VILNIAUS GEDIMINAS TECHNICAL UNIVERSITY

FACULTY OF ENVIRONMENTAL ENGINEERING

DEPARTMENT OF BUILDING ENERGETICS

David Santiago Escribano

MICROCLIMATE SYSTEMS CHARACTERISTICS OF A THREE FLOOR HOTEL IN VILNIUS

Final Thesis

Vilnius, 2014

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Academic supervisor	Assoc. prof. Kęstutis Valančius	(Signature)	2014.06.25. (Date)
Student	David Santiago Escribano	(Signature)	2014.06.25 (Date)

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CONFIRMATION

This is to certify that Mr. **David Santiago Escribano** was enrolled as an Erasmus student at Vilnius Gediminas Technical University for the spring semester 2014 at the Faculty of Environmental Engineering and the Department of Building Energetics.

During this period he has written a thesis titled "MICROCLIMATE SYSTEMS CHARACTERISTICS OF A THREE FLOOR HOTEL IN VILNIUS" which was defended on 25/06/14.

The thesis (6 ECTS) is evaluated – excellent (10) or ECTS grade A.

Academic supervisor: Assoc. Prof. Kęstutis Valančius ____________

2014.06.25.

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1. INTRODUCTION

This final work consists of the functioning of the air conditioning of a hotel in the city of Vilnius (Lithuania), adjusting the legal and technical conditions at our facilities, using simultaneously the last and more usual techniques in recent years. Firstly we are going to describe the characteristics of the building and the climatic conditions of the zone where it's going to be placed.
After we will calculate the loads of heating, ventilation and cooling and finally we are going to explain and compare the solutions that we could adopt for fight against that loads.

2. BUILDING CHARACTERISTICS

2.1 Location

This three floor hotel is located in Vilnius. It has an elevation of 108 meters above the sea level. The exactly zone where the hotel will be placed is Saulėtekio alėja 55 A. Its coordinates are the following: 54º 43' 16.0'' N / 25º 20' 42.4'' E

Figure 1. Location of building

We choose that place because this hotel will be designed as a student residence, and the location for that is almost perfect with three big universities near it.

2.2 Climatic conditions

The climate of Vilnius is humid continental, that is, it has large seasonal temperature differences, with warm to hot (and often humid) summers and cold (sometimes severely cold) winters. The average annual temperature is 6.1 °C ; in January the average temperature is −4.9 °C , in July it is 17.0 °C. The average precipitation is about 661 millimeters per year.

The following temperatures we are going to use along the final work:

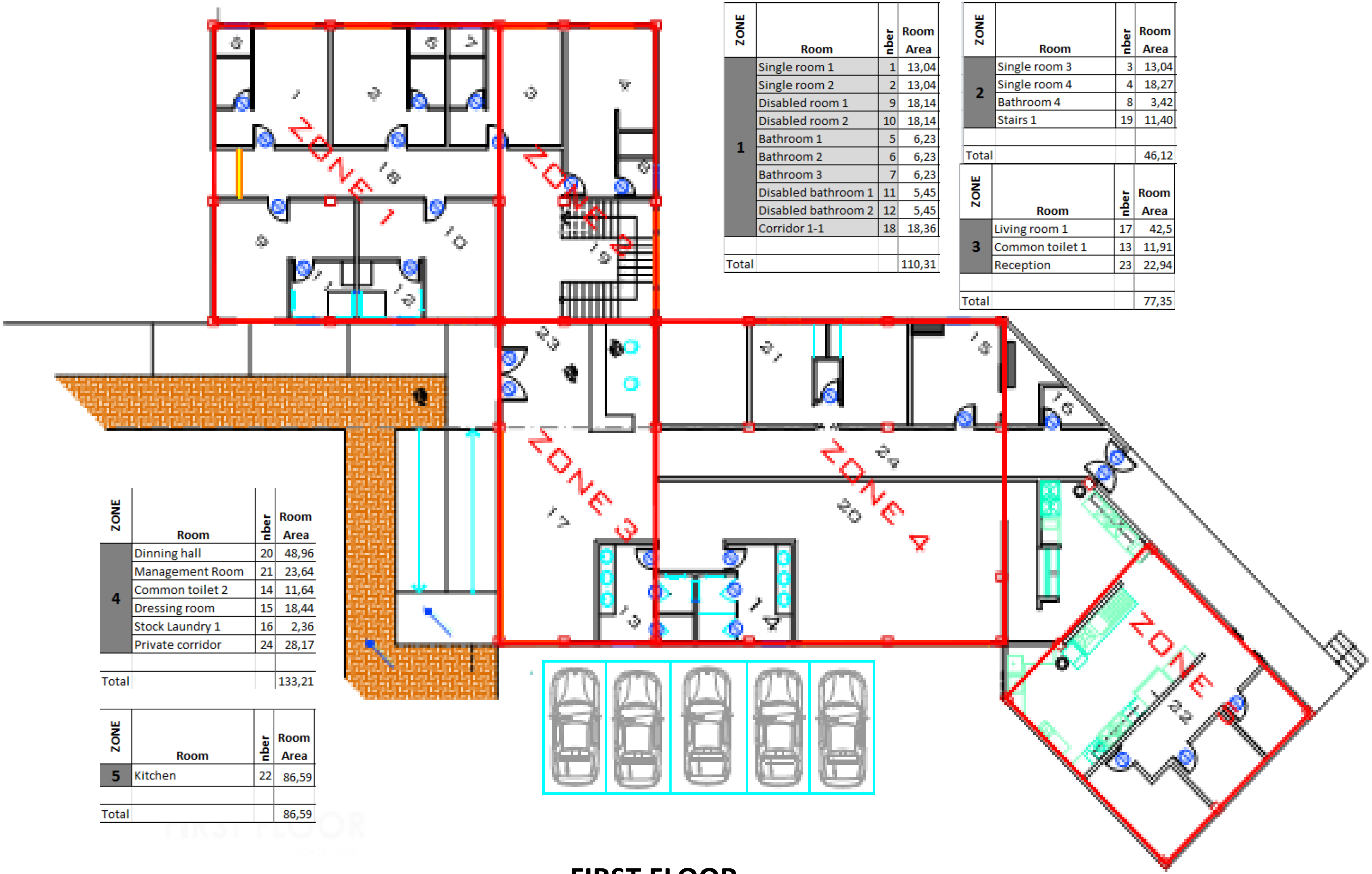
- Design indoor temperature (cold period): 22 ºC
- Design indoor temperature (hot period): 24 ºC
- Relative indoor humidity: 50 %
- Average temperature in heating season: 0,5 ºC
- Average annual temperature: 6,1 ºC
- Average relative outdoor humidity: 60-80%
- Design outdoor temperature (heating season): -24 ºC
- Design outdoor temperature (cooling season): 28 ºC

2.3 Building data

The building has 3 floor, with 469,34 m^2, 424,34 m2 and 418,71 m2, floor 1, 2 and 3, respectively. There is no basement below the first floor. The building has:

- 17 single rooms and single bathrooms
- 23 double rooms and double bathrooms.
- 2 handicapped accessible rooms and 2 handicapped accessible bathrooms

These are the floor plan of the building:



ZONE	Room	nber	Room Area
1	Single room 1	1	13,04
	Single room 2	2	13,04
	Disabled room 1	9	18,14
	Disabled room 2	10	18,14
	Bathroom 1	5	6,23
	Bathroom 2	6	6,23
	Bathroom 3	7	6,23
	Disabled bathroom 1	11	5,45
	Disabled bathroom 2	12	5,45
	Corridor 1-1	18	18,36
Total			110,31

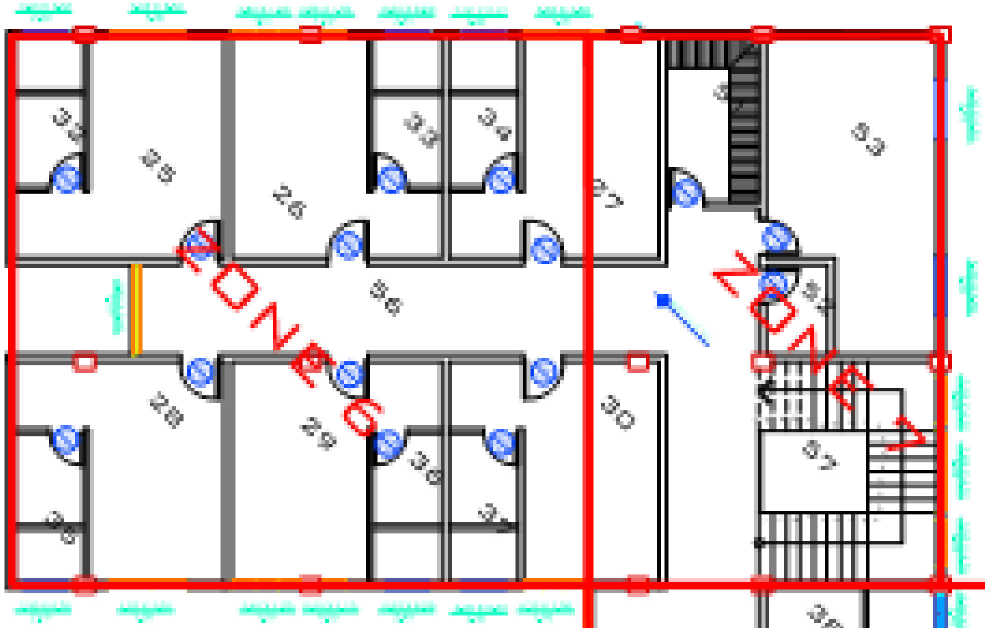
ZONE	Room	nber	Room Area
2	Single room 3	3	13,04
	Single room 4	4	18,27
	Bathroom 4	8	3,42
	Stairs 1	19	11,40
Total			46,12

ZONE	Room	nber	Room Area
3	Living room 1	17	42,5
	Common toilet 1	13	11,91
	Reception	23	22,94
Total			77,35

ZONE	Room	nber	Room Area
4	Dinning hall	20	48,96
	Management Room	21	23,64
	Common toilet 2	14	11,64
	Dressing room	15	18,44
	Stock Laundry 1	16	2,36
	Private corridor	24	28,17
Total			133,21

ZONE	Room	nber	Room Area
5	Kitchen	22	86,59
Total			86,59

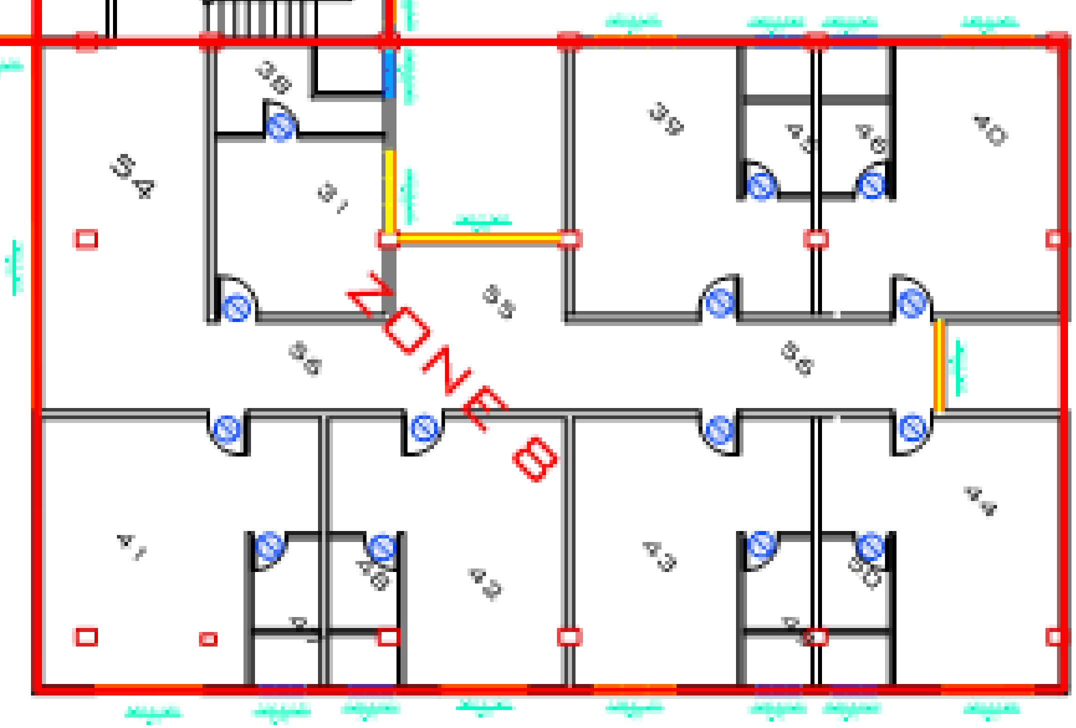
FIRST FLOOR



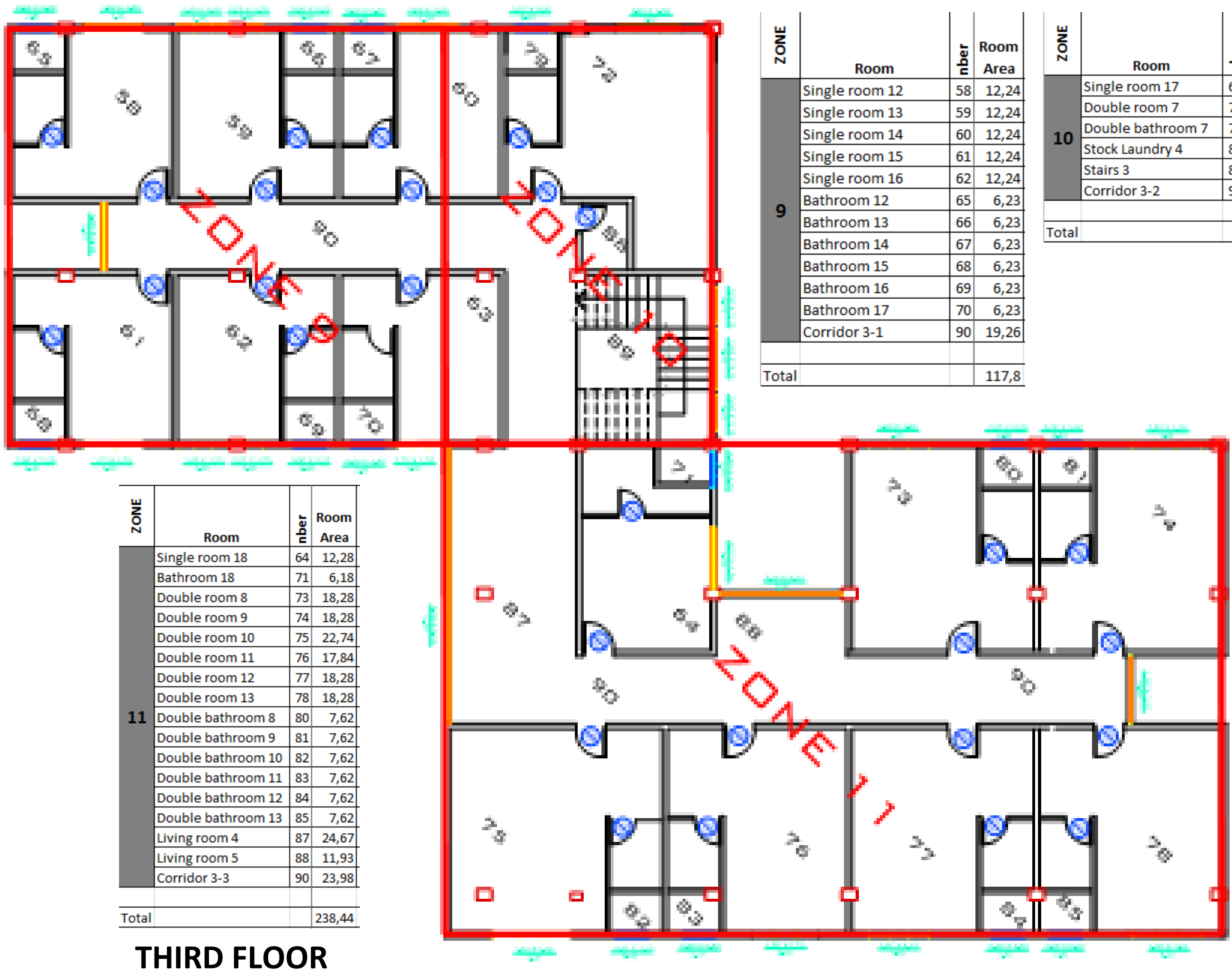
ZONE	Room	nber	Room Area
6	Single room 5	25	12,24
	Single room 6	26	12,24
	Single room 7	27	12,24
	Single room 8	28	12,24
	Single room 9	29	12,24
	Bathroom 5	32	6,23
	Bathroom 6	33	6,23
	Bathroom 7	34	6,23
	Bathroom 8	35	6,23
	Bathroom 9	36	6,23
	Bathroom 10	37	6,23
	Corridor 2-1	56	19,26
Total			117,83

ZONE	Room	nber	Room Area
7	Single room 10	30	12,24
	Stock Laundry 2	51	6,20
	Stock Laundry 3	52	2,00
	Laundry	53	19,16
	Stairs 2	57	11,40
	Corridor 2-2	56	8,93
Total			59,93

ZONE	Room	nber	Room Area
8	Single room 11	31	12,28
	Bathroom 11	38	6,18
	Double room 1	39	18,28
	Double room 2	40	18,28
	Double room 3	41	22,74
	Double room 4	42	17,84
	Double room 5	43	18,28
	Double room 6	44	18,28
	Double bathroom 1	45	7,62
	Double bathroom 2	46	7,62
	Double bathroom 3	47	7,62
	Double bathroom 4	48	7,62
	Double bathroom 5	49	7,62
	Double bathroom 6	50	7,62
	Living room 2	54	24,98
	Living room 3	55	11,87
	Corridor 2-3	56	27,27
Total			241,96



SECOND FLOOR



ZONE	Room	nber	Room Area
9	Single room 12	58	12,24
	Single room 13	59	12,24
	Single room 14	60	12,24
	Single room 15	61	12,24
	Single room 16	62	12,24
	Bathroom 12	65	6,23
	Bathroom 13	66	6,23
	Bathroom 14	67	6,23
	Bathroom 15	68	6,23
	Bathroom 16	69	6,23
	Bathroom 17	70	6,23
	Corridor 3-1	90	19,26
Total			117,8

ZONE	Room	nber	Room Area
10	Single room 17	63	12,24
	Double room 7	72	21,71
	Double bathroom 7	79	5,92
	Stock Laundry 4	86	2,25
	Stairs 3	89	11,4
	Corridor 3-2	90	8,93
Total			62,45

ZONE	Room	nber	Room Area
11	Single room 18	64	12,28
	Bathroom 18	71	6,18
	Double room 8	73	18,28
	Double room 9	74	18,28
	Double room 10	75	22,74
	Double room 11	76	17,84
	Double room 12	77	18,28
	Double room 13	78	18,28
	Double bathroom 8	80	7,62
	Double bathroom 9	81	7,62
	Double bathroom 10	82	7,62
	Double bathroom 11	83	7,62
	Double bathroom 12	84	7,62
	Double bathroom 13	85	7,62
	Living room 4	87	24,67
	Living room 5	88	11,93
	Corridor 3-3	90	23,98
Total			238,44

THIRD FLOOR

The distribution of areas in rooms is the following:

<u>First floor areas (m^2):</u>

Room	Room nber	Room Area	Area window	Area door	door position	window position
Single room 1	1	13,04	2,7	0	N	S
Single room 2	2	13,04	2,7	0	N	S
Single room 3	3	13,04	2,52	0	N	S
Single room 4	4	18,27	2,7	0	E	S
Hand. ac room 1	5	18,14	2,25	0	S	N
Hand. ac room 2	6	18,14	2,25	0	S	N
Bathroom 1	7	6,23	0,45	0	N	S
Bathroom 2	8	6,23	0,45	0	N	S
Bathroom 3	9	6,23	0,45	0	N	S
Bathroom 4	10	3,416	0,45	0	E	W
Hand. ac bathroom 1	11	5,45	0,45	0	S	N
Hand. ac bathroom 2	12	5,45	0,45	0	S	N
Common toilet 1	13	11,91	0,45	0	W	N
Common toilet 2	14	11,64	0,45	0	E	N
Dressing room	15	18,44	0,45	0	N	S
Stock Laundry 1	16	2,35	0	0	N	-
Living room 1	17	42,50	27,936	0	-	E
		-	7,668	0	-	N
Corridor 1	18	29,5	6,48	0	-	-
Stairs 1	19	16,02	10,8	0	-	W
Dinning hall	20	48,96	24,696	0	-	N
Management Room	21	23,64	4,8	0	N	S
Kitchen	22	86,59	0	0	W	-
Reception	23	22,94	0	4,2	E	-
Private corridor	24	28,17	0	3,15	W	-

Total		469,34	101,55	7,35		

Table 1. First floor area values

Second floor areas (m^2):

Room	Room nber	Room Area	Area window	Area door	door position	window position
Single room 5	25	12,24	2,43	0	-	S
Single room 6	26	12,24	2,85	0	-	S
Single room 7	27	12,24	2,43	0	-	S
Single room 8	28	12,24	2,43	0	-	N
Single room 9	29	12,24	2,85	0	-	N
Single room 10	30	12,24	1,875	0	-	N
Single room 11	31	12,28	2,43	0	-	W
Bathroom 5	32	6,23	0,45	0	-	S
Bathroom 6	33	6,23	0,45	0	-	S
Bathroom 7	34	6,23	0,45	0	-	S
Bathroom 8	35	6,23	0,45	0	-	N
Bathroom 9	36	6,23	0,45	0	-	N
Bathroom 10	37	6,23	0,45	0	-	N
Bathroom 11	38	6,17	0,45	0	-	W
Double room 1	39	18,28	2,4	0	-	S
Double room 2	40	18,28	2,7	0	-	S
Double room 3	41	22,74	2,43	0	-	N
Double room 4	42	17,84	2,7	0	-	N
Double room 5	43	18,28	2,4	0	-	N
Double room 6	44	18,28	2,7	0	-	N
Double bathroom 1	45	7,62	0,45	0	-	S
Double bathroom 2	46	7,62	0,45	0	-	S
Double bathroom 3	47	7,62	0,45	0	-	N
Double bathroom 4	48	7,62	0,45	0	-	N
Double bathroom 5	49	7,62	0,45	0	-	N
Double bathroom 6	50	7,62	0,45	0	-	N
Stock Laundry 2	51	6,2	0	0	-	-
Stock Laundry 3	52	2	0	0	-	-
Laundry	53	19,16	1,2	0	-	W
Living room 2	54	24,98	26,604	0	-	E
Living room 3	55	11,86	11,7	0	-	S
Corridor 2	56	55,46	12,96	0	-	-
Stairs 2	57	16,02	12,78	0		

Total		424,34	103,72	0		

Roof	90	475,55	-	-	-	-

Table 2. Second floor area values

Third floor areas (m^2):

Room	Room nber	Room Area	Area window	Area door	door position	window position
Single room 12	58	12,24	2,43	0	-	S
Single room 13	59	12,24	2,85	0	-	S
Single room 14	60	12,24	2,43	0	-	S
Single room 15	61	12,24	2,43	0	-	N
Single room 16	62	12,24	2,85	0	-	N
Single room 17	63	12,24	1,875	0	-	N
Single room 18	64	12,28	2,43	0	-	W
Bathroom 12	65	6,23	0,45	0	-	S
Bathroom 13	66	6,23	0,45	0	-	S
Bathroom 14	67	6,23	0,45	0	-	S
Bathroom 15	68	6,23	0,45	0	-	N
Bathroom 16	69	6,23	0,45	0	-	N
Bathroom 17	70	6,23	0,45	0	-	N
Bathroom 18	71	6,17	0,45	0	-	W
Double room 7	72	21,71	2,7	0	-	S
Double room 8	73	18,28	2,4	0	-	S
Double room 9	74	18,28	2,7	0	-	S
Double room 10	75	22,74	2,43	0	-	N
Double room 11	76	17,84	2,7	0	-	N
Double room 12	77	18,28	2,4	0	-	N
Double room 13	78	18,28	2,7	0	-	N
Double bathroom 7	79	5,922	0,45	0	-	S
Double bathroom 8	80	7,62	0,45	0	-	S
Double bathroom 9	81	7,62	0,45	0	-	S
Double bathroom 10	82	7,62	0,45	0	-	N
Double bathroom 11	83	7,62	0,45	0	-	N
Double bathroom 12	84	7,62	0,45	0	-	N
Double bathroom 13	85	7,62	0,45	0	-	N
Stock Laundry 4	86	2,25	0	0	-	-
Living room 4	87	24,67	22,909	0	-	E
Living room 5	88	11,93	10,075	0	-	S
Stairs 3	89	11,4	11,005	0	-	W
Corridor 3	90	52,17	11,16	0	-	-
Total		418,71	96,77	0		

Table 3. Third floor area values

Finally, the total values of areas are the following:

$$\mathbf{A}_{total} = 469{,}34 + 424{,}34 + 418{,}71 = \mathbf{1312,39}\ \boldsymbol{m^2}$$
$$\mathbf{A}_{total\ window} = 103{,}72 + 90{,}94 + 96{,}77 = \mathbf{291,43}\ \boldsymbol{m^2}$$
$$\mathbf{A}_{total\ door} = \mathbf{7,35}\ \boldsymbol{m^2}$$

3 HEATING SYSTEM

The cold period (heating season) in Vilnius is officially opened when the average daily temperature stays below 10 degrees for three consecutive days. Searching in some official documents, we determined that the heating season will start more or less on 6th of October and will finish on 4 of May (the conditions of close the heating season are the opposite than for open, that is, when the temperature stays above 10 degrees for three consecutive days).

In this part of the report, we are going to calculate the heat losses of the building, and with that we will calculate the heating loads of the building and the annual heat demand.

3.1 Heat losses

The heat loss of the room is due to two factors. One is the heat loss due to heat transmission through envelope Hen and the other through ventilation H_v.

The heat loss coefficient H can be calculated by following expression:

$$H = H_{en} + H_v \text{ [W/K]}$$

Where:

H_{en} –heat loss coefficient due to heat transmission through the envelope, W/K;
H_v – heat loss coefficient due to ventilation, W/K.

3.1.1 Envelope heat losses

3.1.1.1 Thermal characteristics of the envelopes

The U-values for the elements constituting the envelope are assumed to be the normative values. No changes were considered due to variable temperature correction coefficient κ, since κ is approximately equal to 1.

The temperature correction coefficient can be calculated by following expression:

$$\kappa = \frac{20}{(\theta_i - \theta_{e,heating\ season})} = \frac{20}{(22 - 0{,}5)} \approx 1$$

Where:

θ_i - indoor design temperature equal to building room temperature, ºC;
$\theta_{e,heating\ season}$ - average temperature of heating season, ºC.

The normative values used in our case depend on the type of building that we are going to build, that is, depend on the energy performance of the building.

Construction element	Index	Dwelling-houses	Non dwelling-houses	
			Office building	Industry building
Roofs	r	$U_N = 0{,}16 \cdot \kappa$	$U_N = 0{,}20 \cdot \kappa$	$U_N = 0{,}25 \cdot \kappa$
Ceiling	ce			
Floor above unheated room	fg	$U_N = 0{,}25 \cdot \kappa$	$U_N = 0{,}30 \cdot \kappa$	$U_N = 0{,}40 \cdot \kappa$
Ceiling above non heating basement	cc			
Walls	w	$U_N = 0{,}20 \cdot \kappa$	$U_N = 0{,}25 \cdot \kappa$	$U_N = 0{,}3 \cdot \kappa$
Windows	wd	$U_N = 1{,}6 \cdot \kappa$	$U_N = 1{,}6 \cdot \kappa$	$U_N = 1{,}9 \cdot \kappa$
Doors, gates	d	$U_N = 1{,}6 \cdot \kappa$	$U_N = 1{,}6 \cdot \kappa$	$U_N = 1{,}9 \cdot \kappa$
Thermal bridges	t	$\Psi_N = 0{,}18 \cdot \kappa$	$\Psi_N = 0{,}20 \cdot \kappa$	$\Psi_N = 0{,}25 \cdot \kappa$

Table 4. Normative U-values, W/(m^{2}K)

Therefore, assumed $\kappa = 1$ the U-values used in our hotel are:

$$\boldsymbol{U_{ceiling/roof} = 0,16 \;;\; U_{wall} = 0,2 \;;\; U_{window} = 1,6 \;;\; U_{door} = 1,6 \;;\; U_{floor} = 0,25}$$

3.1.1.2 Heat losses due to heat transmission through the envelope

Heat loss due to transmission through the envelope is the heat loss through the construction elements, naming, walls, windows, slabs and thermal bridges. Thermal bridges are heterogeneities in heat transfer coefficients of the element that make it particularly prone to heat transfer. A simple example of thermal bridges is when a concrete beam is crossing a brick wall.

The **heat loss coefficient due to heat transmission through the envelope** can be calculated by following expression:

$H_{en} = \sum H_{el} + \sum H_{\Psi} + \sum H_g$ [W/K]

Where:

$\sum H_{el}$ – heat loss coefficient of the envelope elements, W/K;
$\sum H_{\Psi}$ – heat loss coefficient of the thermal bridges, W/K;
$\sum H_g$ – heat loss coefficient of a floor on the ground, W/K.

Thermal bridges are heterogeneities in heat transfer coefficients of the element that make it particularly prone to heat transfer.

The **heat loss coefficient of the thermal bridges H_{Ψ}** is barely impossible to calculate so the best estimate for this coefficient is between 10% and 40% of H_{el}. Because we need to design for the worst case, we are going to use 40% of H_{el} .

The final equation taking into account this clarification is:

$$H_{en} = 1{,}4 \cdot \sum H_{el} + \sum H_g$$

The **heat loss through the construction elements** is calculated by following expression:

$$H_{el} = U \cdot A \cdot k_a \cdot b_u \cdot (1 + \Delta k_o + \Delta k_w + \Delta k_h)$$

Where

U – heat transfer coefficient of the envelope element, W/m^{2}K;
A – area of the element, m^2;
k_a – correction coefficient;
b_u – correction coefficient;
Δk_o – correction coefficient due orientation to part of the earth lying for vertical elements;
Δk_w – correction coefficient due to wind for vertical elements;
Δk_h – correction coefficient due to heating devices

Some values of correction coefficients we will find in the following table:

Correction coefficient, Δk	Used when/situation	Δk value
Δk_o	The element faces north-east, north or north-west (for vertical elements)	0,05
Δk_w	For city buildings when lodges are on the sixth floor or higher also for building which is in a plain place and lodges are till sixth floor	0,02
	For building which is in a plain place and lodges are on the sixth floor or higher	0,05
Δk_h	Radiators, convectors and convectional heating devices	0,02
	Air heating	0,00
	Radiant heating devices till 500 °C	-0,10
	High temperature radiant heating devices, 500 °C and higher	-0,15
	Floor hating systems	0,10
	Other heating systems	0,04

Table 5. The values of correction coefficient Δk

In our case, we have more or less the 70% of the vertical elements facing north, north-east or north-west, therefore we will use this value of Δk_o :

$$\Delta k_o = 0{,}7 \cdot 0{,}05 = 0{,}035$$

As our building is plain place and lodges are till third floor, we will use this value of Δk_w :

$$\Delta k_w = 0{,}02$$

We are going to use 2 types of heating design:

1. For the first one, we will use conventional heating devices (radiators), then:
$$\Delta k_h = 0{,}02$$
2. For the second design, we will use air heating devices, then:
$$\Delta k_h = 0{,}00$$

In our building, we don't have elements in contact with other premise (room) with a temperature θ_a (except the ground floor, which we are going to calculate later), therefore, the correction coefficients k_a and b_u shall not be used, ergo their value will be 1.

➔ ***As summary the correction coefficients will be:***

$$\boldsymbol{\Delta k_o = 0,035 \ ; \ \Delta k_h = 0,02 \ / \ 0,00 \ ; \ \Delta k_w = 0,02 \ ; \ k_a = 1 \ ; \ b_u = 1}$$

The **heat loss coefficient of a floor on the ground**, as there isn't unheated basement or other room with another temperature under the first floor, can't be equal.
In this case, we can calculate $\sum H_g$ using the same formula used for calculate H_{el} but using k_a as:

$$k_a = \frac{\theta_i - \theta_a}{\theta_i - \theta_e} = \frac{22 - 5}{22 - (-10)} = 0{,}531$$

Where:
θ_i – Design indoor temperature ºC
θ_e – Design outdoor temperature ºC
θ_a – Ground temperature (5–10 ºC)

Then, the heating losses of the envelope are the following:

First floor:

Room	Room nber	Room Area	Area window	Area door	door position	window position	Hel	Hg	HΨ	Hen
Single room 1	1	13,039	2,7	0	N	S	9,438	1,489	3,775	14,703
Single room 2	2	13,039	2,7	0	N	S	6,540	1,489	2,616	10,645
Single room 3	3	13,039	2,52	0	N	S	6,278	1,489	2,511	10,278
Single room 4	4	18,270	2,7	0	E	S	12,809	2,087	5,124	20,019
Hand. ac room 1	5	18,143	2,25	0	S	N	4,662	0,712	1,865	7,239
Hand. ac room 2	6	18,143	2,25	0	S	N	1,902	0,712	0,761	3,374
Bathroom 1	7	6,230	0,45	0	N	S	1,902	0,712	0,761	3,374
Bathroom 2	8	6,230	0,45	0	N	S	2,002	0,390	0,801	3,193
Bathroom 3	9	6,230	0,45	0	N	S	11,706	2,072	4,682	18,461
Bathroom 4	10	3,416	0,45	0	E	W	6,009	2,072	2,404	10,485
Hand. ac bathroom 1	11	5,450	0,45	0	S	N	2,978	0,622	1,191	4,791
Hand. ac bathroom 2	12	5,450	0,45	0	S	N	2,978	0,622	1,191	4,791
Common toilet 1	13	11,905	0,45	0	W	N	4,082	1,360	1,633	7,075
Common toilet 2	14	11,636	0,45	0	E	N	4,082	1,329	1,633	7,044
Dressing room	15	18,439	0,45	0	N	S	3,762	2,106	1,505	7,373
Stock Laundry 1	16	2,355	0	0	N	-	1,859	0,269	0,744	2,871
Living room 1	17	42,504	27,94	0	-	E	49,184	4,855	19,674	73,713
			7,67	0	-	N	14,927	0,000	5,971	20,897
Corridor 1	18	29,498	6,48	0	-	-	12,802	3,369	5,121	21,292
Stairs 1	19	16,020	10,8	0	-	W	20,349	1,830	8,140	30,318
Dinning hall	20	48,964	24,69	0	-	N	44,593	5,593	17,837	68,023
Management Room	21	23,639	4,8	0	N	S	12,455	2,700	4,982	20,137
Kitchen	22	86,590	0	0	W	-	17,659	9,890	7,063	34,612
Reception	23	22,940	0	4,2	E	-	9,726	2,620	3,890	16,236
Private corridor	24	28,173	0	3,15	-	-	4,741	3,218	1,896	9,855
Total		469,34	101,55	7,35			269,42	53,61	107,77	430,80

Table 5. First floor envelope's heat losses

Summary first floor:

$$\left.\begin{array}{l} H_{el} = 269{,}42\ W/K \\ H_{\Psi} = 107{,}77\ W/K \\ H_g = 53{,}61\ W/K \end{array}\right\} \quad H_{en} = 430{,}8\ W/K$$

Second floor:

Room	Room nber	Room Area	Area window	Area door	door position	window position	Hel	HΨ	Hen
Single room 5	25	12,238	2,43	0	-	S	7,229	2,891	10,120
Single room 6	26	12,238	2,85	0	-	S	6,598	2,639	9,237
Single room 7	27	12,238	2,43	0	-	S	5,986	2,394	8,381
Single room 8	28	12,238	2,43	0	-	N	7,430	2,972	10,402
Single room 9	29	12,238	2,85	0	-	N	6,820	2,728	9,548
Single room 10	30	12,238	1,875	0	-	N	3,225	1,290	4,515
Single room 11	31	12,282	2,43	0	-	W	4,180	1,672	5,851
Bathroom 5	32	6,230	0,45	0	-	S	4,662	1,865	6,527
Bathroom 6	33	6,230	0,45	0	-	S	1,902	0,761	2,662
Bathroom 7	34	6,230	0,45	0	-	S	1,902	0,761	2,662
Bathroom 8	35	6,230	0,45	0	-	N	4,726	1,890	6,617
Bathroom 9	36	6,230	0,45	0	-	N	1,966	0,786	2,752
Bathroom 10	37	6,230	0,45	0	-	N	1,966	0,786	2,752
Bathroom 11	38	6,176	0,45	0	-	W	2,315	0,926	3,241
Double room 1	39	18,278	2,4	0	-	S	10,074	4,030	14,104
Double room 2	40	18,278	2,7	0	-	S	15,048	6,019	21,067
Double room 3	41	22,739	2,43	0	-	N	12,509	5,004	17,513
Double room 4	42	17,843	2,7	0	-	N	7,082	2,833	9,914
Double room 5	43	18,278	2,4	0	-	N	6,704	2,682	9,385
Double room 6	44	18,278	2,7	0	-	N	15,179	6,072	21,250
Double bathroom 1	45	7,616	0,45	0	-	S	1,902	0,761	2,662
Double bathroom 2	46	7,616	0,45	0	-	S	1,902	0,761	2,662
Double bathroom 3	47	7,616	0,45	0	-	N	1,966	0,786	2,752
Double bathroom 4	48	7,616	0,45	0	-	N	1,966	0,786	2,752
Double bathroom 5	49	7,616	0,45	0	-	N	1,966	0,786	2,752
Double bathroom 6	50	7,616	0,45	0	-	N	1,966	0,786	2,752
Stock Laundry 2	51	6,204	0	0	-	-	1,674	0,669	2,343
Stock Laundry 3	52	2,000	0	0	-	-	0,000	0,000	0,000
Laundry	53	19,159	1,2	0	-	W	10,665	4,266	14,932
Living room 2	54	24,978	26,604	0	-	E	46,839	18,736	65,575
Living room 3	55	11,865	11,7	0	-	S	20,151	8,060	28,211
Corridor 2	56	55,462	12,96	0	-	-	25,604	10,242	35,845
Stairs 2	57	16,020	12,78	0	-	W	23,329	9,332	32,660
Total		408,32	90,94	0			267,43	106,97	374,40

Table 6. Second floor envelope's heat losses

Summary second floor:

$$H_{el} = 267{,}43\ W/K$$

$$H_{\Psi} = 106{,}97\ W/K$$

$$H_{en} = 374{,}4\ W/K$$

Third floor:

Room	Room nber	Room Area	Area window	Area door	door position	window position	Hel	HΨ	Hen
Single room 12	58	12,238	2,43	0	N	S	6,81	2,73	9,54
Single room 13	59	12,238	2,85	0	N	S	6,32	2,53	8,85
Single room 14	60	12,238	2,43	0	N	S	5,71	2,28	8,00
Single room 15	61	12,238	2,43	0	S	N	7,01	2,80	9,81
Single room 16	62	12,238	2,85	0	S	N	6,54	2,61	9,15
Single room 17	63	12,238	1,875	0	S	N	3,23	1,29	4,52
Single room 18	64	12,282	2,43	0	N	W	5,20	2,08	7,28
Bathroom 12	65	6,230	0,45	0	N	S	4,21	1,69	5,90
Bathroom 13	66	6,230	0,45	0	N	S	1,76	0,70	2,47
Bathroom 14	67	6,230	0,45	0	N	S	1,76	0,70	2,47
Bathroom 15	68	6,230	0,45	0	S	N	4,27	1,71	5,98
Bathroom 16	69	6,230	0,45	0	S	N	1,82	0,73	2,55
Bathroom 17	70	6,230	0,45	0	S	N	1,82	0,73	2,55
Bathroom 18	71	6,176	0,45	0	N	W	2,13	0,85	2,98
Double room 7	72	21,709	2,7	0	E	S	13,36	5,35	18,71
Double room 8	73	18,278	2,4	0	N	S	10,07	4,03	14,10
Double room 9	74	18,278	2,7	0	N	S	15,05	6,02	21,07
Double room 10	75	22,739	2,43	0	S	N	12,51	5,00	17,51
Double room 11	76	17,843	2,7	0	S	N	7,08	2,83	9,91
Double room 12	77	18,278	2,4	0	S	N	6,70	2,68	9,39
Double room 13	78	18,278	2,7	0	S	N	15,18	6,07	21,25
Double bathroom 7	79	5,922	0,45	0	N	S	1,76	0,70	2,47
Double bathroom 8	80	7,616	0,45	0	N	S	1,76	0,70	2,47
Double bathroom 9	81	7,616	0,45	0	N	S	1,76	0,70	2,47
Double bathroom 10	82	7,616	0,45	0	S	N	1,82	0,73	2,55
Double bathroom 11	83	7,616	0,45	0	S	N	1,82	0,73	2,55
Double bathroom 12	84	7,616	0,45	0	S	N	1,82	0,73	2,55
Double bathroom 13	85	7,616	0,45	0	S	N	1,82	0,73	2,55
Stock Laundry 4	86	2,250	0	0	E	-	0	0	0
Living room 4	87	24,668	22,909	0	-	E	40,46	16,18	56,64
Living room 5	88	11,934	10,075	0	-	S	17,44	6,97	24,41
Stairs 3	89	11,4	11,005	0	-	W	20,20	8,08	28,28
Corridor 3	90	52,175	11,16	0	-	-	22,14	8,85	30,99
Roof	91	475,548	0	0	-	-	76,09	30,44	106,52

Total		418,71	96,77	45,57			327,45	130,98	458,42

Table 7. Second floor envelope's heat losses

Summary second floor:

$$\left.\begin{aligned} H_{el} &= 327{,}45\ W/K \\ H_{\Psi} &= 130{,}98\ W/K \end{aligned}\right\} \quad H_{en} = 458{,}42\ W/K$$

3.1.2 Ventilation heat losses

The ventilation heat losses include the heat losses due to:

- **Natural ventilation**: heat loss associated with air flow through a building by natural means, that is, through small openings and cracks in the structure. The rate of natural ventilation (infiltration and exfiltration) depends on several factors such as; wind strength, direction, air tightness and stack effect.
- **Mechanical ventilation**: When mechanical ventilation is installed in a building then the amount of heat loss is increased. Heat loss calculations primarily include infiltration only and allowances for extract ventilation in small rooms such as; Bathroom, Toilet, Kitchen or Utility room. This is because heat emitters such as radiators can be sized to overcome this additional extract ventilation heat loss.
- **Infiltration**: heat loss due to cold infiltration.
- **Doors**: heat loss due to opening doors in all the building.

The **formula** for the **ventilation heat loses** is the next:

$$H_v = \sum H_{ev} + \sum H_{\text{in}} + \sum H_{nv} + \sum H_{de} \quad \text{[W/K]}$$

Where:

H_{ev} : heat loss due to mechanical ventilation (if system is balanced H_{ev}=0), W/K.
H_{in} : heat loss due to infiltration, W/K.
H_{nv} : heat loss due to natural ventilation (if system is mechanical H_{nv}=0), W/K.
H_{de} : heat loss due to door opening, W/K.

➔ ***In our case, we will have all the components of ventilation heat losses except the heat loss due to natural ventilation, because as our ventilation will be mechanical ventilation, H_{nv}=0.***

Heat loss due to infiltration can be calculated by following expression:

$$H_{in} = c \cdot \rho \cdot L_{in} \quad \text{[W/K]}$$

Where:
c – specific heat of air, $c = 0{,}279$ [Wh/kgK];
ρ – density of air, $\rho = 1{,}2$ [kg/m^3];
L_{in} – infiltration air flow, m3/h.

The **air flow of infiltration** can be calculated by following expression:

$L_{in} = n_{in} \cdot V_p \cdot \Delta k_c \cdot (1 + \Delta k_b) \cdot (1 + k_g)$ [m^3/h]

Where:
n_{in} – air change ratio, h^{-1};
V_p – the volume of the room, m^3.
Δk_c – correction coefficient depend on the position of angular lodge (if windows of angular lodge are in different walls Δk_c=1,2 in another way Δk_c=1);
Δk_b – correction coefficient depend on the type of ventilation.
k_g – correction coefficient depends on the position of the room in the building.

Area		Coastal areas	Mainland areas
Level of lee	Keep from wind (in the forest, on the hillside, in the centre of city)	0,3	0,2
	Keep from moderately (high buildings, buildings in the city without flora)	0,4	0,3
	Naked (in plain places, in plain places near water or in the fields)	0,5	0,4

Table 8. The air of renovation ratio n_{in} , h^{-1}

Mechanical ventilation	-0,1
Only exhausted ventilation system	0,1
Other case	0

Table 9. Values of correction coefficient Δk_b

<u>Correction coefficient k_g</u> depends on the position of room in the building and can be calculated by following expression:

$$k_g = \left|\frac{N}{2} - N_i + 1\right| \frac{0,05}{\sqrt{N}}$$

Where:
N – number of floors in building;
N_i –number of floor, where is calculated room.

- ***In our case, we will have the following values for the coefficients:***
  - $\boldsymbol{n_{in} = 0,2}$ *(Keep from wind)*
  - $\boldsymbol{\Delta k_c = 1}$ *(another way of position of angular lodge)*
  - $\boldsymbol{\Delta k_b = -0,1}$ ***/ 0*** *(mechanical ventilation / natural ventilation)*

Heat loss due opening doors can be calculated by following expression (public building):

$$H_{de} = 0{,}12 \cdot A_{door} \cdot (1 + 0{,}2 \cdot h_{building}) \text{ [W/K]}$$

Where:
A_{door} – area of external doors, m^2;
$h_{building}$ – height of the building, m.

➔ **In our case:** $\boldsymbol{A_{door} = 7{,}35\ m^2}$; $\boldsymbol{h_{building} = 14{,}2\ m}$

$$\boldsymbol{H_{de} = 0{,}12 \cdot 7{,}35 \cdot (1 + 0{,}2 \cdot 14{,}2) = 3{,}387\ W/K}$$

Now we are going to make a comparison between the heat loss obtained if we use in our systems just mechanical ventilation and if we use just natural ventilation.

Heat loss due to mechanical ventilation can be calculated by following expression:

$$H_{ev} = c \cdot \rho \cdot L_{ev} \cdot (1 - \eta_{hr}) \text{ [W/K]}$$

Where:
c – specific heat of air, $c = 0{,}279$ [Wh/kgK];
ρ – density of air, $\rho = 1{,}2$ [kg/m^3];
L_{ev} – supply air flow by mechanical ventilation, m3/h.
η_{hr} – effectiveness of ventilation heat recovery (recuperation).

➔ ***In our case:*** $\boldsymbol{\eta_{hr} = 0{,}55}$ *(Heat recovery = Heat pipes)*

Heat loss due to natural ventilation can be calculated by following expression:

$$H_{nv} = c \cdot \rho \cdot L_{nv} \text{ [W/K]}$$

Where:
c – specific heat of air, $c = 0{,}279$ [Wh/kgK];
ρ – density of air, $\rho = 1{,}2$ [kg/m^3];
L_{nv} – natural ventilation air flow, m^3/h.

The **air flow** in **natural ventilation** can be calculated by following expression:

$$L_{nv} = n_{nv} \cdot V_p \cdot \Delta k_c \cdot (1 + \Delta k_b) \cdot (1 + k_g) \text{ [m}^3\text{/h]}$$

Where:
n_{nv} – air change ratio, h^{-1};
V_p – the volume of the room, m^3.
Δk_c – correction coefficient depend on the position of angular lodge (if windows of angular lodge are in different walls Δk_c=1,2 in another way Δk_c=1);

Δk_b – correction coefficient depend on the type of ventilation.
k_g – correction coefficient depend on the position of the room in the building.

The **air change ratio** of the **natural ventilation** can be calculated by following expression:

$$n_{nv} = n_{tv} - n_{in}$$

Where:
n_{in} – air change ratio due to indoor air infiltration, h^{-1};
n_{tv} – air change ratio due to general natural ventilation, h^{-1}.

Level of lee	Dwelling house (3-16 floors)						Dwelling house (1-2 floors)		
	More than 2 facade			Only 1 facade					
	The tightness of the building								
	Small	Medium	High	Small	Medium	High	Small	Medium	High
Naked	1,2	0,7	0,5	1,0	0,6	0,5	1,5	0,8	0,5
Medium level	0,9	0,6	0,5	0,5	0,5	0,5	1,1	0,6	0,5
Keep from	0,6	0,5	0,5	0,5	0,5	0,5	0,7	0,5	0,5

Table 10. The total air change ratio n_{tv} , h^{-1}.

- ***In our case:***
  - $\boldsymbol{n_{tv} = 0,6}$ *(Medium level, 3 floor building)*
  - $\boldsymbol{n_{nv} = n_{tv} - n_{in} = 0,4}$
  - $\boldsymbol{\Delta k_c = 1}$ *(another way of position of angular lodge)*
  - $\boldsymbol{\Delta k_b = -0,1\,/\,0}$ *(mechanical ventilation / natural ventilation)*

The comparison between the heat losses of both types of ventilation is the following:

	First floor	Second floor	Third floor	Total building
H_{nv}	282,22 W/K	247,84 W/K	219,51 W/K	**749,57 W/K**
H_{ev}	318,69 W/K	185,54 W/K	179,31 W/K	**683,54 W/K**

Table 11. Comparison of natural ventilation and mechanical ventilation heat losses

As you can see, the obtained values for the heat losses are lower in just mechanical ventilation than in just natural ventilation. This affirmation is valid in all the floors except in the first one, because in this floor we will have a big amount of supply air flow, due to some rooms (dinning room, kitchen,…)

Then, we will choose just mechanical ventilation for the whole building. The values of the ventilation heat losses per floor are the following:

Ventilation heat losses in the 1st floor:

Room	Room nber	Room Volume (m3/h)	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)	Hev (W/K)	Hin (W/K)	Hv (W/K)
Single room 1	1	55,805	46,94	0,00	7,07	3,563	10,635
Single room 2	2	55,805	46,94	0,00	7,07	3,563	10,635
Single room 3	3	55,805	46,94	0,00	7,07	3,563	10,635
Single room 4	4	78,196	65,77	0,00	9,91	4,993	14,902
Bathroom 1	5	26,664	0,00	54,00	0,00	1,703	1,703
Bathroom 2	6	26,664	0,00	54,00	0,00	1,703	1,703
Bathroom 3	7	26,664	0,00	54,00	0,00	1,703	1,703
Bathroom 4	8	14,620	0,00	54,00	0,00	0,934	0,934
Hand. ac room 1	9	77,650	65,31	0,00	9,84	4,958	14,798
Hand. ac room 2	10	77,650	65,31	0,00	9,84	4,958	14,798
Hand. ac bathroom 1	11	23,326	0,00	108,00	0,00	1,489	1,489
Hand. ac bathroom 2	12	23,326	0,00	108,00	0,00	1,489	1,489
Common toilet 1	13	50,953	0,00	216,00	0,00	3,253	3,253
Common toilet 2	14	49,802	0,00	216,00	0,00	3,180	3,180
Dressing room	15	78,918	199,14	199,14	30,00	5,039	35,041
Stock Laundry 1	16	10,080	16,96	16,96	2,55	0,644	3,198
Living room 1	17	181,917	306,03	0,00	46,11	11,615	57,722
Corridor 1	18	126,253	53,10	0,00	8,00	8,061	16,061
Stairs 1	19	48,792	20,52	20,52	3,09	3,115	6,207
Dinning hall	20	209,564	881,34	0,00	132,78	13,381	146,164
Management Room	21	101,175	85,10	0,00	12,82	6,460	19,281
Kitchen	22	370,605	0,00	881,34	0,00	23,663	23,663
Reception	23	98,183	165,17	0,00	24,88	6,269	31,153
Private corridor	24	120,580	50,71	0,00	7,64	7,699	15,339
Total		1989,00	2115,28	1981,96	318,69	127,00	445,69

Table 12. First floor ventilation heat losses

Summary first floor:

$$H_{ev} = 318{,}69\ W/K$$

$$H_{in} = 127\ W/K$$

$$H_v = 445{,}69\ W/K$$

Ventilation heat losses in the 2nd floor:

Room	Room nber	Room Volume	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)	Hev	Hin	Hv
Single room 5	25	52,38	44,055	0	6,637	3,252	9,889
Single room 6	26	52,38	44,055	0	6,637	3,252	9,889
Single room 7	27	52,38	44,055	0	6,637	3,252	9,889
Single room 8	28	52,38	44,055	0	6,637	3,252	9,889
Single room 9	29	52,38	44,055	0	6,637	3,252	9,889
Single room 10	30	52,38	44,055	0	6,637	3,252	9,889
Single room 11	31	52,57	44,215	0	6,661	3,264	9,925
Bathroom 5	32	26,66	0	54	0	1,655	1,655
Bathroom 6	33	26,66	0	54	0	1,655	1,655
Bathroom 7	34	26,66	0	54	0	1,655	1,655
Bathroom 8	35	26,66	0	54	0	1,655	1,655
Bathroom 9	36	26,66	0	54	0	1,655	1,655
Bathroom 10	37	26,66	0	54	0	1,655	1,655
Bathroom 11	38	26,43	0	54	0	1,641	1,641
Double room 1	39	78,23	65,802	0	9,914	4,857	14,771
Double room 2	40	78,23	65,802	0	9,914	4,857	14,771
Double room 3	41	97,32	81,861	0	12,333	6,042	18,375
Double room 4	42	76,37	64,236	0	9,678	4,741	14,419
Double room 5	43	78,23	65,802	0	9,914	4,857	14,771
Double room 6	44	78,23	65,802	0	9,914	4,857	14,771
Double bathroom 1	45	32,60	0	108	0	2,024	2,024
Double bathroom 2	46	32,60	0	108	0	2,024	2,024
Double bathroom 3	47	32,60	0	108	0	2,024	2,024
Double bathroom 4	48	32,60	0	108	0	2,024	2,024
Double bathroom 5	49	32,60	0	108	0	2,024	2,024
Double bathroom 6	50	32,60	0	108	0	2,024	2,024
Stock Laundry 2	51	26,55	44,669	44,6688	6,730	1,649	8,378
Stock Laundry 3	52	8,56	14,4	14,4	2,170	0,531	2,701
Laundry	53	82,00	68,972	68,9724	10,391	5,091	15,482
Living room 2	54	106,91	179,843	0	27,095	6,637	33,732
Living room 3	55	50,78	85,428	0	12,871	3,153	16,023
Corridor 2	56	237,38	99,832	0	15,041	14,737	29,778
Stairs 2	57	48,79	20,520	20,52	3,092	3,029	6,121
Total		1796,41	1231,51	1174,56	185,54	111,53	297,07

Table 13. Second floor ventilation heat losses

Summary second floor:

$H_{ev} = 185{,}54\ W/K$

$H_{in} = 111{,}53\ W/K$

$$H_v = 297{,}07\ W/K$$

Ventilation heat losses in the 3rd floor:

Room	Room nber	Room Volume	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)	Hev	Hin	Hv
Single room 12	58	46,50	44,055	0	6,637	2,887	9,524
Single room 13	59	46,50	44,055	0	6,637	2,887	9,524
Single room 14	60	46,50	44,055	0	6,637	2,887	9,524
Single room 15	61	46,50	44,055	0	6,637	2,887	9,524
Single room 16	62	46,50	44,055	0	6,637	2,887	9,524
Single room 17	63	46,50	44,055	0	6,637	2,887	9,524
Single room 18	64	46,67	44,2152	0	6,661	2,898	9,559
Bathroom 12	65	23,67	0	54	0	1,470	1,470
Bathroom 13	66	23,67	0	54	0	1,470	1,470
Bathroom 14	67	23,67	0	54	0	1,470	1,470
Bathroom 15	68	23,67	0	54	0	1,470	1,470
Bathroom 16	69	23,67	0	54	0	1,470	1,470
Bathroom 17	70	23,67	0	54	0	1,470	1,470
Bathroom 18	71	23,47	0	54	0	1,457	1,457
Double room 7	72	82,49	78,1506	0	11,774	5,121	16,896
Double room 8	73	69,46	65,80224	0	9,914	4,312	14,226
Double room 9	74	69,46	65,80224	0	9,914	4,312	14,226
Double room 10	75	86,41	81,86112	0	12,333	5,365	17,698
Double room 11	76	67,80	64,23552	0	9,678	4,210	13,887
Double room 12	77	69,46	65,80224	0	9,914	4,312	14,226
Double room 13	78	69,46	65,80224	0	9,914	4,312	14,226
Double bathroom 7	79	22,50	0	108	0	1,397	1,397
Double bathroom 8	80	28,94	0	108	0	1,797	1,797
Double bathroom 9	81	28,94	0	108	0	1,797	1,797
Double bathroom 10	82	28,94	0	108	0	1,797	1,797
Double bathroom 11	83	28,94	0	108	0	1,797	1,797
Double bathroom 12	84	28,94	0	108	0	1,797	1,797
Double bathroom 13	85	28,94	0	108	0	1,797	1,797
Stock Laundry 4	86	8,55	16,2	16,2	2,441	0,531	2,972
Living room 4	87	93,74	177,61248	0	26,759	5,820	32,579
Living room 5	88	45,35	85,9248	0	12,945	2,815	15,761
Stairs 3	89	43,32	20,52	20,52	3,092	2,689	5,781
Corridor 3	90	198,26	93,9141	0	14,149	12,309	26,458
Total		1591,11	1190,17	1170,72	179,31	98,78	278,09

Table 14. Third floor ventilation heat losses

Summary second floor:

$H_{ev} = 179{,}31\ W/K$

$H_{in} = 98{,}78\ W/K$

$H_v = 278{,}09\ W/K$

The heat losses of the whole building shall be:

First floor	Second floor	Third floor
$H_{en} = 430{,}8\ W/K$ $H_v = 445{,}69\ W/K$	$H_{en} = 374{,}4\ W/K$ $H_v = 297{,}07\ W/K$	$H_{en} = 458{,}42\ W/K$ $H_v = 278{,}09\ W/K$

Table 15. Heat losses of each floor of the building

$$\boldsymbol{H_{en}} = 430{,}8 + 374{,}4 + 458{,}42 = \mathbf{1263{,}62}\ \boldsymbol{W/K}$$

$$\boldsymbol{H_v} = 445{,}69 + 297{,}07 + 278{,}09 = \mathbf{1020{,}85}\ \boldsymbol{W/K}$$

$$\boldsymbol{H = H_{en} + H_v = \mathbf{2284{,}47}\ W/K}$$

3.2 Heating loads

The heating power of a house is the most important part to know if we want to make it a comfortable place to live.

The **heating power P_h**, is the necessary power that the furnace must employ in the design case. This design case is as mentioned above an extreme situation, that is, when the outside temperature reaches its design value. The necessary heating power of the furnace is then calculated as the sum of all heat losses in each compartment, and can be calculated by following expression:

$$P_h = \left(H - H_g\right) \cdot (\theta_i - \theta_e) + H_g \cdot (\theta_i - \bar{\theta}_e) \quad kW$$

Where:

H – total heat loss coefficient, W/K;
H_g – heat loss coefficient of the ground floor;
θ_i – design indoor temperature, ºC;
θ_e – design outdoor temperature, ºC.
$\bar{\theta}_e$ – average annual temperature.

Constructions	**Design outdoor temperature θ_e**
External walls mass till 50 kg/m2; Windows area more 50% of facades area	Coldest day average temperature
External walls mass 50–100 kg/m2	Coldest day and 5 coldest days average temperature
External walls mass more than 100 kg/m2	5 coldest days average temperature

Table 16. Design outdoor temperatures of heating power

➔ ***In our case:***

$\boldsymbol{\theta_i = 22}$ **ºC** *(design indoor temperature in heating season)*
$\boldsymbol{\theta_e = -24}$ **ºC** *(coldest day and 5 coldest days average temperature)*
$\boldsymbol{\bar{\theta}_e = 6,7}$ **ºC** *(average annual temperature)*

Heat source heating power can be calculated by following expression ("stable" heating):

$$P = 1{,}1 \cdot \frac{\sum P_h}{\eta_2 \cdot \eta_3} \quad kW$$

Where:
η_2 – the heat source effectiveness coefficient;
η_3 – the main heating system pipes insulation effectiveness coefficient (for modern systems 0,97, for old 0,9).

Type of regulation	Heating network	Kid of fuel			Electric
		Gas	Liquid	Solid	
Hand regulation	0,90	0,80	0,75	0,60	0,90
Automatic regulation	1,00	0,94	0,87	0,85	1,00

Table 17. The coefficient of efficiency, η_2.

Type of thermal isolation	Effectiveness coeffient, η_3
New heating system pipes thermal isolation	0,97
Old heating system thermal isolation	0,9
Without thermal isolation	0,7

Table 18. The main heating system pipes efficiency, η_3.

➔ ***In our case:***

$\boldsymbol{\eta_2 = 1}$ (Heating network, automatic regulation)
$\boldsymbol{\eta_3 = 0,97}$ (New heating system pipes thermal isolation)

Now, we are going to calculate the heat power of each room and, at the end, the heat power of the whole building:

Heat power by rooms on the first floor:

Room	Room nber	Hen (W/K)	Hv (W/K)	Hg (W/K)	Ph (W)	P (W)
Single room 1	1	14,703	10,635	1,489	1119,813	1269,891
Single room 2	2	10,645	10,635	1,489	933,142	1058,202
Single room 3	3	10,278	10,635	1,489	916,264	1039,062
Single room 4	4	20,019	14,902	2,087	1542,319	1749,021
Bathroom 1	5	7,239	1,703	0,712	389,445	441,638
Bathroom 2	6	3,374	1,703	0,712	211,662	240,029
Bathroom 3	7	3,374	1,703	0,712	211,662	240,029
Bathroom 4	8	3,193	0,934	0,390	177,862	201,699
Hand. ac room 1	9	18,461	14,798	2,072	1466,289	1662,802
Hand. ac room 2	10	10,485	14,798	2,072	1099,381	1246,721
Hand. ac bathroom 1	11	4,791	1,489	0,622	269,802	305,961
Hand. ac bathroom 2	12	4,791	1,489	0,622	269,802	305,961
Common toilet 1	13	7,075	3,253	1,360	433,340	491,417
Common toilet 2	14	7,044	3,180	1,329	429,488	487,049
Dressing room	15	7,373	35,041	2,106	1886,409	2139,227
Stock Laundry 1	16	2,871	3,198	0,269	270,942	307,254
Living room 1	17	94,610	57,722	4,855	6858,232	7777,376
Corridor 1	18	21,292	16,061	3,369	1614,797	1831,213
Stairs 1	19	30,318	6,207	1,830	1623,982	1841,629
Dinning hall	20	68,023	146,164	5,593	9680,935	10978,380
Management Room	21	20,137	19,281	2,700	1730,342	1962,243
Kitchen	22	34,612	23,663	9,890	2377,042	2695,614
Reception	23	16,236	31,153	2,620	2099,474	2380,847
Private corridor	24	9,855	15,339	3,218	1060,141	1202,221
Total		430,80	445,69	53,61	38672,57	43855,49

Table 19. First floor heat loads

Summary first floor:

$$P_h = 38672,57\ W = 38,67\ kW$$

$$P = 43855,49\ W = 43,85\ kW$$

Heat power by rooms on the second floor:

Room	Room nber	Hen (W/K)	Hv (W/K)	Hg (W/K)	Ph (W)	P (W)
Single room 5	25	10,120	9,889	0	920,412	1043,766
Single room 6	26	9,237	9,889	0	879,791	997,702
Single room 7	27	8,381	9,889	0	840,409	953,042
Single room 8	28	10,402	9,889	0	933,386	1058,479
Single room 9	29	9,548	9,889	0	894,091	1013,917
Single room 10	30	4,515	9,889	0	662,586	751,386
Single room 11	31	5,851	9,925	0	725,716	822,977
Bathroom 5	32	6,527	1,655	0	376,391	426,835
Bathroom 6	33	2,662	1,655	0	198,608	225,226
Bathroom 7	34	2,662	1,655	0	198,608	225,226
Bathroom 8	35	6,617	1,655	0	380,512	431,508
Bathroom 9	36	2,752	1,655	0	202,729	229,899
Bathroom 10	37	2,752	1,655	0	202,729	229,899
Bathroom 11	38	3,241	1,641	0	224,582	254,681
Double room 1	39	14,104	14,771	0	1328,240	1506,252
Double room 2	40	21,067	14,771	0	1648,545	1869,484
Double room 3	41	17,513	18,375	0	1650,878	1872,129
Double room 4	42	9,914	14,419	0	1119,337	1269,352
Double room 5	43	9,385	14,771	0	1111,179	1260,100
Double room 6	44	21,250	14,771	0	1656,969	1879,037
Double bathroom 1	45	2,662	2,024	0	215,549	244,437
Double bathroom 2	46	2,662	2,024	0	215,549	244,437
Double bathroom 3	47	2,752	2,024	0	219,670	249,111
Double bathroom 4	48	2,752	2,024	0	219,670	249,111
Double bathroom 5	49	2,752	2,024	0	219,670	249,111
Double bathroom 6	50	2,752	2,024	0	219,670	249,111
Stock Laundry 2	51	2,343	8,378	0	493,185	559,282
Stock Laundry 3	52	0,000	2,701	0	124,243	140,894
Laundry	53	14,932	15,482	0	1399,034	1586,534
Living room 2	54	65,575	33,732	0	4568,136	5180,360
Living room 3	55	28,211	16,023	0	2034,799	2307,504
Corridor 2	56	35,845	29,778	0	3018,672	3423,236
Stairs 2	57	32,660	6,121	0	1783,927	2023,010
Total		374,40	297,07	0	30887,47	35027,03

Table 20. Second floor heat loads

Summary second floor:

$$P_h = 30887,47\ W = 30,89\ kW$$

$$P = 35027,03\ W = 35,03\ kW$$

Heat power by rooms on the third floor:

Room	Room nber	Hen (W/K)	Hv (W/K)	Hg (W/K)	Ph (W)	P (W)
Single room 12	58	9,540	9,524	0	876,983	994,516
Single room 13	59	8,852	9,524	0	845,335	958,627
Single room 14	60	7,996	9,524	0	805,953	913,967
Single room 15	61	9,810	9,524	0	889,362	1008,554
Single room 16	62	9,150	9,524	0	859,039	974,168
Single room 17	63	4,515	9,524	0	645,810	732,362
Single room 18	64	7,282	9,559	0	774,676	878,499
Bathroom 12	65	5,898	1,470	0	338,911	384,332
Bathroom 13	66	2,466	1,470	0	181,066	205,333
Bathroom 14	67	2,466	1,470	0	181,066	205,333
Bathroom 15	68	5,981	1,470	0	342,729	388,662
Bathroom 16	69	2,549	1,470	0	184,885	209,663
Bathroom 17	70	2,549	1,470	0	184,885	209,663
Bathroom 18	71	2,984	1,457	0	204,287	231,665
Double room 7	72	18,709	16,896	0	1637,814	1857,315
Double room 8	73	14,104	14,226	0	1303,184	1477,838
Double room 9	74	21,067	14,226	0	1623,489	1841,070
Double room 10	75	17,513	17,698	0	1619,707	1836,781
Double room 11	76	9,914	13,887	0	1094,878	1241,614
Double room 12	77	9,385	14,226	0	1086,123	1231,686
Double room 13	78	21,250	14,226	0	1631,913	1850,623
Double bathroom 7	79	2,466	1,397	0	177,724	201,543
Double bathroom 8	80	2,466	1,797	0	196,107	222,390
Double bathroom 9	81	2,466	1,797	0	196,107	222,390
Double bathroom 10	82	2,549	1,797	0	199,926	226,720
Double bathroom 11	83	2,549	1,797	0	199,926	226,720
Double bathroom 12	84	2,549	1,797	0	199,926	226,720
Double bathroom 13	85	2,549	1,797	0	199,926	226,720
Stock Laundry 4	86	0,000	2,972	0	136,689	155,008
Living room 4	87	56,642	32,579	0	4104,151	4654,191
Living room 5	88	24,410	15,761	0	1847,852	2095,503
Corridor 3	89	28,277	5,781	0	1566,688	1776,657
Stairs 3	90	30,991	26,458	0	2642,649	2996,819
Roof	91	106,523	0,000	0	4900,041	5556,748
Total		458,42	278,09	0	33879,81	38420,40

Table 21. Third floor heat loads

Summary third floor:

$$\boldsymbol{P_h = 33879,81\ W = 33,88\ kW}$$

$$\boldsymbol{P = 38420,4\ W = 38,42\ kW}$$

For the whole building:

$$\boldsymbol{H = H_{en} + H_v = 2284,47\ \ W/K}$$
$$\boldsymbol{H_g = 53,61\ \ W/K}$$

$$P_h = (2284{,}47 - 53{,}61) \cdot (22 - (-24)) + 53{,}61 \cdot (22 - 6{,}7) = 103439{,}79\ W$$

$$\boldsymbol{P_h = 103,44\ kW}$$

$$\boldsymbol{P} = 1{,}1 \cdot \frac{103{,}44}{1 \cdot 0{,}97} = \boldsymbol{117,3\ \ kW}$$

3.3 Annual heat demand

The **annual heat demand** for this building is the sum of all contributories systems to heating that require to operate. Such systems in the case considered are only the radiators. The annual heat demand will be the difference between the average heat consumption and the heat gains during the year.

The **annual heat demand** can be calculated by following expression:

$$Q_{hs} = \frac{\sum Q_h}{\eta_1 \cdot \eta_2 \cdot \eta_3 \cdot \eta_4} \quad kWh$$

Where:

Q_h – the heat demand for room, W;

η_1 – heat system regulation effectiveness coefficient;

η_2 – heat source effectiveness coefficient;

η_3 – main heating system pipes insulation effectiveness coefficient;

η_4 – the hydraulic balancing of heat system effectiveness coefficient.

➔ ***In our case:***

$\boldsymbol{\eta_1 = 0,95}$ *(Heating system regulation due to outdoor temperature and/or heat devices with thermostatic waves)*

$\boldsymbol{\eta_2 = 1}$ *(Heating network, automatic regulation)*

$\boldsymbol{\eta_3 = 0,9}$ *(New pipes, high insulation effectiveness coefficient)*

$\boldsymbol{\eta_4 = 0,92}$ *(Heat system without balancing waves and circulation pump)*

The **heat demand for room** $\boldsymbol{Q_h}$ can be calculated by following expression:

$$Q_h = Q_{en} + Q_v - \eta_0 \cdot Q_{hg} \;\; kWh$$

Where:
Q_{en} – heat demand to compensate envelopes heat losses , kWh;
Q_v – heat demand to compensate ventilation heat losses , kWh;
η_0 – heat gains use efficiency coefficient;
Q_{hg} – heat gains, kWh.

- ***In our case:***
  $\boldsymbol{\eta_0 = 0,8}$ *(Heating system controlled according outdoor temperature, thermostats)*

The **heat demand to compensate envelopes heat losses** can be calculated by following simplified expression:

$$Q_{en} = H_{en} \cdot (\theta_i - \theta_{em}) \cdot t \cdot 24 \cdot 10^{-3} \quad kWh$$

Where:
H_{en} – heat loss coefficient through envelopes, W/K.
θ_i – indoor design temperature, ºC;
θ_{em} – external average temperature of calculation (heating season) period, ºC;
t – duration of the heating season in days.

- ***In our case:***

$$\boldsymbol{\theta_i = 22\ ºC\ ;\ \theta_{em} = -0,5\ ºC\ ;\ t = 210\ days}$$

The **heat demand to compensate ventilation heat losses** can be calculated by following expression:

$$Q_v = H_v \cdot (\theta_i - \theta_{em}) \cdot t \cdot 24 \cdot 10^{-3} \quad kWh$$

Where:
H_v – ventilation heat loss, W/K.
θ_i – indoor design temperature, ºC.
θ_{em} – external average temperature of calculation (heating season) period, ºC;
t – duration of the heating season in days

- ***In our case:***

$$\boldsymbol{\theta_i = 22\ ºC\ ;\ \theta_{em} = -0,5\ ºC\ ;\ t = 210\ days}$$

The **heat gains $\boldsymbol{Q_{hg}}$** are calculated in two parcels. One refers to the internal heat gains and the other to heat gains due to sun light. The heat gains can be calculated by following expression:

$$Q_{hg} = Q_{ig} + Q_{sg} \quad kWh$$

Where:
Q_{ig} – the internal heat gains, kWh;
Q_{sg} – the external - solar heat gains, kWh.

The **internal heat gains** can be calculated by following expression:

$$Q_{ig} = \Phi_{ig} \cdot t \cdot 24 \cdot 10^{-3} \quad kWh$$

Where:
Φ_{ig} – heat gain power of internal sources, kW
t – duration in days.

- ➔ ***In our case:***
  $\boldsymbol{t = 210\ days}$

Heat gain power of internal heat sources can be calculated by following expression

$$\Phi_{ig} = A_p \cdot (q_{el} + q_p) + \Phi_{em} + \Phi_{eq} + \Phi_{hc} \quad kW$$

Where:
A_p – room floor area, m^2;
q_{el} – heat gain of electric equipment, W/m^2;
q_p – heat gain of persons, W/m^2.

For dwelling and most public houses, the sum $\Phi_{em} + \Phi_{eq} + \Phi_{he}$ could be accepted as 0.

- ➔ ***In our case:***

  Heat gain of electric equipment $\boldsymbol{q_{el}}$ and heat gain of persons $\boldsymbol{q_p}$ will be calculated with the following table:

Nber		Area per person, A_o, m^2/pr.	Heat gain per person, q_o, W/pr.	Heat gain of persons $Q_{p,0}$ W/m^2	Occupancy per day in hours	Heat gains of lighting and other el. equipment W/m^2
1	Living (1-2 floor) buildings	60	70	1,2	12	1,6
2	Multistorey (dweling) houses	40	70	1,8	12	2,4
3	Office buildings	20	80	4	6	2,1
4	Educational buildings	10	70	7	4	1,0
5	Hospitals	30	80	2,7	16	2,4
6	Restauranst, bars, cafe,	5	100	20	3	2,4
7	Supermarkets	10	90	9	4	2,7
8	Sport halls	20	100	5	6	1,0
9	Water pools buildings	20	60	3	4	4,8
10	Culture buildings	5	80	16	3	1,8
11	Garages and industry buildings	20	100	5	6	2,1
12	Storey houses	100	100	1	6	0,6
13	Hotels	40	70	1,8	12	2,4
14	Other	40	70	1,8	12	2,4

Table 22. Equipment heat gains and persons heat gains per room

The **external heat gains due to the solar radiation** can be calculated by following expression:

$$Q_{sg} = \Phi_{sg} \cdot t \cdot 24 \cdot 10^{-3} \quad kWh$$

Where:
Φ_{sg} – heat gain power of solar radiation, kW;
t – the duration in days.

The **heat gain power of solar radiation** can be calculated by following expression:

$$\Phi_{sg} = \sum (q_{sj} \cdot g \cdot A_{gl} \cdot a) \quad kW$$

Where:
q_{sj} – solar radiation, W/m^2;
g – Solar radiation transmittance coefficient of glass.
A_{gl} – windows glazing area, m^2;
a – shading coefficient.

$A_{gl} = 0{,}8 \cdot A_{window}$

The value of solar radiation varies between 8 and 100 and for heating season could be assumed as 50 W/m2.

The solar radiation transmittance coefficient of glass varies between 0,5 and 0,9 and usually accepted as 0,7.

The shading coefficient varies between 0,2 and 0,7 and usually accepted as 0,5.

- ➔ ***In our case:***

  We will use the following simplification:

$$\boldsymbol{\Phi_{sg} = q_{s,ave} \cdot A_{window} \quad kW}$$

Where:
$\boldsymbol{q_{s,ave} = 10 \ \ W/m^2}$ *(North)*
$\boldsymbol{q_{s,ave} = 15 \ \ W/m^2}$ *(East and West)*
$\boldsymbol{q_{s,ave} = 25 \ \ W/m^2}$ *(South)*

Now, we are going to calculate the heat gains and annual demand of each room, where:

Q_{en} = annual heat demand due to envelope heat losses, kWh
Q_{en} = annual heat demand due to ventilation heat losses, kWh
Q_{hg} = heat gains due to internal and external factors, kWh
Q_h = annual heat demand per room, kWh

Heat gains and heat demand first floor

Room	Room nber	Qen (kWh)	Qv (kWh)	Qhg (kWh)	Qh (kWh)
Single room 1	1	1593,192	1152,399	478,199	2363,031
Single room 2	2	1153,458	1152,399	478,199	1923,297
Single room 3	3	1113,700	1152,399	455,519	1901,682
Single room 4	4	2169,298	1614,781	533,570	3357,223
Bathroom 1	5	784,372	184,485	122,638	870,747
Bathroom 2	6	365,578	184,485	122,638	451,952
Bathroom 3	7	365,578	184,485	122,638	451,952
Bathroom 4	8	346,042	101,156	70,175	391,058
Hand. ac room 1	9	2000,414	1603,512	305,420	3359,589
Hand. ac room 2	10	1136,107	1603,512	305,420	2495,283
Hand. ac bathroom 1	11	519,190	161,388	80,363	616,287
Hand. ac bathroom 2	12	519,190	161,388	80,363	616,287
Common toilet 1	13	766,599	352,536	148,683	1000,189
Common toilet 2	14	763,270	344,570	145,835	991,172
Dressing room	15	798,945	3797,086	251,857	4394,545
Stock Laundry 1	16	311,136	346,563	24,926	637,758
Living room 1	17	7987,536	6254,725	2561,824	12192,802
Corridor 1	18	2264,436	1740,357	386,467	3695,620
Stairs 1	19	2307,203	672,581	312,211	2730,015
Dinning hall	20	3285,283	15838,341	816,480	18470,440
Management Room	21	7371,021	2089,316	1762,909	8050,010
Kitchen	22	2182,028	2564,140	854,995	4062,171
Reception	23	3750,588	3375,762	916,469	6393,175
Private corridor	24	1759,356	1662,155	242,797	3227,273
Total		45613,52	48294,52	11580,60	84643,56

Table 23. First floor heat gains and heat demands

Summary first floor:

$$Q_{hg} = 11580,6 \ kWh$$

$$Q_h = 84643,56 \ kWh$$

Heat gains and heat demand second floor:

Room	Room nber	Qen (kWh)	Qv (kWh)	Qhg (kWh)	Qh (kWh)
Single room 5	25	1096,594	1071,576	435,702	1819,608
Single room 6	26	1000,907	1071,576	488,622	1681,585
Single room 7	27	908,137	1071,576	435,702	1631,151
Single room 8	28	1127,156	1071,576	251,994	1997,137
Single room 9	29	1034,591	1071,576	273,162	1887,637
Single room 10	30	489,245	1071,576	224,022	1381,604
Single room 11	31	634,062	1075,472	313,701	1458,574
Bathroom 5	32	707,265	179,381	122,638	788,535
Bathroom 6	33	288,471	179,381	122,638	369,741
Bathroom 7	34	288,471	179,381	122,638	369,741
Bathroom 8	35	716,973	179,381	88,618	825,459
Bathroom 9	36	298,179	179,381	88,618	406,665
Bathroom 10	37	298,179	179,381	88,618	406,665
Bathroom 11	38	351,226	177,812	99,381	449,532
Double room 1	39	1528,325	1600,547	495,859	2732,185
Double room 2	40	2282,853	1600,547	533,659	3456,473
Double room 3	41	1897,737	1991,156	363,144	3598,379
Double room 4	42	1074,331	1562,439	324,932	2376,823
Double room 5	43	1017,004	1600,547	314,419	2366,016
Double room 6	44	2302,696	1600,547	329,539	3639,612
Double bathroom 1	45	288,471	219,288	137,308	397,912
Double bathroom 2	46	288,471	219,288	137,308	397,912
Double bathroom 3	47	298,179	219,288	103,288	434,837
Double bathroom 4	48	298,179	219,288	103,288	434,837
Double bathroom 5	49	298,179	219,288	103,288	434,837
Double bathroom 6	50	298,179	219,288	103,288	434,837
Stock Laundry 2	51	253,900	907,873	65,663	1109,243
Stock Laundry 3	52	0,000	292,674	21,168	275,739
Laundry	53	1617,982	1677,656	293,499	3060,839
Living room 2	54	7105,709	3655,230	2275,632	8940,433
Living room 3	55	3056,993	1736,286	1599,779	3513,456
Corridor 2	56	3884,217	3226,723	587,010	6641,333
Stairs 2	57	3539,071	663,241	1086,826	3332,851
Total		40569,93	32190,22	12134,95	63052,19

Table 24. Second floor heat gains and heat demands

Summary second floor:

$$Q_{hg} = 12134,95 \ kWh$$

$$Q_h = 63052,19 \ kWh$$

Heat gains and heat demand third floor:

Room	Room nber	Qen (kWh)	Qv (kWh)	Qhg (kWh)	Qh (kWh)
Single room 12	58	1033,807	1032,059	435,702	1717,305
Single room 13	59	959,255	1032,059	488,622	1600,417
Single room 14	60	866,485	1032,059	435,702	1549,983
Single room 15	61	1062,967	1032,059	251,994	1893,432
Single room 16	62	991,537	1032,059	273,162	1805,067
Single room 17	63	489,245	1032,059	224,022	1342,087
Single room 18	64	789,055	1035,812	313,701	1573,907
Bathroom 12	65	639,093	159,263	122,638	700,245
Bathroom 13	66	267,266	159,263	122,638	328,419
Bathroom 14	67	267,266	159,263	122,638	328,419
Bathroom 15	68	648,087	159,263	88,618	736,456
Bathroom 16	69	276,261	159,263	88,618	364,629
Bathroom 17	70	276,261	159,263	88,618	364,629
Bathroom 18	71	323,359	157,870	99,381	401,723
Double room 7	72	2027,317	1830,804	569,963	3402,150
Double room 8	73	1528,325	1541,523	495,859	2673,161
Double room 9	74	2282,853	1541,523	533,659	3397,449
Double room 10	75	1897,737	1917,729	363,144	3524,951
Double room 11	76	1074,331	1504,821	324,932	2319,205
Double room 12	77	1017,004	1541,523	314,419	2306,993
Double room 13	78	2302,696	1541,523	329,539	3580,588
Double bathroom 7	79	267,266	151,390	119,378	323,153
Double bathroom 8	80	267,266	194,695	137,308	352,115
Double bathroom 9	81	267,266	194,695	137,308	352,115
Double bathroom 10	82	276,261	194,695	103,288	388,325
Double bathroom 11	83	276,261	194,695	103,288	388,325
Double bathroom 12	84	276,261	194,695	103,288	388,325
Double bathroom 13	85	276,261	194,695	103,288	388,325
Stock Laundry 4	86	0,000	321,992	23,814	302,941
Living room 4	87	6137,714	3530,237	1993,011	8073,542
Living room 5	88	2645,050	1707,847	1395,759	3236,290
Corridor 3	89	3064,144	626,428	552,215	3248,800
Stairs 3	90	3358,180	2866,982	831,978	5559,580
Roof	91	11542,793	0,000	0,000	11542,793
Total		49674,93	30134,11	11691,49	70455,85

Table 25. Third floor heat gains and heat demands

Summary third floor:

$$Q_{hg} = 11691,49\ kWh$$

$$Q_h = 70455,85\ kWh$$

Now that we have all the data it is possible to calculate the heat demand for all the rooms:

$$Q_h = 84643,56 + 63052,19 + 70455,85 = 218151,6\ kWh = 218,15\ MWh$$

First floor (MWh)	Second floor (MWh)	Third floor (MWh)	TOTAL (MWh)
84,64	**63,05**	**70,45**	**218,15**

Table 26. Annual heat demand for whole building

4 VENTILATION SYSTEM

Ventilation it is an improvement and support of air quality by changing the air in premises.

Functions of ventilation:

- Create proper indoor climate conditions for human activities which resulting increase of productivity.
- Regulate (control) indoor air quality (IAQ), in particular the pollution, which is a needed for health and manufacture of precision technology products.
- Prevention measure for fire, explosion and accident as it reduces explosive and flammable impurity concentration.
- Prolong the lifetime of the envelope.

➔ ***In our case, we are going to use MECHANICAL VENTILATION in our building; therefore, NO NATURAL VENTILATION is taken into account.***

4.1 Ventilation air flow

The air flow calculation for mechanical ventilation follows standardized values according to room function. These values serve as pointers but are however normally regulated by law. The design value of the air flow will be the largest value obtained either by calculating per square meter or renovation ratio.

The normative values for buildings are based not to the amount of people that is the difficult to predict, but on the floor area and air renovation area. The calculation of supply and exhaust air for each room according to geometrical characteristics.

The **design air flows** of the rooms of the building have been calculated according to the following table normative:

Rooms	**Supply air flow (m3/h)**	**Exhaust air flow (m3/h)**
Hotel room	3,6/m2	-
Hall	7,2/m2	-
Corridor	1,8/m2	-
Dinning room	18/m2	-
WC (public)	-	108/equipment
Bathroom	-	54/room

Table 27. Air flow rates per room

Therefore, the ventilation air flow rates of the building are the following:

Design air flow per room in first floor

Room	Room nber	Room Area	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)
Single room 1	1	13,039	46,94	0
Single room 2	2	13,039	46,94	0
Single room 3	3	13,039	46,94	0
Single room 4	4	18,27	65,77	0
Bathroom 1	5	6,23	0	54
Bathroom 2	6	6,23	0	54
Bathroom 3	7	6,23	0	54
Bathroom 4	8	3,416	0	54
Disabled room 1	9	18,143	65,31	0
Disabled room 2	10	18,143	65,31	0
Disabled bathroom 1	11	5,45	0	108
Disabled bathroom 2	12	5,45	0	108
Common toilet 1	13	11,905	0	216
Common toilet 2	14	11,636	0	216
Dressing room	15	18,439	199,14	199,14
Stock Laundry 1	16	2,355	16,96	16,96
Living room 1	17	42,504	306,03	0
Corridor 1	18	29,498	53,10	0
Stairs 1	19	11,4	20,52	20,52
Dinning hall	20	48,964	881,34	0
Management Room	21	23,639	85,10	0
Kitchen	22	86,59	0	881,34
Reception	23	22,94	165,17	0
Private corridor	24	28,173	50,71	0
Total		464,72	2115,28	1981,96

Table 28. First floor air flow rates

Summary first floor:

$$L_{supply} = 2115,28 \ \ m^3/h$$

$$L_{exhaust} = 1981,96 \ \ m^3/h$$

Design air flow per room in second floor

Room	Room nber	Room Area	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)
Single room 5	25	12,2375	44,055	0
Single room 6	26	12,2375	44,055	0
Single room 7	27	12,2375	44,055	0
Single room 8	28	12,2375	44,055	0
Single room 9	29	12,2375	44,055	0
Single room 10	30	12,2375	44,055	0
Single room 11	31	12,282	44,215	0
Bathroom 5	32	6,23	0	54
Bathroom 6	33	6,23	0	54
Bathroom 7	34	6,23	0	54
Bathroom 8	35	6,23	0	54
Bathroom 9	36	6,23	0	54
Bathroom 10	37	6,23	0	54
Bathroom 11	38	6,1755	0	54
Double room 1	39	18,2784	65,802	0
Double room 2	40	18,2784	65,802	0
Double room 3	41	22,7392	81,861	0
Double room 4	42	17,8432	64,236	0
Double room 5	43	18,2784	65,802	0
Double room 6	44	18,2784	65,802	0
Double bathroom 1	45	7,616	0	108
Double bathroom 2	46	7,616	0	108
Double bathroom 3	47	7,616	0	108
Double bathroom 4	48	7,616	0	108
Double bathroom 5	49	7,616	0	108
Double bathroom 6	50	7,616	0	108
Stock Laundry 2	51	6,204	44,669	44,6688
Stock Laundry 3	52	2	14,4	14,4
Laundry	53	19,159	68,972	68,9724
Living room 2	54	24,9782	179,843	0
Living room 3	55	11,865	85,428	0
Corridor 2	56	55,462	99,832	0
Stairs 2	57	11,4	20,520	20,52
Total		419,7227	1231,51	1174,56

Table 29. Second floor air flow rates

Summary second floor:

$$L_{supply} = 1231,51 \quad m^3/h$$

$$L_{exhaust} = 1174,56 \quad m^3/h$$

Design air flow per room in third floor

Room	Room nber	Room Area	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)
Single room 12	58	12,24	44,055	0
Single room 13	59	12,24	44,055	0
Single room 14	60	12,24	44,055	0
Single room 15	61	12,24	44,055	0
Single room 16	62	12,24	44,055	0
Single room 17	63	12,24	44,055	0
Single room 18	64	12,28	44,215	0
Bathroom 12	65	6,23	0	54
Bathroom 13	66	6,23	0	54
Bathroom 14	67	6,23	0	54
Bathroom 15	68	6,23	0	54
Bathroom 16	69	6,23	0	54
Bathroom 17	70	6,23	0	54
Bathroom 18	71	6,18	0	54
Double room 7	72	21,71	78,151	0
Double room 8	73	18,28	65,802	0
Double room 9	74	18,28	65,802	0
Double room 10	75	22,74	81,861	0
Double room 11	76	17,84	64,236	0
Double room 12	77	18,28	65,802	0
Double room 13	78	18,28	65,802	0
Double bathroom 7	79	5,92	0	108
Double bathroom 8	80	7,62	0	108
Double bathroom 9	81	7,62	0	108
Double bathroom 10	82	7,62	0	108
Double bathroom 11	83	7,62	0	108
Double bathroom 12	84	7,62	0	108
Double bathroom 13	85	7,62	0	108
Stock Laundry 4	86	2,25	16,2	16,2
Living room 4	87	24,67	177,6125	0
Living room 5	88	11,93	85,925	0
Stairs 3	89	11,40	20,52	20,52
Corridor 3	90	52,17	93,914	0
Total		418,71	1190,17	1170,72

Table 30. Third floor air flow rates

Summary third floor:

$$L_{supply} = 1190,17 \;\; m^3/h$$

$$L_{exhaust} = 1170,72 \;\; m^3/h$$

Then, the total air flow for the whole building for supply and for exhaust:

$$\boldsymbol{L_{supply,T} = 2115,28 + 1231,51 + 1190,17 = 4536,96\ m^3/h}$$

$$\boldsymbol{L_{exhaust,T} = 1981,96 + 1174,56 + 1170,72 = 4326,24\ m^3/h}$$

4.2 Ventilation heat power and demand

The calculation of heat power follows the same principle when calculating the heat losses through ventilation.

Fan's (ventilator) electric power:

$$N = \frac{L \cdot p}{3{,}6 \cdot 10^6 \cdot \eta_v} \quad kW$$

Where:
L – air flow, m^3/h
p – ventilation's systems aerodynamic pressure losses, more or less the fan's working preassure , Pa.
η_v – fan efficiency

➔ ***In our case, the ventilation pressure losses and the fan efficiency we can obtain from the manufacture's page of characteristics:***

$$\boldsymbol{p = 893\ Pa} \qquad\qquad \boldsymbol{\eta_v = 0,75}$$

Then we can calculate the ventilator electric power for supply and for extract:

$$\boldsymbol{N_{supply}} = \frac{L_{supply} \cdot p}{3{,}6 \cdot 10^6 \cdot \eta_v} = \frac{4536{,}96 \cdot 893}{3{,}6 \cdot 10^6 \cdot 0{,}75} = \boldsymbol{1,5\ kW}$$

$$\boldsymbol{N_{extract}} = \frac{L_{extract} \cdot p}{3{,}6 \cdot 10^6 \cdot \eta_v} = \frac{4326{,}24 \cdot 893}{3{,}6 \cdot 10^6 \cdot 0{,}75} = \boldsymbol{1,431\ kW}$$

Fan's electricity demands:

$$W = N \cdot t_{vent} \cdot n_{vent} \quad kWh$$

Where:
t_{vent} – fan's "working" days
n_{vent} – fan's "working" hours per day .

- ***In our case, the fan's working days will be 365 days, because we will use the ventilation system the whole year, and the fan's working ours will be 24 hours per day, because the ventilation of the hotel must be operative the whole day.***

Therefore the electricity demands for fans are the following:

$$\boldsymbol{W_{supply}} = N_{supply} \cdot t_{vent} \cdot n_{vent} = 1{,}5 \cdot 365 \cdot 24 = \mathbf{13140\ \ kWh}$$

$$\boldsymbol{W_{extract}} = N_{extract} \cdot t_{vent} \cdot n_{vent} = 1{,}431 \cdot 365 \cdot 24 = \mathbf{12535{,}56\ \ kWh}$$

$$\boldsymbol{W_T = 13140 + 12535{,}56 = 25675{,}56\ \ kWh = 25{,}68\ \ MWh}$$

The **designed heat power with heat recovery** is calculating using this formula:

$$P_{vent} = n \cdot c \cdot \rho \cdot L_{supply} \cdot (\theta_{supply} - \theta_{outdoor}) \cdot (1 - \eta_r) \quad kW$$

Where:
P_{vent} – the heat power for ventilation, kW;
n – the number of air heater in the AHU.
L_{supply} – the total amount of supplied air, m³/h;
c – the specific heat of air, c = 0,279 Wh/kgK,
ρ – the density of air, ρ = 2,1 kg/m³;
θ_{supply} / $\theta_{outdoor}$ – are respectively the supply, outdoor temperatures, ºC;
η_r – heat recovery efficiency.

- ***In our case, the <u>ventilation supply temperature</u> will be the <u>same</u> than the <u>design indoor temperature</u> (22 ºC). We don't need to increase this temperature because we will have the radiators working inside the building and we don't need that the ventilation modifies the indoor temperature.***
  The <u>outdoor temperature</u>, as we know already, will be -24 ºC.
  We will have just <u>1 air heater</u> in this case.
  And finally, the heat recovery efficiency in our case will be 0,55 because we have selected a AHU with a heat pipes recovery.

  $\boldsymbol{n = 1}$ $\boldsymbol{\theta_{supply} = 22\ ºC}$ $\boldsymbol{\theta_{outdoor} = -24\ ºC}$ $\boldsymbol{\eta_r = 0{,}55}$

The **annual heat demand of ventilation system** (**with heat recovery**):

$$Q_v = 0{,}34 \cdot L_{supply} \cdot \left(\theta_{supply} - \theta_{outdoor,average}\right) \cdot t_{heat} \cdot n_{heat} \cdot 10^{-3} \cdot (1 - \eta_r) \quad kWh$$

Where:
t_{heat} – heater "working" days
n_{heat} – heater "working" hours per day, usually = n_{vent} .

➔ ***In our case, the <u>heater working days</u> will be <u>210 days</u>, because the <u>heater</u> is going to be <u>operative</u> <u>during the all heating season</u>.***
The <u>heater working hours per day</u> will be less than n_{vent} , because sometimes it's not necessary to heat the ventilation air flow because the outdoor temperature it's not too low. Then this value will be <u>18 hours per day</u>.
And the <u>outdoor average temperature</u> of this heating season in Vilnius is -0,5 ºC.

$$t_{heat} = 210\ days$$

$$n_{heat} = 18\ hours/day$$

$$\theta_{outdoor,average} = -0{,}5\ \ ºC$$

Now, we are going to show the calculations of ventilation heat power and heat demand:

Ventilation heat power and heat demand in first floor

Room	Room nber	Room Area	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)	Pvent (W)	Qvent (kWh)
Single room 1	1	13,039	46,94	0	330,35	610,80
Single room 2	2	13,039	46,94	0	330,35	610,80
Single room 3	3	13,039	46,94	0	330,35	610,80
Single room 4	4	18,270	65,77	0	462,90	855,87
Bathroom 1	5	6,230	0	54,00	0	0
Bathroom 2	6	6,230	0	54,00	0	0
Bathroom 3	7	6,230	0	54,00	0	0
Bathroom 4	8	3,416	0	54,00	0	0
Hand. ac room 1	9	18,143	65,31	0	459,67	849,90
Hand. ac room 2	10	18,143	65,31	0	459,67	849,90
Hand. ac bathroom 1	11	5,450	0	108,00	0	0
Hand. ac bathroom 2	12	5,450	0	108,00	0	0
Common toilet 1	13	11,905	0	216,00	0	0
Common toilet 2	14	11,636	0	216,00	0	0
Dressing room	15	18,439	199,14	199,14	1401,55	2591,34
Stock Laundry 1	16	2,355	16,96	16,96	119,34	220,65
Living room 1	17	42,504	306,03	0	2153,83	3982,25
Corridor 1	18	29,498	53,10	0	373,70	690,93
Stairs 1	19	11,400	20,52	20,52	144,42	267,02
Dinning hall	20	48,964	881,34	0	6202,90	11468,63
Management Room	21	23,639	85,10	0	598,94	1107,38
Kitchen	22	86,590	0	881,34	0	0
Reception	23	22,940	165,17	0	1162,45	2149,27
Private corridor	24	28,173	50,71	0	356,91	659,89
Total		464,72	2115,28	1981,96	14887,35	27525,41

Table 31. First floor ventilation heat power and demand

Summary first floor:

$$P_{vent} = 14887,35\ W = 14,9\ kW$$

$$Q_{vent} = 27525,41\ \ kWh$$

Ventilation heat power and heat demand in second floor

Room	Room nber	Room Area	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)	Pvent,cold (W)	Qvent,cold (kWh)
Single room 5	25	12,2375	44,055	0	310,06	573,27
Single room 6	26	12,2375	44,055	0	310,06	573,27
Single room 7	27	12,2375	44,055	0	310,06	573,27
Single room 8	28	12,2375	44,055	0	310,06	573,27
Single room 9	29	12,2375	44,055	0	310,06	573,27
Single room 10	30	12,2375	44,055	0	310,06	573,27
Single room 11	31	12,282	44,215	0	311,19	575,36
Bathroom 5	32	6,23	0	54	0	0
Bathroom 6	33	6,23	0	54	0	0
Bathroom 7	34	6,23	0	54	0	0
Bathroom 8	35	6,23	0	54	0	0
Bathroom 9	36	6,23	0	54	0	0
Bathroom 10	37	6,23	0	54	0	0
Bathroom 11	38	6,1755	0	54	0	0
Double room 1	39	18,2784	65,802	0	463,12	856,26
Double room 2	40	18,2784	65,802	0	463,12	856,26
Double room 3	41	22,7392	81,861	0	576,14	1065,23
Double room 4	42	17,8432	64,236	0	452,09	835,87
Double room 5	43	18,2784	65,802	0	463,12	856,26
Double room 6	44	18,2784	65,802	0	463,12	856,26
Double bathroom 1	45	7,616	0	108	0	0
Double bathroom 2	46	7,616	0	108	0	0
Double bathroom 3	47	7,616	0	108	0	0
Double bathroom 4	48	7,616	0	108	0	0
Double bathroom 5	49	7,616	0	108	0	0
Double bathroom 6	50	7,616	0	108	0	0
Stock Laundry 2	51	6,204	44,669	44,6688	314,38	581,26
Stock Laundry 3	52	2	14,4	14,4	101,35	187,38
Laundry	53	19,159	68,972	68,9724	485,43	897,51
Living room 2	54	24,9782	179,843	0	1265,74	2340,23
Living room 3	55	11,865	85,428	0	601,24	1111,64
Corridor 2	56	55,462	99,832	0	702,61	1299,07
Stairs 2	57	11,4	20,520	20,52	144,42	267,02
Total		419,7227	1231,51	1174,56	8667,40	16025,27

Table 32. Second floor ventilation heat power and demand

Summary second floor:

$$P_{vent} = 8667,4\ W = 8,67\ kW$$

$$Q_v = 16025,27\ kWh$$

Ventilation heat power and heat demand in third floor

Room	Room nber	Room Area	Supply air flow rates (m3/h)	Exhaust air flow rates (m3/h)	Pvent,cold (W)	Qvent,cold (kWh)
Single room 12	58	12,24	44,055	0	310,06	573,27
Single room 13	59	12,24	44,055	0	310,06	573,27
Single room 14	60	12,24	44,055	0	310,06	573,27
Single room 15	61	12,24	44,055	0	310,06	573,27
Single room 16	62	12,24	44,055	0	310,06	573,27
Single room 17	63	12,24	44,055	0	310,06	573,27
Single room 18	64	12,28	44,2152	0	311,19	575,36
Bathroom 12	65	6,23	0	54	0	0
Bathroom 13	66	6,23	0	54	0	0
Bathroom 14	67	6,23	0	54	0	0
Bathroom 15	68	6,23	0	54	0	0
Bathroom 16	69	6,23	0	54	0	0
Bathroom 17	70	6,23	0	54	0	0
Bathroom 18	71	6,18	0	54	0	0
Double room 7	72	21,71	78,1506	0	550,02	1016,95
Double room 8	73	18,28	65,80224	0	463,12	856,26
Double room 9	74	18,28	65,80224	0	463,12	856,26
Double room 10	75	22,74	81,86112	0	576,14	1065,23
Double room 11	76	17,84	64,23552	0	452,09	835,87
Double room 12	77	18,28	65,80224	0	463,12	856,26
Double room 13	78	18,28	65,80224	0	463,12	856,26
Double bathroom 7	79	5,92	0	108	0	0
Double bathroom 8	80	7,62	0	108	0	0
Double bathroom 9	81	7,62	0	108	0	0
Double bathroom 10	82	7,62	0	108	0	0
Double bathroom 11	83	7,62	0	108	0	0
Double bathroom 12	84	7,62	0	108	0	0
Double bathroom 13	85	7,62	0	108	0	0
Stock Laundry 4	86	2,25	16,2	16,2	114,02	210,80
Living room 4	87	24,67	177,61248	0	1250,04	2311,21
Living room 5	88	11,93	85,9248	0	604,74	1118,11
Stairs 3	89	11,40	20,52	20,52	144,42	267,02
Corridor 3	90	52,17	93,9141	0	660,97	1222,07
Total		418,71	1190,17	1170,72	8376,44	15487,30

Table 33. Third floor ventilation heat power and demand

Summary third floor:

$$P_{vent} = 8376,44\ W = 8,38\ kW$$

$$Q_v = 15487,3\ \ kWh$$

Therefore, we will have the following values for heat power of ventilation and annual heat demand for ventilation in the whole building:

$$P_{vent} = 14,9 + 8,67 + 8,38 = 31,95\ kW$$

$$Q_v = 27525,41 + 16025,27 + 15487,3 = 59037,98\ kWh = 59,04\ MWh$$

5 COOLING SYSTEM

For the design the cooling system of our building, as we doesn't have any resources for trying to do the calculations, we must use some software which help us. Then, we are going to use the software provided by Swegon, Proclim.

ProClim web is a program for calculating the heat balance in a room. ProClim web aids the planner by calculating the size of cooling effect required for each room. It is also possible to select a product and calculate the resulting temperature if so desired.

Using this software you can design one room, and you can calculate the heating and cooling power, temperatures and graphics about this room.

The comfort temperature design for our case is 24,5 ºC (summer).

We have divided the building into 11 zones, and the following step is calculating the cooling power.

5.1 ProClim tutorials

5.1.1 Cooling loads with cooling devices

Now we are going to show, how we have calculated the cooling loads using cooling devices.

First of all, we have to go to this webpage (http://www.swegon.com/en/Resources/Software/ProClim-Web/) and register us on the system. After that we will be able to use the program.

On the first screen, we have to select the city where we want to place the building or room, the dimensions of the room (we can change it after), and the period of time when we are going to simulate (summer or winter).

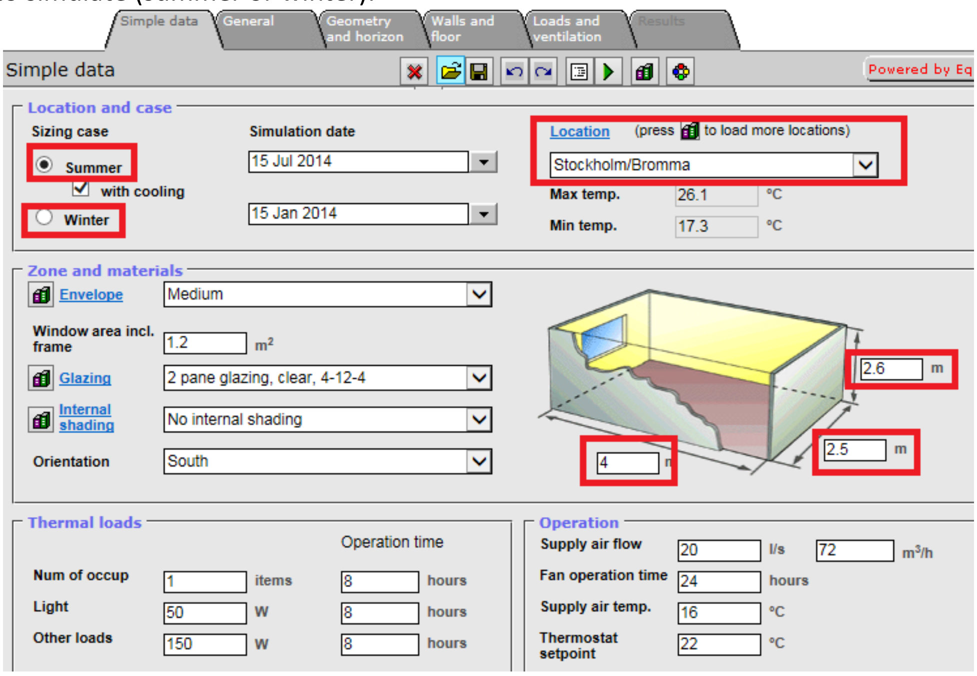


Figure 2. ProClim, city selection and sizing case

After, we should click the sheet 'General', where we can change the water temperatures of supply and return of each period. And also we can change the exact day which we want to make the simulation.

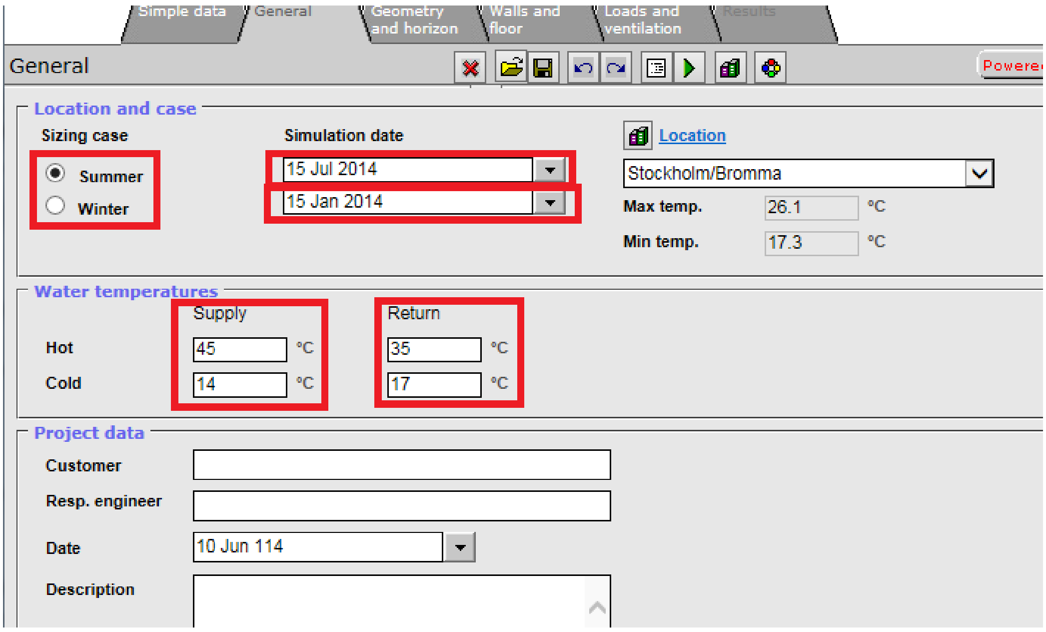


Figure 3. ProClim with cooling device, supply and return water temperatures

In the next sheet called "Geometry and horizon" we will have the possibility to change again the dimensions of the room, change the orientation and a scheme of the room with the objects on surfaces that we are going to include in the next sheet.

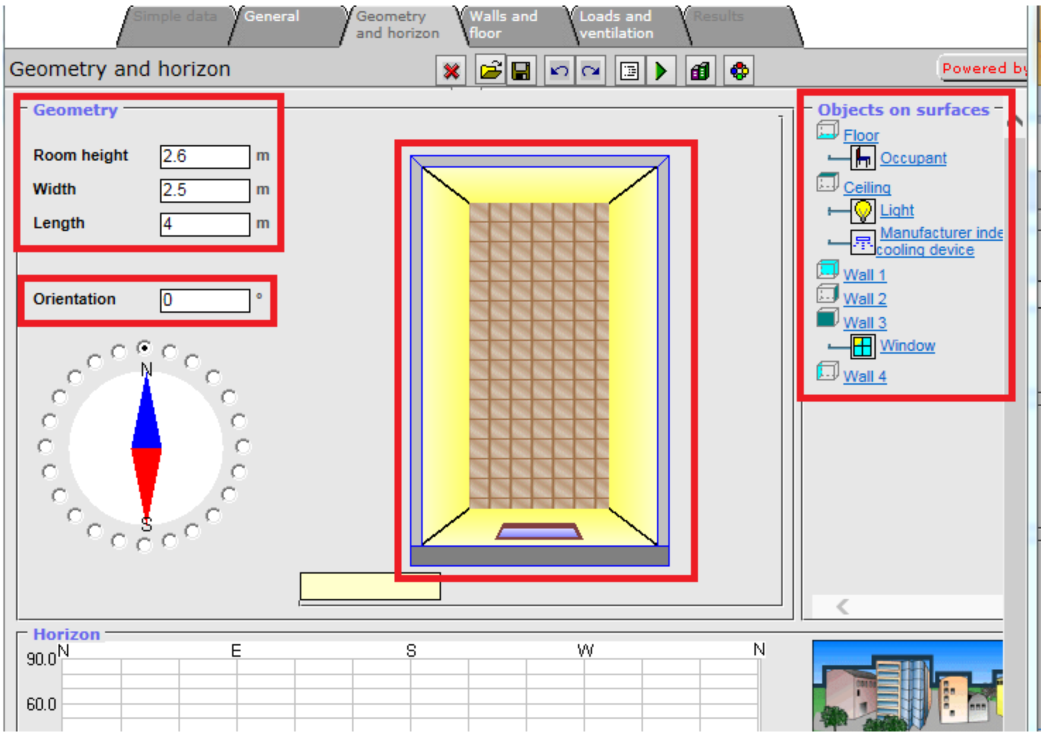


Figure 4. ProClim with cooling device, geometry and horizon

As we said before, in the next sheet "Walls and floor" we can select each different wall of the room (also floor and ceiling) and we can modify its constructions parameters. Also we can add and remove some elements on the surface:

- In ceiling wall, you will be able to add/remove: cooling device, chilled beam, radiator, window and skylight. Also you can modify the light parameters.
- In floor wall, you can change the position or modify the parameters of the persons in the room.
- In the rest of the walls, you can add/remove: cooling device, radiator and window.

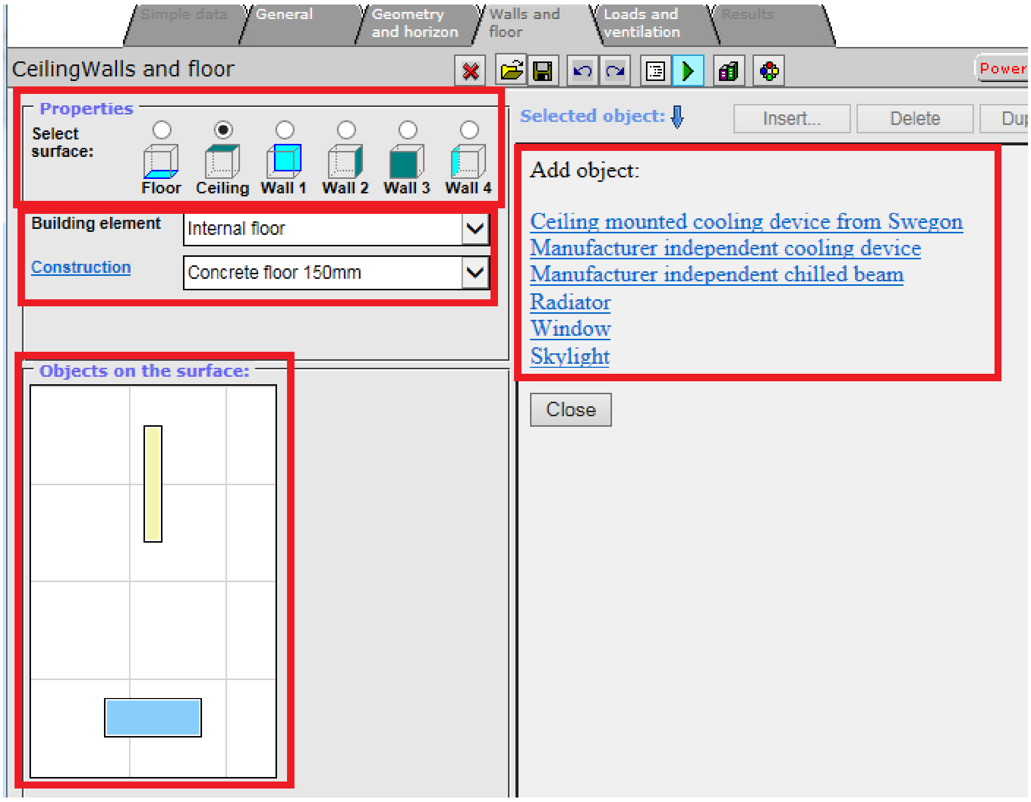


Figure 5. ProClim with cooling device, walls and floor

The "Loads and ventilation" sheet is the most important sheet. In this sheet you will be able to:

- Change the heat loads: number of occupants, light and other loads. Change its power and its working hours.
- Modify the operation conditions: set the thermostat point for cooling and heating, set the heat exchanger efficiency, modify the supply and extract air flow and change the functioning of the chiller and the fan.
- Supply temperatures: modify the supply air maximum and minimum tempertature.

We you have already finished this parameters, clicking “Start simulation” you will get another sheet more “Results”.

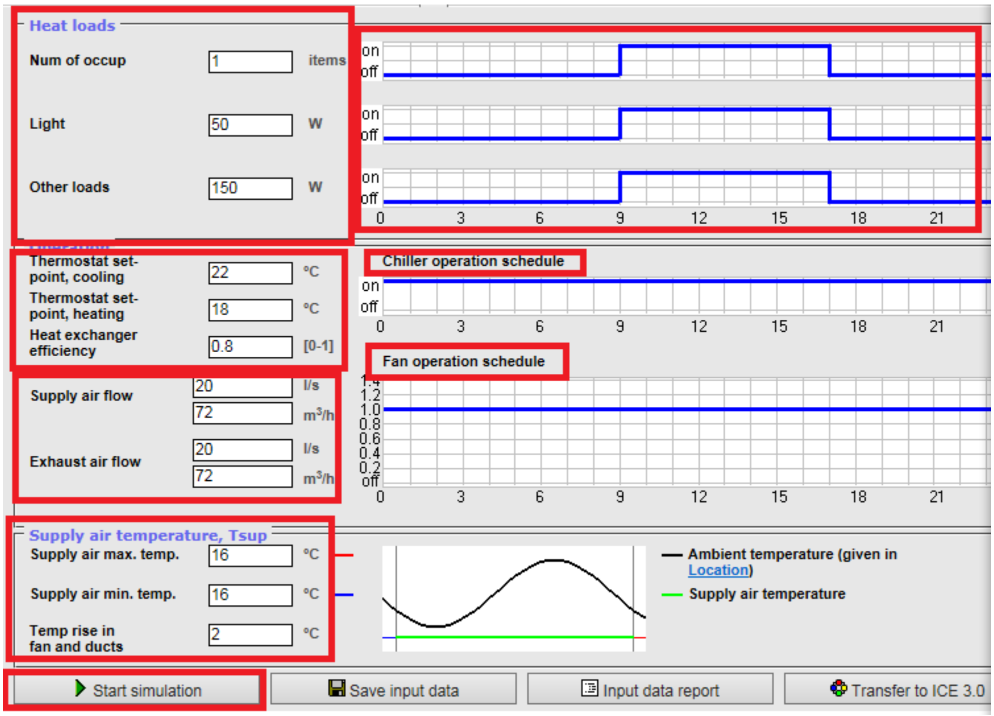


Figure 6. ProClim with cooling device, loads and ventilation

In the last sheet, you will find the results obtained when you simulate the model with your parameters included. In this sheet we have the numerical information about the heat power for heating and/or cooling and the following graphics and schemes:

- **AHU temperatures**
- **Power supplied by plant**
- **Main temperatures**
- **Directed operative temperature**
- **Heat balance**

The most important graphic is the graphic of the main temperatures, because with that graphic you can know if you obtain the temperature required for the room or not (if the curve is near to that temperature).

5.1.2 Cooling and heating loads using AHU

To be sure about this calculation is not wrong, we are going to use the ProClim program and we will try to insert the values of supply air and extract air, and will obtain the heating and cooling power necessary for each zone.

Now the explanation about how we did that calculation in ProClim:

We will use the same zones which we used last time for calculate the cooling power.

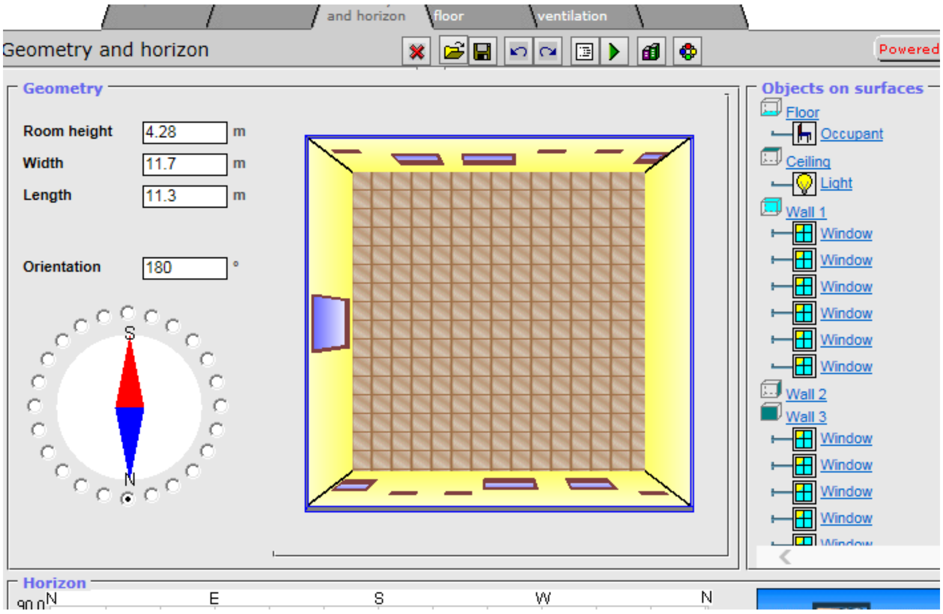


Figure 7. ProClim with AHU, geometry and horizon

The different points in this case are the following:

- We will remove the cooling device which we put in the ceiling (sheet "walls and floors") because in this case, we want that all the heating and cooling is supplied just by AHU.

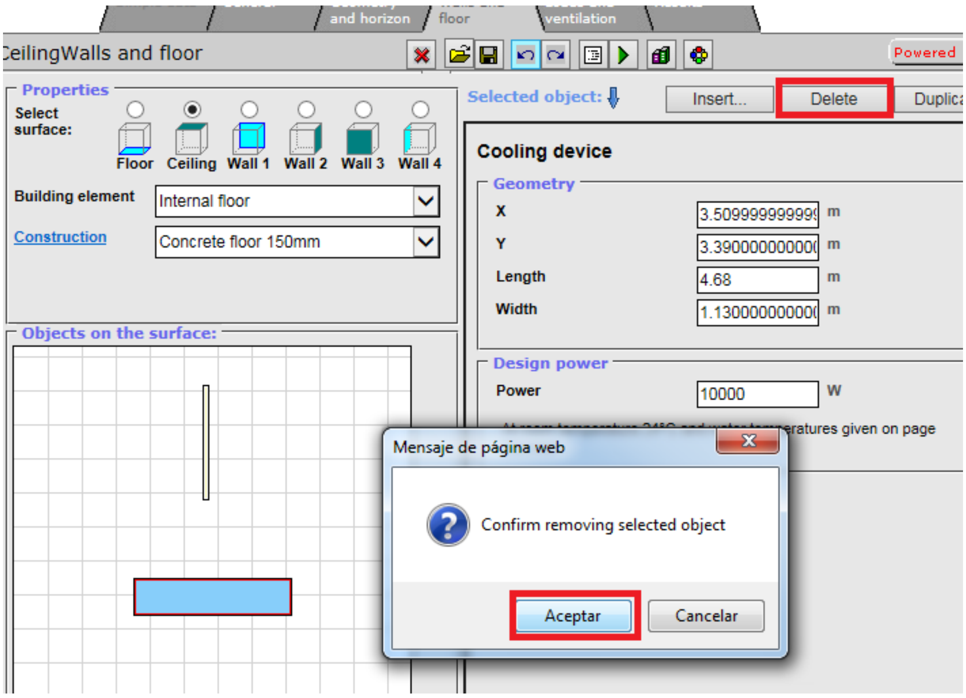


Figure 8. ProClim with AHU, walls and floor

- We will change the supply air maximum and minimum temperature.
  - In heating season: $\theta_{supply,max} = 27\ ºC$; $\theta_{supply,min} = 27\ ºC$
  - In cooling season: $\theta_{supply,max} = 18\ ºC$; $\theta_{supply,min} = 16\ ºC$

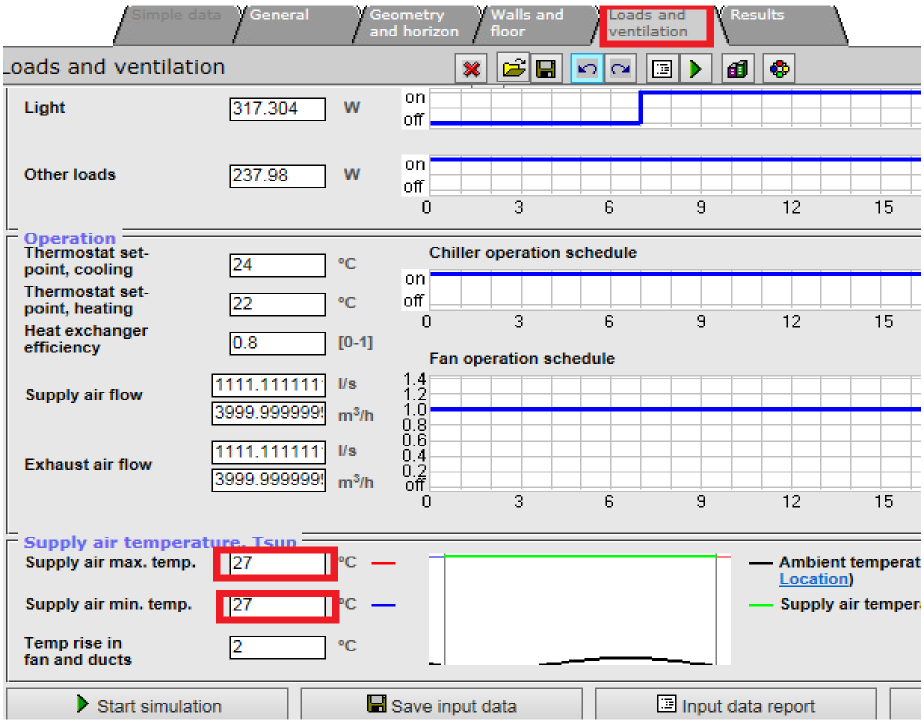


Figure 9. ProClim with AHU, supply air temperature

And finally we will change the supply and exhaust air flow (sheet "loads and ventilation") for the new values that we have obtained. First we will write that values, observe if the main temperature graphic is correct (its values has to be between 20ºC and 25ºC for heating season, and between 22 ºC and 27ºC for cooling season), and after we will decrease the value of this air flow until the main temperatures will not corrects.

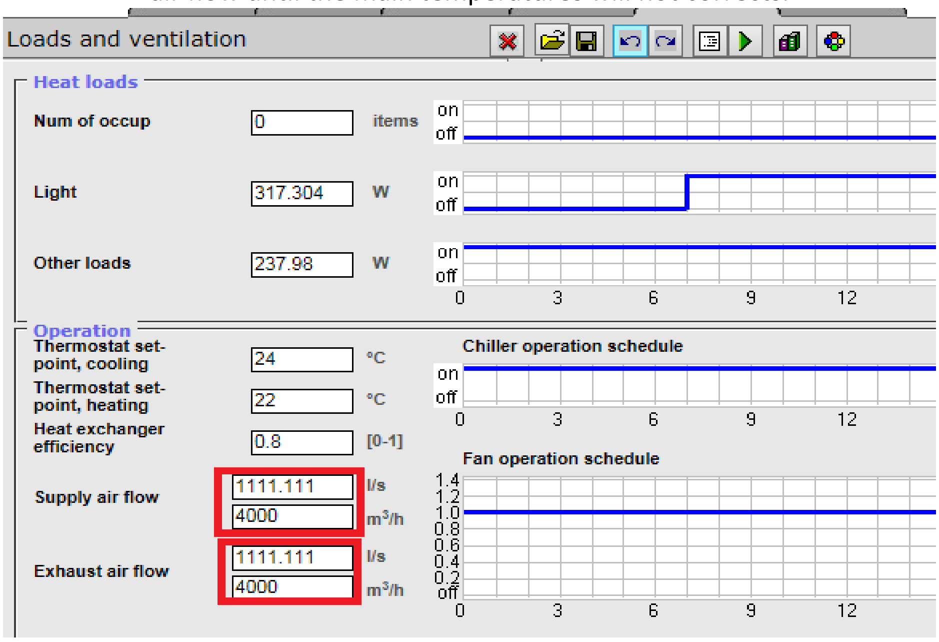


Figure 10. ProClim with AHU, loads and ventilation

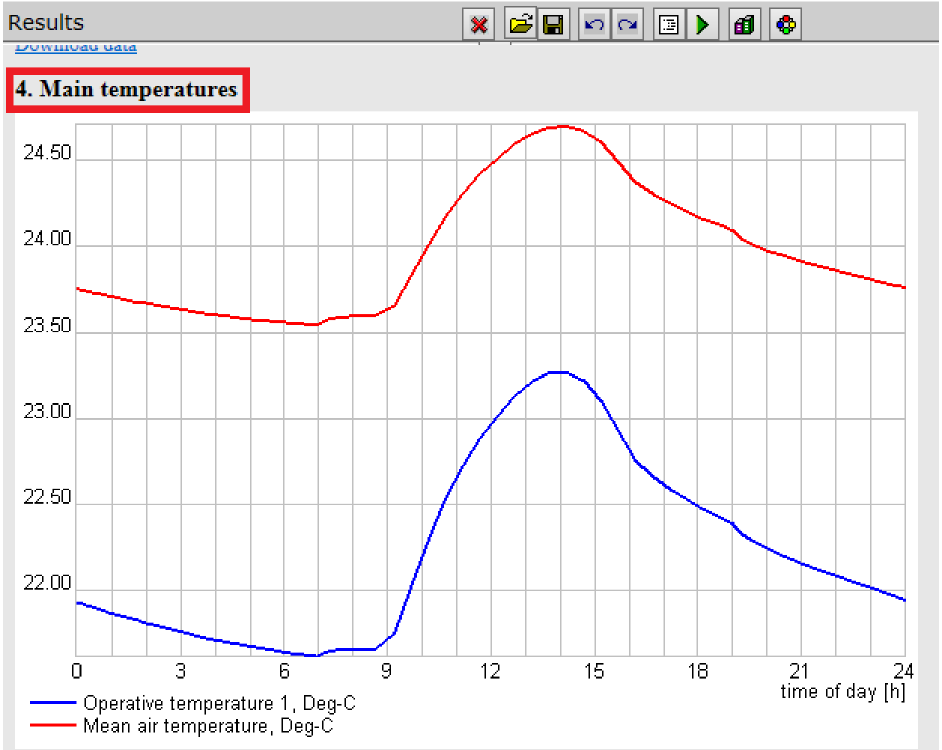


Figure 6. ProClim with AHU, main temperatures graphic

5.2 Cooling loads

Now, we are going to show the cooling loads for each zone and the main temperature graphic, for demonstrate that the calculations are correct (we can see that the operative temperature never is high than 26 ºC (our maximum comfort temperature)):

Zone 1

ZONE	Room Area (m2)	COOLING Pc (W)
1	101,31	2745

Table 33. Cooling load zone 1

The main temperature graphic provided by ProClim:

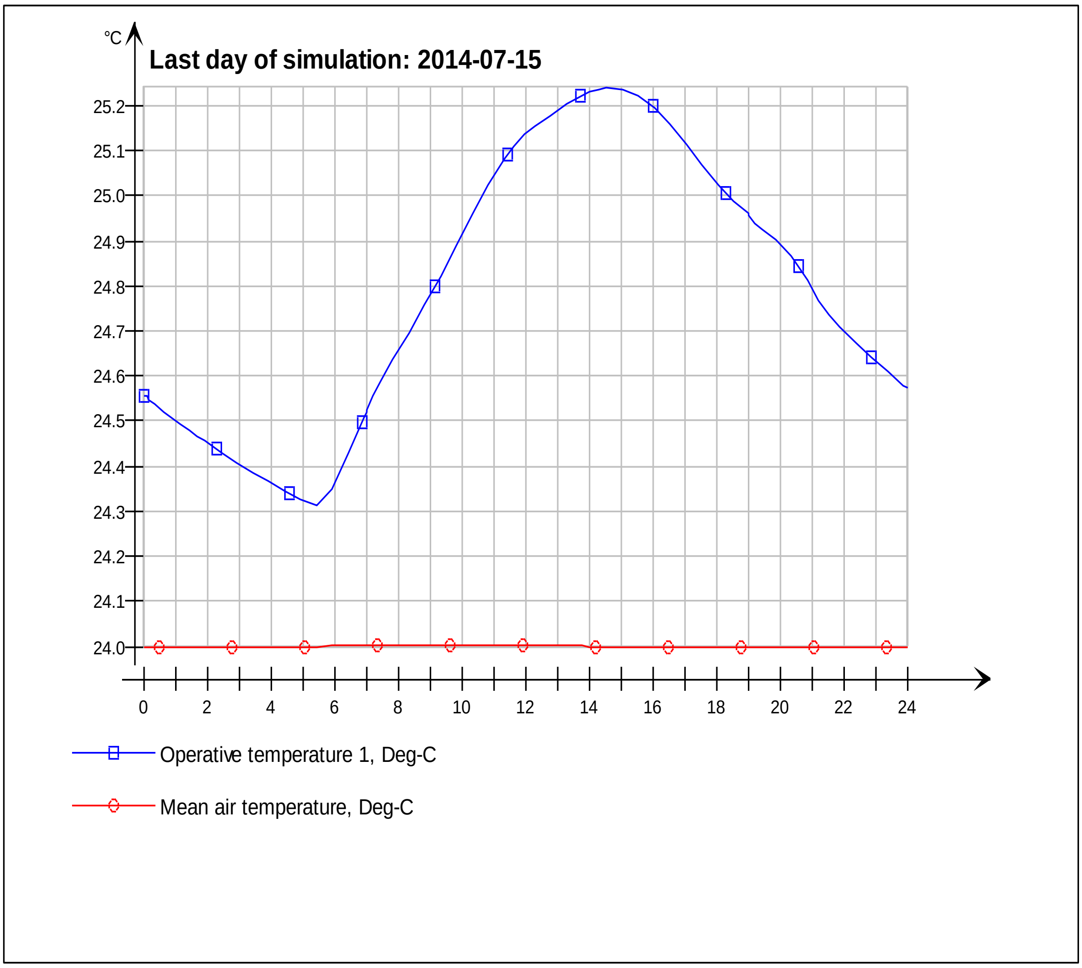


Figure 7. ProClim, main temperatures of Zone 1

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature).

Zone 2

		COOLING
ZONE	Room Area (m2)	Pc (W)
2	46,12	4940

Table 34. Cooling load zone 2

The main temperature graphic provided by ProClim:

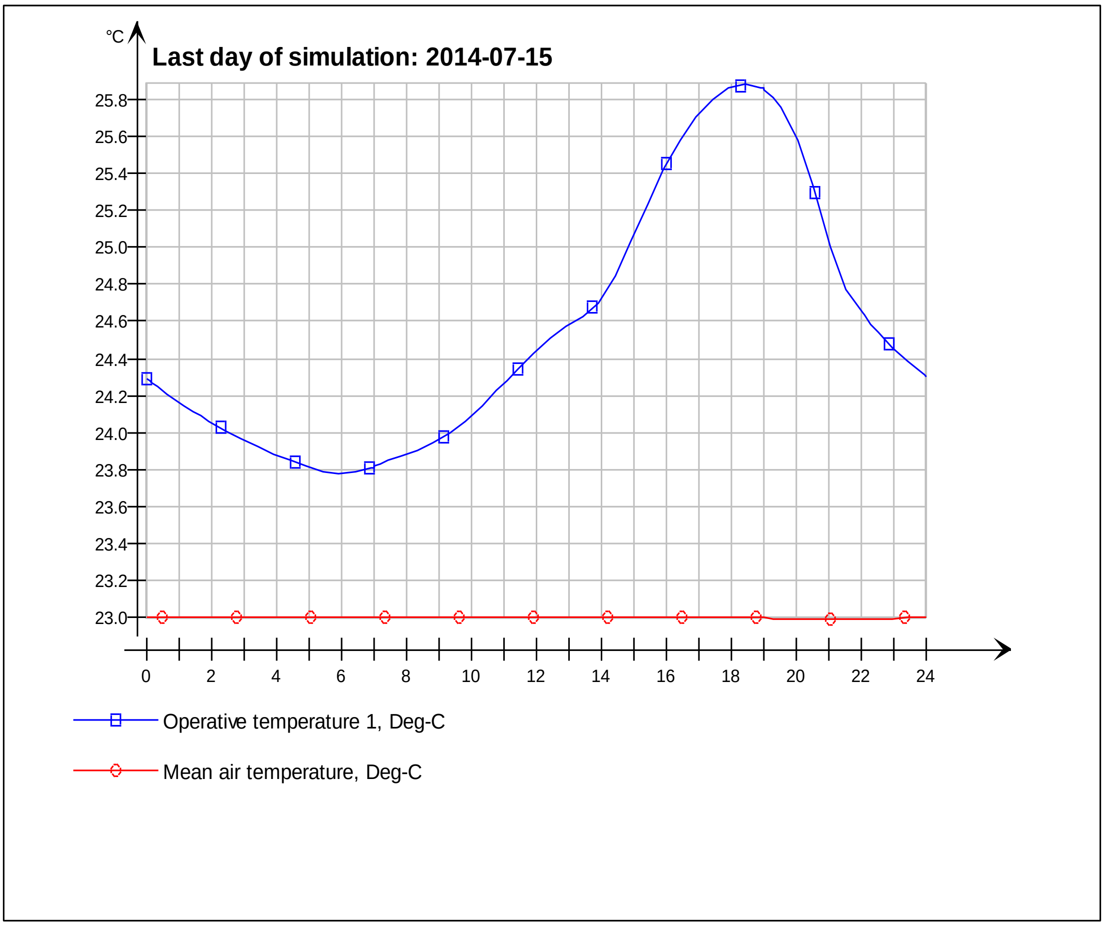


Figure 8. ProClim, main temperatures of Zone 2

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 3

		COOLING
ZONE	**Room Area (m2)**	**Pc (W)**
3	77,35	6921

Table 35. Cooling load zone 3

The main temperature graphic provided by ProClim:

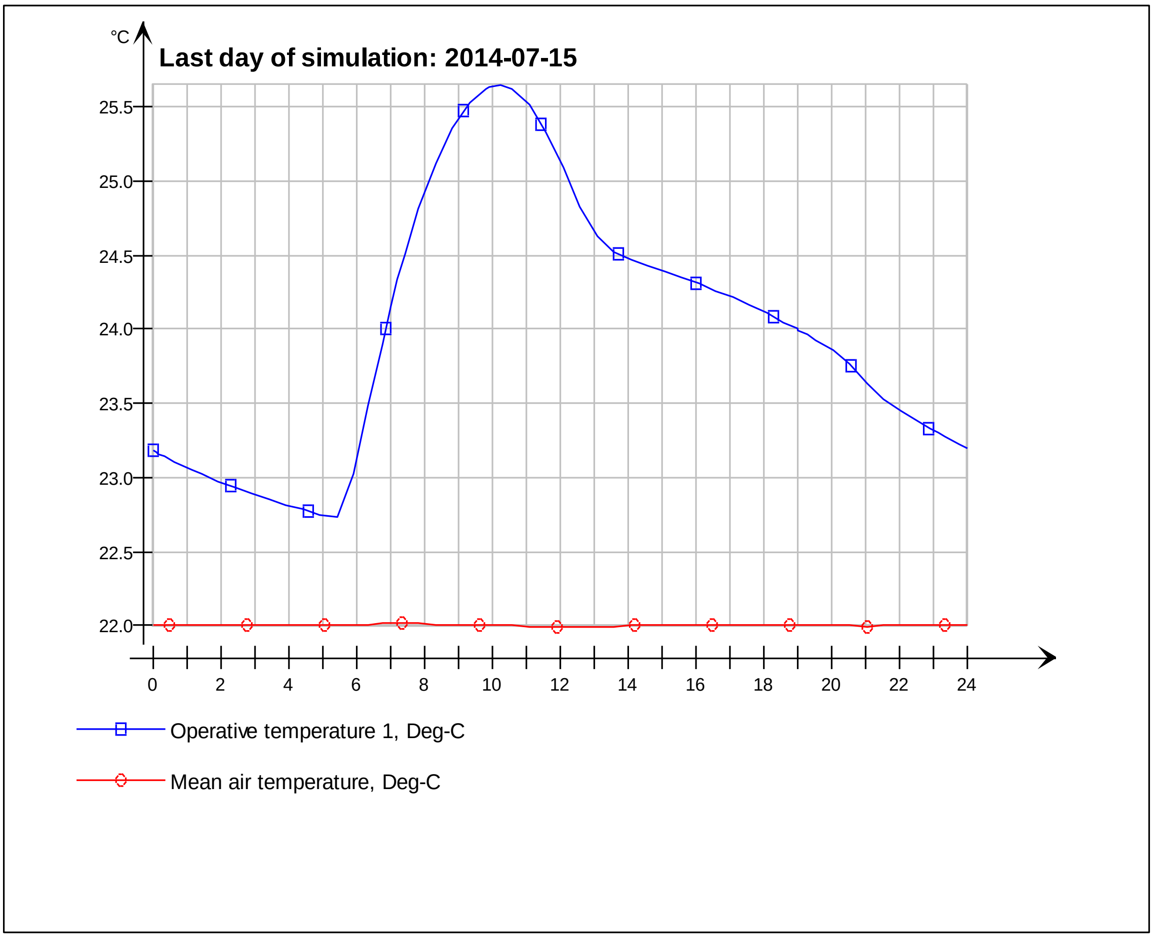


Figure 9. ProClim, main temperatures of Zone 3

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 4

		COOLING
ZONE	**Room Area (m2)**	**Pc (W)**
4	133,21	10086

Table 36. Cooling load zone 4

The main temperature graphic provided by ProClim:

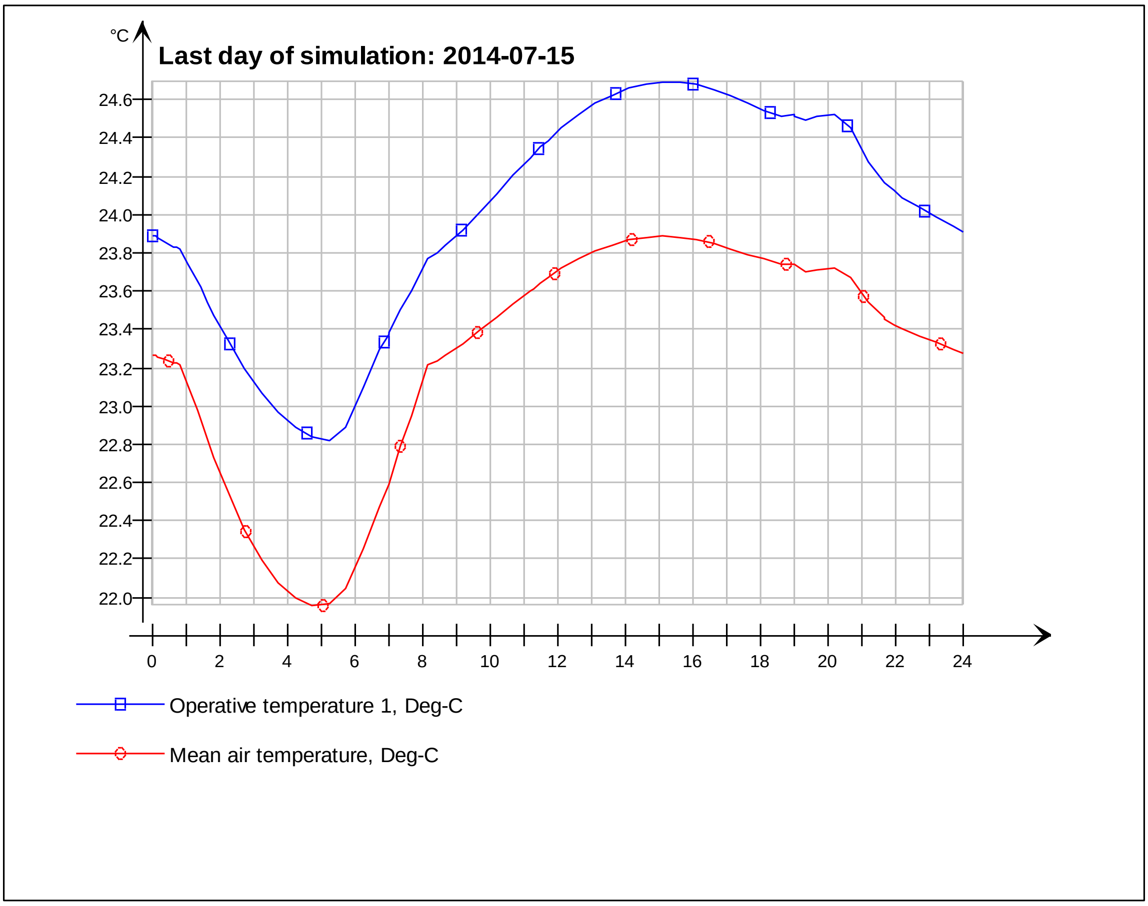


Figure 10. ProClim, main temperatures of Zone 4

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 5

		COOLING
ZONE	**Room Area (m2)**	**Pc (W)**
5	86,59	379

Table 37. Cooling load zone 5

The main temperature graphic provided by ProClim:

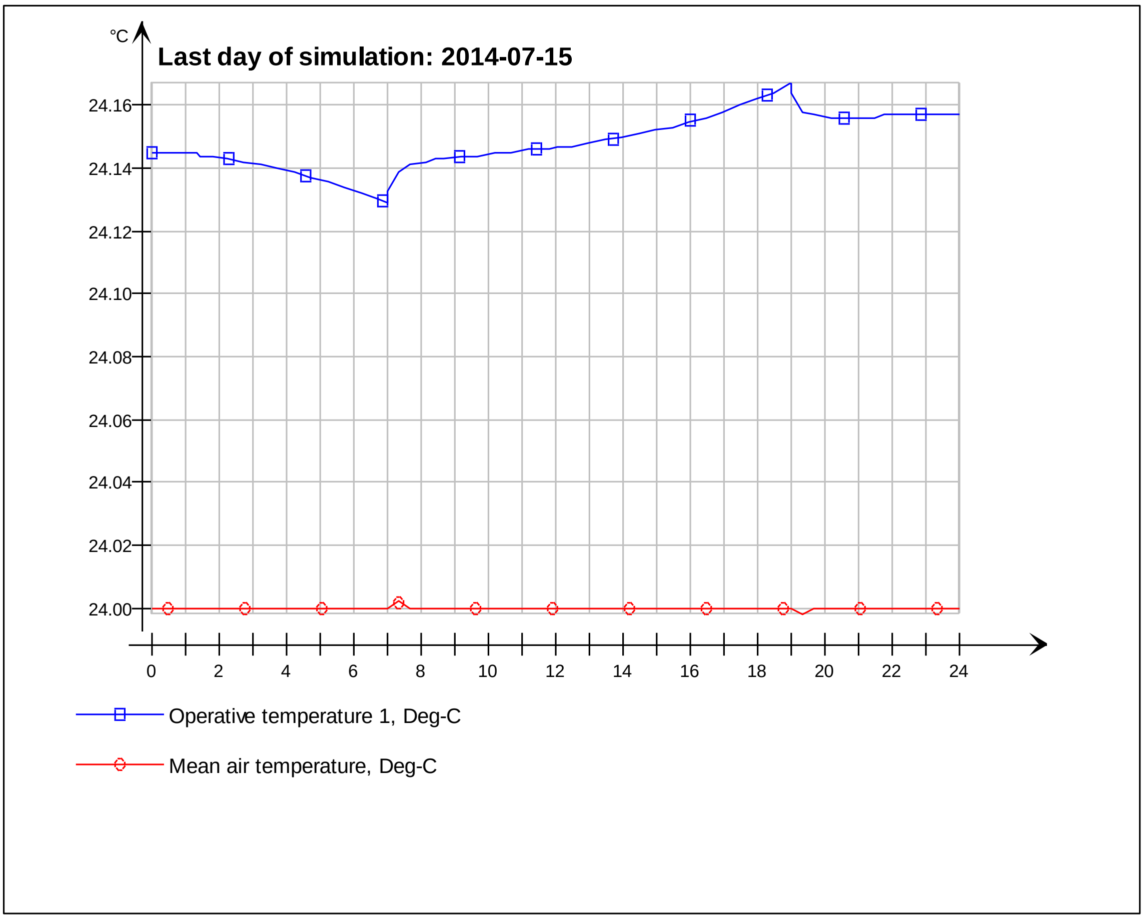


Figure 11. ProClim, main temperatures of Zone 5

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 6

		COOLING
ZONE	Room Area (m2)	Pc (W)
6	254,94	3425

Table 38. Cooling load zone 6

The main temperature graphic provided by ProClim:

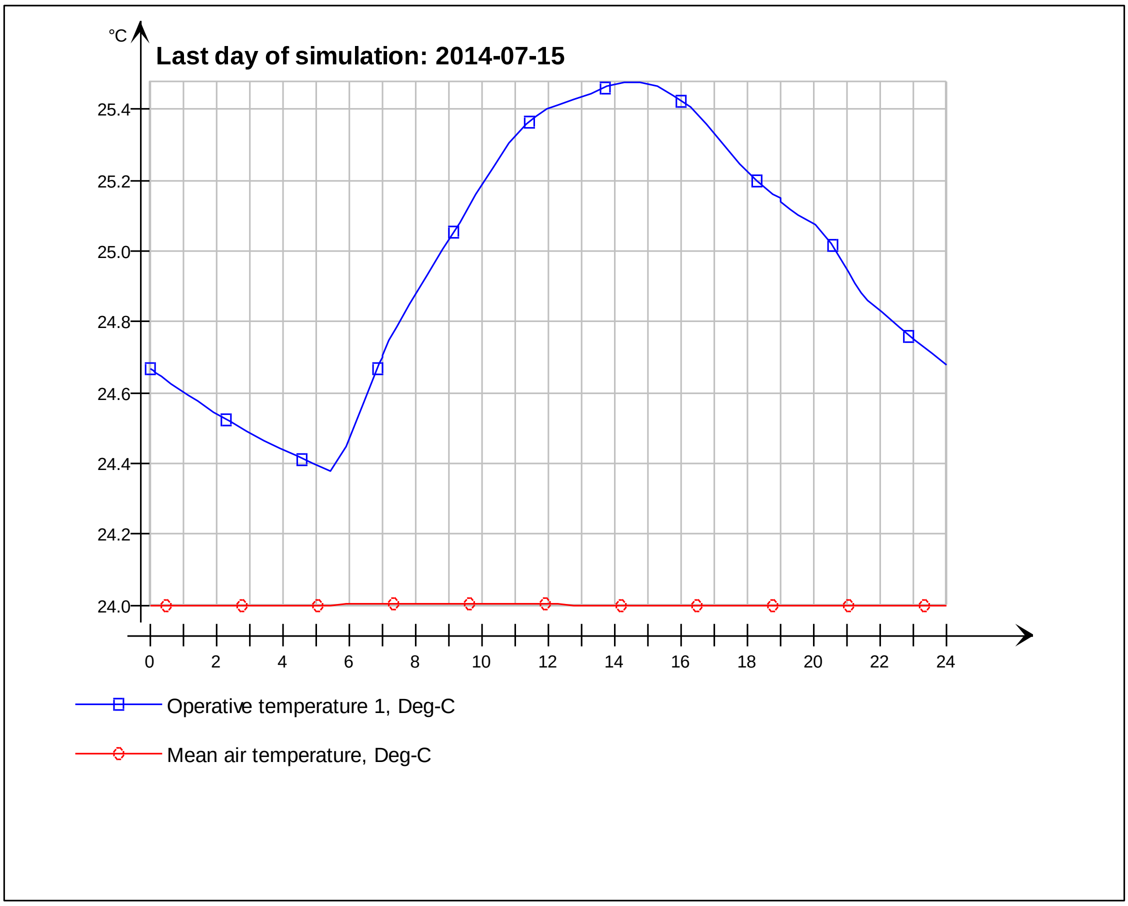


Figure 12. ProClim, main temperatures of Zone 6

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 7

		COOLING
ZONE	**Room Area (m2)**	**Pc (W)**
7	59,93	4952

Table 39. Cooling load zone 7

The main temperature graphic provided by ProClim:

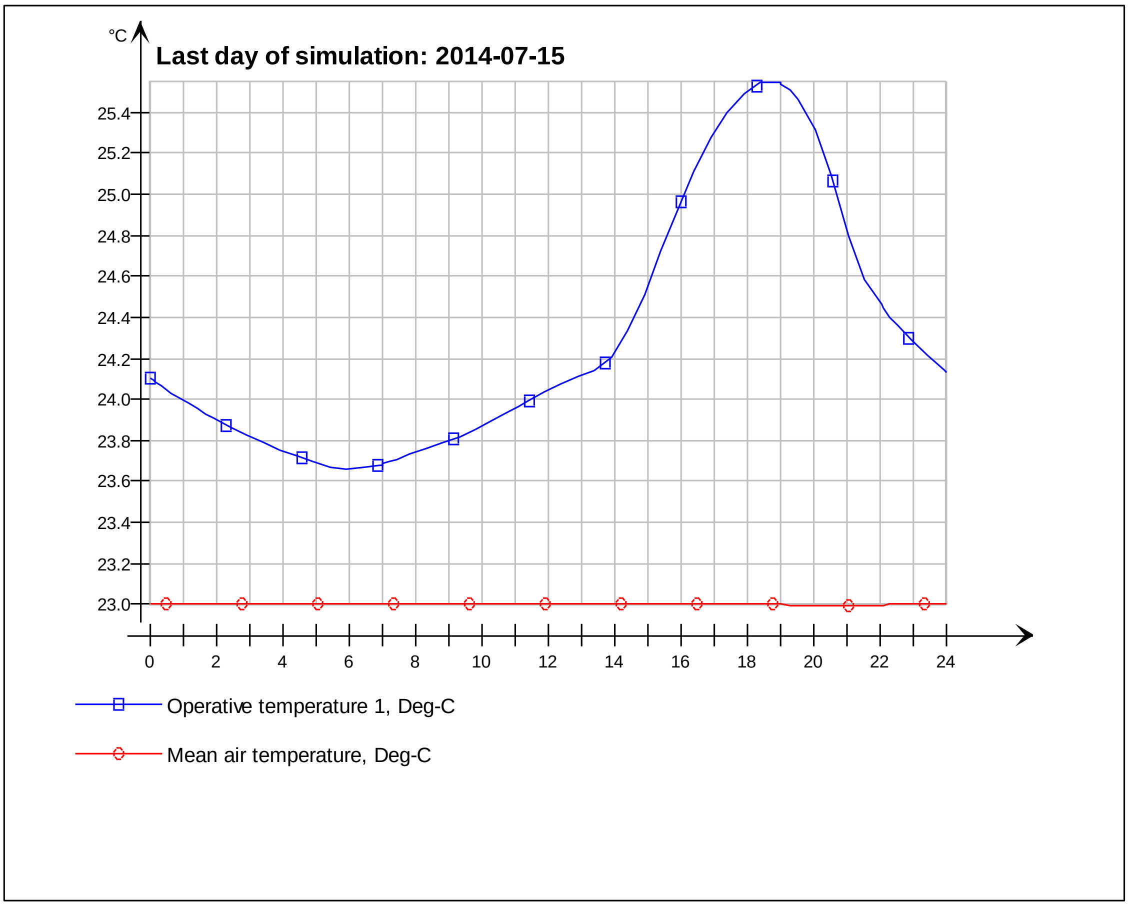


Figure 13. ProClim, main temperatures of Zone 7

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 8

		COOLING
ZONE	Room Area (m2)	Pc (W)
8	241,96	9114

Table 40. Cooling load zone 8

The main temperature graphic provided by ProClim:

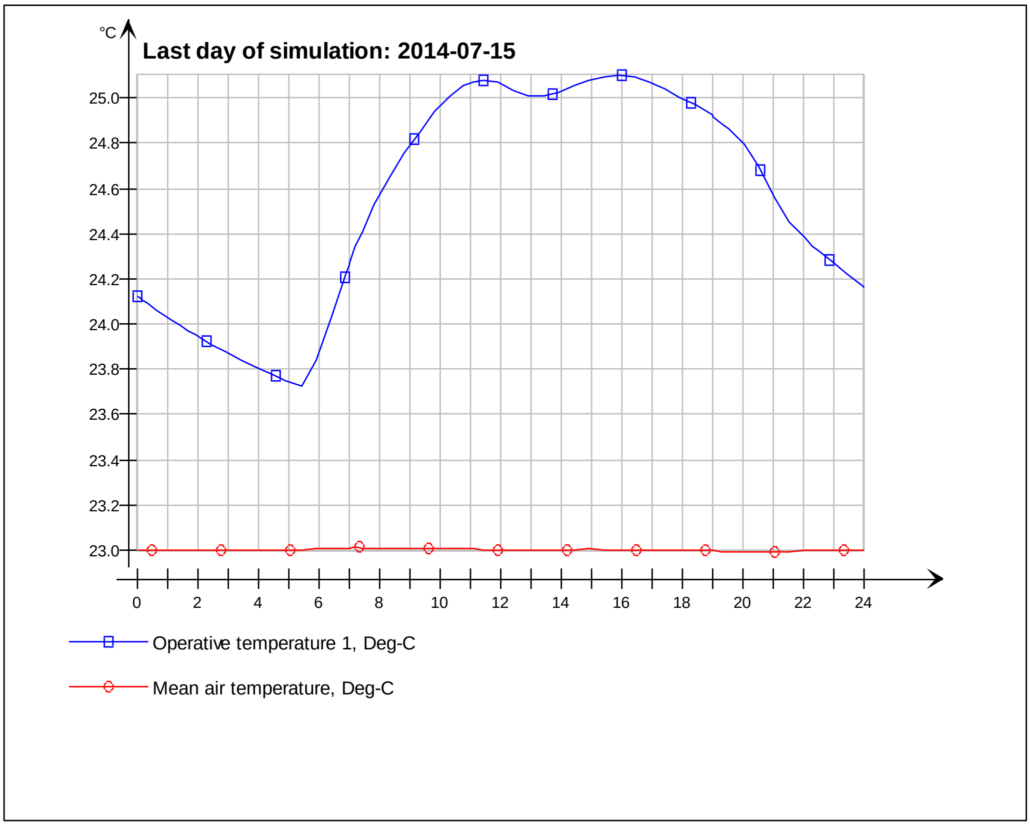


Figure 14. ProClim, main temperatures of Zone 8

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 9

		COOLING
ZONE	Room Area (m2)	Pc (W)
9	117,8	2663

Table 41. Cooling load zone 9

The main temperature graphic provided by ProClim:

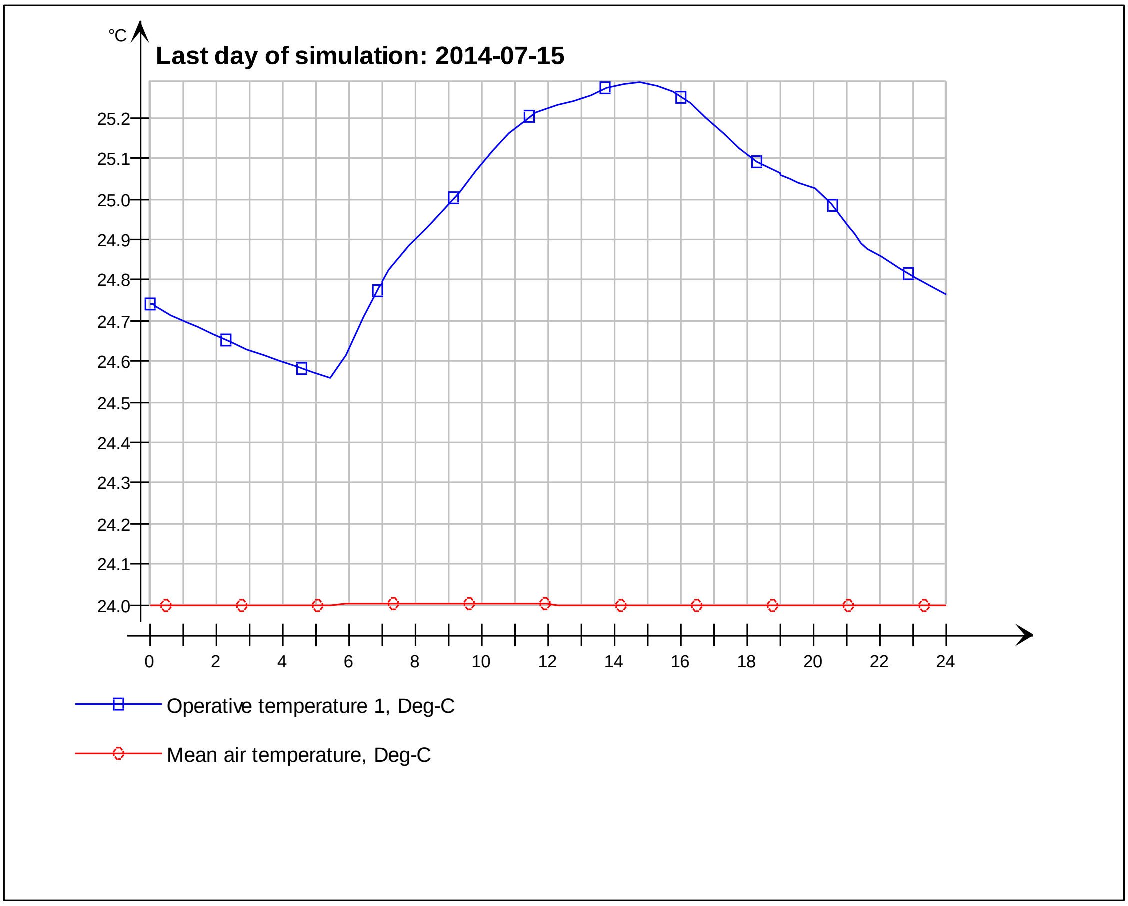


Figure 15. ProClim, main temperatures of Zone 9

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 10

		COOLING
ZONE	**Room Area (m2)**	**Pc (W)**
10	62,45	3412

Table 42. Cooling load zone 10

The main temperature graphic provided by ProClim:

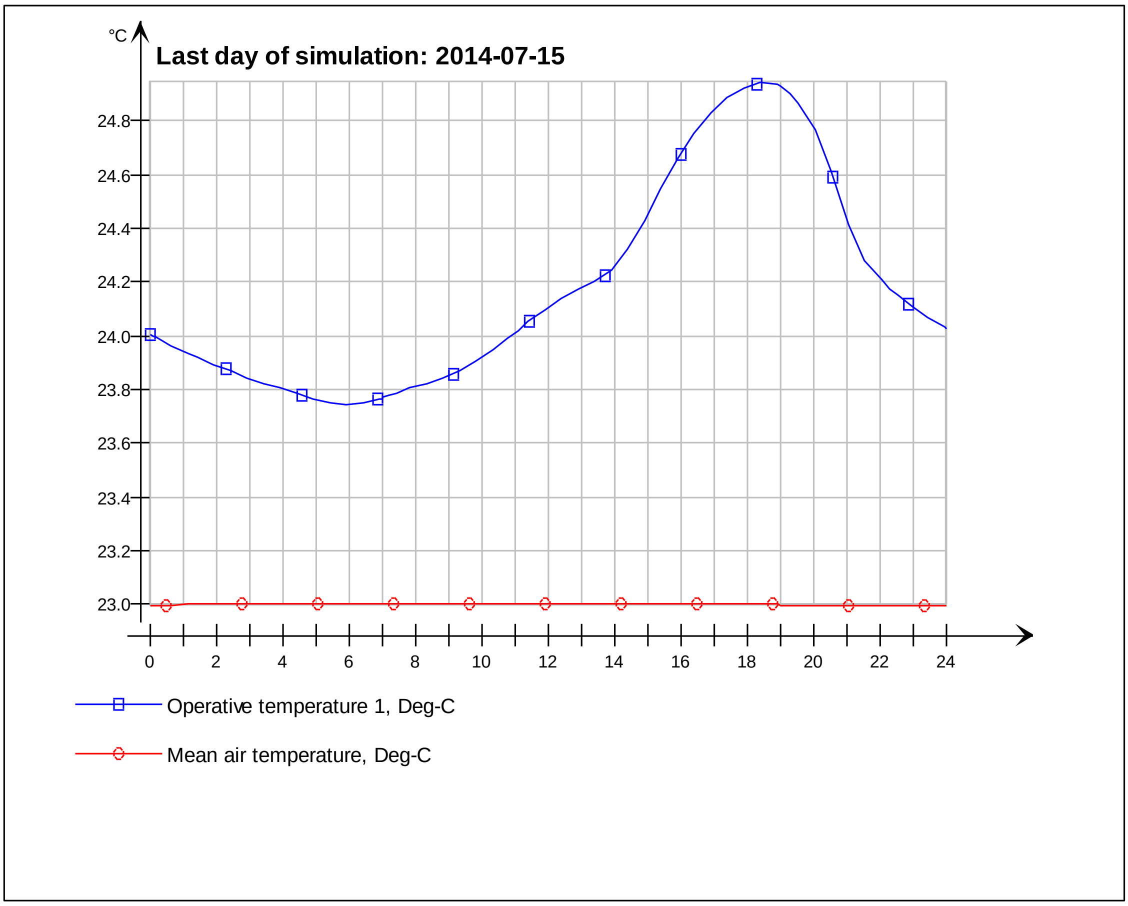


Figure 16. ProClim, main temperatures of Zone 10

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Zone 11

		COOLING
ZONE	Room Area (m2)	Pc (W)
11	238,44	10700

Table 43. Cooling load zone 11

The main temperature graphic provided by ProClim:

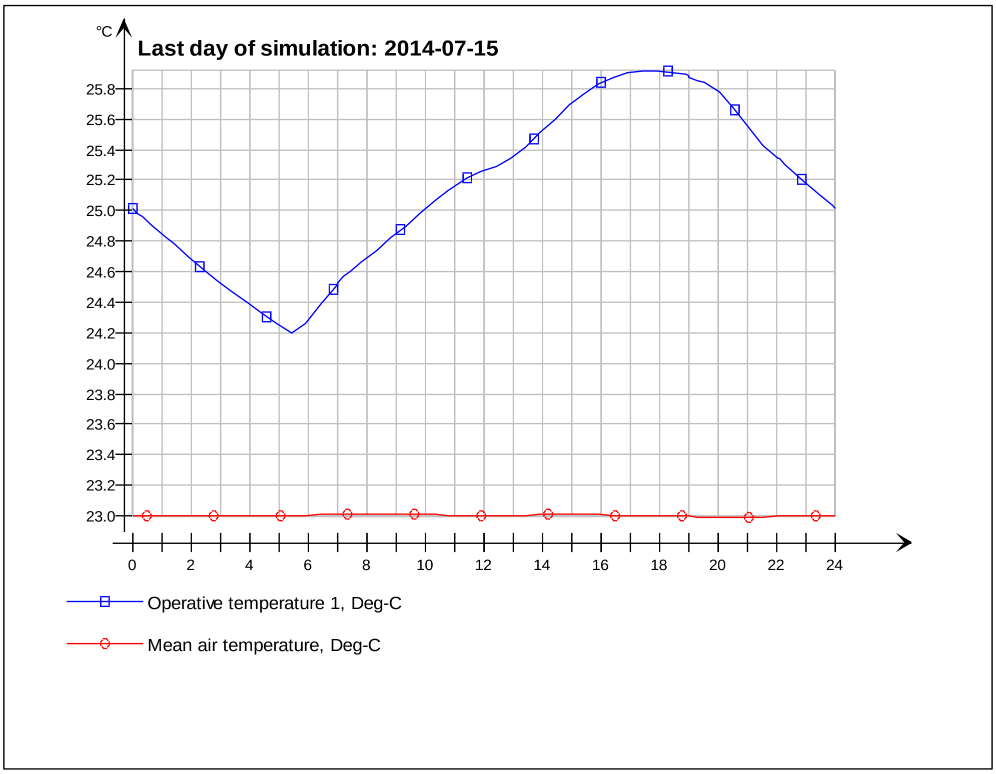


Figure 17. ProClim, main temperatures of Zone 11

We can see that the operative temperature is never high than 26 ºC (our maximum comfort temperature)

Then, the cooling power for the whole building is the following:

$$P_{cooling} = 2745 + 4940 + 6921 + 10086 + 379 + 3425 + 4952 + 9114 + 2663 + 3412 + 10700$$

$$P_{cooling} = 59337\ W = 59,34\ kW$$

After the calculations, the next step would be selecting the equipment.

For perform this step, firstly, we are going to choose basic equipment and after that we will talk about other alternatives.

6. EQUIPMENT

We have just calculated the heating, ventilation and cooling loads, then the next step will be design some equipment which can compensate that loads in cold and hot period.
For that, we decide to do 2 solutions: one basic solution with basic equipment and another one alternative solution, which we will be able to compare and select the best in the conclusion.

6.1 Basic equipment

The basic equipment of our case will be the following:

- For **heating**, we are going to install **radiators** in all the building.
- For **ventilation**, we are going to use an **Air Handling Unit** for the whole building.
- For **cooling**, we are going to use **air conditioners** in each room.

6.1.1 Heating system

The heating devices are one of the main elements in heating systems. Its main purpose is to transfer heat to the heated room.

The type, shape, exploitation properties, the surface temperature of the heating devices must meet hygiene norms, requirements concerning fire protection, also the requirements of room destination and its technological processes.

The heat provided by heating devices can be transferred by: radiation (>50% of heat), radiation-convection (convection 50-75%) or convection (>75% of heat).

The main types of heating devices are the following:

- **Radiators**: most common heating device. Its heat provided is radiant-convection and their percentage depends on the type of radiator. There are 3 main types of radiator:
    - <u>Panel radiators</u>: are generally made of pressed steel or cast iron panels mounted on walls, through which the water is circulated. Heat is given off to room air by natural convection and direct radiation. It has a simple installation, medium inertia, not resistant for hydraulic shocks and high possibilities of corrosion.

    - <u>Section radiators</u>: cast iron radiators, don’t react to the quality of the medium (can be used in old building/renovated) and are stabile (for schools, kindergartens,…). They have high inertia, rustproof, high installation costs and difficult to clean.

- Aluminium radiators: are more expensive than steel panel but are light with high heat output for size, compact and with good appearance. The material used and production techniques ensure a clean smooth finish but one of the problems with using aluminium is corrosion of the metal in contact with hot water which may have a small quantity of air absorbed in it.

- **Convectors**: where the heat is distributes to the area and forces it to move in circle. They are usually made of steel and can be mounted on walls, in the floor ground, installed by the windows.
  Convectors can be used with steam or hot water. Like radiators, they should be installed in areas of greatest heat loss. They are particularly applicable where wall space is limited. They have easy installation, low inertia, difficult to clean from dust and they can be used for cooling also.

As we have said, radiators will be our basic solution for the heating season. We chose radiator because we will need a lot of amount of heat for compensate the low temperatures in cold winter, and we would spend more money with convectors than radiators.

The type of radiator selected will be aluminum radiators. It's the most expensive radiator but, on the other hand, their heat ratios are much better and it will look better for the consumers (hotel guests).

We will need to compensate all the amount of heating loads with this radiators, so, counting all the radiators, we will have 55 radiators, then we will need that each radiator compensate:

$$\boldsymbol{P_h = 103,44\ kW} \qquad \boldsymbol{P_{radiator} = \frac{P_h}{55} = 1,88\ kW}$$

Then, we have found the following aluminum radiator that could be used in our case:

- Company and model: **BAXIROCA BAXI JET 80**
- Heat power: **1984,16 W per radiator**
- Length: **960 mm**

Figure 18. Selected radiator for building

On the annex there are some characteristics of the manufacturers catalog.

The recommendations for the installation of the heating devices are the following:

- The recommended length of the radiator has to be at least 75% of the length of the window.
- The best location of the radiators is in the external walls or windows, because these are the zones which biggest heat losses.
- In stairs premises, the radiators are installed in lower floors, because the heat goes up.

For the connection of radiators to the pipes, we can use two types of configurations, one-pipe or two-pipe.

The type of system installed will have an influence on dimensioning radiators and piping. With a one- pipe system, heated water from the boiler is delivered to each radiator by a single pipe which returns to the boiler to complete the circuit. This method of connecting the radiators was very popular in the early days of central heating, but it is rarely used on a modern system. In our case, we shall use two-pipe system, where heated water, close to the temperature of the water leaving the boiler flow, is delivered to each radiator from an independent circuit, thus overcoming some of the problems of the single pipe system.

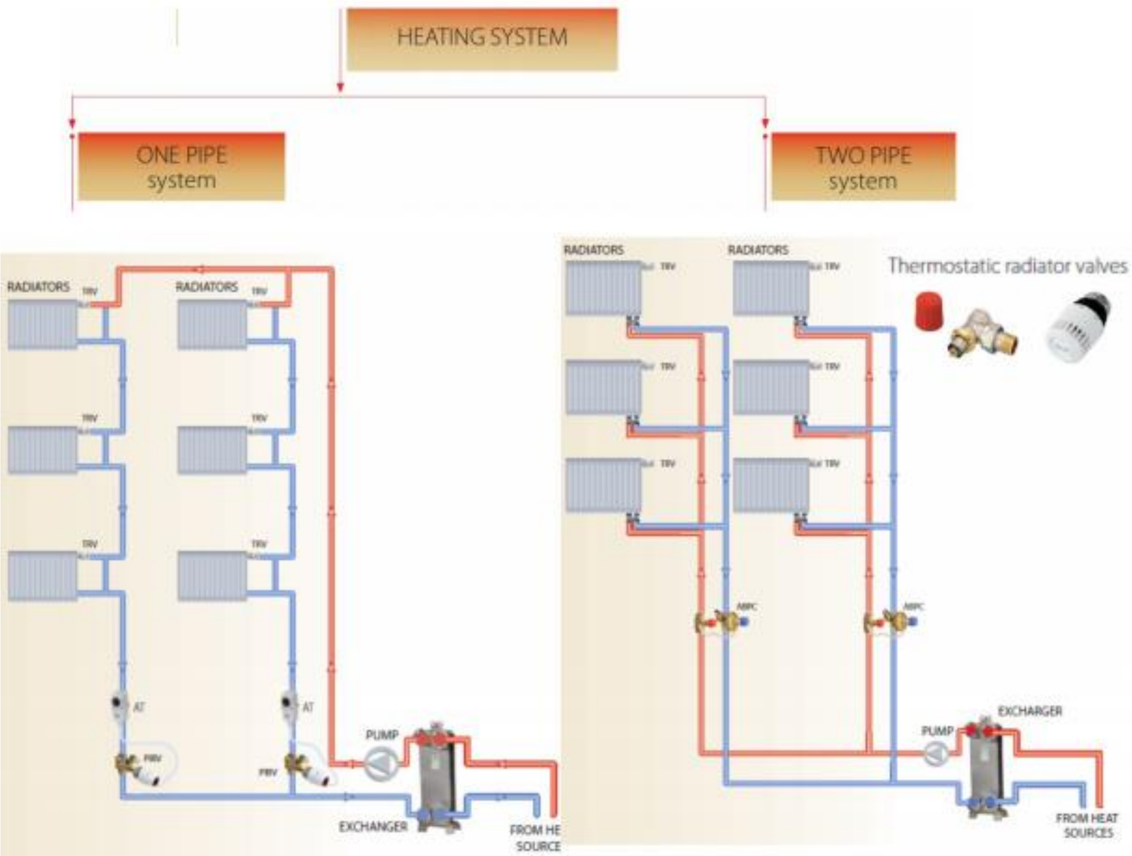


Figure 19. Differences between one-pipe and two-pipe system

The rest of equipment in heating system is the fixtures:

- Automated balancing valves. We will use automatic balancing valves on stands and main pipes. Their purpose is to ensure design flows in hydraulic systems, that is, it performs the following functions: closing, setpoint fixation, dumping, and pressure

drop, flow and temperature measurement.
If the system is not balanced we could have problems with the energy consumption, overheated or overcooled rooms, and flow noises at the valves.

- Thermostatic valves with pre-setting. They are installed on a branch and distributes flow users according to each user's needs.

➔ **In summary, our basic heating systems will be form by:**

- Aluminium radiators: **BAXI JET 80 (1984,16 W)**
- **TWO-PIPE SYSTEM CONFIGURATION**
- **AUTOMATIC BALANCING VALVES**, for regulate automatically the system in the pipes.
- **THERMOSTATIC VALVES WITH PRE-SETTING**, for allow the user regulating the flow as much as user needs.

6.1.2 Ventilation system

The ventilation system is compound basically by:

- **Air Handling Unit** (AHU). The AHU provides the necessary ventilation for the whole building. Essentially, an Air Handling Unit system comprises a large insulated metal box that contains the following components:
    - **Filters**
      Filtration is typically placed first in the AHU in order to keep all the downstream components clean. Depending upon the grade of filtration required, typically filters will be arranged in two (or more) successive banks with a coarse-grade panel filter provided in front of a fine-grade bag filter, or other "final" filtration medium. The panel filter is cheaper to replace and maintain, and thus protects the more expensive bag filters.

    - **Heating/cooling elements**
      AHU may need to provide heating, cooling, or both to change the supply air temperature, and humidity level depending on the location and the application. In our basic case, we are not going to use cooling in AHU, just heating (for heat the air from outdoor to indoor temperature). For cooling we will use other alternatives for that.

    - **Heat recovery device**
      A heat recovery device heat exchanger of many types, may be fitted to the air handler between supply and extract airstreams for energy savings and increasing capacity. These types more commonly include for:
        - Recuperator (Plate Heat exchanger): A sandwich of plastic or metal plates with interlaced air paths. Heat is transferred between airstreams from one side of the plate to the other. Heat recovery efficiency up to 70%.
        - Thermal Wheel (Rotary heat exchanger): A slowly rotating matrix of finely corrugated metal, operating in both opposing airstreams. Heat recovery efficiency up to 85%.
        - Heat Pipe: Operating in both opposing air paths, using a confined refrigerant as a heat transfer medium. Heat is absorbed on one side of the pipe, by evaporation of the refrigerant, and released at the other side, by condensation of the refrigerant. Condensed refrigerant flows by gravity to the first side of the pipe to repeat the process. Heat recovery efficiency up to 65%.
        - Run-around coil: System of two exchangers – placed in the exhaust air flow, which takes over the heat (cooler) and transfers it through an intermediate agent (water and glycol solution) to an exchanger, mounted in the supply air flow (heater).

- **Balancing**
  Un-balanced fans wobble and vibrate. For home AC fans, this can be a major problem: air circulation is greatly reduced at the vents (as wobble is lost energy), efficiency is compromised, and noise is increased.

- **Fan/Blower**
  Air handlers typically employ a large squirrel cage blower driven by an AC induction electric motor to move the air. The blower may operate at a single speed, offer a variety of set speeds, or be driven by a Variable Frequency Drive to allow a wide range of air flow rates. Flow rate may also be controlled by inlet vanes or outlet dampers on the fan.

➔ ***In our case:***
As we are designing the ventilation of a hotel, public building we have to take in account the comfort of the guests. Of course the best heat recoveries are thermal wheel and also plate exchanger, because their efficiency is around 70%.

In our building we can't use no one of those recoveries, because in that recoveries exist air mixing between supply air and exhaust air. And if we do that, we are connecting the air coming from bathrooms with the air supply to the living room, for example.

Then the only possible solution is to choose one heat recovery where there aren't air mixing. Therefore, a <u>run around coil heat recovery</u> is used in our case.

Figure 20. AHU with run around coil

Our ventilation air flow rates are the following:

$$\boldsymbol{L_{supply} = 4536{,}96\ m^3/h\ ;\ L_{exhaust} = 4326{,}24\ m^3/h}$$

Therefore, we have selected the AHU from the company **VTS Group**, the European leader in HVAC technology. This AHU is divided in supply part and exhaust part:

Supply

VTS-30-R-GH/S

Maximum air flow rate:	**1,26 m^3/s**
Maximum fan static pressure:	**893 Pa**
Fan efficiency:	**0,75**
Heat recovery efficiency:	**0,55**

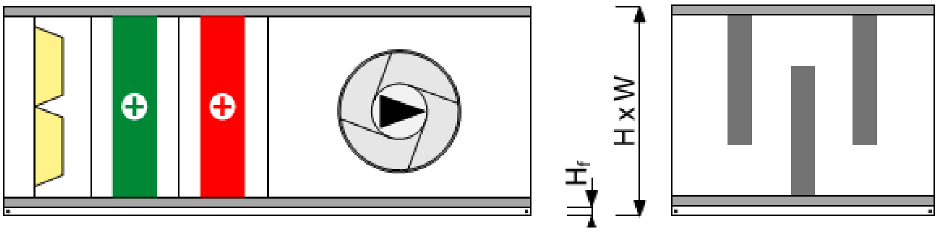


Figure 21. Supply design of AHU with air heater

Exhaust

VS-40-R-S/G

Maximum air flow rate:	**1,26 m3/s**
Maximum fan static pressure:	**678 Pa**
Fan efficiency:	**0,76**
Heat recovery efficiency:	**0,44**

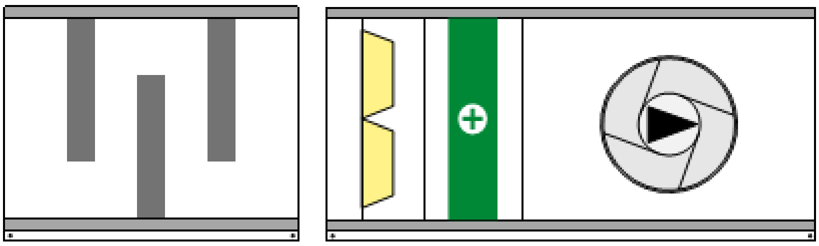


Figure 23. Exhaust design of AHU with air heater

Rest of characteristics in Annex.

6.1.3 Cooling system

There are different types of cooling systems for buildings, but in our basic case, we have selected individually air coolers for each room.

➔ ***In our case:***
We will need to compensate all the amount of cooling loads with these individually air coolers per room.
The cooling load of our building is the following:

$$P_{cooling} = 59337\ W = 59,34\ kW$$

And we have installed 46 individual air coolers. But we need to know what's the air cooler which needs more cooling load. The zone 11 needs more cooling load than the other zones but in this zone there are 9 air coolers. Although, the zone 3 needs 6,92 kW and it has just 2 devices. Then:

$$P_{air\ cooler,max} = \frac{4,94}{2} = 3,46\ kW$$

The air coolers selected are the following devices from the known company FUJITSU:

- Various outdoor units (AOY36AM5) which can be used for multiple indoor units (in our case 5, 2 of ASY12AM and 3 of ASY17AM)
  - **ASY12AM: Power 3,5 kW**
  - **ASY17AM: Power 4,0 kW**

Figure 24. Individual air cooler selected (FUJITSU)

The rest of the characteristics are in the Annex.

6.2 Alternative

The last point we talked about the basic design and their equipment of our building. Now, we are going to talk about other possibility for design the HVAC of our building.

6.2.1 AHU with air heater and air cooler

Our main alternative is to install a big air conditioner (AHU) in the whole building.

Usually, the Air Handling Units are used just as ventilation system of the building, but it's possible to use it as heating and cooling system. And this will be our first alternative, Air Handling Unit where we are going to include the three main HVAC systems (ventilation, heating and cooling).

We talked about Air Handling Unit in the point of ventilation system, but now we are going to explain how it works when we include equipment for heating and cooling.

The following scheme is the scheme of our AHU selected. In the scheme we can see how the air goes from outside through the AHU, to inside the building.

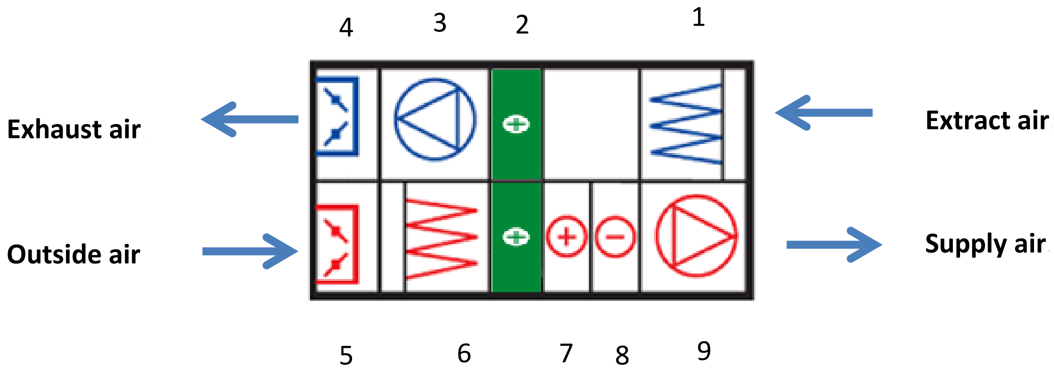


Figure 25. AHU design with air heater and air cooler

1 ··> Extract air filter
2 ··> Run around coil (heat exchanger)
3 ··> Exhaust fan/ventilator
4 ··> Exhaust air damper (air mixing)
5 ··> Supply air damper (air mixing)
6 ··> Supply air filter
7 ··> Air heater
8 ··> Air cooler
9 ··> Supply fan/ventilator

The AHU takes air from outside, goes through the supply air mixing and after the supply air filter, to the heat exchanger (rotatory thermal wheel in our case). In the heat exchanger this air increases their temperature because it takes hot from the extract air which goes out. After heat exchanger, the air gets hot in the air heater (or gets cold in the air cooler) and after that goes through the supply ventilator to indoor room.
In the other way, the extract air is taken from indoor at high temperature, goes through the extract air filter, goes inside the heat exchanger, where exchanges their temperature with the new outside air, and then goes through the exhaust ventilator to outside.

If we want to use the AHU for heat (in heating season) and cool (in cooling season) the whole building, we need to take into account the following points:

- We have calculated the amount of power necessary for maintain the building at the required temperature, in heating and cooling. But in the basic solution, we haven't used the AHU for those issues but we used radiators (for heating) and air conditioners (for cooling). Therefore, in this case, we should provide this power with the AHU. This increase of power will cause that the AHU increase also the supply air flow.
  We can calculate the supply air flow extra needed if we just have AHU heating and cooling the building, with the following formula:

$$L_{supply,AHU} = \frac{P_h}{0{,}34 \cdot (\theta_{supply} - \theta_{indoor})}$$

  The $\boldsymbol{\theta_{supply}}$ is the temperature of the air flow supplied by AHU to the room. In **heating season** (winter) this temperature will be **27 ºC**, and in the **cooling season** this temperature will be **18 ºC**.
  The $\boldsymbol{\theta_{indoor}}$ is the temperature of the indoor room, that is, the design indoor temperature, **22 ºC in winter** and **24,5 ºC in summer**.
  For the extract air flow, we will assume that the exhaust air flow extra will be the same than the supply air flow extra.

  Therefore, these are the values of the new extra air flow rates, the total air flow rates and the ventilation loads:

ZONE	Total supply air flow, heating season (m3/h)	Total supply air flow, cooling season (m3/h)	Pvent, heating season (W)	Pvent, cooling season (W)
1	5768,53	699,91	36087,94	8797,08
2	3014,42	893,23	18858,24	5314,41
3	6318,24	1535,97	39526,92	10681,72
4	7702,97	2784,95	48189,79	14263,57
5	1681,04	58,31	10516,61	2365,52
6	5638,27	781,867	35273,046	8731,3914
7	3607,65	970,54	22569,46	6226,33
8	13594,31	2170,03	85045,99	21439,50
9	5397,03	664,64	33763,79	8243,86
10	3377,12	699,92	21127,28	5544,78
11	12897,72	2406,38	80688,17	20813,59
Total	**68997,32**	**13665,73**	**431647,23**	**112421,75**

Table 44. Extra air flow and ventilation loads

In summary:

- Heating season:
  - **Extra air flow: 64460,36 m3/h**
  - **Total air flow: 68997,32 m3/h**
  - **Total ventilation load: 431647,23 W = 431,647 kW**

- Cooling season:
  - **Extra air flow: 9128,77 m3/h**
  - **Total air flow: 13665,73 m3/h**
  - **Total ventilation load: 112421,75 W = 112,421 kW**

To be sure about this calculation is not wrong, we are going to use the ProClim program and we will try to insert the values of supply air and extract air, and will obtain the heating and cooling power necessary for each zone. This procedure we explained in Cooling system title, Proclim tutorials (Page 54).

These are the values obtained of each zone for heating and cooling, and their comparision between the last values calculated:

Zone	Supply air flow, h.s. formula (m3/h)	Supply air flow, h.s. ProClim (m3/h)	Supply air flow, c.s. formula (m3/h)	Supply air flow, c.s. ProClim (m3/h)	Pvent, h.s. formula (W)	Pvent, h.s. ProClim (W)	Pvent, c.s. formula (W)	Pvent, c.s. ProClim (W)
1	5769	2200	700	1100	36088	17978	8797	4502
2	3014	1600	893	2000	18858	13116	5314	8131
3	6318	3200	1536	3000	39527	25254	10682	11164
4	7703	2800	2785	1000	48190	22446	14264	4179
5	1681	500	58	100	10517	4037	2366	421
6	5638	2200	782	1200	35273	4197	8731	5187
7	3608	1800	971	1600	22569	14492	6226	6844
8	13594	7000	2170	4000	85046	55450	21440	16582
9	5397	1300	665	1300	33764	10649	8244	5085
10	3377	1500	700	1100	21127	12012	5545	4572
11	12898	13000	2406	5000	80688	112209	20814	20188
Total	**68997**	**37100**	**13666**	**21400**	**431647**	**291839**	**112422**	**86856**

Table 45. Air flow and ventilation load's comparison between values by formula and values by ProClim

As we can see from the obtained values, there is a big difference between the values obtained applying the formula and the values obtained with the software ProClim. It stands to reason that we are going to take the one whose value of total ventilation load is lower, because after we will save energy, money and maintenance. Following this principle, in this case we will choose the values obtained from the software ProClim.

Finally, our **values** of **ventilation load** in **this alternative solution** are the following (we are going to calculate also the annual ventilation heat demand):

Heating season

Zone	Supply air flow, h.s. ProClim (m3/h)	Pvent, h.s. ProClim (W)	Qvent,h.s. ProClim (kWh)
1	2200	17978	52025
2	1600	13116	37836
3	3200	25254	75673
4	2800	22446	66214
5	500	4037	11824
6	2200	4197	52025
7	1800	14492	42566
8	7000	55450	165534
9	1300	10649	30742
10	1500	12012	35472
11	13000	112209	307420
Total	37100	291839	877328

Cooling season

Supply air flow, h.s. ProClim (m3/h)	Pvent, c.s. ProClim (W)
1100	4502
2000	8131
3000	11164
1000	4179
100	421
1200	5187
1600	6844
4000	16582
1300	5085
1100	4572
5000	20188
21400	86856

Table 46. Air flow and ventilation load of alternative solution

Also, we have to calculate the **electricity power of the fan**:

$$N = \frac{L \cdot p}{3{,}6 \cdot 10^6 \cdot \eta_v} \quad kW$$

➔ Where the pressure losses are obtained from the characteristics page of manufacturer, $\boldsymbol{p = 851\ Pa}$ and also the fan efficiency, $\boldsymbol{\eta_v = 0,74}$. The air flow, we are going to use the air of cold season because is the bigger, $\boldsymbol{L_{supply,cold\ season} = 37100\ m^3/h}$

Therefore, the **electricity power of the fan** will be:

$$N = \frac{2 \cdot 37100 \cdot 851}{3,6 \cdot 10^6 \cdot 0,74} = 23,7 \ kW$$

We have multiplied the electricity power per 2 because, we said before that the exhaust air flow will be the same than the supply air flow, then the electricity will be the double in each season.

Now, the **fan electricity demands** are the following:

$$W = N \cdot t_{vent} \cdot n_{vent} \quad kWh$$

Where the fan's "working" days are 365 days; and the fan's "working" hours per day are 24 hours. Therefore:

$$W = N_{cold\ season} \cdot t_{vent} \cdot n_{vent} = 38{,}05 \cdot 365 \cdot 24 = 207612 \ kWh$$

The AHU selected for the basic solution couldn't hold the air flow obtained in this alternative solution and also can't compensate the cooling loads because it does not have air cooler. Therefore, we had to search another AHU from the same manufacturer.

Finally the AHU selected, has been the following AHU:

Supply

VS-300-R-GHC/S

Maximum air flow rate:	**10,31 m^3/s**
Maximum fan static pressure:	**851 Pa**
Fan efficiency:	**0,74**
Heat recovery efficiency:	**0,42**

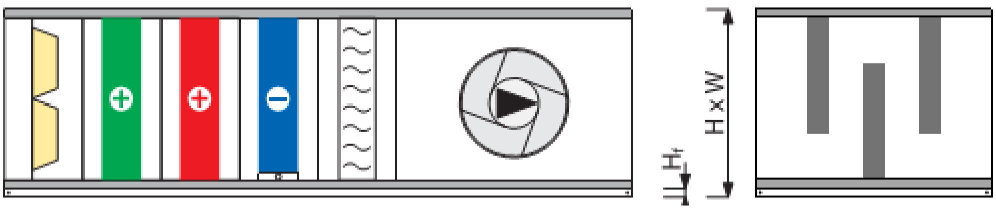


Figure 26. Supply design of AHU with air heater and air cooler

Exhaust

VS-300-R-S/G

Maximum air flow rate:	**10,31 m3/s**
Maximum fan static pressure:	**771 Pa**
Fan efficiency:	**0,73**
Heat recovery efficiency:	**0,42**

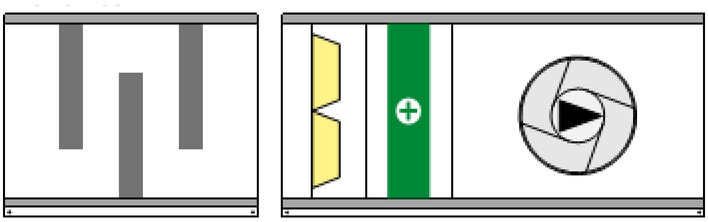


Figure 27. Exhaust design of AHU with air heater and air cooler

Rest of the characteristics in the Annex page.

7. CONCLUSION

In this final work, we spoke about the microclimate characteristics in a three floor hotel placed in Vilnius. We made the calculations of the heating, ventilation and cooling loads, and after we were searching solutions for compensate these loads and get the comfort environment which is needed for a public and commercial building.

The best way to find out a conclusion about this final work is performing a comparison between the two obtained solutions, the basic solution and the alternative one.

Firstly, the basic solution is named 'basic' because is the first solution of HVAC systems with which you should keep in mind when you are designing HVAC systems. Because is the most common, and maybe cheaper also.
When you are calculating the HVAC systems in a big city, you must to know what type of heat resources you have at your disposal. Well, this hotel is located in Vilnius, where there is a big net of district heating in the entire city. Then, it will be economic and useful, if you use that heat source for the heating season with, for example, some heating devices which work with heated water.
But why do you have to choose radiators? Because you have a lot of other alternatives for heating devices. Well now we are going to enumerate some other alternatives of heating devices and its disadvantages:

- Section radiators: It has high installation costs, difficult to clean and doesn't look good for a public and commercial building.
- Iron panel radiators: it hasn't resistant for hydraulic shocks and it has a high grade of corroding.
- Convectors: difficult to clean from dust and it must to be long, because it has a small heating area.

In our case, the aluminum radiators provide a good appearance, lightweight construction, they are easy to change the length, compact and can be used with high pressure.

For ventilation premises, the AHU is always the best solution. An AHU it's possible for the consumer customization, doesn't matter the conditions or request that the consumer needs. For example, in our case, on the basic solution we have just used the AHU as ventilation system, but in the alternative solution, we have used it as heating, ventilation and cooling system, usually that is called air conditioner. You can add or remove boxes as much as you can or as much as you need.

In cooling premises, nowadays, it's not so usual to see new HVAC systems with cooling air conditioners separate from other systems. Usually this air conditioners are connected with the AHU or other ventilation systems.

We spoke about both solutions but now we are going to make a comparison between their annual demands and we will find out which one demands more energy.

7.1 Economic comparison

For make a comparison between both solutions, we need the following values of each one:

- Annual heat demand
  - Heating
  - Ventilation
  - Cooling

- Annual electricity demand
  - Ventilation

In the following table we will show the values of both solutions:

	Annual heat demand (MWh)			Annual electricity demand (MWh)
	Heating	**Ventilation**	**Cooling**	**Ventilation**
Basic solution	**218,15**	**59,04**	**-**	**25,68**
Alternative solution	**-**	**877,33**	*****	**207,61**

Table 47. Demands comparison between both solutions

In the cooling case for the alternative solution, we would have heat demand (because we need heat for compensate the high temperatures in summer), but we are not going to take in account because we would need another program which can calculate this values.

Now, we will calculate the costs of both solutions, using these coefficients for heat costs and electricity costs in Lithuania ($\boldsymbol{c_{heat} = 0,08\ €/kWh}$; $\boldsymbol{c_{electricity} = 0,08\ €/kWh}$)

	Annual heat cost (€)			**Annual electricity cost (€)**
	Heating	**Ventilation**	**Cooling**	**Ventilation**
Basic solution	**17452**	**4723,2**	**-**	**3852**
Alternative solution	**-**	**70186,4**	**-**	**31141,5**
Differences (Alternative vs basic)	**48011,2 more expensive**			**27289,5 € more expensive**

Table 48. Cost comparison between both solutions

As we can see in last tables, the differences in the demand and also in the cost are very big between the basic solution and the alternative solution. With a first sight maybe you could say that there are no doubts about which is the best solution, but you should pay attention to the cost of the equipment.

In our project we haven't calculated the cost of the equipment of each solution, but you have to take in account because:

- Basic solution:
  - Costs, installation and maintenance of heating devices (radiators)
  - Costs, installation and maintenance of ventilation system (AHU with air heater)
  - Costs, installation and maintenance of cooling devices (air coolers)
- Alternative solution:
  - Costs, installation and maintenance of ventilation system (AHU with air heater and air cooler)

Then we can say that maybe with the alternative solution its cost per year because of the demand it will be too high, but in that case, the rest of the costs will be less than basic solution.

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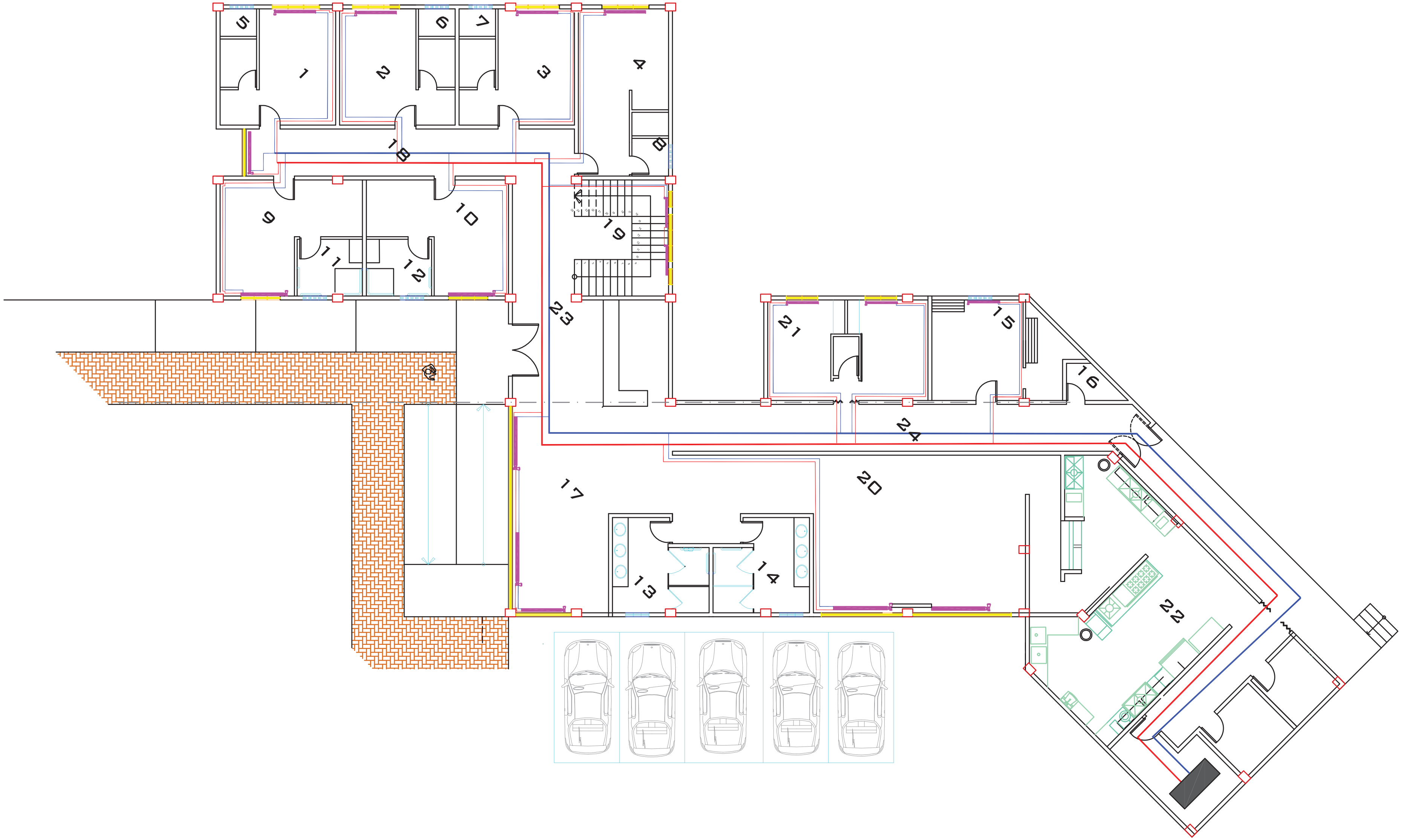
DRAWINGS



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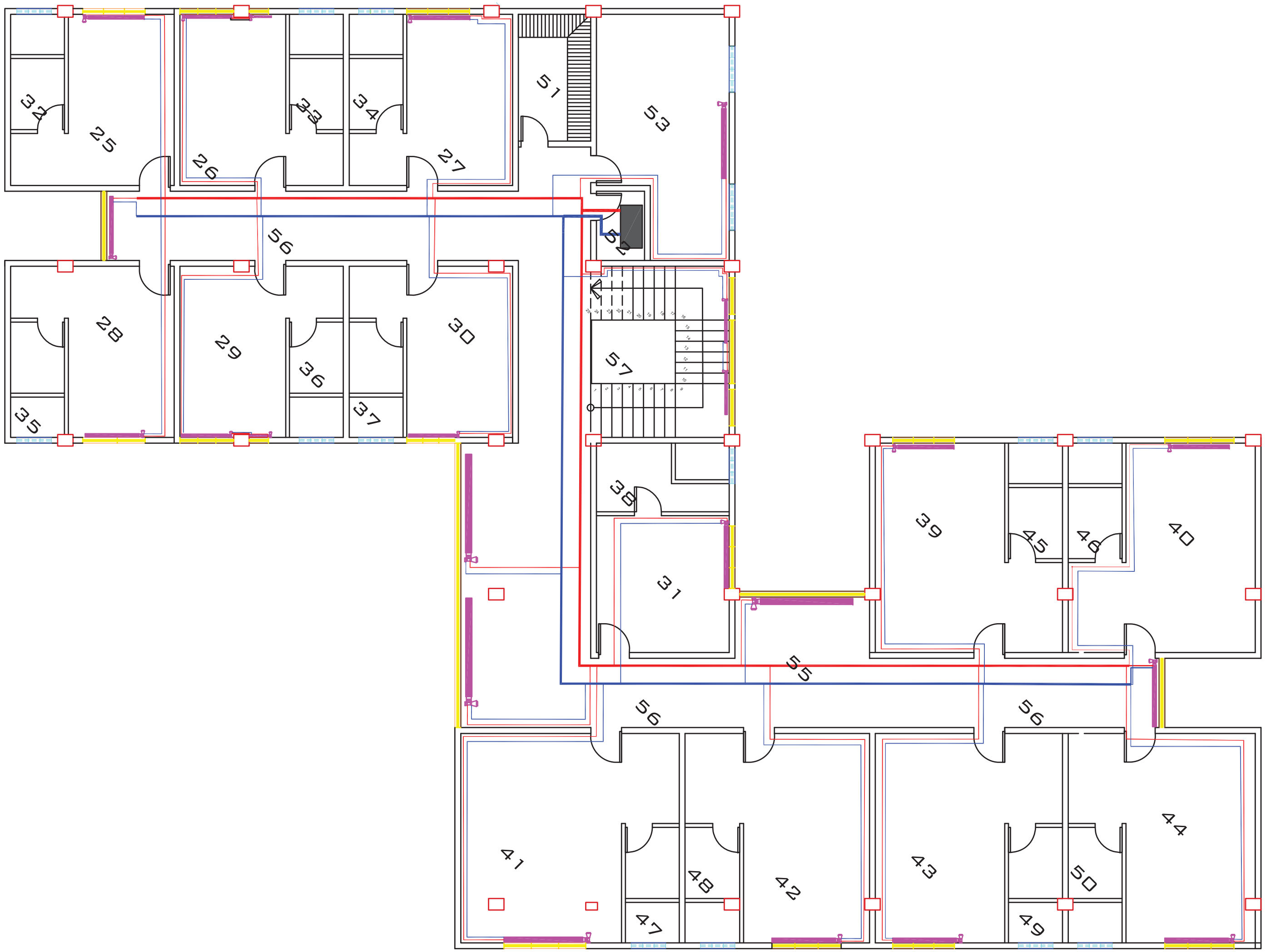

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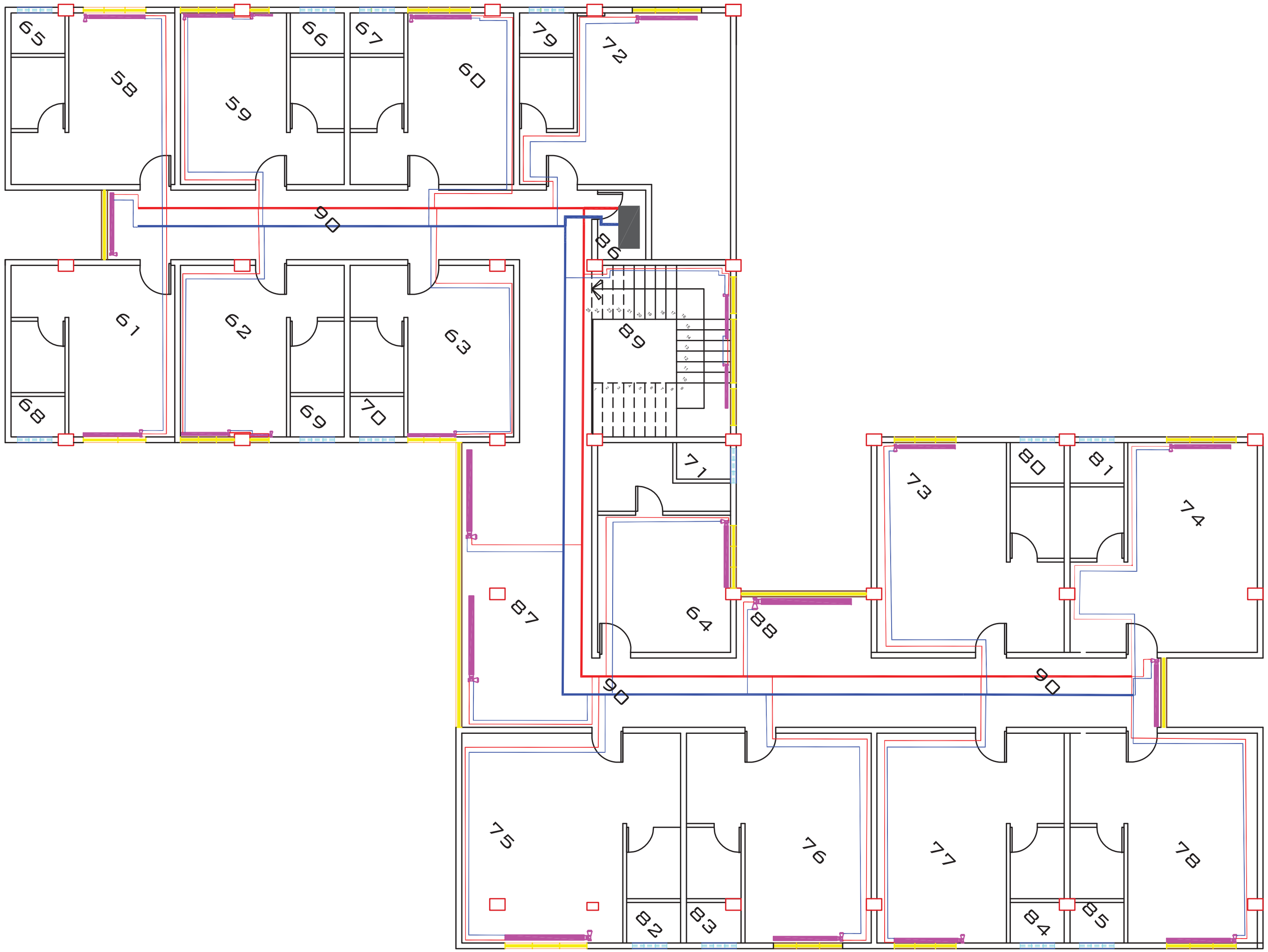

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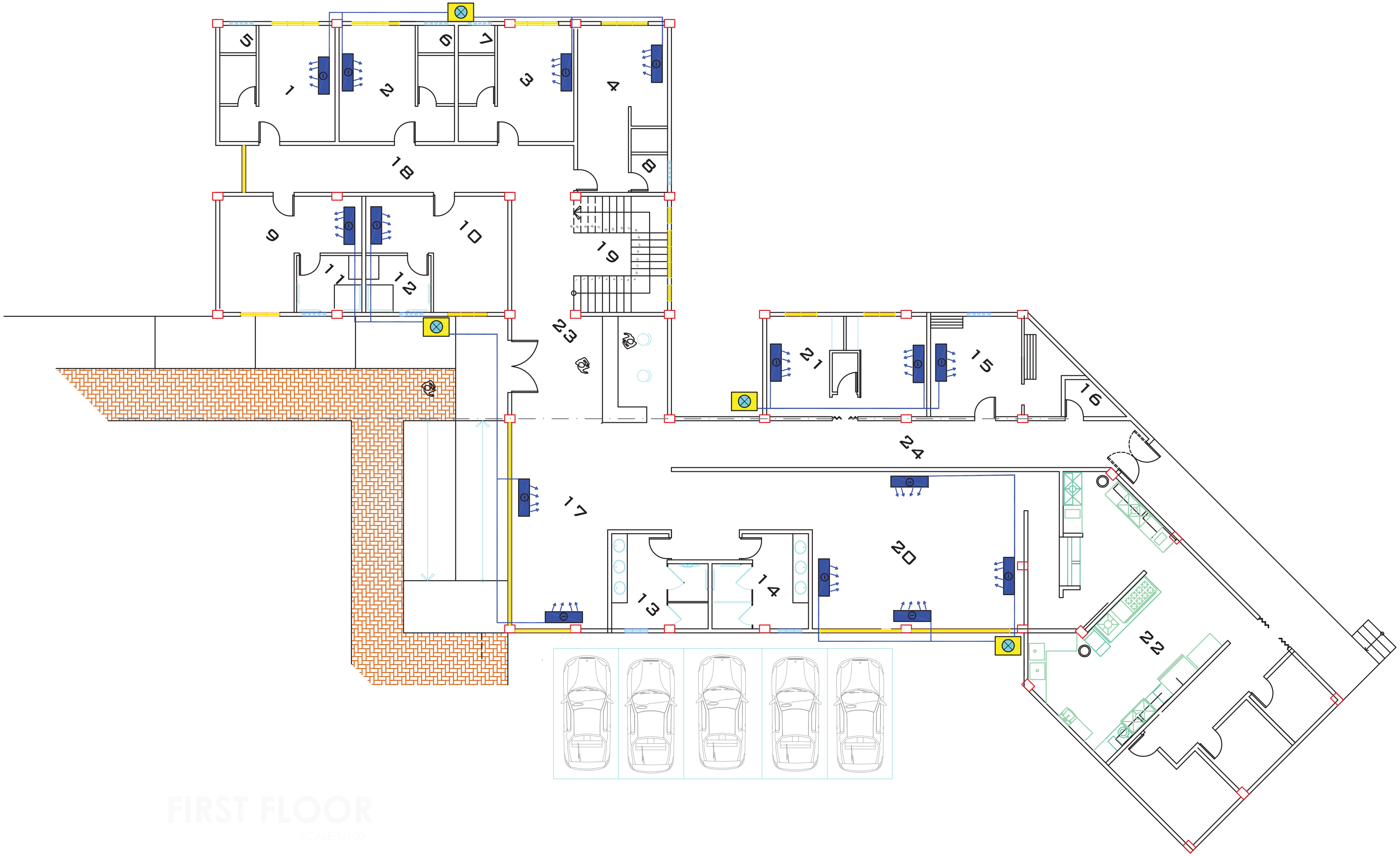

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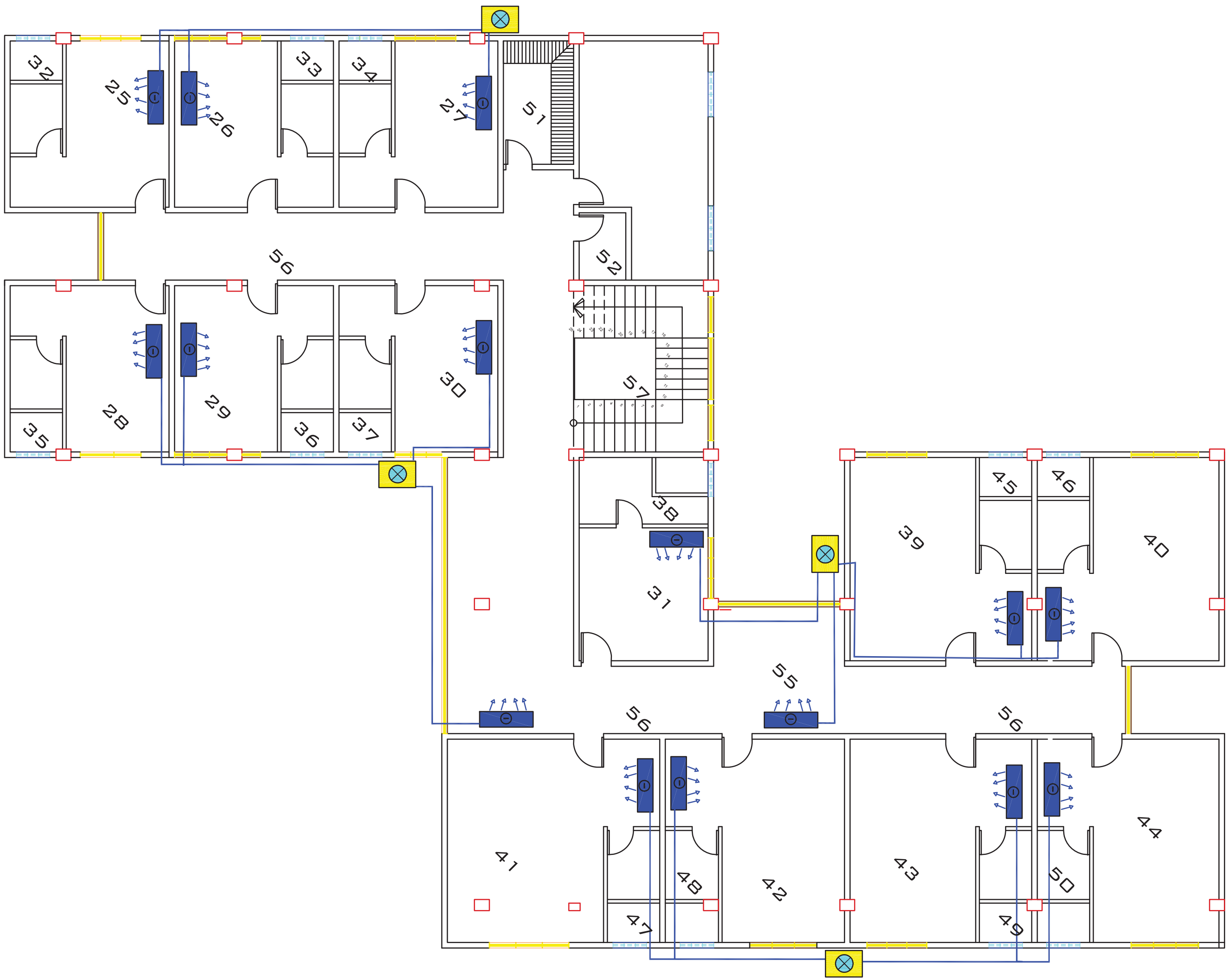

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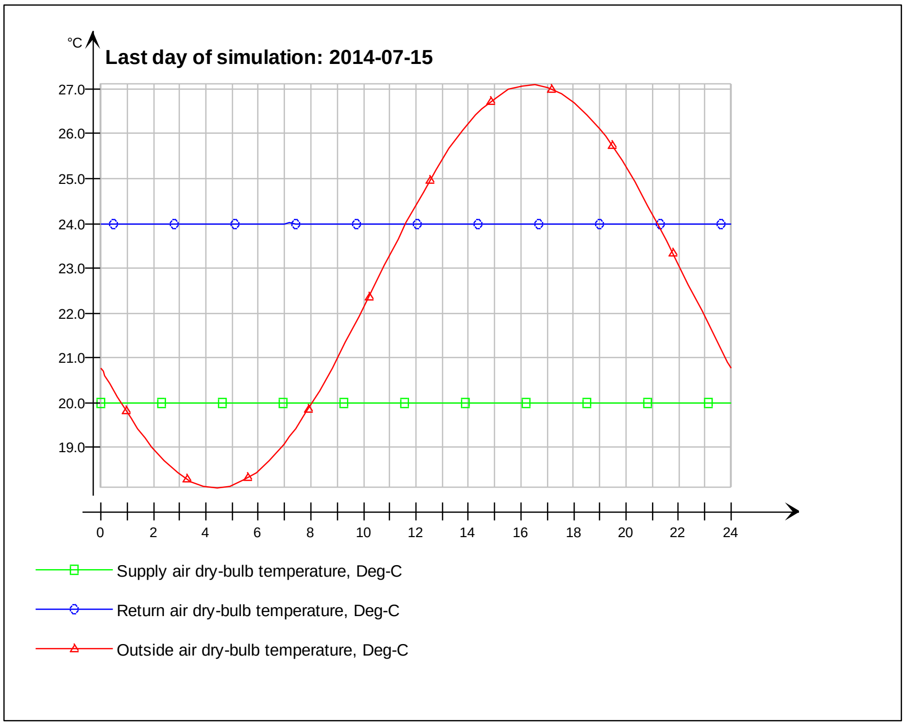
ANNEXES

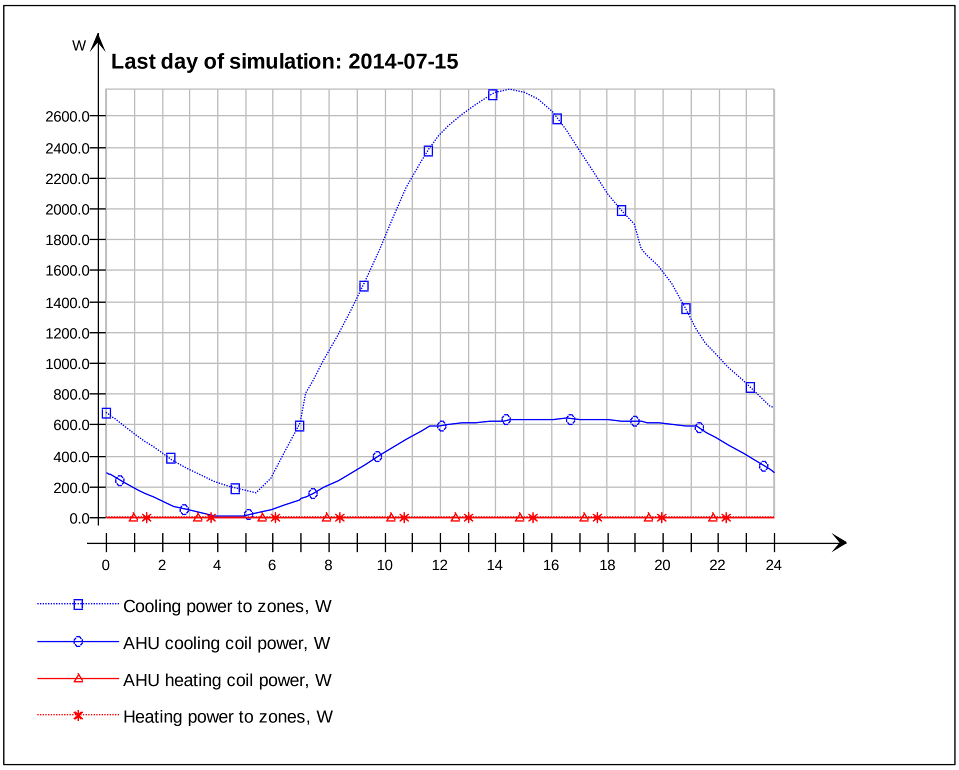
ProClim cooling data

Zone 1

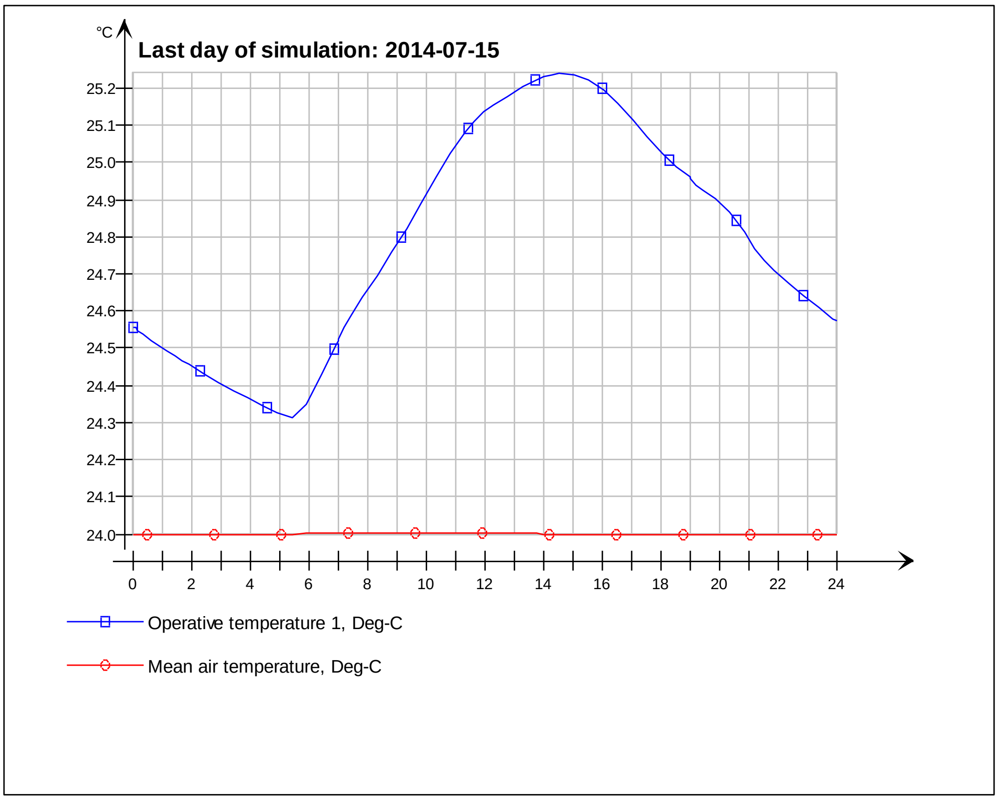
AHU temperatures



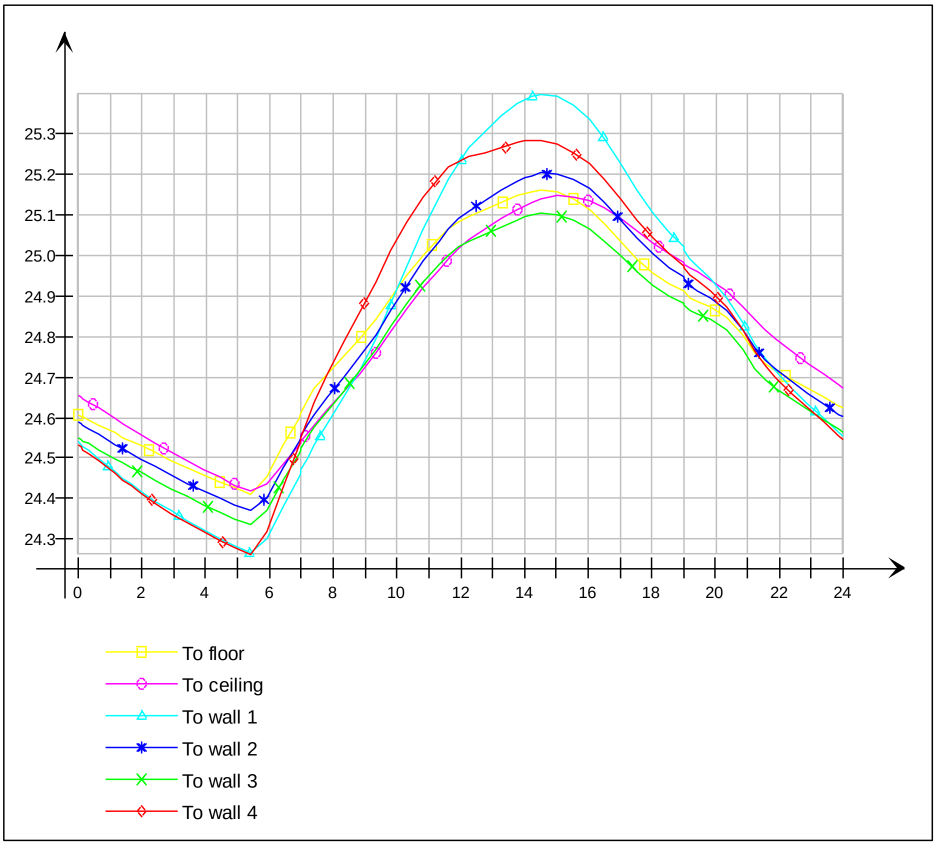
Power supplied by plant



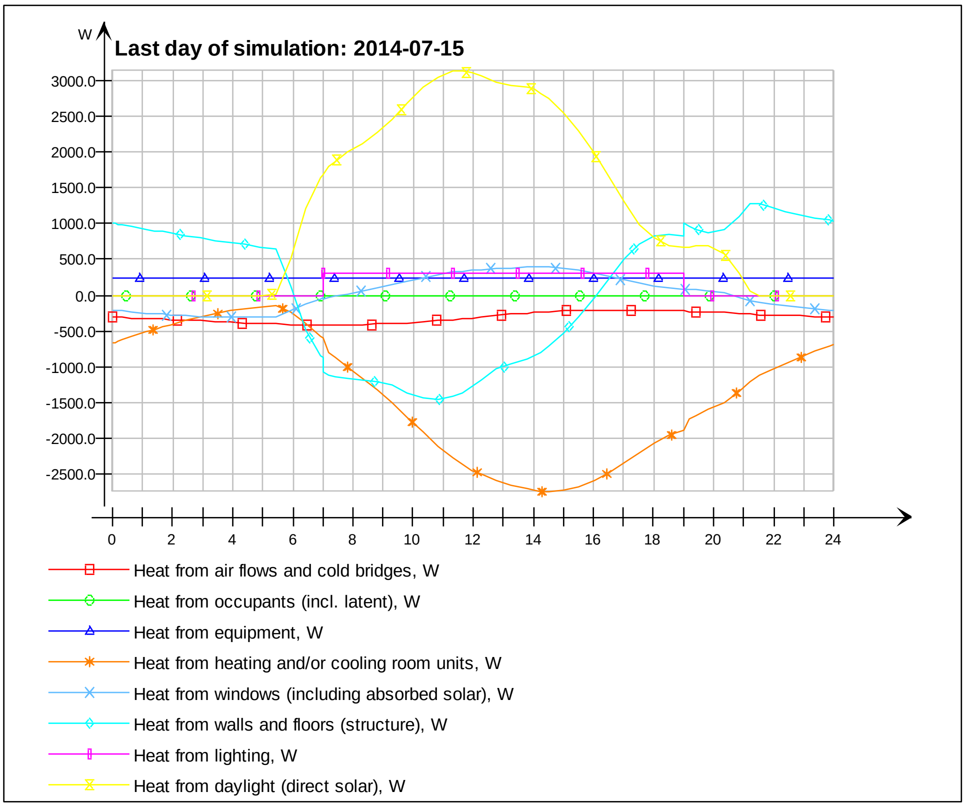
Main temperatures



Directed operative temperatures

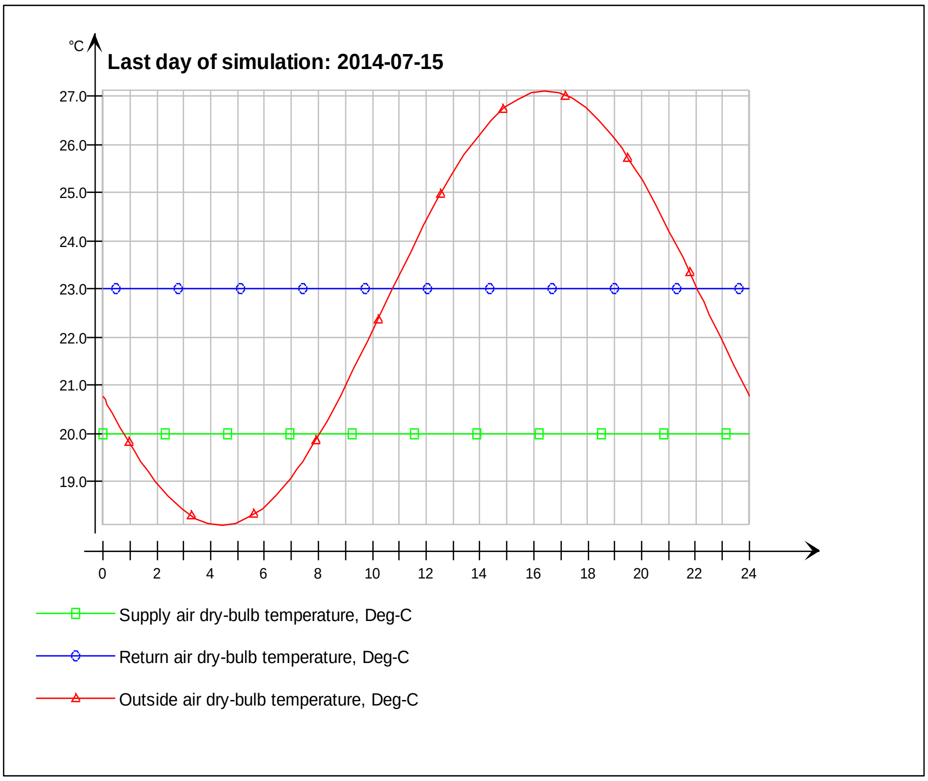


Heat balance



Zone 2

AHU temperatures



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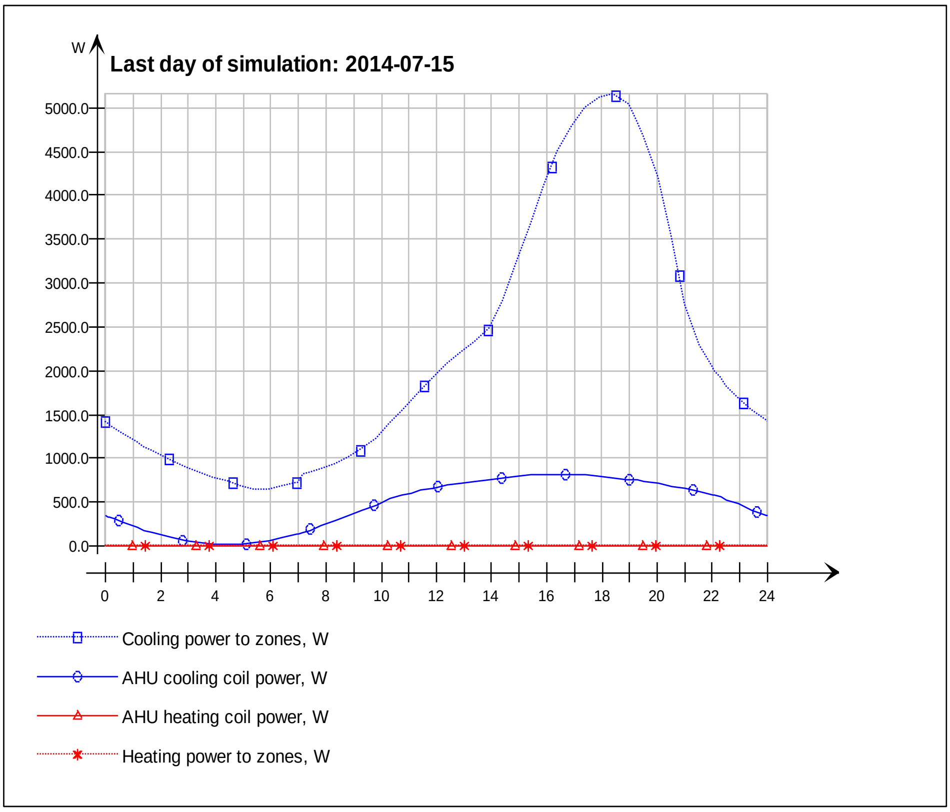

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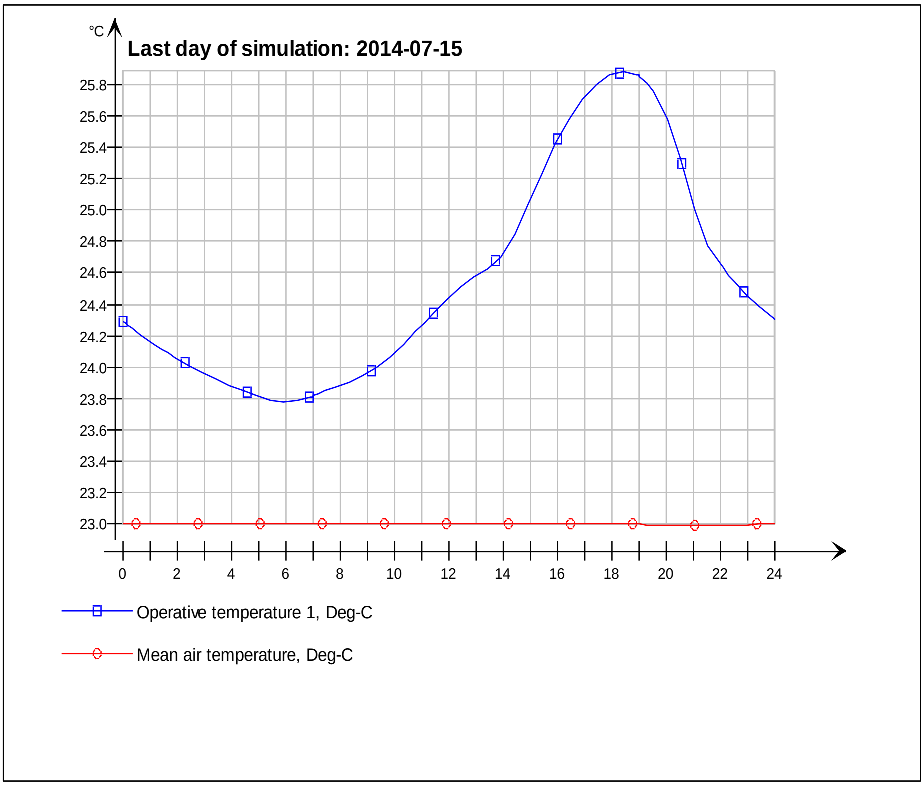

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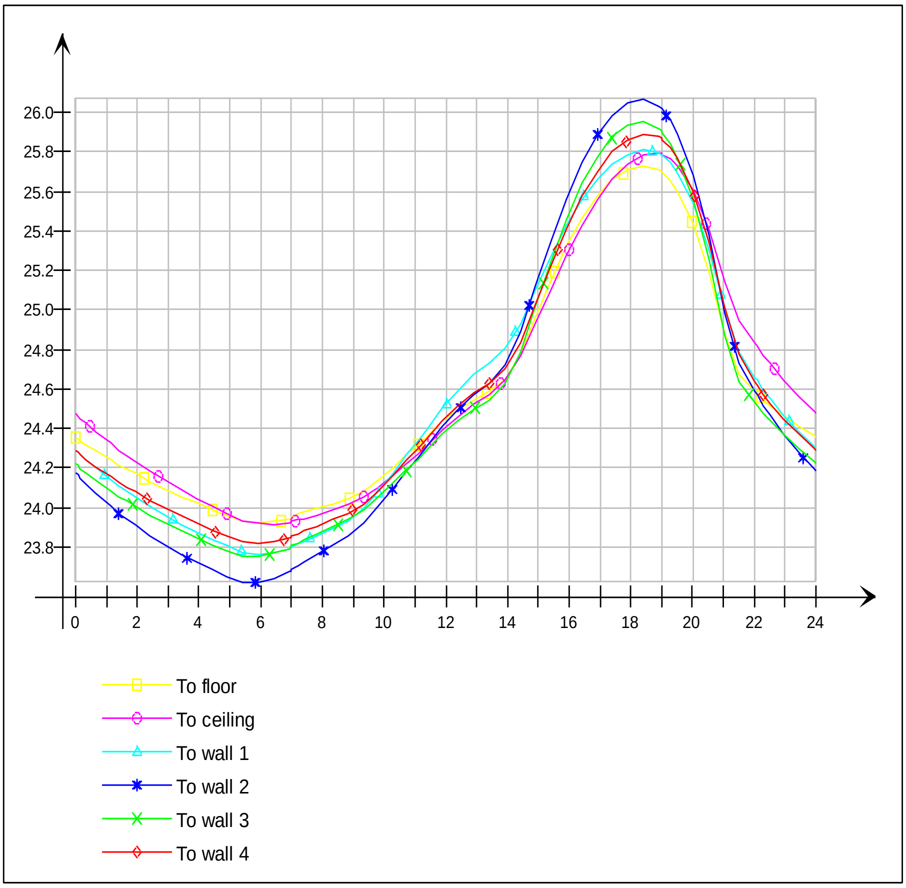

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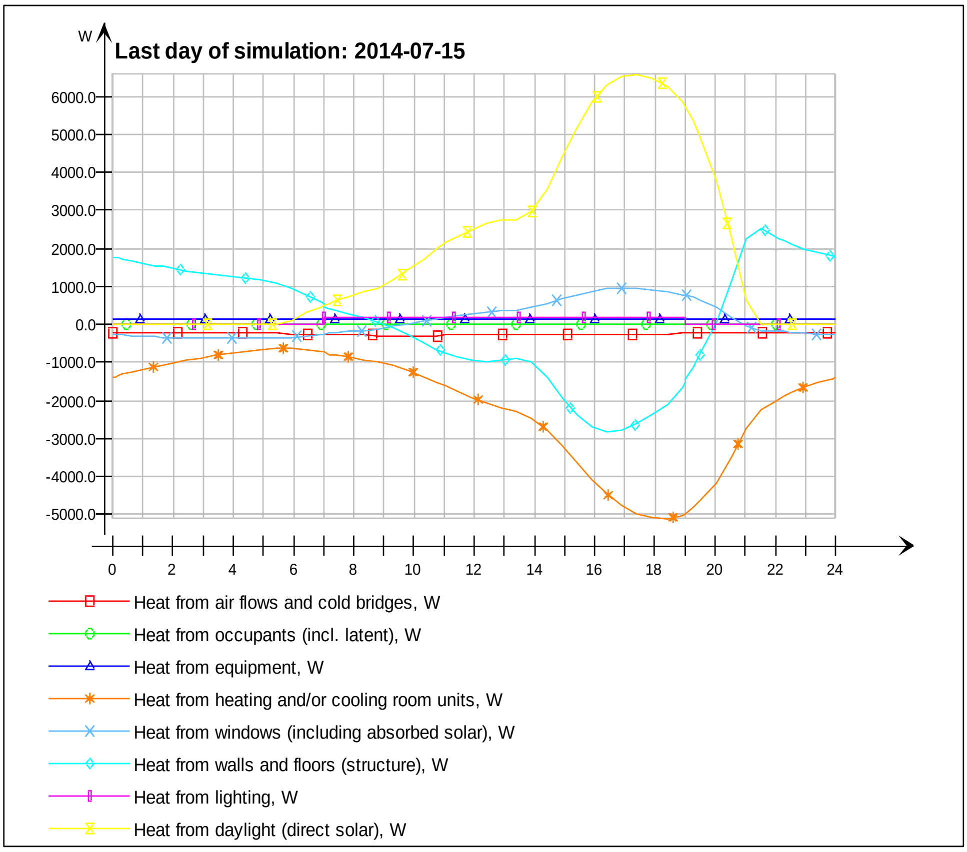
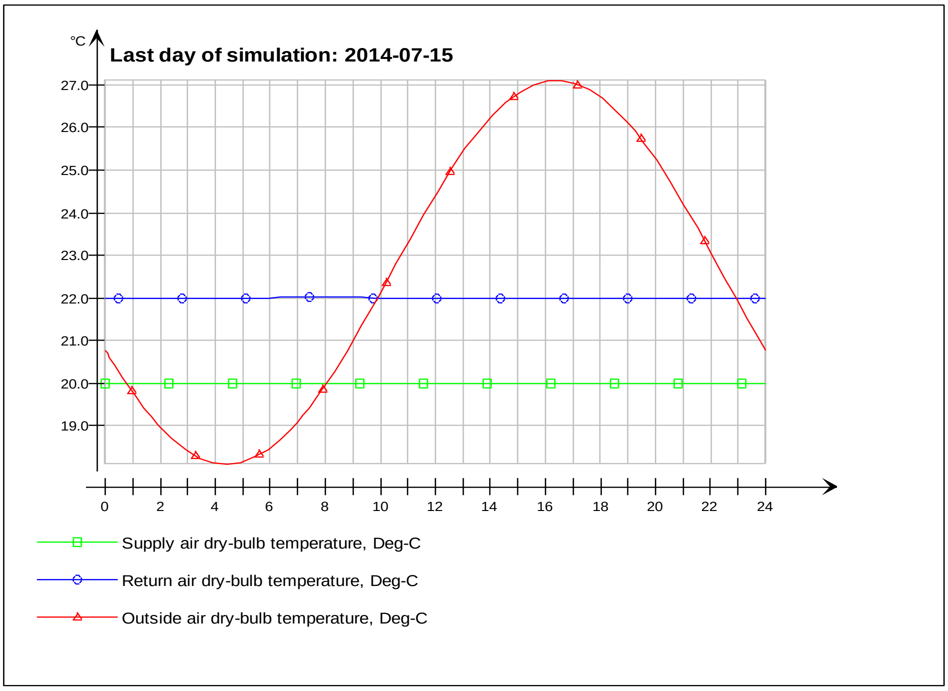


Zone 3

AHU temperatures



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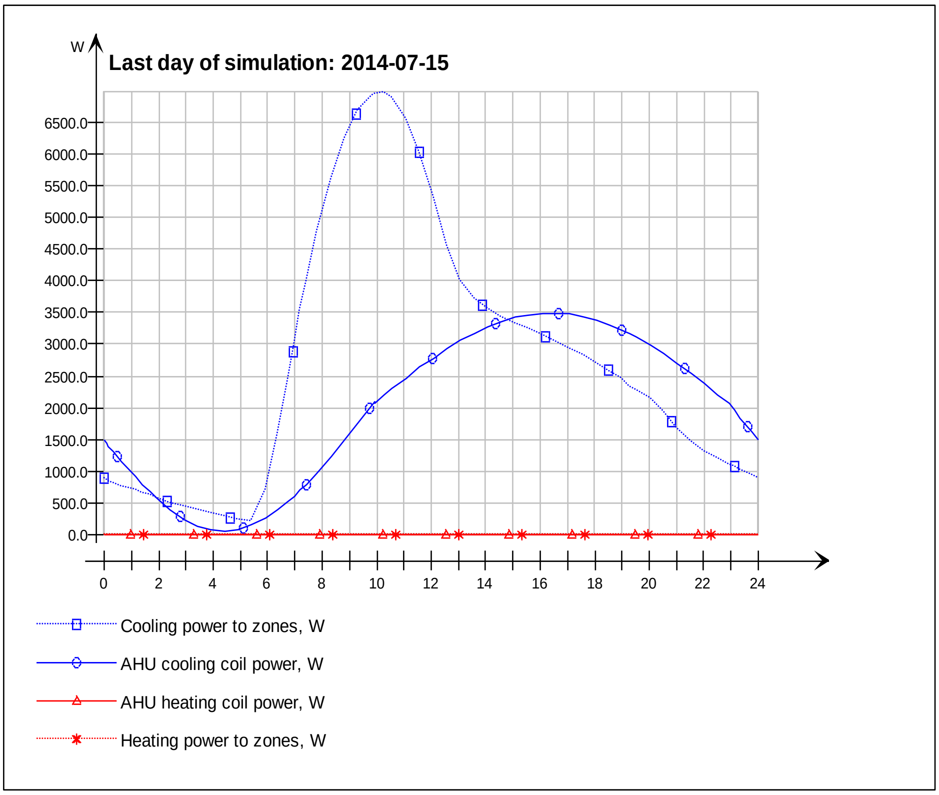

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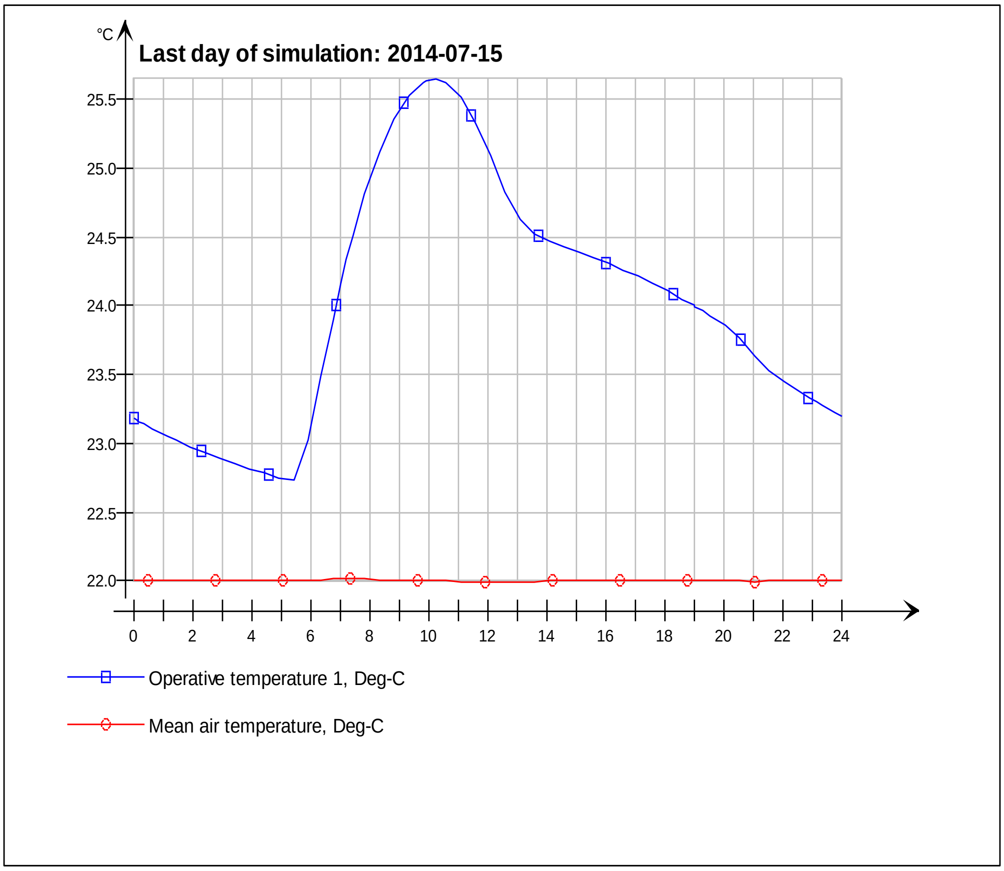

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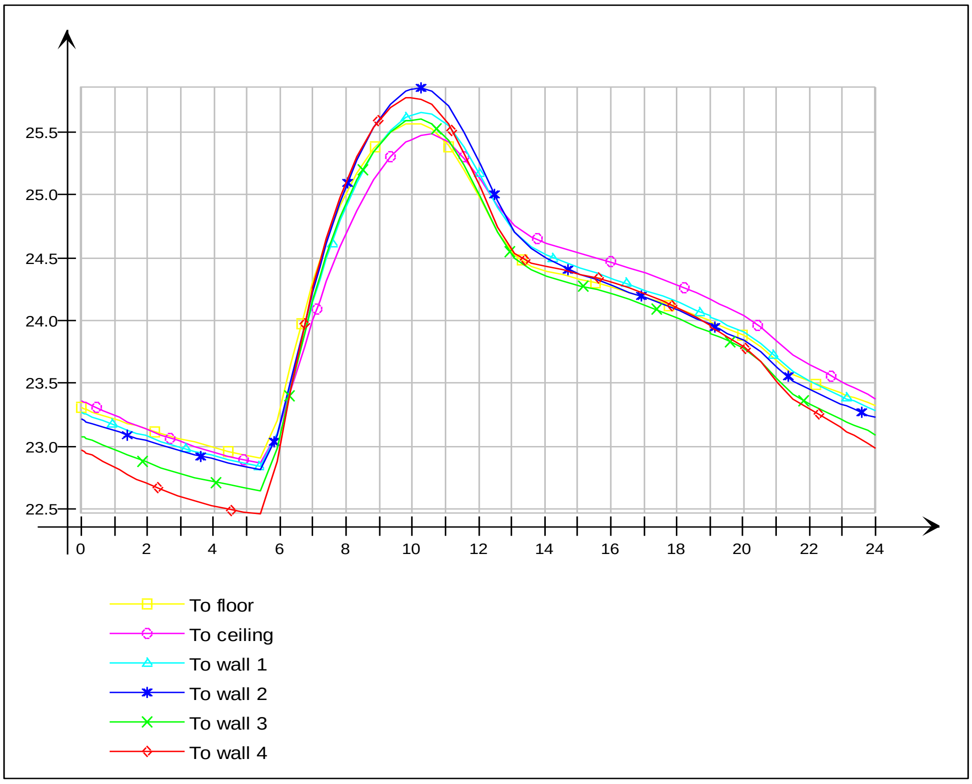
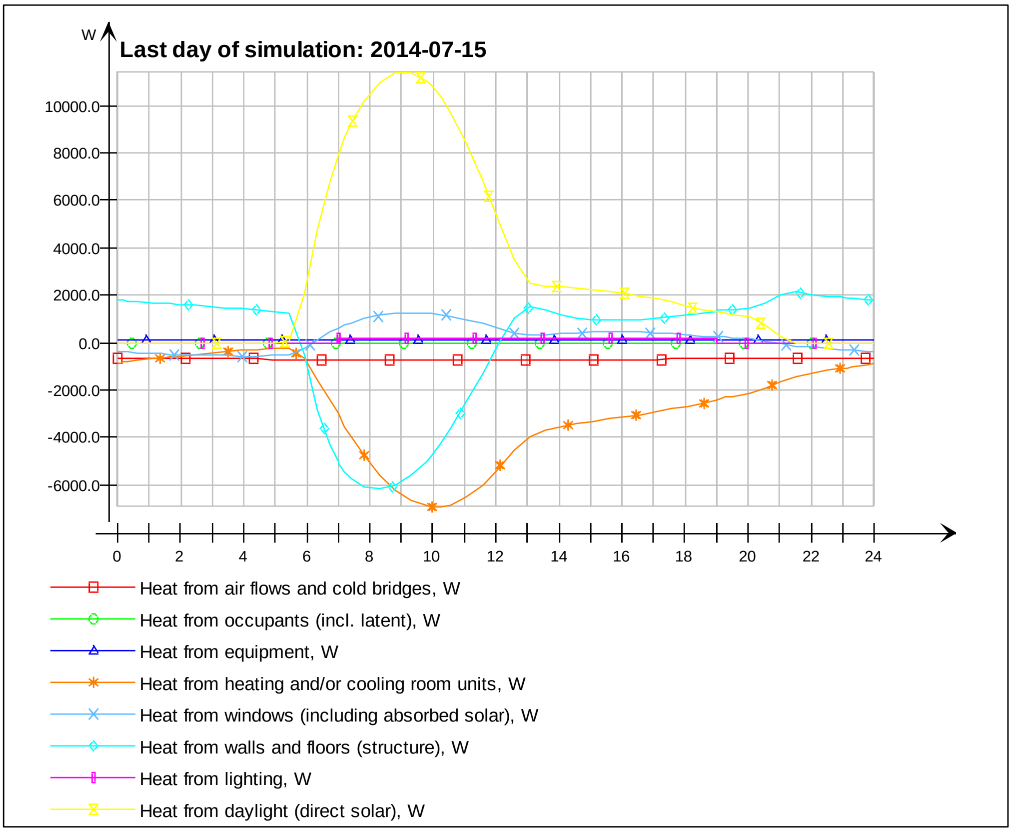
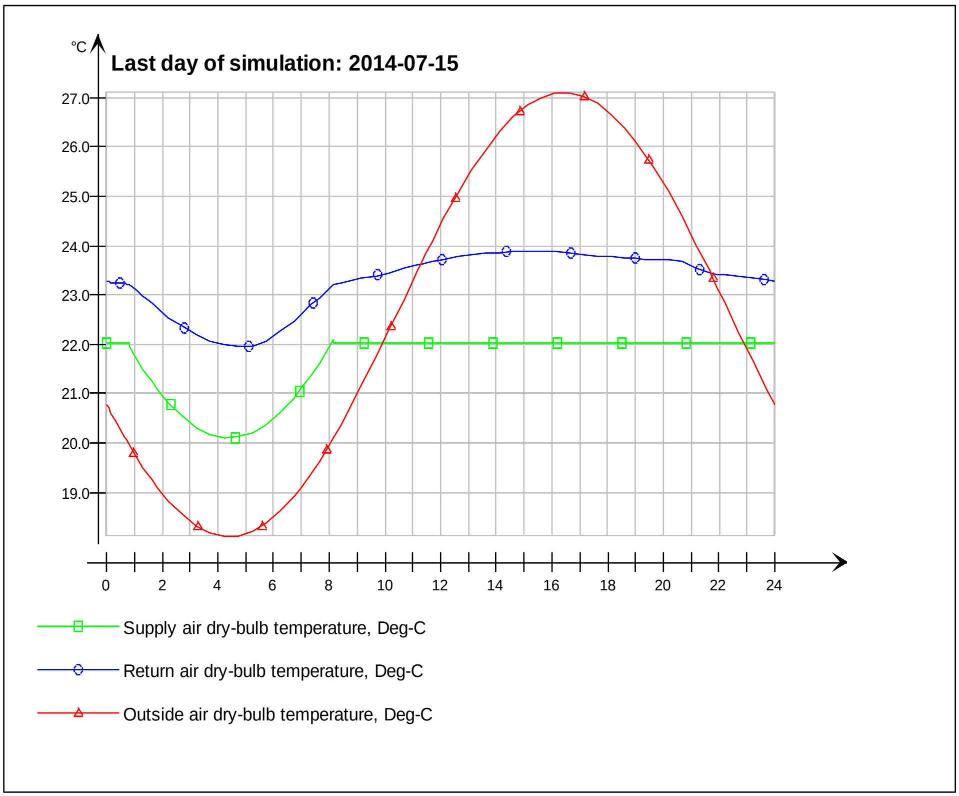


Heat balance



Zone 4

AHU temperatures



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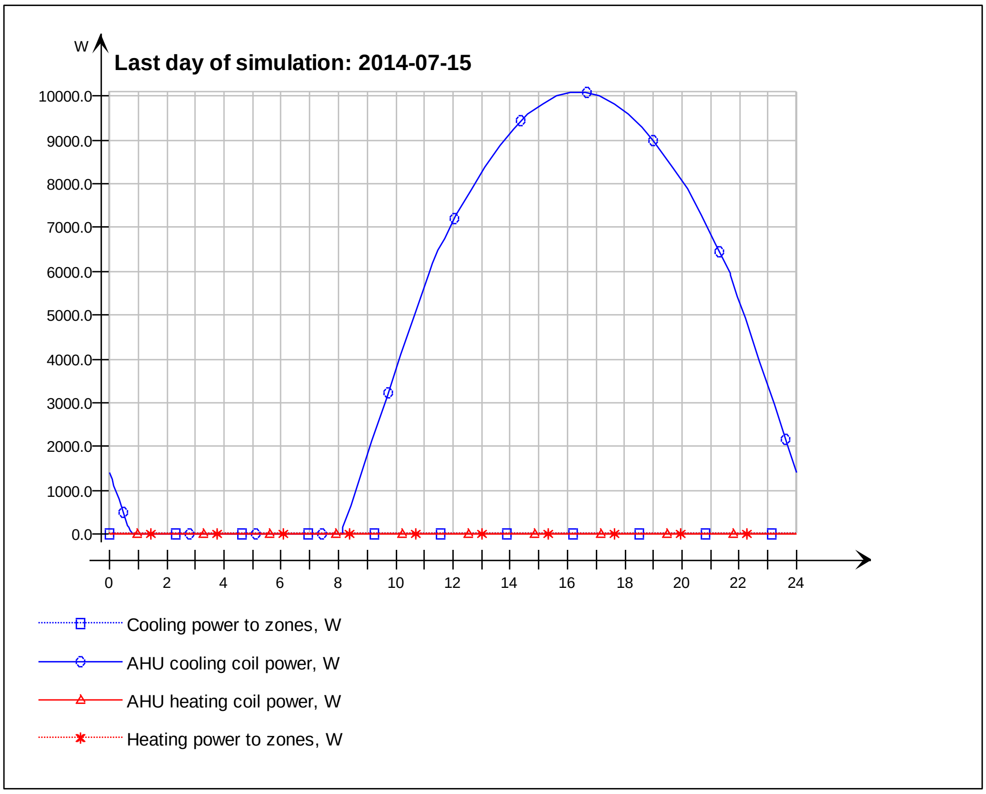
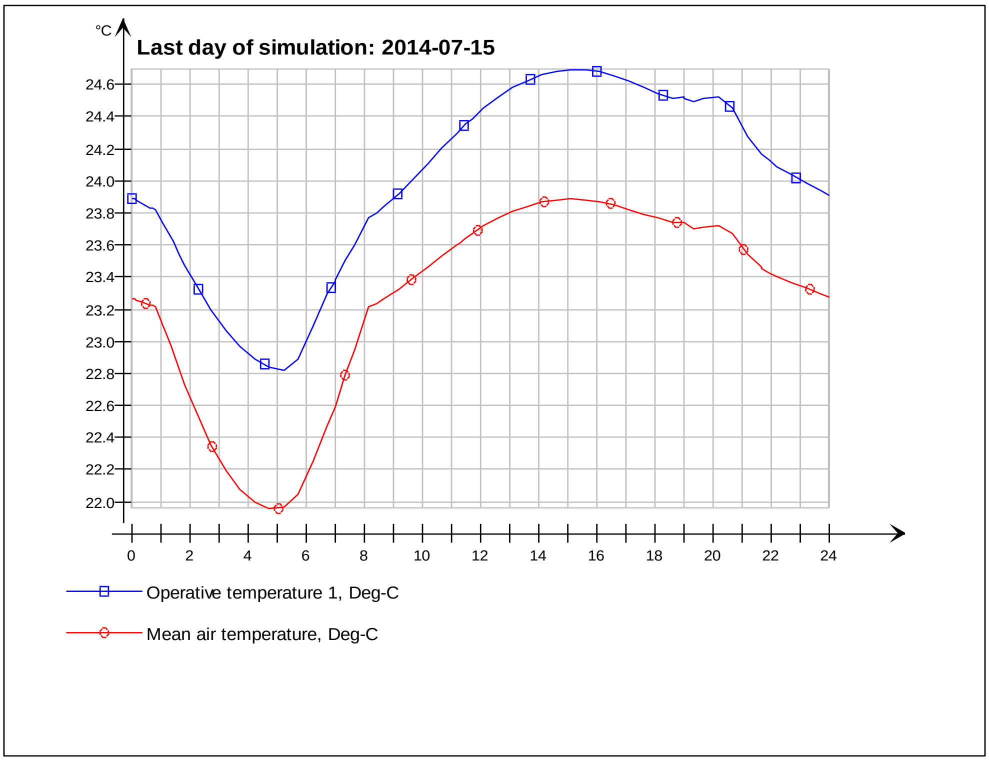


Main temperatures



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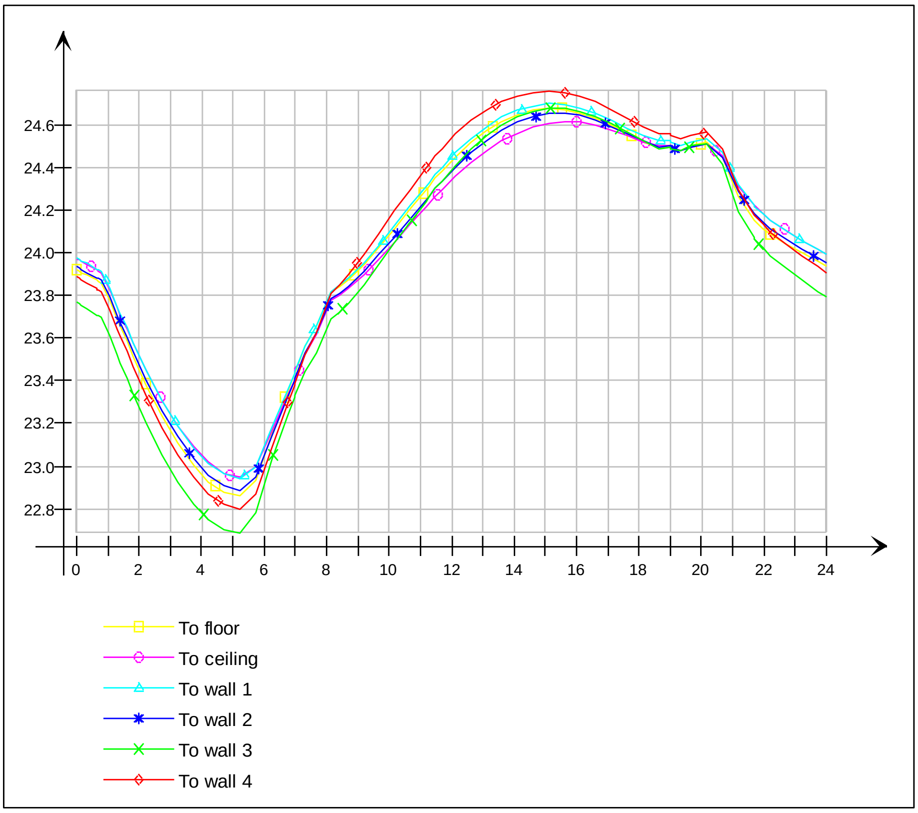

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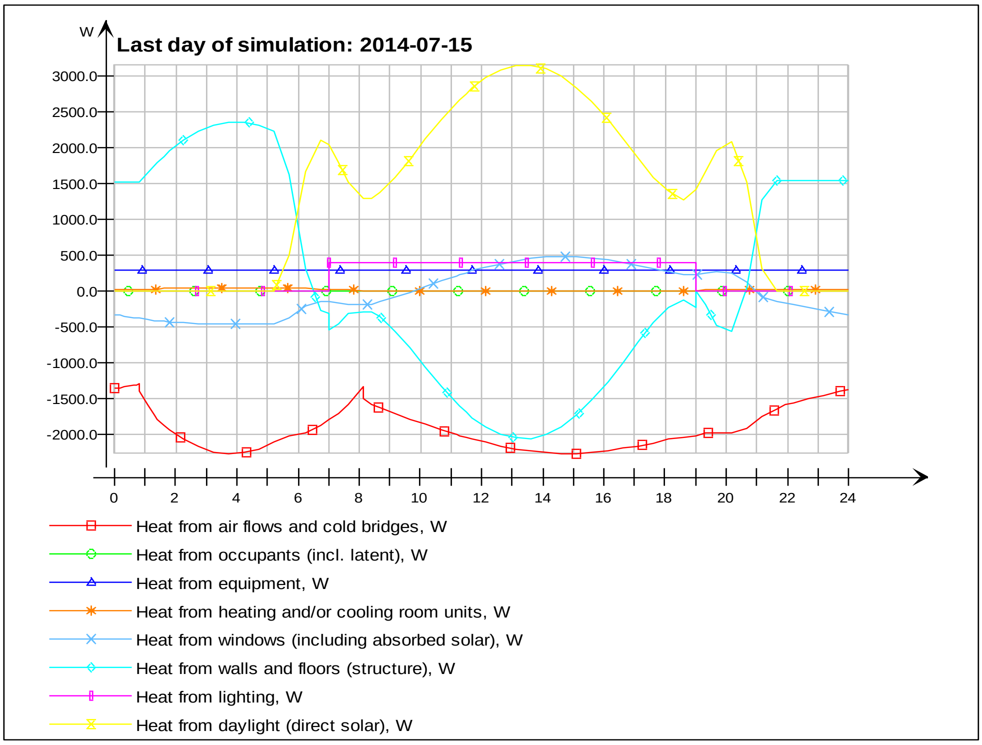
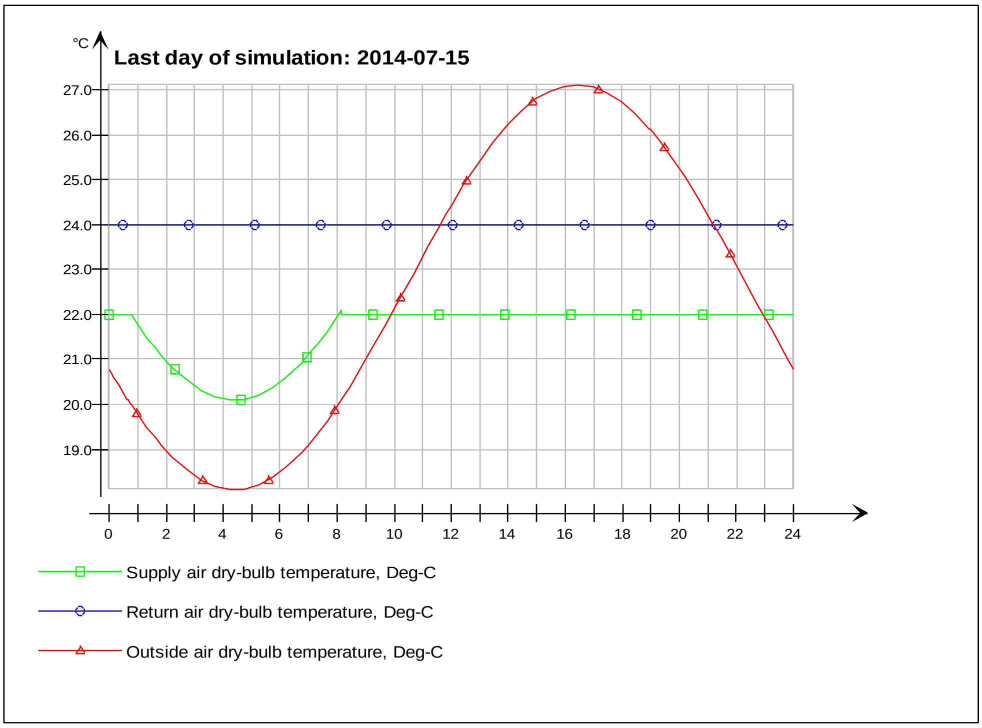


Zone 5

AHU temperatures



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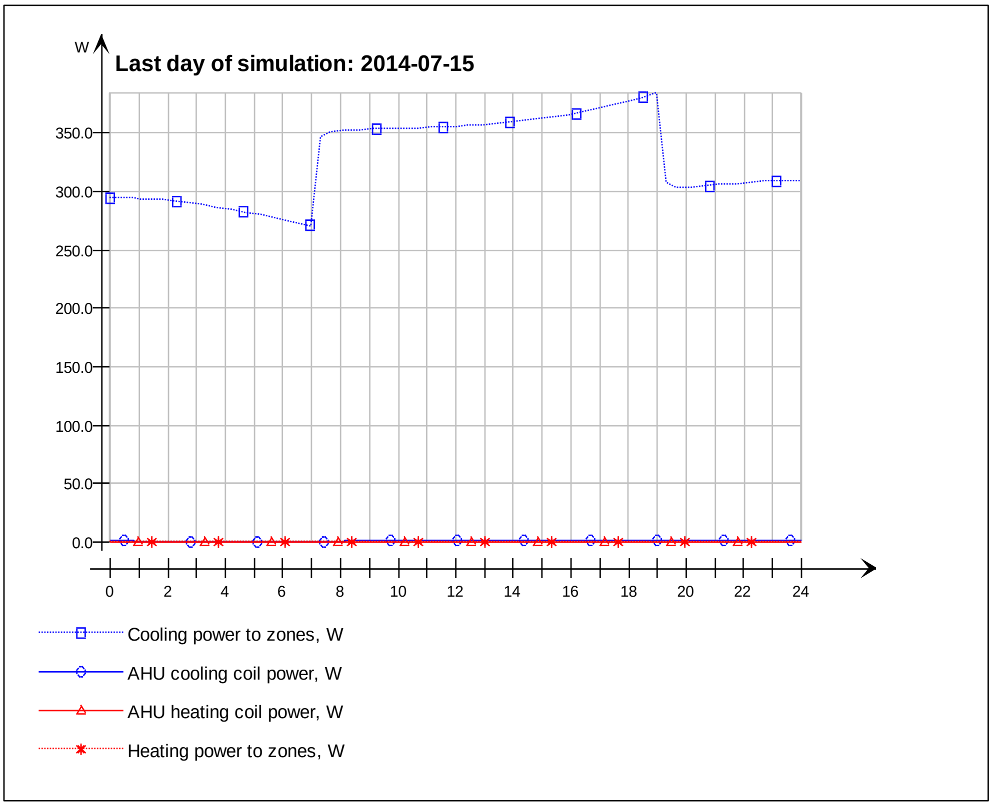
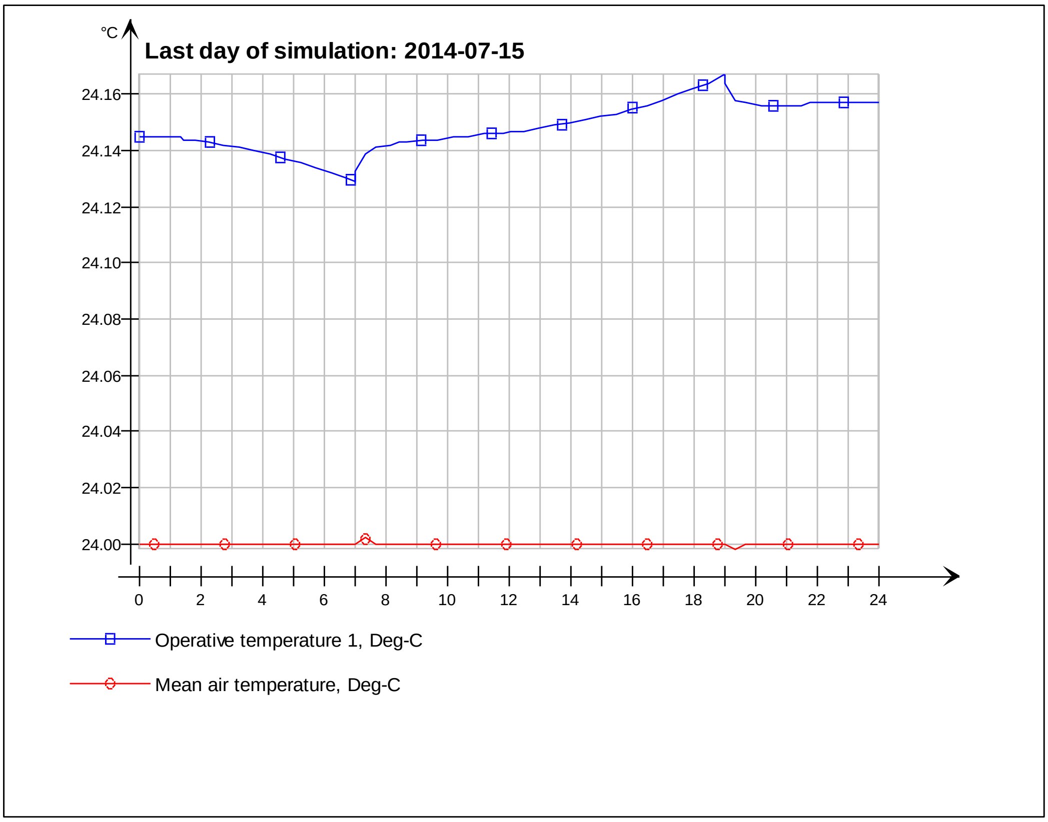
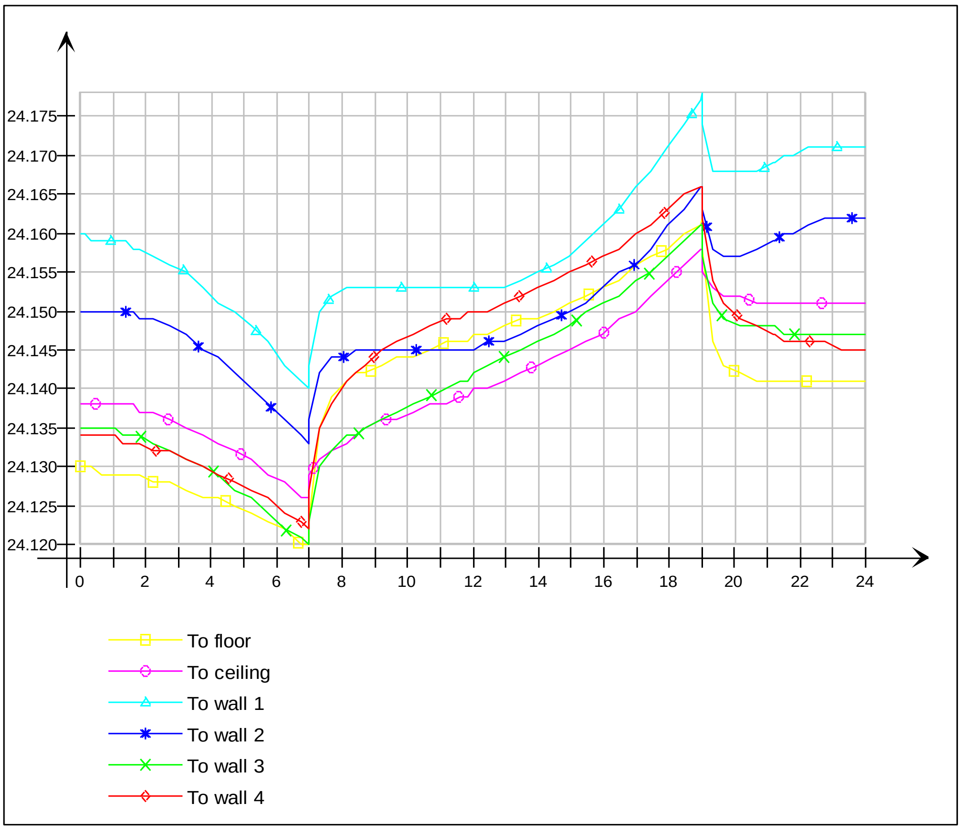


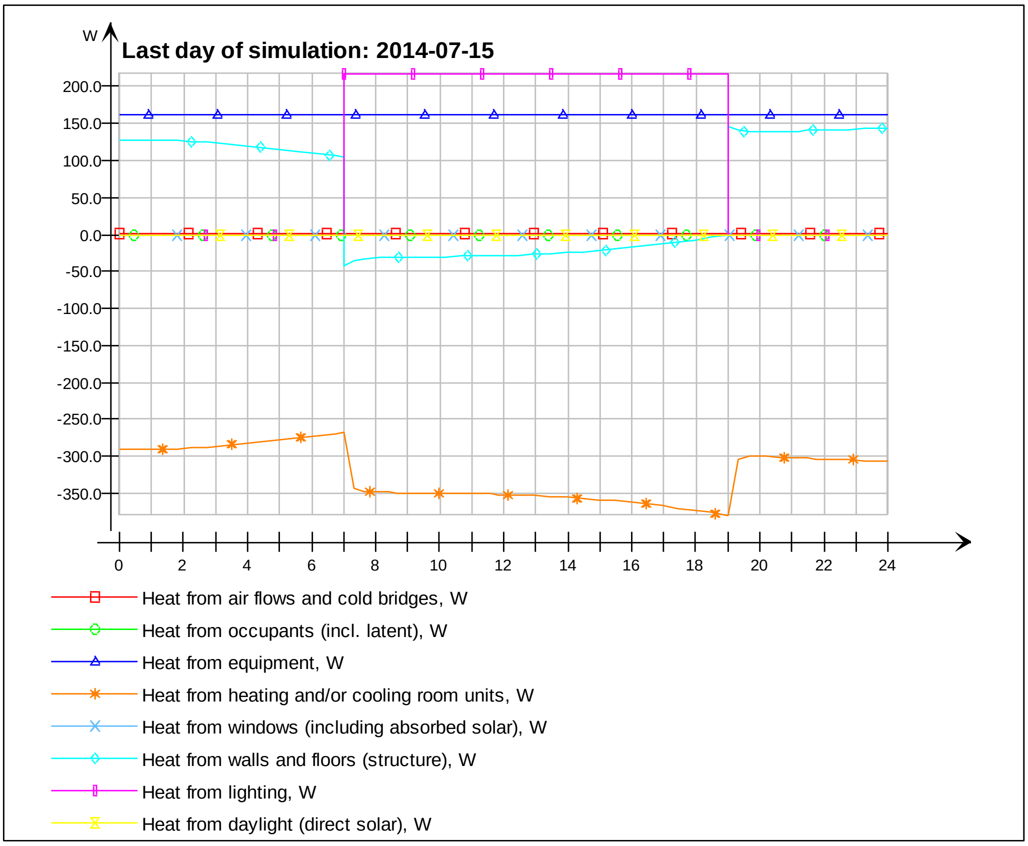
Main temperatures



Directed operative temperatures

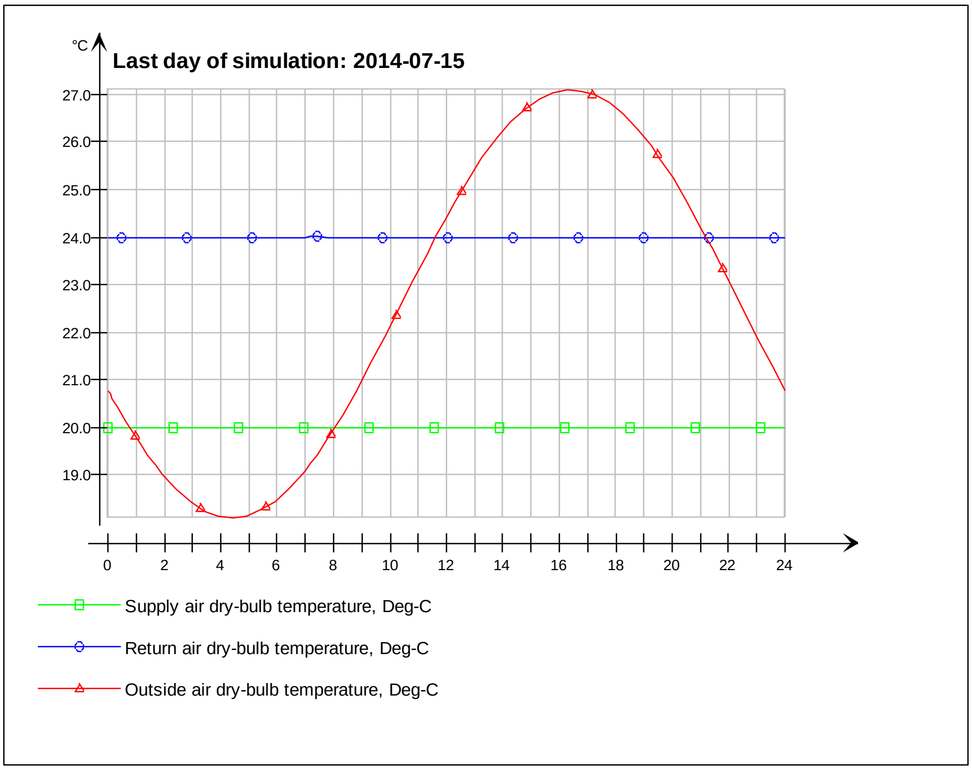


Heat balance



Zone 6

AHU temperatures



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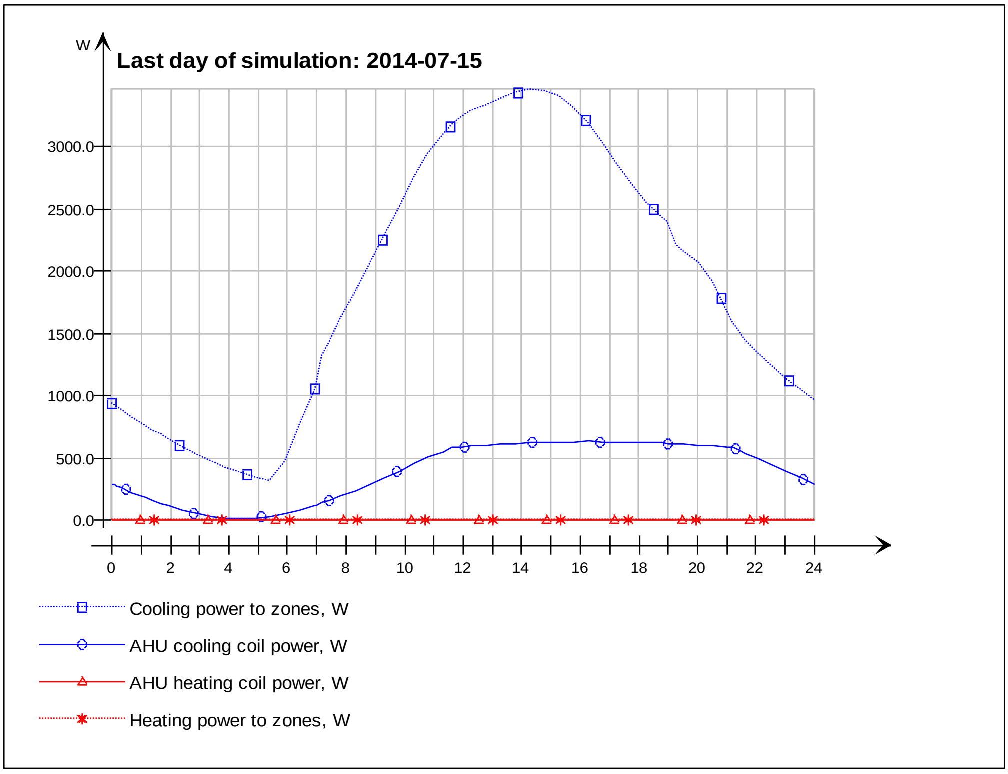
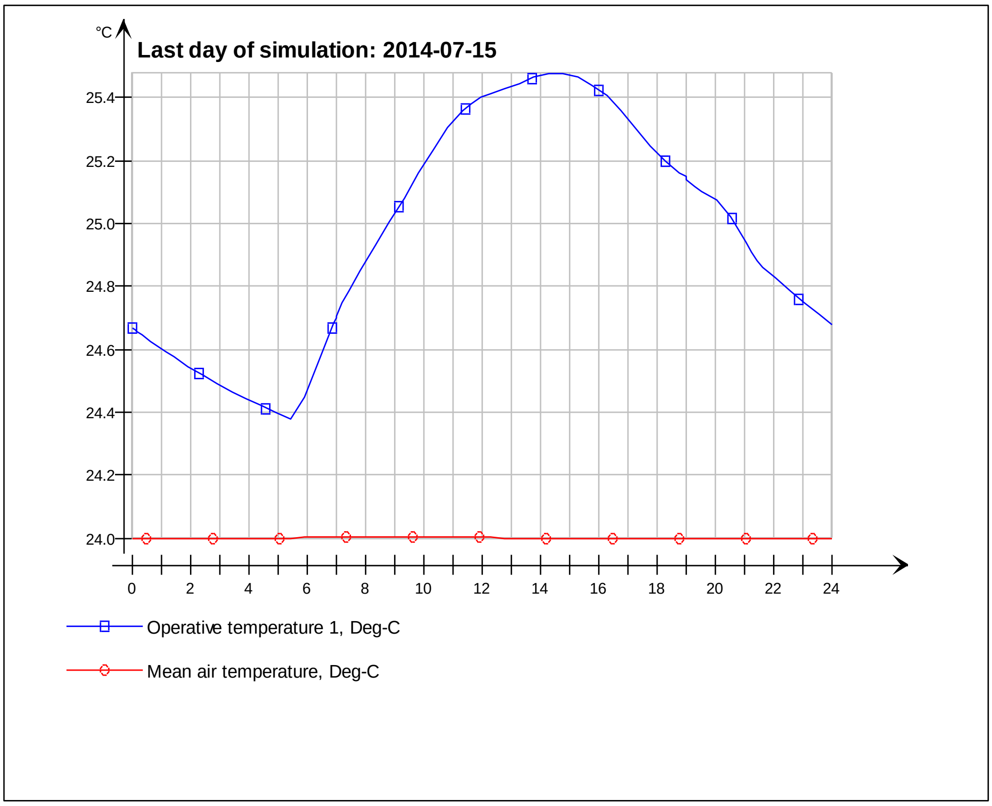
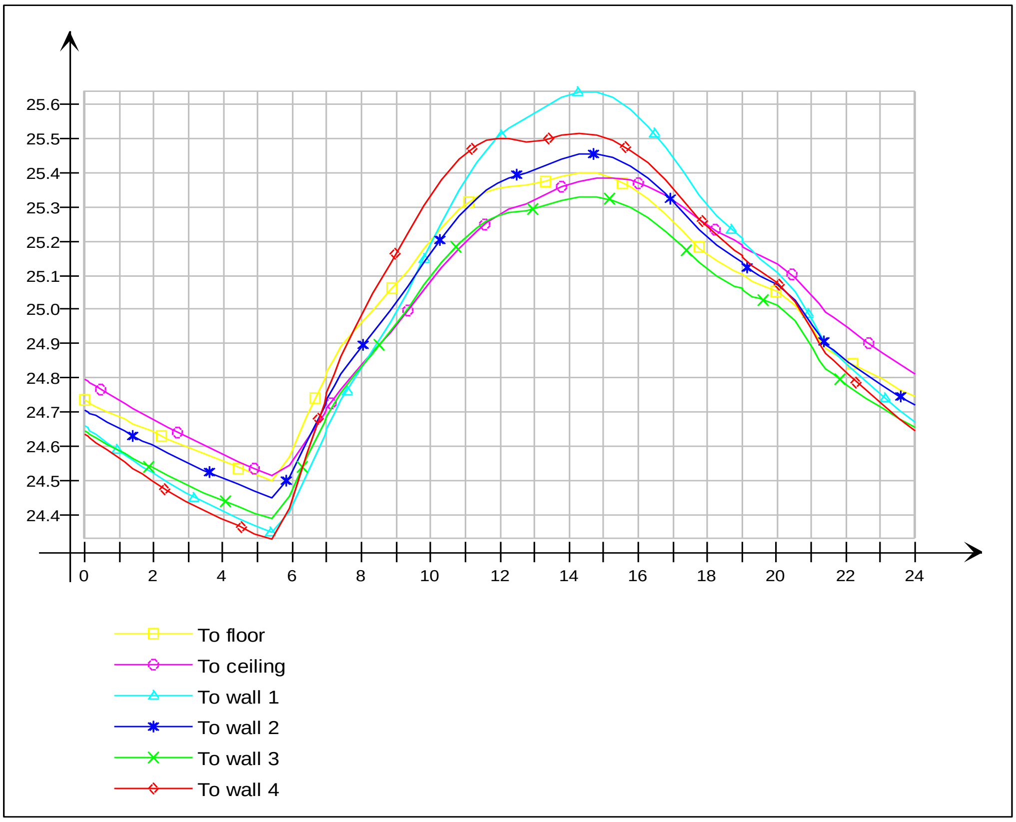


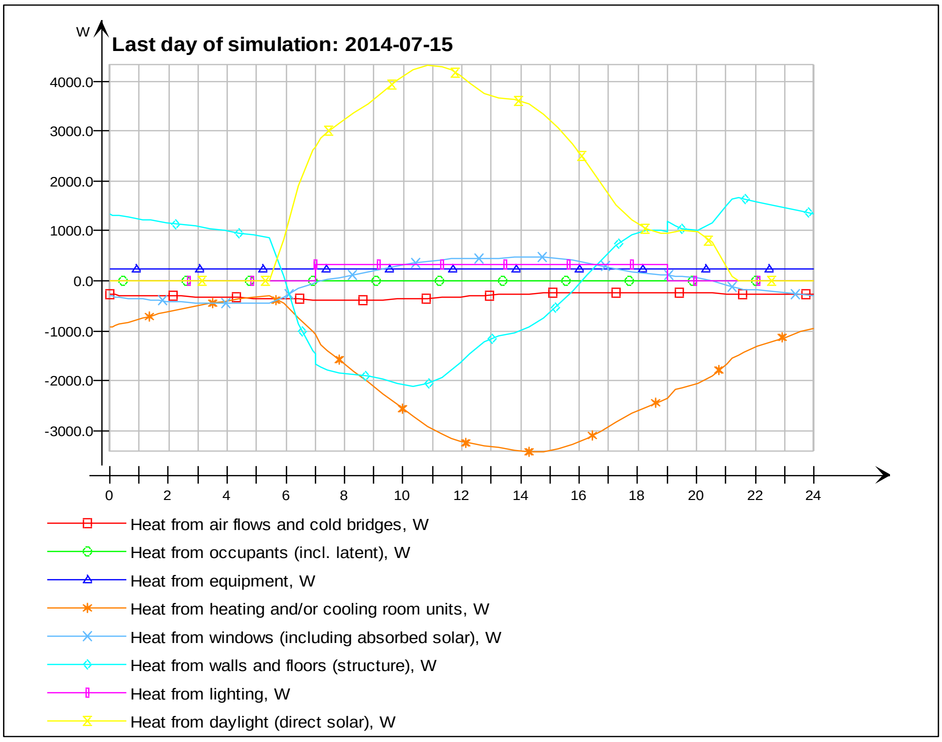
Main temperatures



Directed operative temperatures

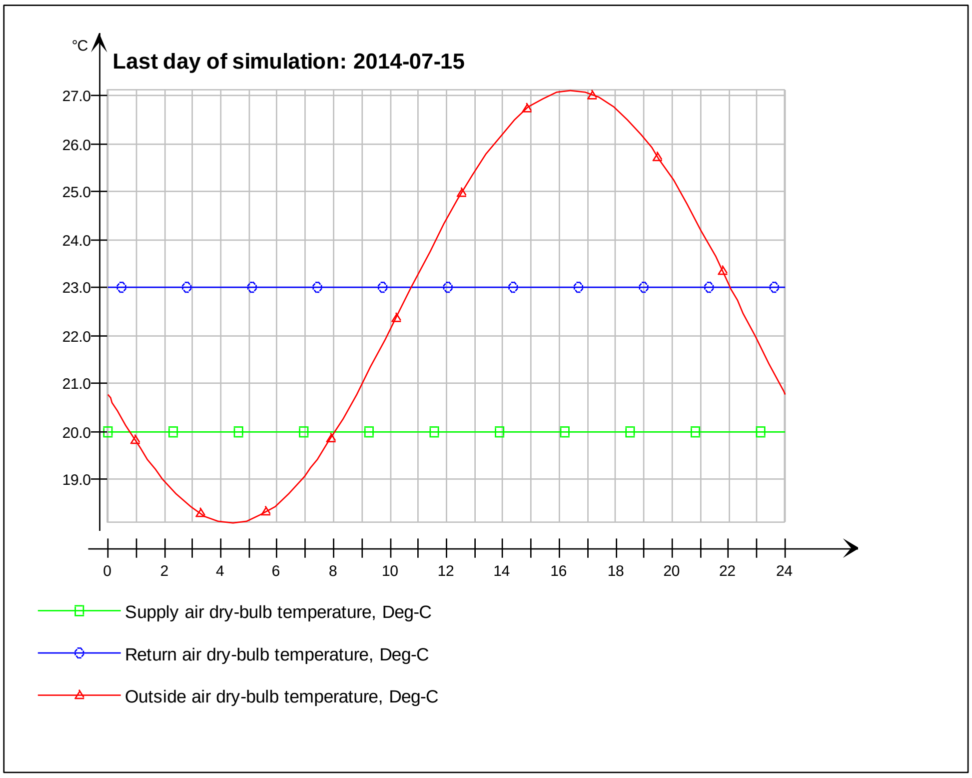


Heat balance

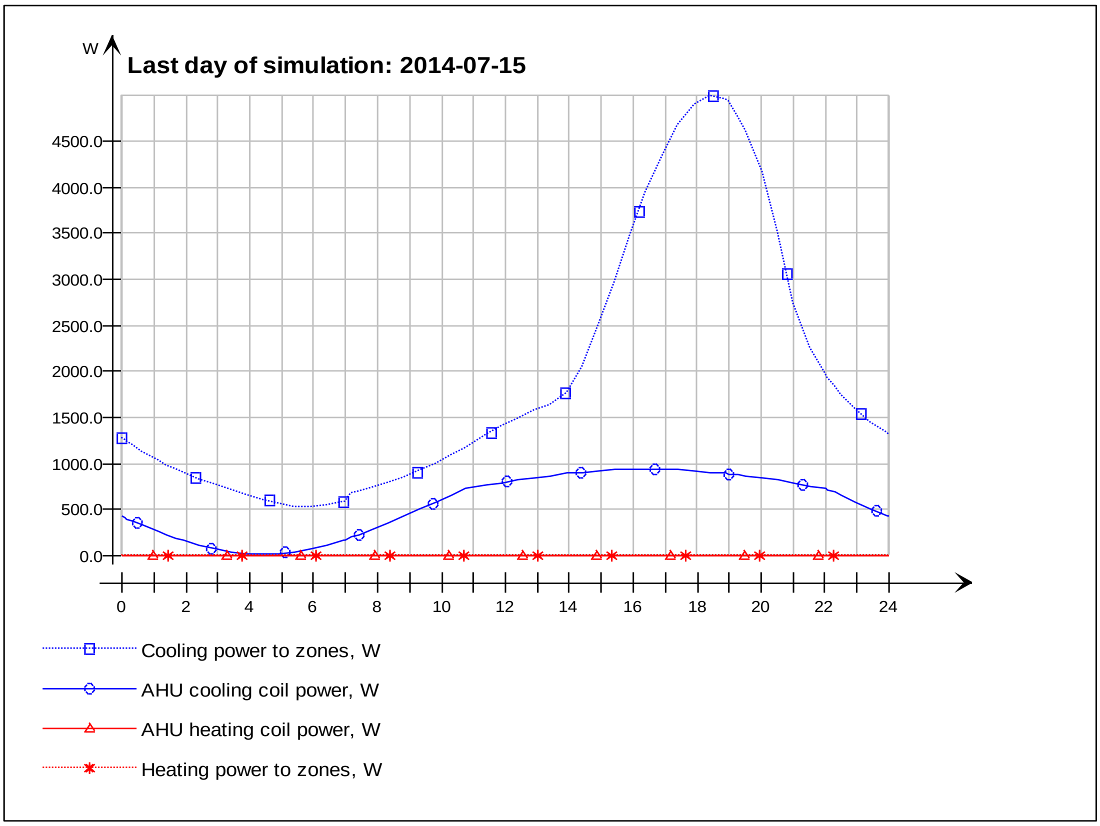


Zone 7

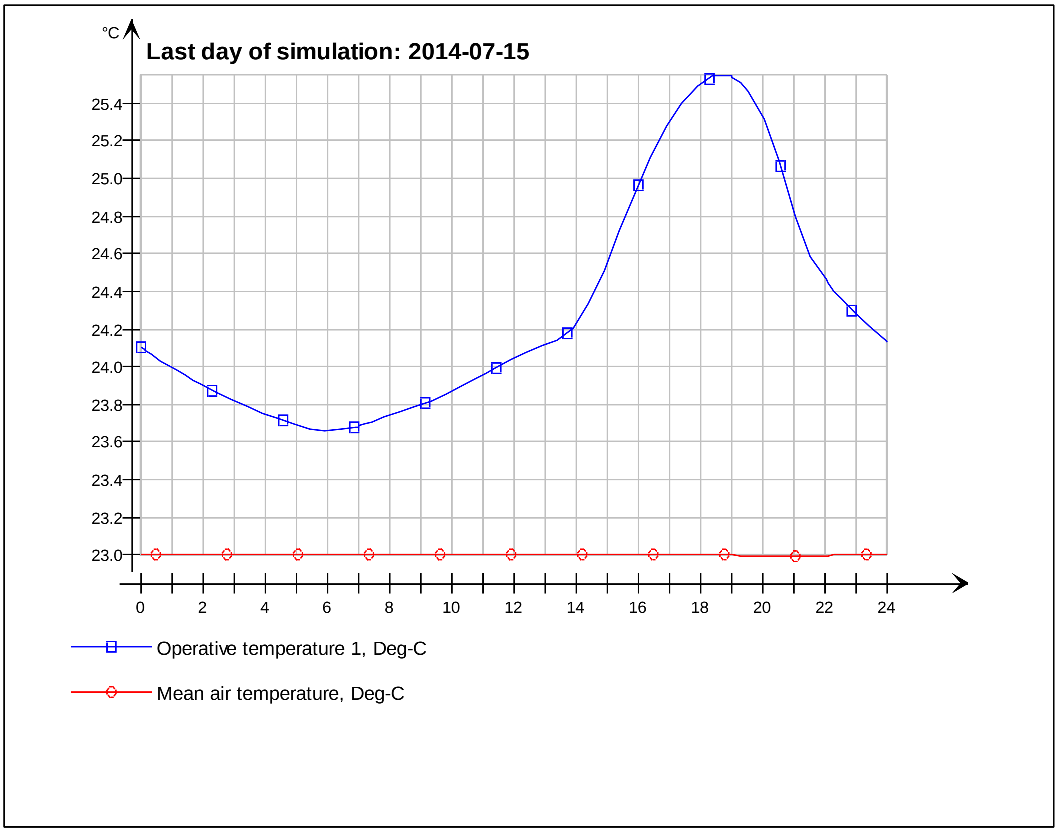
AHU temperatures



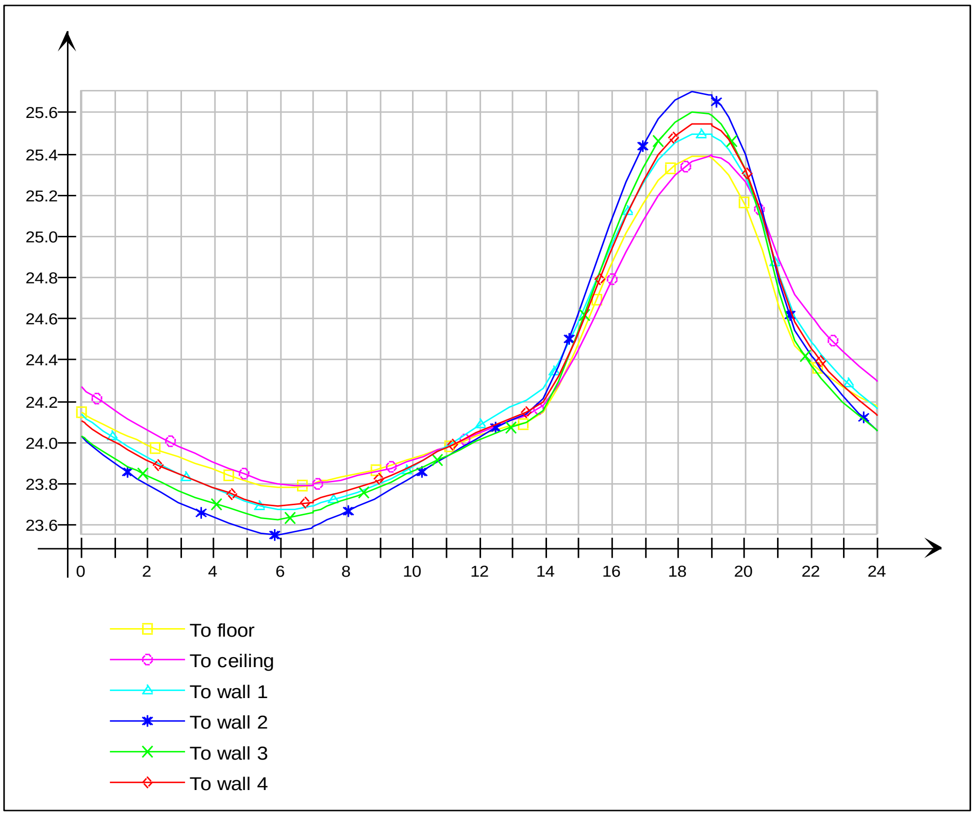
Power supplied by plant



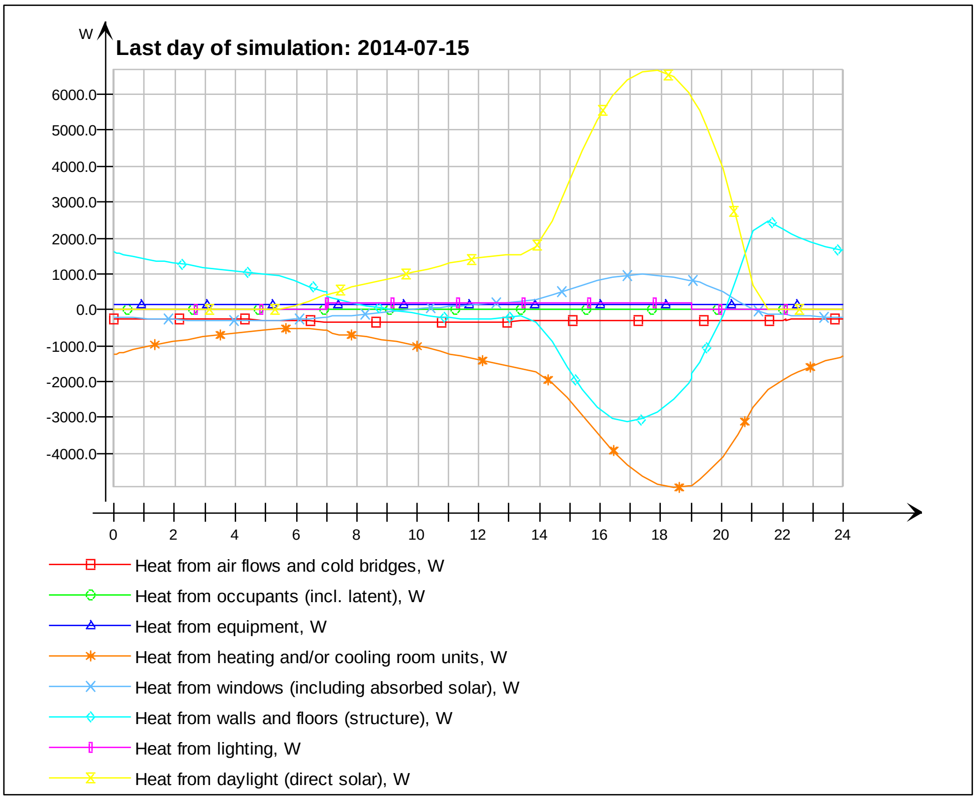
Main temperatures



Directed operative temperatures

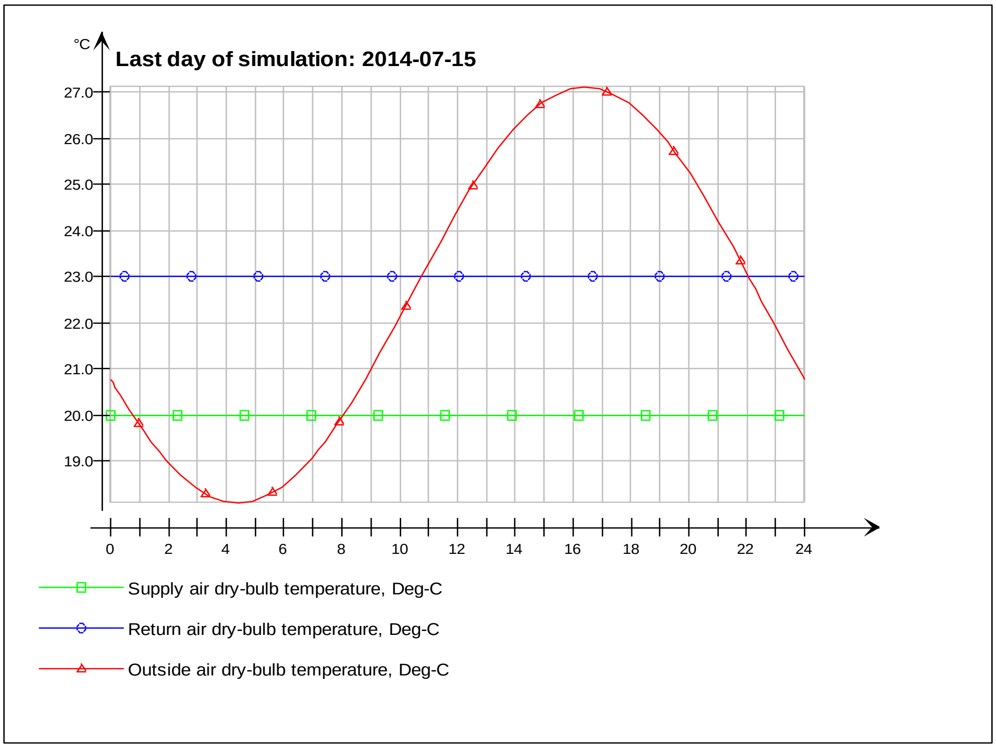


Heat balance

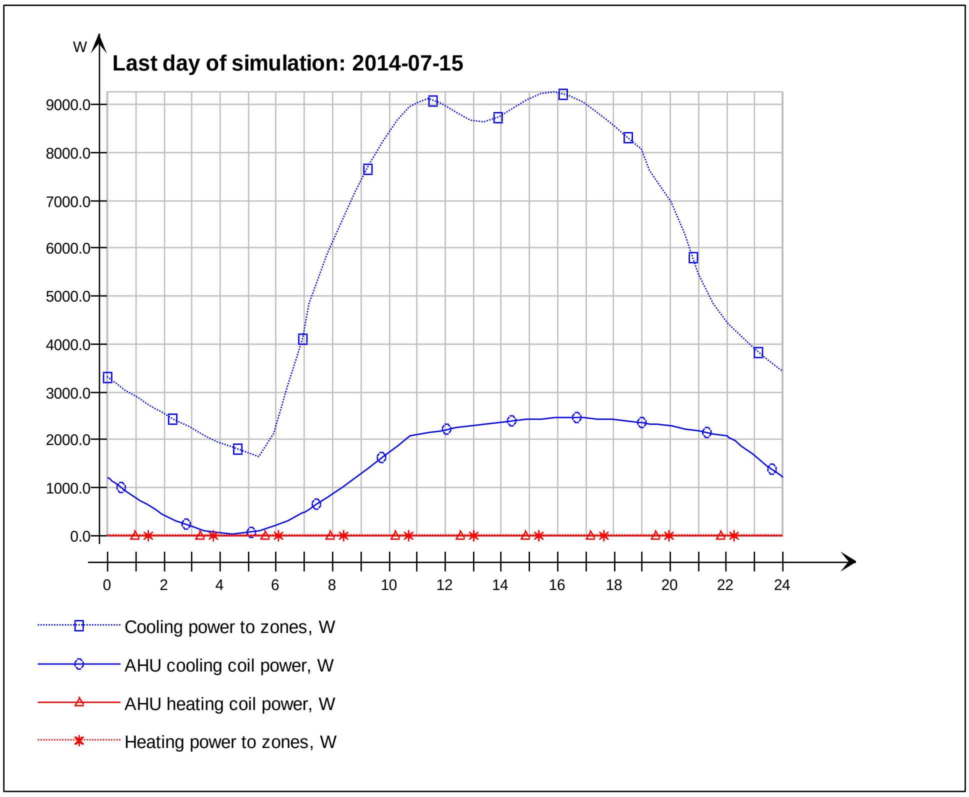


Zone 8

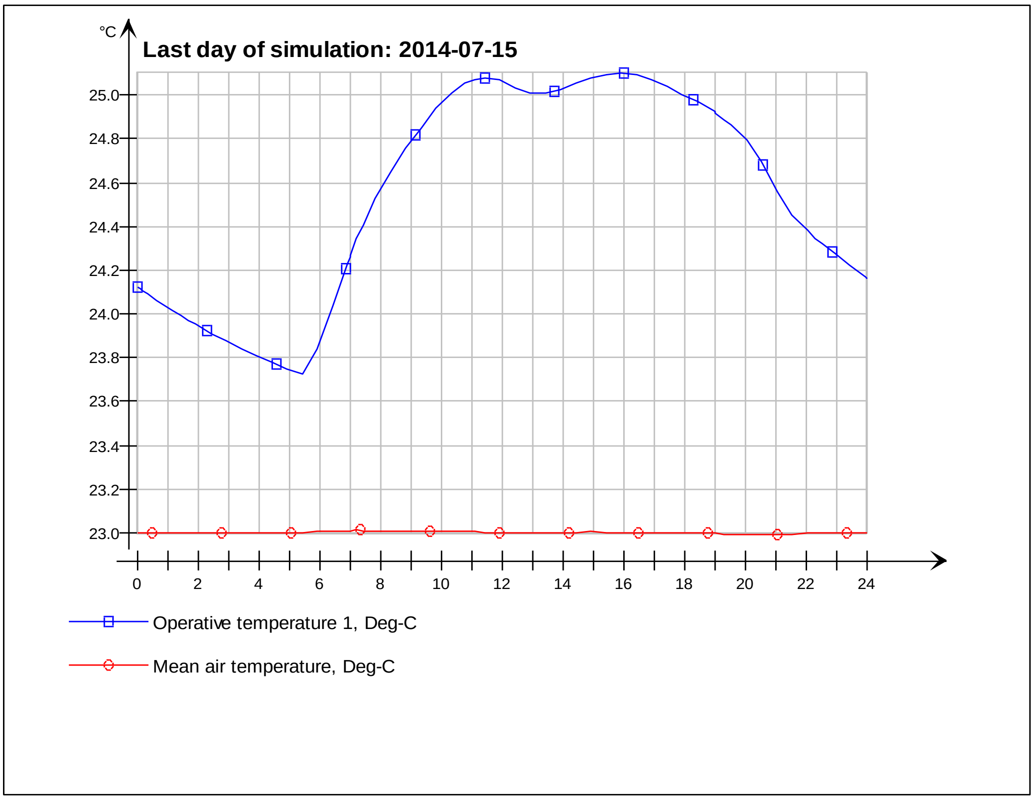
AHU temperatures



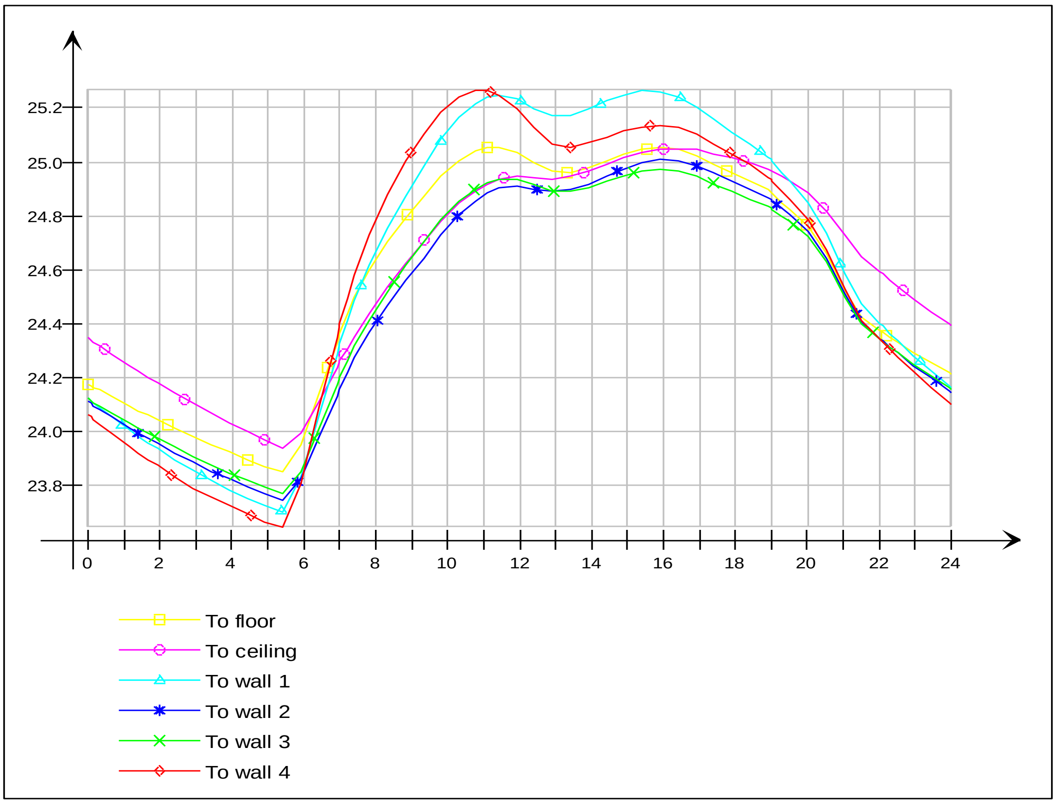
Power supplied by plant



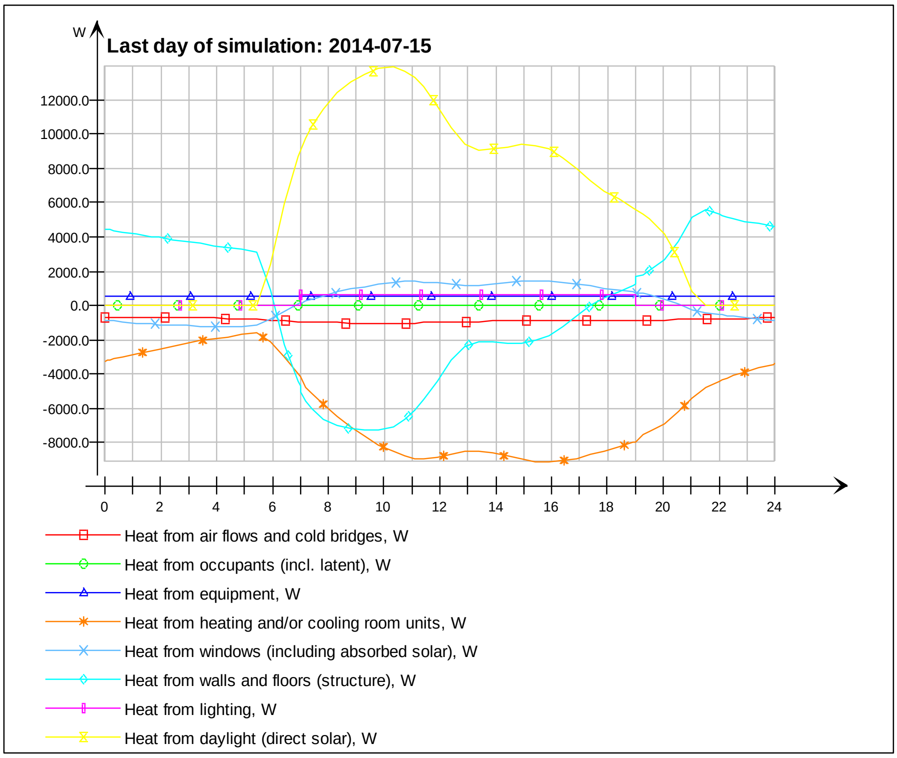
Main temperatures



Directed operative temperatures

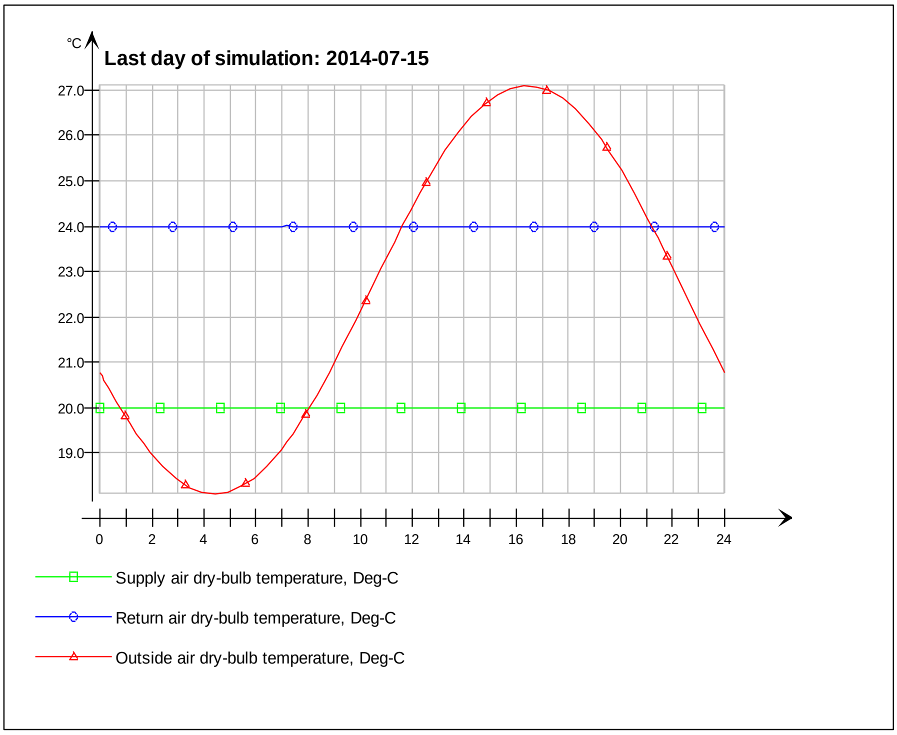


Heat balance

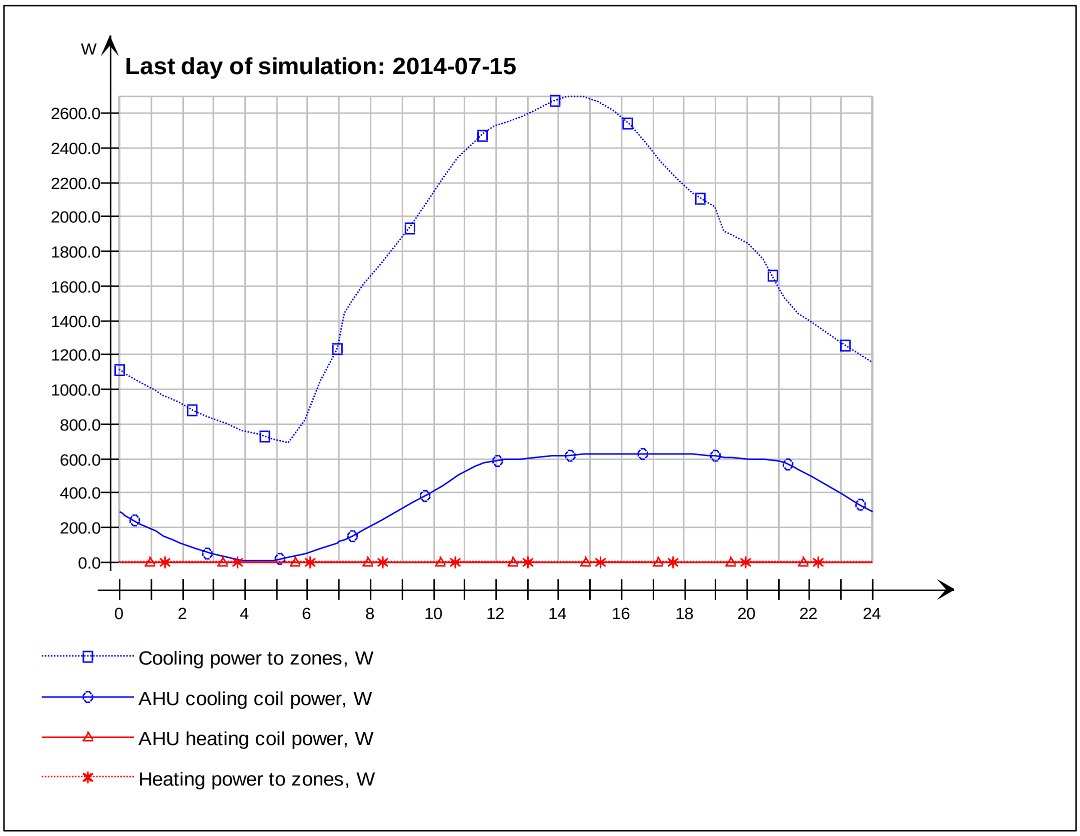


Zone 9

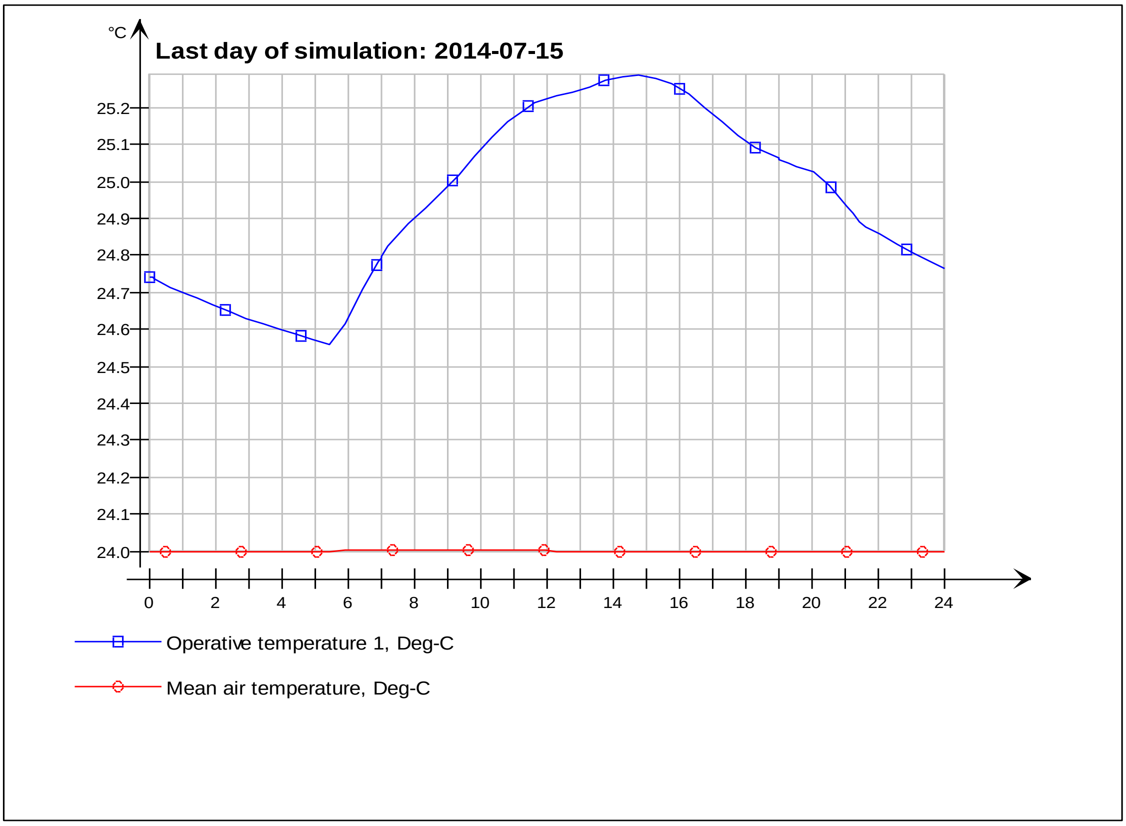
AHU temperatures



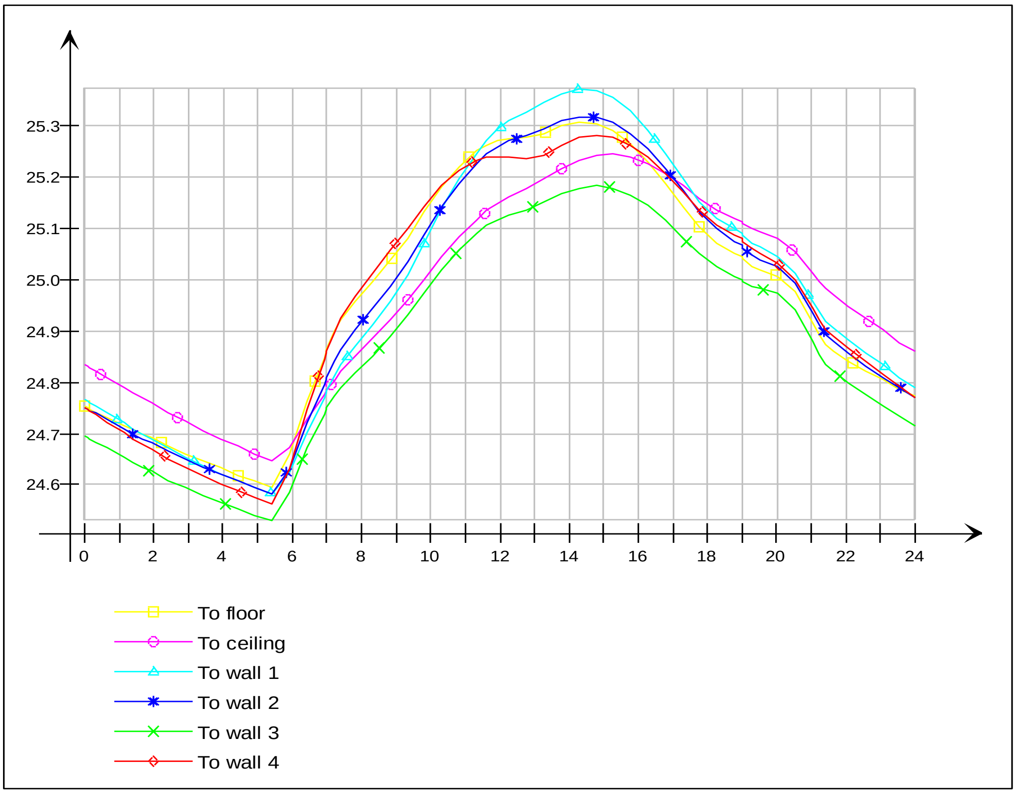
Power supplied by plant



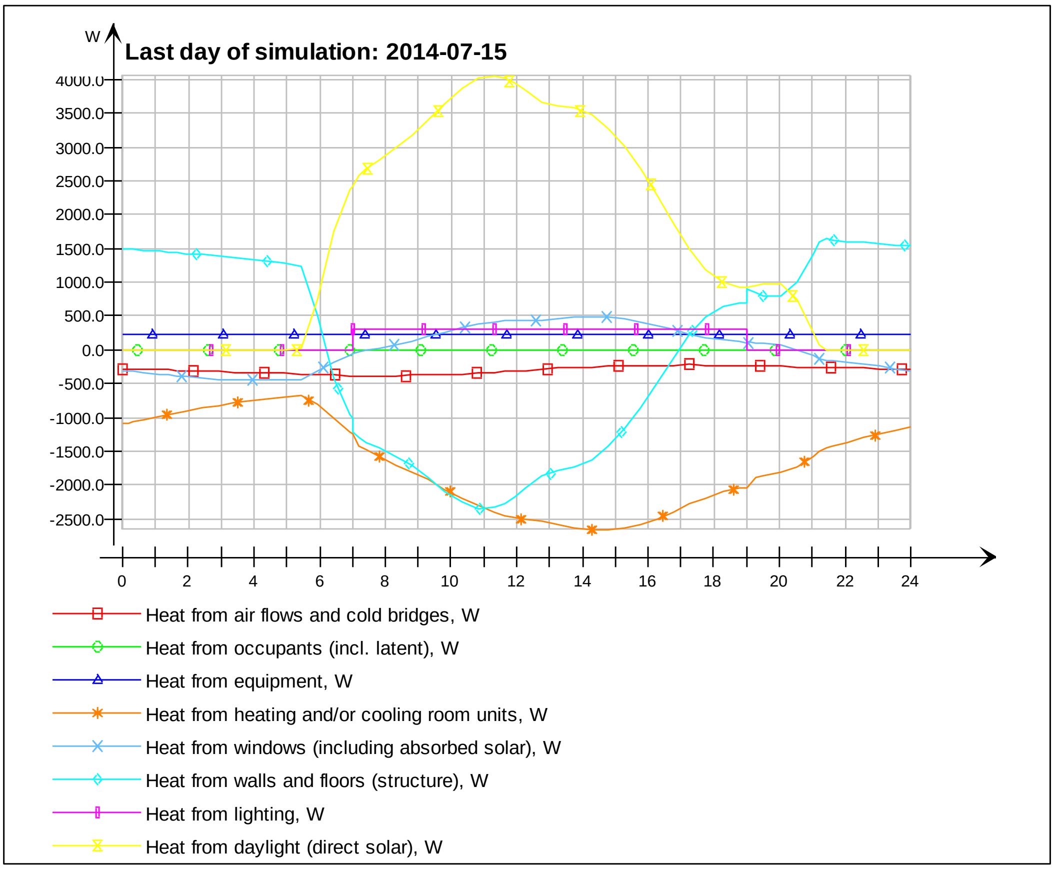
Main temperatures



Directed operative temperatures

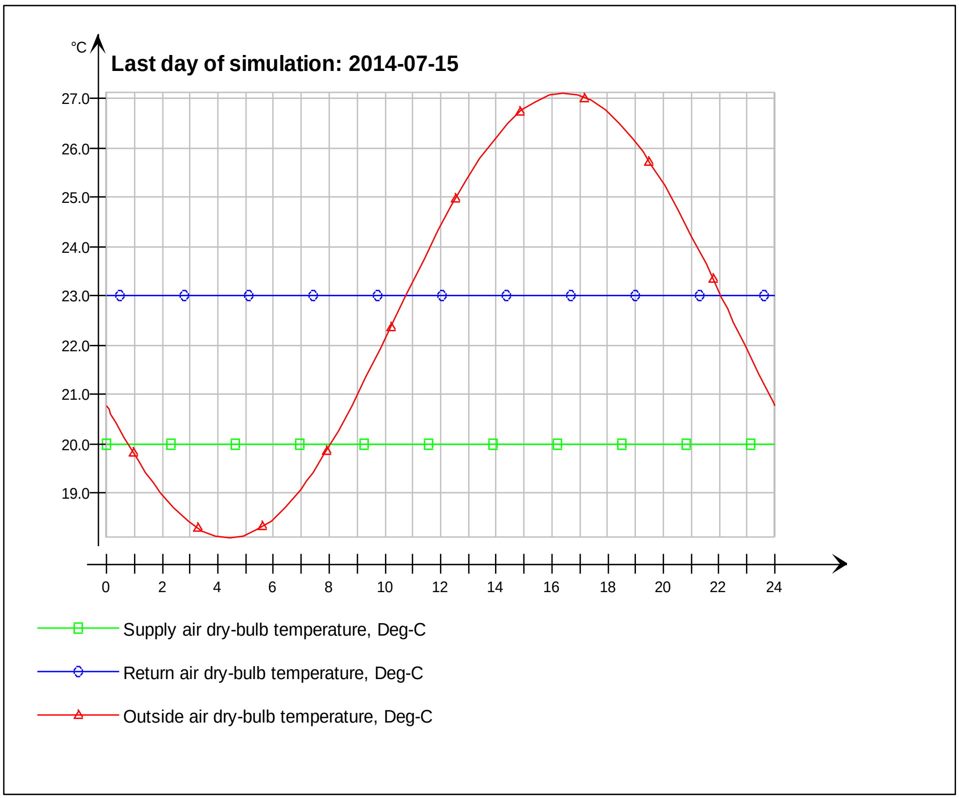


Heat balance

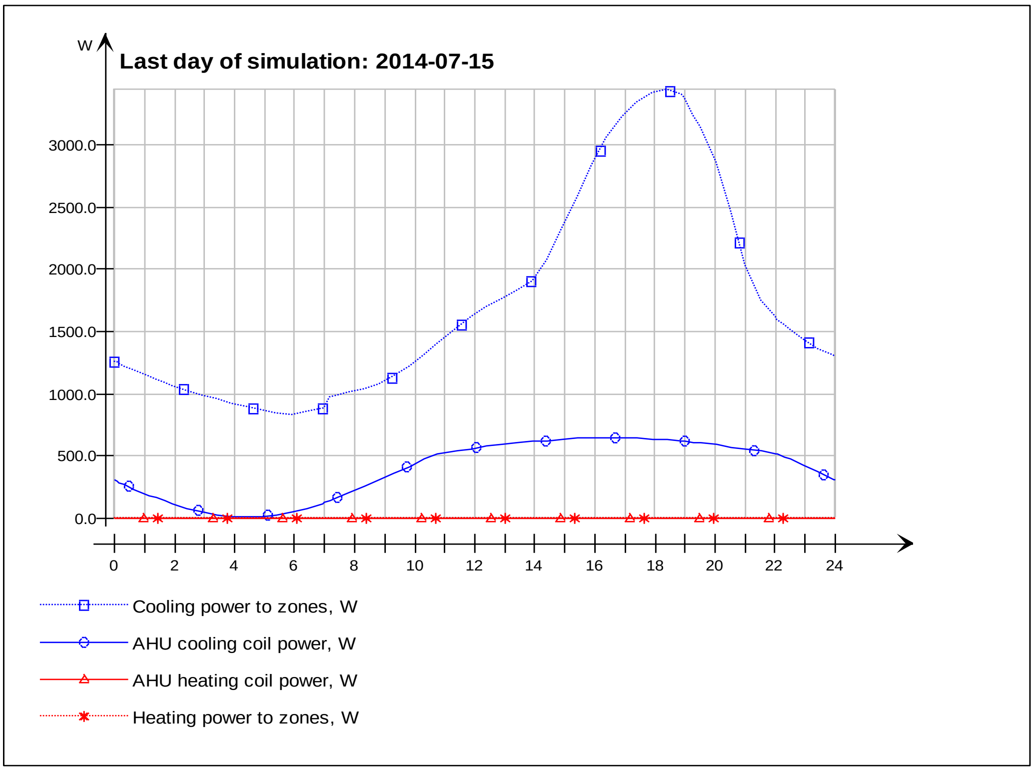


Zone 10

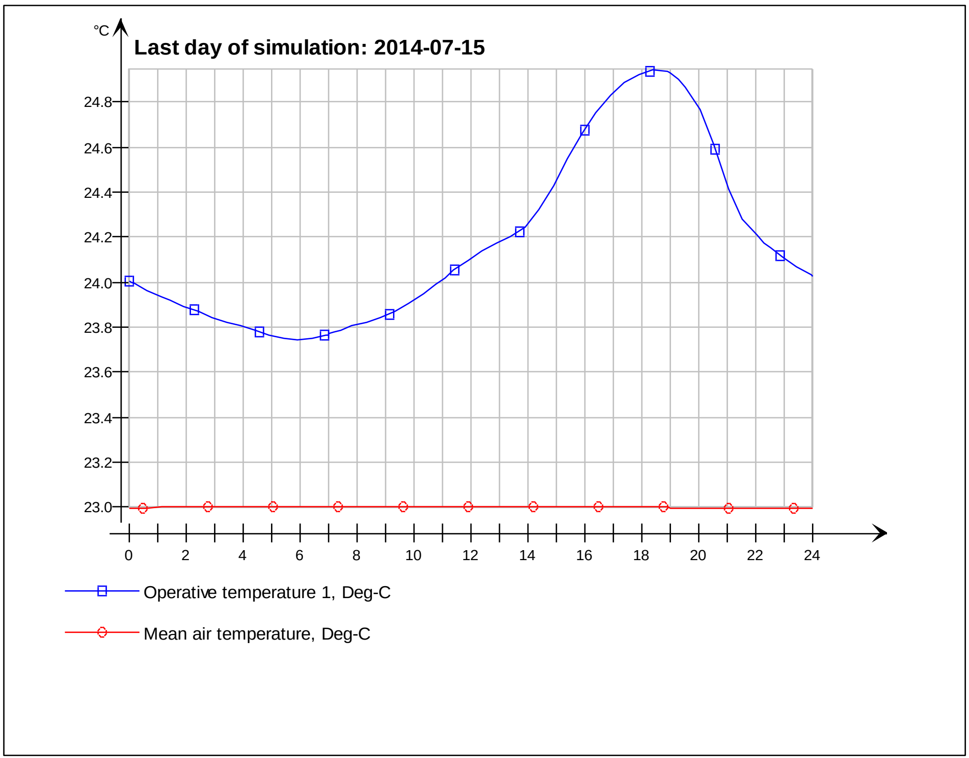
AHU temperatures



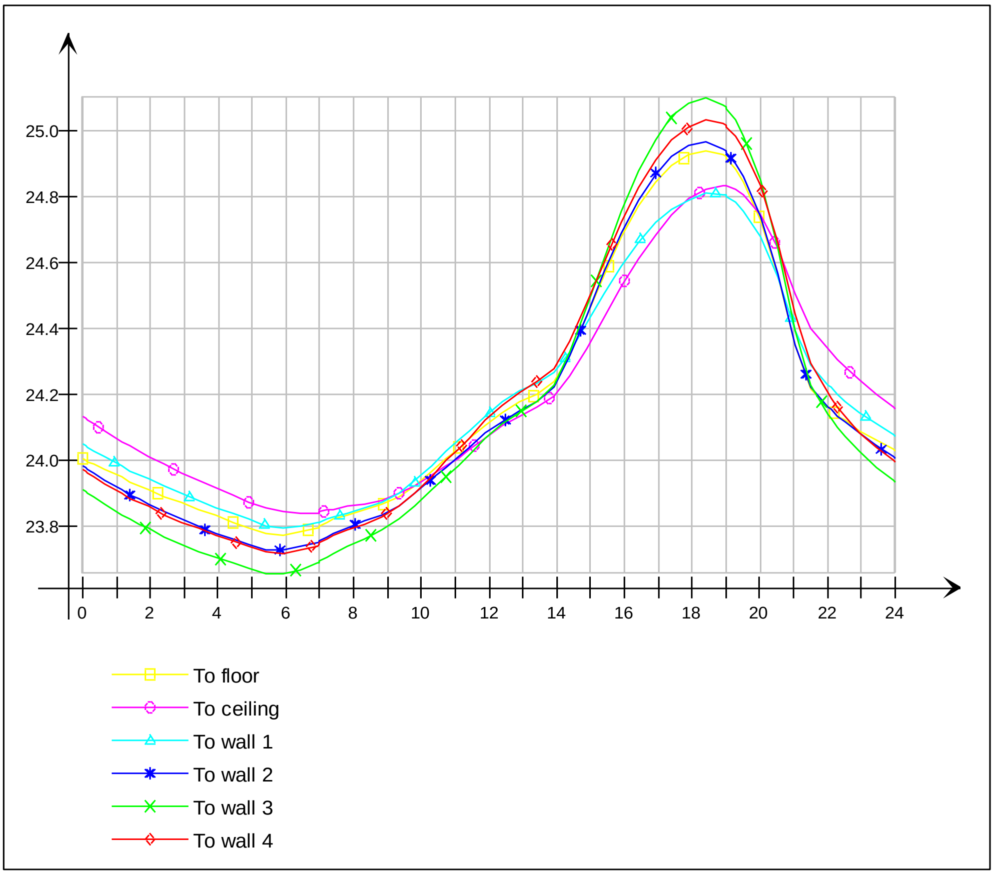
Power supplied by plant



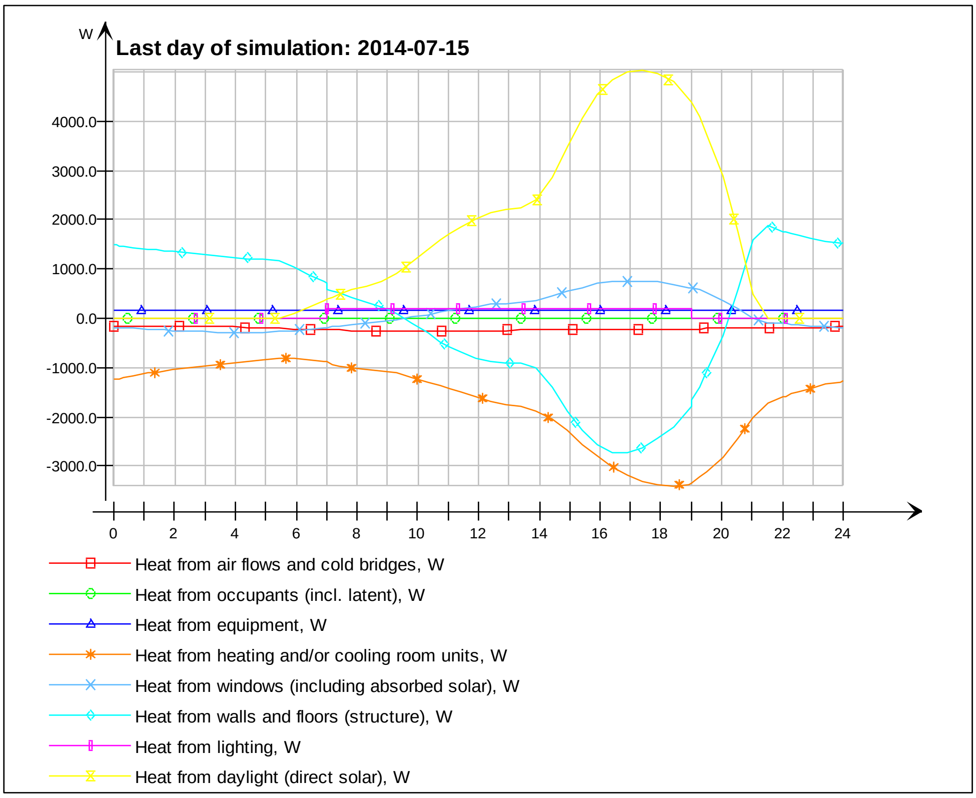
Main temperatures



Directed operative temperatures

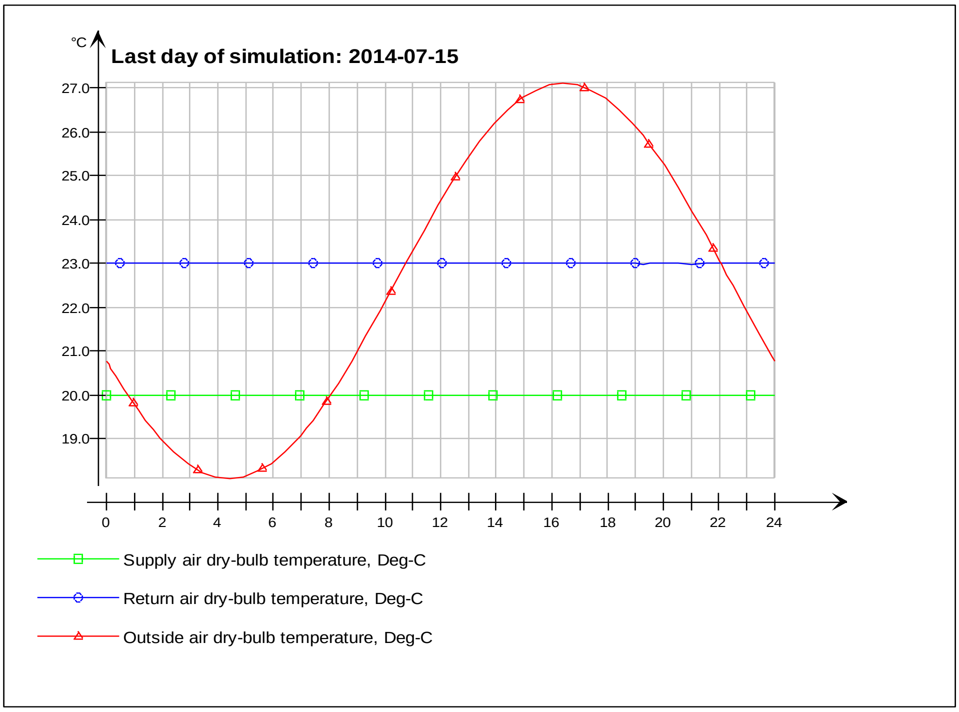


Heat balance

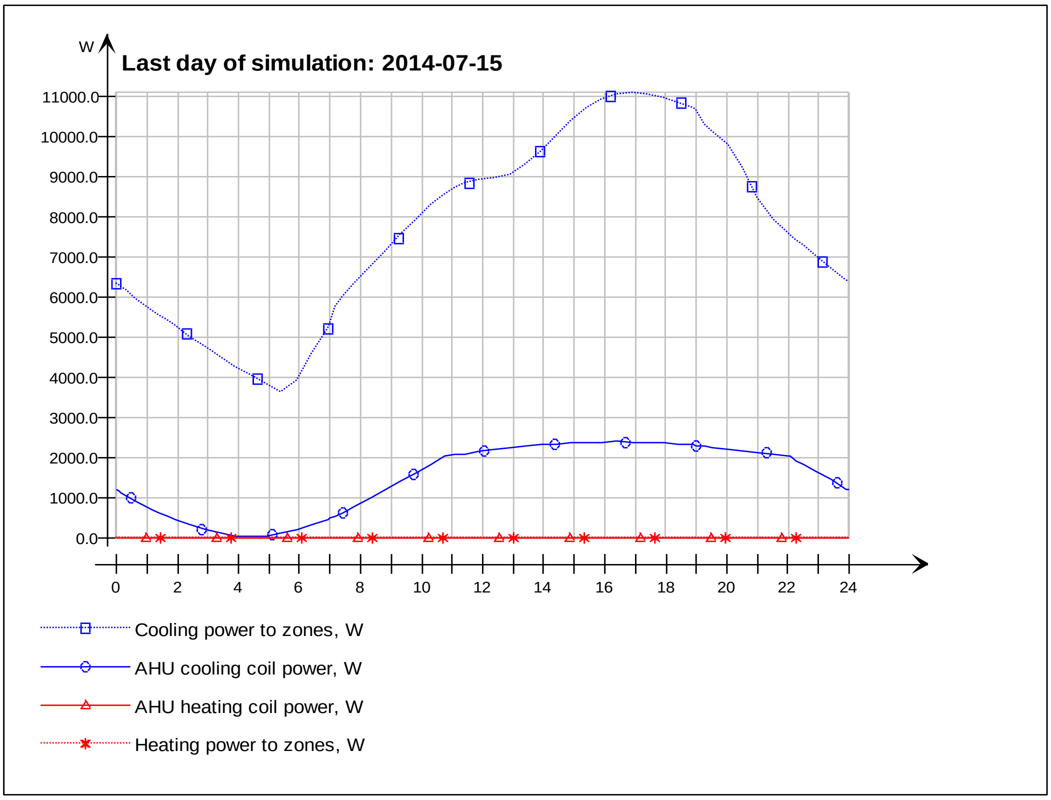


Zone 11

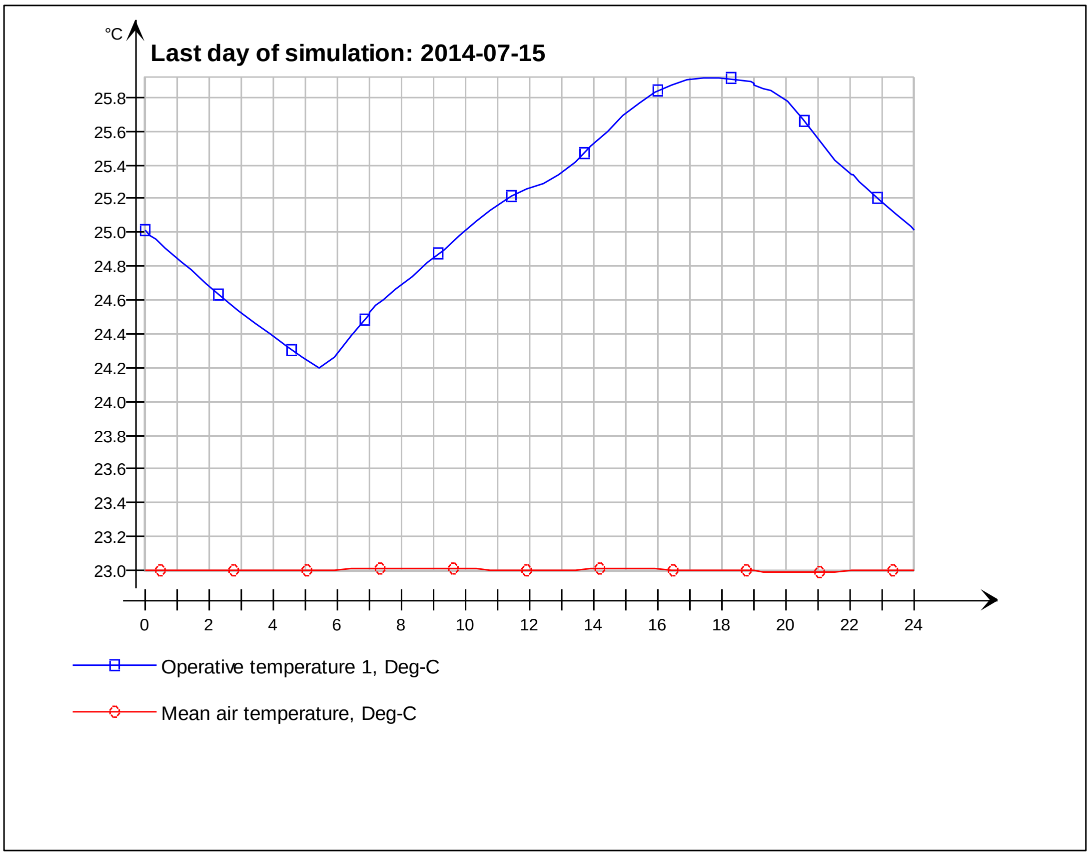
AHU temperatures



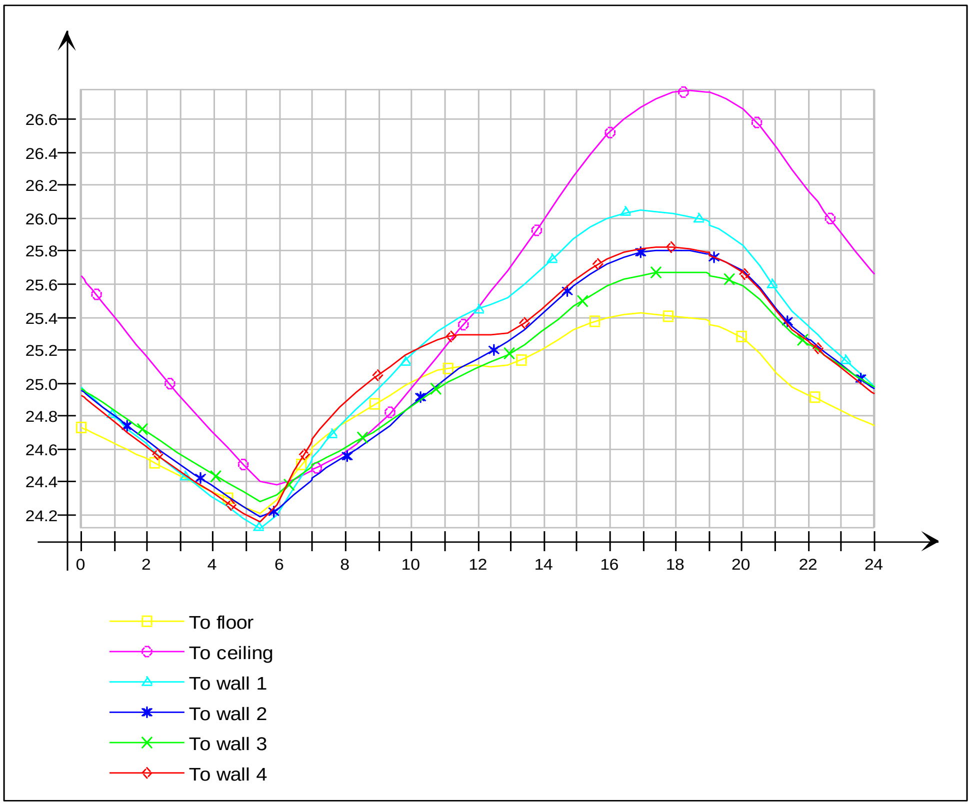
Power supplied by plant



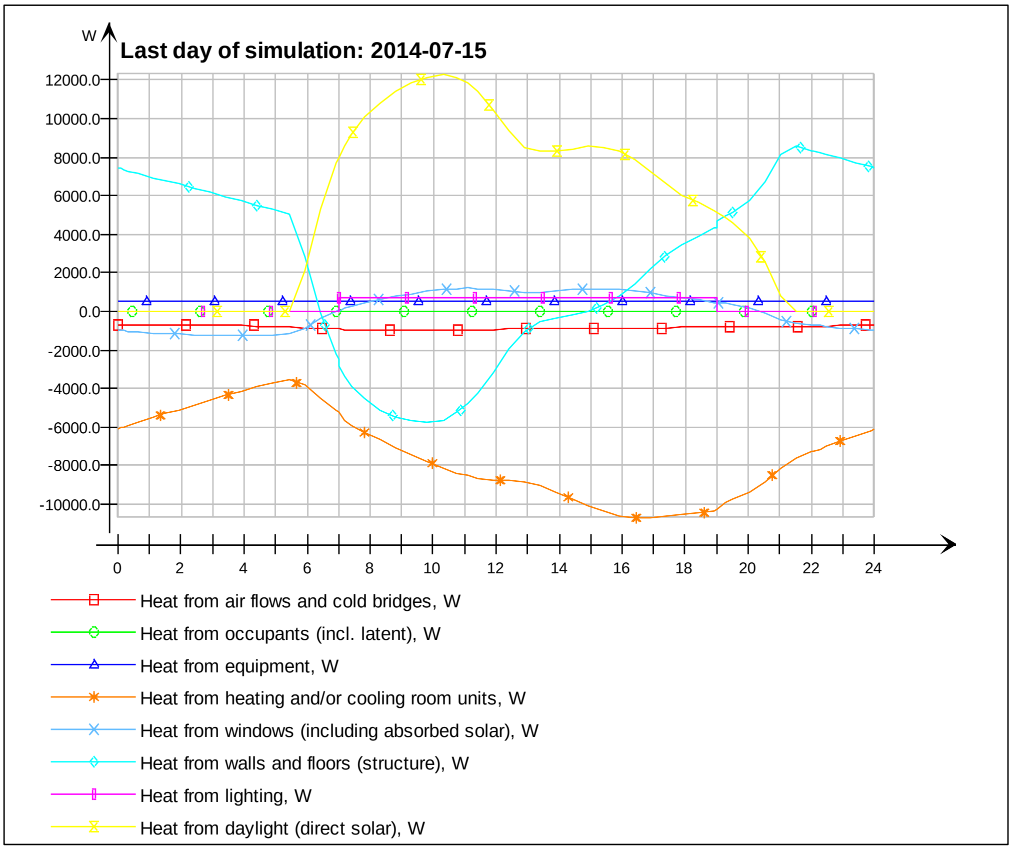
Main temperatures



Directed operative temperatures

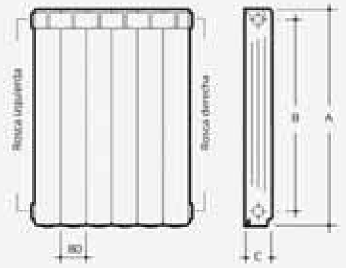


Heat balance



Manufacturer’s characteristic of heating devices

DISEÑO DE LÍNEAS ELEGANTES
Y SOBRIAS. EL RADIADOR MEC
COMBINA CON TODO TIPO
DE DECORACIÓN.



DIMENSIONES Y CARACTERÍSTICAS TÉCNICAS

Modelos	Cotas en mm			Cap. agua	Peso aprox.	Por elemento en Kcal/h		Exponente "n" de la curva característica
	A	B	C	L	Kg	(1)	(2)	
MEC 45	425	350	80	0,29	1,03	104,4	74,7	1,30
MEC 60	575	500	80	0,40	1,34	156,9	98,6	1,32
MEC 70	675	600	80	0,46	1,53	158,8	113,8	1,33

(1) = Emisión calorífica en Kcal/h según UNE 9-015-86 para Δt= 60 °C (A título informativo)
(2) = Emisión calorífica en Kcal/h según UNE EN-442 para Δt= 50 °C
Δt = (T. media radiador - T. ambiente) en °C
Exponente "n" de la curva característica según UNE EN-442

Los orificios de los elementos van roscados a 1" derecha a un lado e izquierda al otro.
Al realizar el pedido, prestar especial atención en la acertada elección del sentido de rosca de las reducciones y tapones.

Forma de suministro

Los Radiadores de Aluminio MEC se presentan embalados individualmente en bloques de 3 a 12 elementos con cantoneras de poliestireno expandido y retractilado con plástico individual.

JET

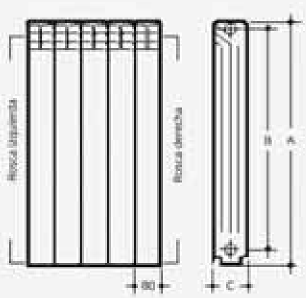
SUS ABERTURAS ANTERIORES
ESTÁN CONCEBIDAS PARA APROVECHAR
AL MÁXIMO LA EMISIÓN DE CALOR
POR CONVECCIÓN POR LA PARTE
FRONTAL DEL RADIADOR Y OBTENER DE
INMEDIATO LA SENSACIÓN DE CONFORT.

DIMENSIONES Y CARACTERÍSTICAS TÉCNICAS

Modelos	Cotas en mm			Cap. agua	Peso aprox.	Por elemento en Kcal/h		Exponente "n" de la curva característica
	A	B	C	L	Kg	(1)	(2)	
JET 45	420	350	97	0,35	1,17	110,8	83,6	1,298
JET 60	570	500	97	0,44	1,45	147	108,9	1,328
JET 70	670	600	97	0,52	1,76	172	125,6	1,321
JET 80	770	700	97	0,60	1,99	187	142,2	1,342

(1) = Emisión calorífica en Kcal/h según UNE 9-015-86 para Δt=60°C (A título informativo)
(2) = Emisión calorífica en Kcal/h según UNE EN-442 para Δt=50°C
Δt = (T.media radiador - T.ambiente) en °C
Exponente "n" de la curva características según UNE EN-442

Los orificios de los elementos van roscados a 1" derecha a un lado e izquierda al otro.
Al realizar el pedido, prestar especial atención en la acertada elección del sentido de rosca de las reducciones y tapones.



Forma de suministro

Los Radiadores de Aluminio JET se presentan embalados individualmente en bloques de 3 a 12 elementos con cantoneras de poliestireno expandido y retractilado con plástico individual.

LOS MODELOS DUBAL / MEC / JET / ALIS / AV 1800 / DUBAL-GI, ESTAN DISEÑADOS PARA INSTALACIONES DE CALEFACCIÓN POR AGUA CALIENTE HASTA 6 BAR Y 110°C O VAPOR A BAJA PRESIÓN HASTA 0,5 BAR.

FORMADOS POR ELEMENTOS, FABRICADOS EN ALEACIÓN DE ALUMINIO INYECTADO A PRESIÓN, CUYA PRODUCCION SE SOMETE A RIGUROSOS CONTROLES DE CALIDAD DESDE LA PROPIA COMPOSICIÓN QUÍMICA DE LA MATERIA PRIMA, HASTA SU RECUBRIMIENTO FINAL DE DOBLE CAPA.

UNA PRIMERA CAPA DE IMPRIMACIÓN BASE POR ELECTROFORESIS (INMERSIÓN) Y OTRA POSTERIOR DE POLVO EPOXI COLOR BLANCO RAL 9010 (AMBAS CAPAS SECADO AL HORNO).

PROTEGIDOS INTEGRALMENTE PARA SU TRANSPORTE, ALMACENAJE Y MANIPULACIÓN, RESGUARDANDO SU IMPECABLE ACABADO DURANTE LOS TRABAJOS DE INSTALACIÓN

INFORMACIÓN GENERAL

- **Purgador Automático**

  Los Radiadores de Aluminio pueden producir hidrógeno, procedente del agua de la instalación.
  Es conveniente evitar la acumulación de este gas, por lo que debe colocarse en cada radiador un purgador.
  El Purgador Automático **BAXIROCA** de BAXI CALEFACCIÓN, está diseñado para realizar esta función, garantizando el correcto funcionamiento y seguridad de la instalación.

- **Soportes**

  Especialmente diseñados para los radiadores de aluminio, BAXI CALEFACCIÓN dispone de una gama de soportes, tanto murales como de pie.

- **Suministro Opcional**

  Bajo demanda se suministran también los accesorios necesarios, compuestos por tapones y reducciones cincados o pintados en acabado como el radiador, soportes murales o de pavimento, manguitos, juntas y pintura en spray para retoques.

- **Grifería para radiadores**

  Como complemento de la instalación de Calefacción, BAXI CALEFACCIÓN dispone de una extensa gama de llaves con doble regulación del caudal; y termostáticas, con sensor de regulación automática.

MARCAS DE CALIDAD

Nuestros radiadores han obtenido la certificación que otorgan las marcas de calidad NF y N

Estas marcas las conceden respectivamente los dos organismos independientes de certificación, AFNOR y AENOR, y garantizan la conformidad con la Norma europea EN 442, la veracidad de las potencias térmicas declaradas, y el mantenimiento en el tiempo del nivel de calidad de fabricación mediante controles de seguimiento efectuados por los Comités Técnicos de dichos organismos de certificación.

MARCADO CE

Por su parte, la marca CE debe ser aplicada de forma obligatoria sobre todos los radiadores del mercado europeo desde el 01.12.2005, y se trata tan sólo de una auto certificación que efectúa el propio fabricante acreditando la conformidad de sus radiadores con la Directiva 89/106/ CEE Productos de Construcción, la cual no conlleva ningún tipo de control de seguimiento de la calidad de producción por parte de algún organismo independiente externo.

GARANTIA TOTAL 2 AÑOS

ASISTENCIA TÉCNICA CLIENTES

Formado por especialistas altamente cualificados, para atenderle en cualquier punto del país.

CONFORME A LAS DIRECTIVAS

CE

PRESIÓN HIDRÁULICA

Se recomienda probar los radiadores después de la instalación a una presión de 1,3 veces la que deberá soportar.

Dimensiones facilitadas en mm. Características y prestaciones susceptibles de variación sin previo aviso. Ambientaciones reproducidas prescindiendo de exigencias de instalación.

Baxi Calefacción, S.L.U.
Salvador Espriu, 9
08908 L'Hospitalet de Llobregat | Barcelona
Tel. +34 93 263 0009 | Fax +34 93 263 4633
www.baxi.es

C2EE529 1009 Depósito Legal B-0000-0000

Manufacturer’s characteristic of cooling devices

Quantity of Used Indoor Units	Indoor Units	Capacity(BTU/h)
1	A B	13,600 12,000
2	A1+A2 B1+B2(B3) A+B	8,200 + 8,200 7,200 + 7,200 13,600 + 12,000
3	A1+A2+B A+B1+B2 B1+B2+B3	8,200 x 2 + 12,000 13,600 + 7,200 x 2 5,600 x 3
4	A1+A2+B1+B2(B3) A+B1+B2+B3	8,200 x 2 + 7,200 x 2 13,600+5,600 x 3
5	ALL	8,200 x 2 + 5,600 x 3

For ASY17AM For ASY12AM

AOY36AM5 (ASY12AM+ASY17AM)

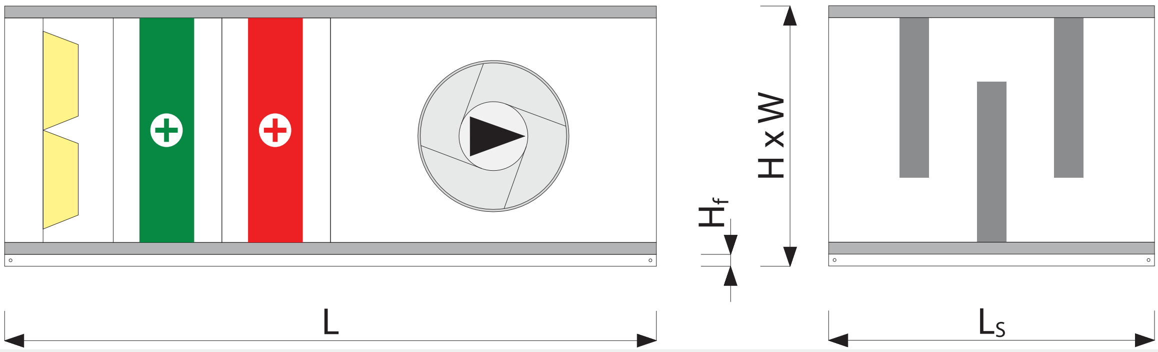
Wash
ASY12AM

Unit A or A2 4.00-4.00kW / 13,600-13,600BTU/h

Unit B1 or B2 or B3 3.50-3.50kW / 12,000-12,000BTU/h

Manufacturer’s characteristic of ventilation devices

TYPE: Supply
SET: VS-30-R-GH/S
SIZE: 30
SUPPLY: 4537 m³/h
INSULATION THICKNESS: 40 mm
EXTERNAL PRESSURE: 300 Pa
WEIGHT OF UNIT (+/- 10%) *: 205 Kg
SFP: 1.7 kW/m³/s (EN 13779)
ENERGY EFFICIENCY CLASS: E



Remarks

OPTIONAL SETS ARE INTEGRAL PART OF BASE UNIT.
(*) Net weight of AHU including optional equipment without controls.

Unit dimensions

Dimension name	W	H	Hf	L	LS	Lt	hxw
Dimension [mm]	961	660	80	1856	1097	2953	440x821

Section's length [mm]
Supply 1856/1124

External dimensions of base frame are put in OMM

Supply part

Filter

Name	VS 30 B.FLT G4		Final pressure drop	150 Pa
Air pressure drop		134 Pa	Air velocity on filter	2.9 m/s
Initial pressure drop		119 Pa	Type	EU4

Water heater

Name	VS 30 WCL 2		Glycol content	0 %
Air pressure drop		92 Pa	Medium pressure drop	10.89 kPa
Air velocity		3.5 m/s	Inlet temp. of medium	90.0 °C
Air intake (in winter)	-9.0 °C	22 %	Outlet temp. of medium	70.0 °C
Air outlet (in winter)	22.0 °C	2 %	Medium flow rate	2.03 m³/h
Air intake (in summer)	28.0 °C	45 %	Total heater capacity	47 kW
Air outlet (in summer)	28.0 °C	45 %	Header type	R 1"
Type of glycol	Ethylene			

Glycol exchanger

Name	VS 30 WCL 8		Inlet temp. of medium	6.2 °C
Air pressure drop		329 Pa	Outlet temp. of medium	-3.5 °C
Air velocity		4.0 m/s	Medium flow rate	2.80 m³/h
Air intake (in winter)	-24.0 °C	90 %	Header type	R 1 1/4"
Air outlet (in winter)	-4.0 °C	14 %	Sensible efficiency (winter)	44 %
Air intake (in summer)	28.0 °C	45 %	**Sensible efficiency (winter)**	**45 %**
Air outlet (in summer)	28.0 °C	45 %	**balanced flow**	
Type of glycol	Ethylene		Sensible efficiency (summer)	0 %
Glycol content		20 %	Total recovery capacity (summer)	0 kW

EUROVENT CERTIFIED PERFORMANCE TÜV EN-1886 TÜV EN-13053 ISO 9001

Medium pressure drop	8.59 kPa	Total recovery capacity (winter)	30 kW
Pressure drop (winter)	329 Pa	Sensible recovery capacity (summer)	0 kW
		Sensible recovery capacity (winter)	30 kW

Fan section

Fan		Rated voltage		3~230 V
Name	VS 30 DRCT.DR.FAN 3 v.2	Rated current		8.1 A
Static pressure	893 Pa	Rated power		2.20 kW
Static pressure (winter)	893 Pa	Electric power consumption		2.23 kW
Dynamic pressure	120 Pa	Electric power consumption (Clean F.)		2.20 kW
External pressure	300 Pa	Electric power consumption (winter)		2.23 kW
Static efficiency	66 %	Rated revolutions		2880 1/min
Total efficiency	75 %	Fan section	VS 30 DRCT.DR.PLUG.FAN.SET 31/2,2/2	1
Rated revolutions	3549 1/min	Frequency converter's power supply		1~230 V
Shaft power	1.73 kW	Frequency		61.6 Hz
Motor	VS EL.MTR M 2,2/2	SFPs		1.7 kW/m³/s
IEC size	90	Designed for wet operating conditions		
Frequency	62 Hz			

Silencer

Name	VS 30 SLCR	Air pressure drop	38 Pa

Sound-level table

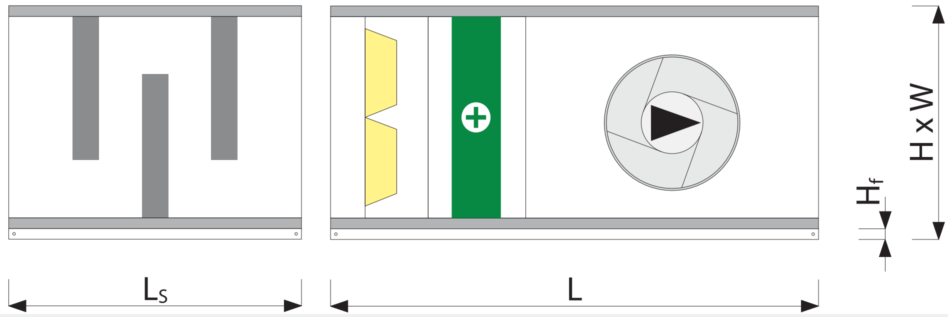
Frequency		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Lw dB(A)
Intake	dB(A)	56.2	69.7	75.7	74	72.3	64.8	57.2	79.7
Outlet	dB(A)	52.7	62.3	60.1	56.3	52.9	47.9	42.7	65.6
Environment	dB(A)	50.8	61	60.6	58.7	59.2	45.1	36.4	66.2
Sound press. **	dB(A)	43.8	54	53.6	51.7	52.2	38.1	29.4	59.2

(**) Approximate data of sound pressure.

Options

Damper	VS 30/55 A.DAMP 821x440	1	Communication Board	Modbus-RTU (iC5)	1
Frequency converter	FC 2,2 1PH	1			

TYPE: Exhaust
SET: VS-40-R-S/G
SIZE: 40
EXHAUST: 4219 m³/h
INSULATION THICKNESS: 40 mm
EXTERNAL PRESSURE: 300 Pa
WEIGHT OF UNIT (+/- 10%) *: 231 Kg
SFP: 1.2 kW/m³/s (EN 13779)
ENERGY EFFICIENCY CLASS: B▲



Remarks

OPTIONAL SETS ARE INTEGRAL PART OF BASE UNIT.
(*) Net weight of AHU including optional equipment without controls.

Unit dimensions

Dimension name	W	H	Hf	L	LS	Lt	hxw
Dimension [mm]	1168	660	80	1490	1097	2587	440x1028

Section's length [mm]
Exhaust 1124/1490

External dimensions of base frame are put in OMM

Exhaust section

Silencer

Name	VS 40 SLCR	Air pressure drop	21 Pa

Filter

Name	VS 40 B.FLT G4		Final pressure drop	150 Pa
Air pressure drop		105 Pa	Air velocity on filter	2.2 m/s
Initial pressure drop		60 Pa	Type	EU4

Glycol exchanger

Name	VS 40 WCL 8		Inlet temp. of medium	-3.5 °C
Air pressure drop		252 Pa	Outlet temp. of medium	6.2 °C
Air velocity		2.8 m/s	Medium flow rate	2.80 m³/h
Air intake (in winter)	22.0 °C	60 %	Header type	R 1 1/4"
Air outlet (in winter)	8.4 °C	100 %	Sensible efficiency (winter)	44 %
Air intake (in summer)	24.0 °C	60 %	Sensible efficiency (summer)	0 %
Air outlet (in summer)	24.0 °C	60 %	Total recovery capacity (summer)	0 kW
Type of glycol	Ethylene		Total recovery capacity (winter)	30 kW
Glycol content		20 %	Sensible recovery capacity (summer)	0 kW
Medium pressure drop		5.49 kPa		
Pressure drop (winter)		252 Pa	Sensible recovery capacity (winter)	30 kW

Fan section

Fan			Rated voltage	3~230 V
Name	VS 40 DRCT.DR.FAN 1 v.2		Rated current	6.0 A
Static pressure		678 Pa	Rated power	1.50 kW
Static pressure (winter)		678 Pa	Electric power consumption	1.54 kW

TÜV EN-1886 TÜV EN-13053 ISO 9001

CLIMA-CAD VERSION: 3.1.3 6/24/2014 12:21:

Dynamic pressure		65 Pa	Electric power consumption (Clean F.)		1.45 kW
External pressure		300 Pa	Electric power consumption (winter)		1.54 kW
Static efficiency		69 %	Rated revolutions		1420 1/min
Total efficiency		76 %	Fan section	VS 40 DRCT.DR.PLUG.FAN.SET 35/1,5/4	1
Rated revolutions		2484 1/min			
Shaft power		1.15 kW			
Motor	VS EL.MTR M 1,5/4				
IEC size		90	Frequency converter's power supply		1~230 V
Frequency		87 Hz	Frequency		87.5 Hz
			SFPe		1.2 kW/m³/s
			Designed for wet operating conditions		

Sound-level table

Frequency		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Lw dB(A)
Intake	dB(A)	42.3	51.2	48	42.5	37	28.2	21.2	53.7
Outlet	dB(A)	56.3	69.8	75.8	76	74.2	69.6	63.8	81
Environment	dB(A)	46.3	56.4	56.1	54.2	54.6	40.6	31.8	61.6
Sound press. **	dB(A)	39.3	49.4	49.1	47.2	47.6	33.6	24.8	54.6

(**) Approximate data of sound pressure.

Options

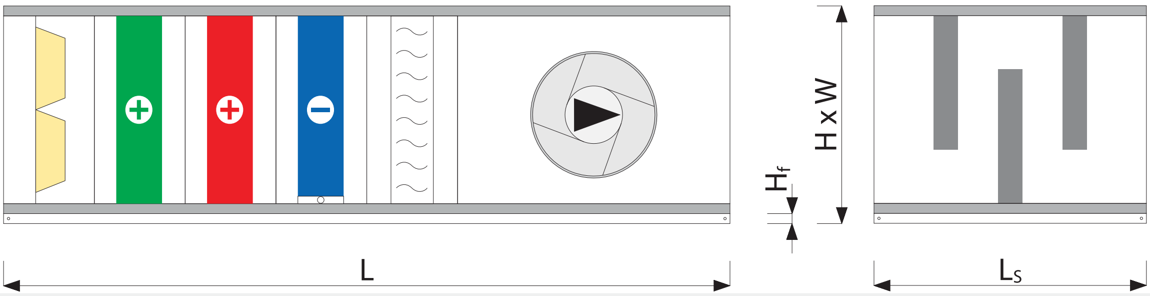
Damper	VS 40/75 A.DAMP 1028x440	1	Communication Board	Modbus-RTU (iC5)	1
Frequency converter	FC 2,2 1PH	1			

Controls AG-1R

Fuse element	VS 21-150 FUSE gG 20A type10x38	1	Throttle valve actuator	VS 00 AD.ACTR ON-OFF 10Nm	1
Fuse element	VS 21-150 FUSE gG 20A type10x38	1	Valve set	VS 00 3W.VLV 6,3	1
			Pressure control	VS 10-150 DFF.PRSS.GG 400 Pa	1
HMI Interface Advanced	HMI ADVANCED UPC	1			
Duct temperature sensor	NTC.TEMP.SNR DUCT	3	Pressure control	VS 10-150 DFF.PRSS.GG 400 Pa	1
Room temperature sensor	NTC.TEMP.SNR ROOM	1	Antifreeze thermostat	VS 10-40 FROST.THMST 2m	1
Throttle valve actuator	VS 00 AD.ACTR ON-OFF/S 10Nm	1	Capillary grip	VS CPLRY.GRIP.SET 3#	1

Control box VS 10-75 CG UPC

TYPE: Supply
SET: VS-300-R-GH/ 4S
SIZE: 300
SUPPLY: 35700 m³4h
INSULATION THICKNESS: P0 mm
EXTERNAL PRESSURE: 300 a2
WEIGHT OF UNIT (+/- 10%) *: 753K g1
SFP: 7.k Ws 4m³4(EN9 7355) O
ENERGY EFFICIENCY CLASS: N



Remarks

T a l AT 9 L F SNI S L RN A9 I NGRL F a L RI T B UL SN * 9 A .
EeO9 t wi t ol hwf nL H* ocdluqoc1 f pwf c2l t r uqomt cwi ohf uwdf cwf l(.

Unit dimensions

Dimension name	s	H	Hn	F	FS	Fw	hbi
Dimension [mm]	8kKk	7xkx	K0	337K	7Px3	P5K7	7P3xb8PPk

Section's length [mm]
Supply 7Kkx4P) 04P) 0

Nbwt6c2l qomt c(of c(f nM2(t m2mt 2d puwoc Tv v

Supply part

Filter

9 2mt	VS 300 U.BFI GP		Boc2l pd ((ud qd p	7k0 a2
L6pd ((ud qd p		77x a2	L6O If doy f c mdwt6	8.5 m4(
Acwl pd ((ud qd p		K8 a2	I ypt	N* P

Water heater

9 2mt	VS 300 s / F 8		Glydf l df cwcw	0 %
L6pd ((ud qd p		xK a2	v t qoum pd ((ud qd p	x.k7 Wa2
L6O If doy		8.) m4(	Aclt wwmp. f nmt qoum	) 0.0 °/
L6ocw2W Ec i ocw6O	-) .x °/	83 %	T uwl wwmp. f nmt qoum	50.0 °/
L6f uwl wEc i ocw6O	88.0 °/	8 %	v t qoum mf i 62wt	7x.) P m³4h
L6ocw2W Ec (ummt 6O	8K.0 °/	Pk %	I f w2l ht 2wt6d2p2doy	3) P Ws
L6f uwl wEc (ummt 6O	8K.0 °/	Pk %	Ht 2qt 6wypt	R 3"
I ypt f n1lydf l	Nwhylt ct			

Glycol exchanger

9 2mt	VS 300 s / F K		Aclt wwmp. f nmt qoum	5.5 °/
L6pd ((ud qd p		83) a2	T uwl wwmp. f nmt qoum	-P.3 °/
L6O If doy		3.7 m4(	v t qoum mf i 62wt	7K.33 m³4h
L6ocw2W Ec i ocw6O	-8P.0 °/	) 0 %	Ht 2qt 6wypt	R 8b3"
L6f uwl wEc i ocw6O	-P.x °/	7k %	St c(oMt t mdd cdy E ocw6O	P8 %
L6ocw2W Ec (ummt 6O	8K.0 °/	Pk %	**Sensible efficiency (winter)**	**42 %**
L6f uwl wEc (ummt 6O	8K.0 °/	Pk %	**balanced flow**	
I ypt f n1lydf l	Nwhylt ct		St c(oMt t mdd cdy E(ummt 6O	0 %
Glydf l df cwcw		80 %	I f w2l 6 df O 6y d2p2doy E(ummt 6O	0 Ws
v t qoum pd ((ud qd p		k.8k Wa2	I f w2l 6 df O 6y d2p2doy E ocw6O	8P8 Ws
ad ((ud qd p E ocw6O		83) a2	St c(oMt 6 df O 6y d2p2doy	0 Ws

E(ummt 6O
St c(dMt 6t df Ct 6y d2p2doy E ocwt 6O 8P8 Ws

Water cooler with droplet eliminator

9 2mt	VS 300 s / F 8	D6y p6t ((u6t q6f p f c wht df f loc 1	K8 a2
L6p6t ((u6t q6f p	) 3 a2	df ol	
L6Ct lf doy	3.7 m4(	v t qoum p6t ((u6t q6f p	8.8k Wa2
L6ocw2Wt Eoc i ocwt 6O	88.0 °/ 8 %	Aclt wwt mp. f nmt qoum	x.0 °/
L6f uwlt wEoc i ocwt 6O	88.0 °/ 8 %	T uwlt wwt mp. f nmt qoum	78.0 °/
L6ocw2Wt Eoc (ummt 6O	8K.0 °/ Pk %	v t qoum rif i 62wt	K.8k m³4h
L6f uwlt wEoc (ummt 6O	8P.0 °/ kx %	I f w2l df f lt 6d2p2doy	kK Ws
I ypt f n1lydf l	Nwhylt ct	St c(dMt d2p2doy	k7 Ws
Glydf l df cwtcw	0 %	Ht 2qt 6wypt	R 3"

Fan section

B2c		R2wt q Cf lw21t	3~P00 V
9 2mt	VS 78047k0 DR/ I .DR.BL9 3 C8	R2wt q du66t cw	8b7k.8 L
		R2wt q pf i t 6	8b5.k0 Ws
Sw2wol p6t ((u6t	Kk7 a2	Nlt dw6ol pf i t 6df c(umpwt c	8bK.85 Ws
Sw2wol p6t ((u6t E ocwt 6O	Kk7 a2	Nlt dw6ol pf i t 6df c(umpwt c E lt 2c B.O	8b5.) K Ws
Dyc2mol p6t ((u6t	78x a2		
Nbwt 6c2l p6t ((u6t	300 a2	Nlt dw6ol pf i t 6df c(umpwt c E ocwt 6O	8bK.85 Ws
Sw2wol t mold cdy	xP %	R2wt q 6t Cf luwt c(	7Pk0 74moc
I f w2l t mold cdy	5P %	B2c (t dwt c	VS 78047k0 8 DR/ I .DR.a F* G.BL9 .SNI x345,k4P
R2wt q 6t Cf luwt c(	75) P 74moc		
Sh2nwpf i t 6	8bx.) 0 Ws		
v f wt6	VS NF.v I R v 5,k4P	B6t r ut cdy df cCt 6wt 6(pf i t 6 (upply	3~P00 V
AN/ (oct	738		
B6t r ut cdy	x8 Hz	B6t r ut cdy	x7.) Hz
		SBa (	7.k Ws 4m³4(
		Dt (dlct q rif 6i t wf pt 62woc 1 df cqowt c(	

Silencer

9 2mt	VS 300 SF/ R	L6p6t ((u6t q6f p	3k a2

Sound-level table

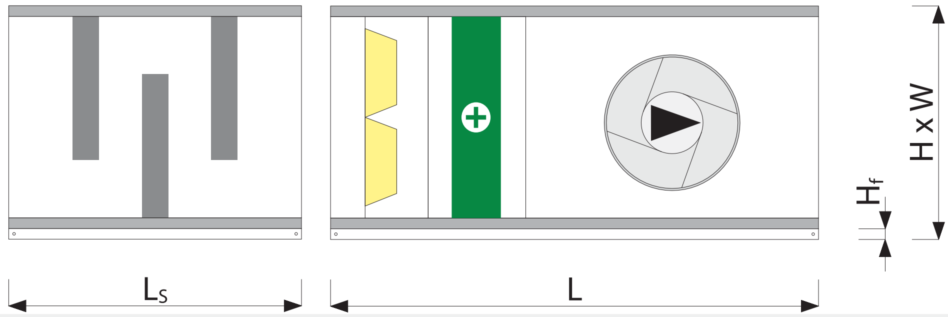
Frequency		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Lw dB(A)
Intake	qUE LO	kP.k	xK.7	53.7	50.x	xP.7	PK.3	35	5x.8
Outlet	qUE LO	k8.3	x0.x	kx.7	k7	P5.7	P7.)	35	x8.K
Environment	qUE LO	k8.)	x3.7	x8.5	x0.K	x7.3	P5.8	3K.k	xK.3
Sound press. **	qUE LO	Pk.)	kx.7	kk.5	k3.K	kP.3	P0.8	37.k	x7.3

EeeOL ppt6f bon2wt q2w2 f n(f ucq p6t ((u6t .

Options

D2mpt 6	VS 300 L.DLv a 7 8PPkb7P3x	B6t r ut cdy df cCt 6wt 6	VS 87-7k0 B/ 5,k C 8 8

TYPE: Nbh2u(w
SET: VS-300-R-S4G
SIZE: 300
EXHAUST: 35700 m³4h
INSULATION THICKNESS: P0 mm
EXTERNAL PRESSURE: 300 a2
WEIGHT OF UNIT (+/- 10%) *: 73Pk g1
SFP: 7.P Ws 4m³4(EN9 7355) O
ENERGY EFFICIENCY CLASS: N▲



Remarks

T a I AT 9 L F SNI S L RN A9 I NGRL F a L RI T B U L SN * 9 A .
EeO9 t wi t o hwf n L H* ocdluqoc1 f pwo c2I t r uqomt cwi owf uwdf cwf l(.

Unit dimensions

Dimension name	s	H	Hn	F	FS	Fw	hbi
Dimension [mm]	8kKk	7xkx	K0	8kK5	7Px3	P0k0	7P3xb8PPk

Section's length [mm]
Nbh2u(w 7P) 0477 8P4 7P) 0

Nbw6c2I qomt c(of c(f nM2(t n62mt 2 6t puwoc T v v

Exhaust section

Silencer

9 2mt	VS 300 SF/ R	L o6p6t ((u6t q6f p	3k a2

Filter

9 2mt	VS 300 U.BFI GP		Boc2I p6t ((u6t q6f p		7k0 a2
L o6p6t ((u6t q6f p		77x a2	L o6Ct If doy f c mdwt 6		8.5 m4(
Acow2I p6t ((u6t q6f p		K8 a2	I ypt	N* P	

Glycol exchanger

9 2mt	VS 300 s / F K		Aclt wwmp. f nmt qoum		-P.3 °/
L o6p6t ((u6t q6f p		380 a2	T uwlt wwmp. f nmt qoum		5.5 °/
L o6Ct If doy		3.7 m4(	v t qoum nf i 62wt		7K33 m³4h
L o6ocw2Vt' Eoc i ocwt 6O	88.0 °/	x0 %	Ht 2qt 6wypt	R 8b3"	
L o6f uwlt wEoc i ocwt 6O	) .3 °/	700 %	St c(oMt t mdd cdy E ocwt 6O		P8 %
L o6ocw2Vt' Eoc (ummt 6O	8P.0 °/	x0 %	St c(oMt t mdd cdy E(ummt 6O		0 %
L o6f uwlt wEoc (ummt 6O	8P.0 °/	x0 %	I f w2I 6t df Ct 6y d2p2doy E(ummt 6O		0 Ws
I ypt f n1lydf I	Nwhylt ct		I f w2I 6t df Ct 6y d2p2doy E ocwt 6O		8P8 Ws
Glydf I df cwcw		80 %	St c(oMt 6t df Ct 6y d2p2doy		0 Ws
v t qoum p6t ((u6t q6f p		k.8k Wa2	E(ummt 6O		
a6t ((u6t q6f p E ocwt 6O		380 a2	St c(oMt 6t df Ct 6y d2p2doy E ocwt 6O		8P8 Ws

Fan section

B2c			R2wt q Cf lw21t	3~P00 V
9 2mt	VS 7804 7k0 DR/ I .DR.BL9 3 C8		R2wt q du66t cw	8b7k.8 L
			R2wt q pf i t 6	8b5.k0 Ws
Sw2wd p6t ((u6t		557 a2	Nlt dw6d pf i t 6df c(umpwf c	8b5.x) Ws

Sw2wd p6t ((u6t E ocwt6O		557 a2	Nlt dw6d pf i t 6df c(umpwf c E/ lt 2c		8b5.P0 W$
Dyc2mod p6t ((u6t		78x a2	B.O		
Nbwt6c2l p6t ((u6t		300 a2	Nlt dw6d pf i t 6df c(umpwf c E ocwt6O		8b5.x) W$
Sw2wd t mddd cdy		x3 %	R2wt q 6t Cf luwf c(		7Pk0 74moc
I f w2l t mddd cdy		53 %	B2c (t dwf c	VS 7804-7k0 DR/ I .DR.a F* G.BL 9 .SNI x345,k4P	8
R2wt q 6t Cf luwf c(		75xx 74moc			
Sh2nwpf i t 6		8bx.P7 W$			
v f wt6	VS NF.v I R v 5,k4P		B6t r ut cdy df cCt 6wt6(pf i t 6 (upply		3~P00 V
AN/ (ozt		738			
B6t r ut cdy		x7 Hz	B6t r ut cdy		x0.) Hz
			SBat		7.P W$ 4m³4(
			Dt (d1ct q rf 6i t wf pt 62wc1 df cqowf c(		

Sound-level table

Frequency		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Lw dB(A)
Intake	qUEL O	P5.P	kk.x	k7.8	Pk.7	3) .P	30.P	83.5	k5.5
Outlet	qUEL O	x8.x	5x.8	K8.7	K8.3	K0.x	5k.)	50.8	K5.3
Environment	qUEL O	k8.x	x8.K	x8.P	x0.k	x7	Px.)	3K.8	xK
Sound press. **	qUEL O	Pk.x	kk.K	kk.P	k3.k	kP	3) .)	37.8	x7

EeeOL pp6f bom2wt q2w2 f n(f ucq p6t ((u6t .

Options

D2mpt 6	VS 300 L.DLv a 8PPkb7P3x	7	B6t r ut cdy df cCt 6wt6	VS 87-7k0 B/ 5,k C 8	8

Controls AG-5R

Bu(t t lt mt cw	VS 87-7k0 B* SN 1G 80L wpt 70b3K	8	V2lCt (t w	VS 00 3s .VFV kK	7
			V2lCt (t w	VS 00 3s .VFV kK	7
Bu(t t lt mt cw	VS 87-7k0 B* SN 1G 80L wpt 70b3K	8	a6t ((u6t df cw6f l	VS 70-7k0 DBB.a RSS.GG P00 a2	7
Hv AAcwt62dt L qC2cdt q	Hv ALDVL 9 / ND * a/	7	a6t ((u6t df cw6f l	VS 70-7k0 DBB.a RSS.GG P00 a2	7
Dudwwt mpt 62wu6t (t c(f 6	9 I / .I Nv a.S9 R D* / I	3			
Rf f m wt mpt 62wu6t (t c(f 6	9 I / .I Nv a.S9 R RT T v	7	L cwo6t t zt wht 6mf (w2w	VS kk-7k0 BRT SI .I Hv SI xm	7
I h6f wlt C2lCt 2dwu2wt6	VS 00 L D.L/ I R T 9 -T BB4S 809 m	7	/ 2pd26y 16qp	VS / a FRY.GRAa.SNI 3#	8
I h6f wlt C2lCt 2dwu2wt6	VS 00 L D.L/ I R T 9 -T BB 809 m	7			

Control box VS 180-300 CG UPC