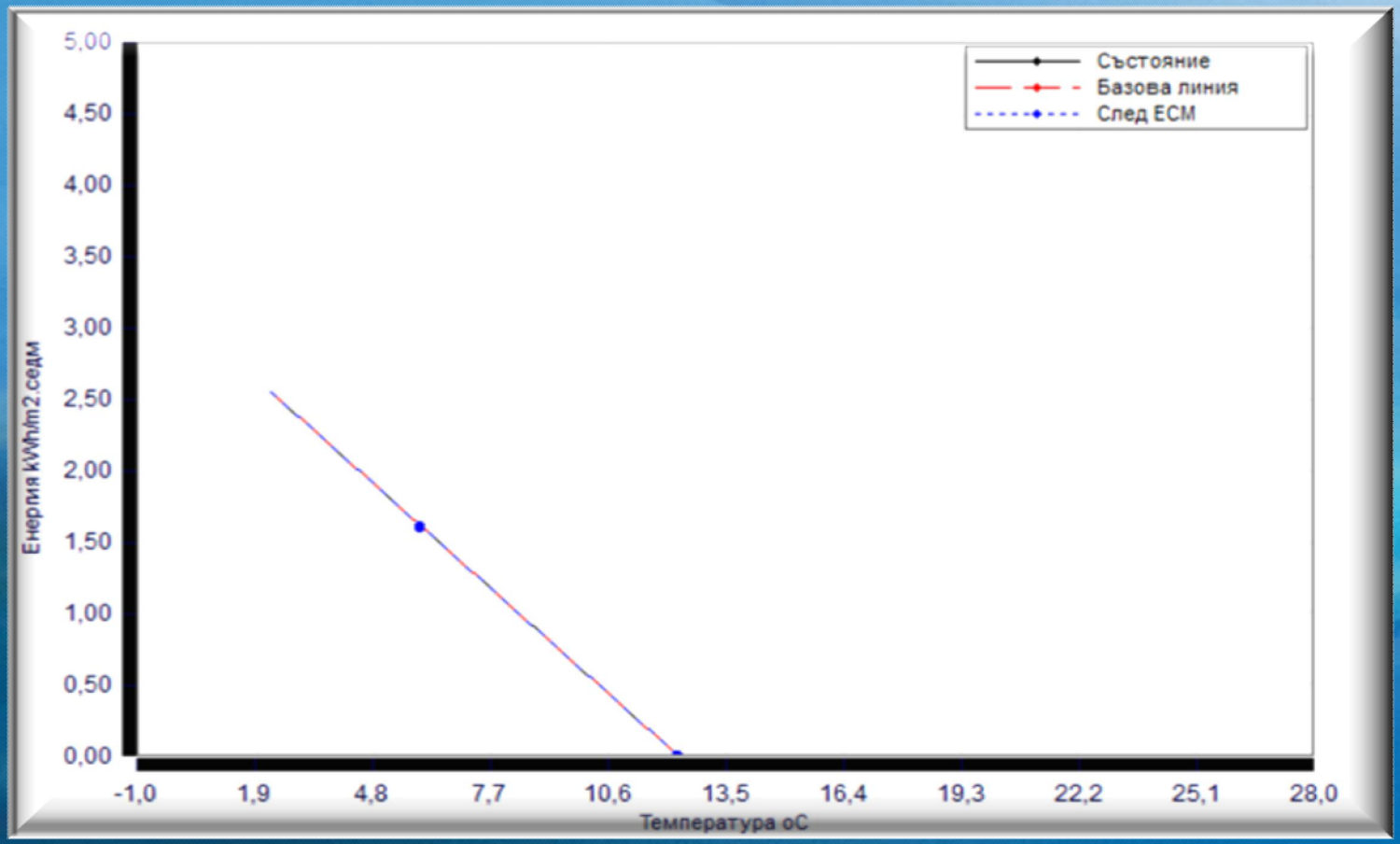
Тип сграда	Потребителски - Жилищен блок 3
Еталонни данни	1985 г.
Клим. зона	Клим. зона 5 - Бургас
Отоплителен сезон	25.10 - 19.4

Параметър	Еталон	Базова линия		След ECM	
	kWh/m²	kWh/m²	kWh/y	kWh/m²	kWh/y
1. Отопление	48,7	38,2	3 093	38,2	3 093
2. Вентилация	0,0	0,0	0	0,0	0
3. БГВ	25,4	25,4	2 055	25,4	2 055
4. Вентилатори и помпи	0,0	0,0	0	0,0	0
5. Осветление	10,9	10,9	887	10,9	887
6. Разни	14,1	14,1	1 140	14,1	1 140
7. Охлаждане	0,0	0,0	0	0,0	0
Общо	99,1	88,6	7 175	88,6	7 175
8. Външни консуматори			0		0

ENERGY MONITORING - ET CURVE

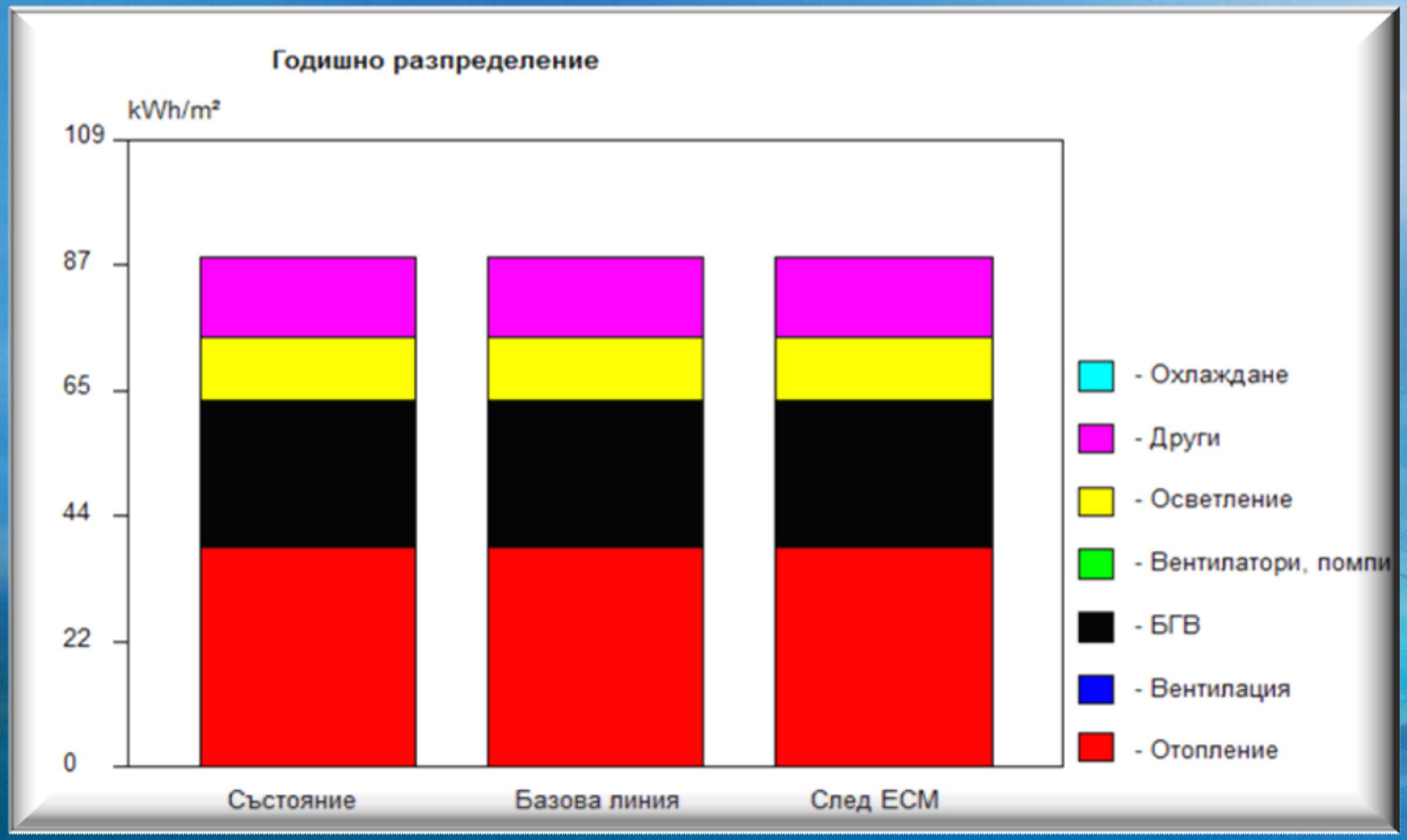
The ENSI software includes calculation of the ET Curve (for Actual, Baseline and After measures situation).

The energy curve as a function of the average outdoor temperature allow to determine the actual energy consumption and compare this consumption with the expected consumption.



ANNUAL ENERGY DISTRIBUTION

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




Thank you for your attention!