



➤ **DELIVERABLE 8:**
A REPORT ON THE ENERGY NEEDS

With the support of:

Intelligent Energy  **Europe**

December 2008

TABLE OF CONTENTS

TABLE OF CONTENTS	2
1. Introduction :	3
2. Site description	4
2.1. Climatic condition:	4
2.2. Energy price	4
2.3. Maps, graphs of the energy needs	5
2.3.1 Study hypothesis.....	5
2.3.2 Energy demands balance:	12
3. Energy Use	17
3.1. Financial conditions	17
3.2. Technical conditions	17
3.3. CO₂ figures	18
4. Main conclusions	18
4.1. Energy demands	Fehler! Textmarke nicht definiert.
5. Main conclusions	<i>Fehler! Textmarke nicht definiert.</i>

1. INTRODUCTION

The objective of this study is to present different energy needs when dealing with heating and cooling demands in the new commercial complex « Au Carré d'Or », located in Perpignan.

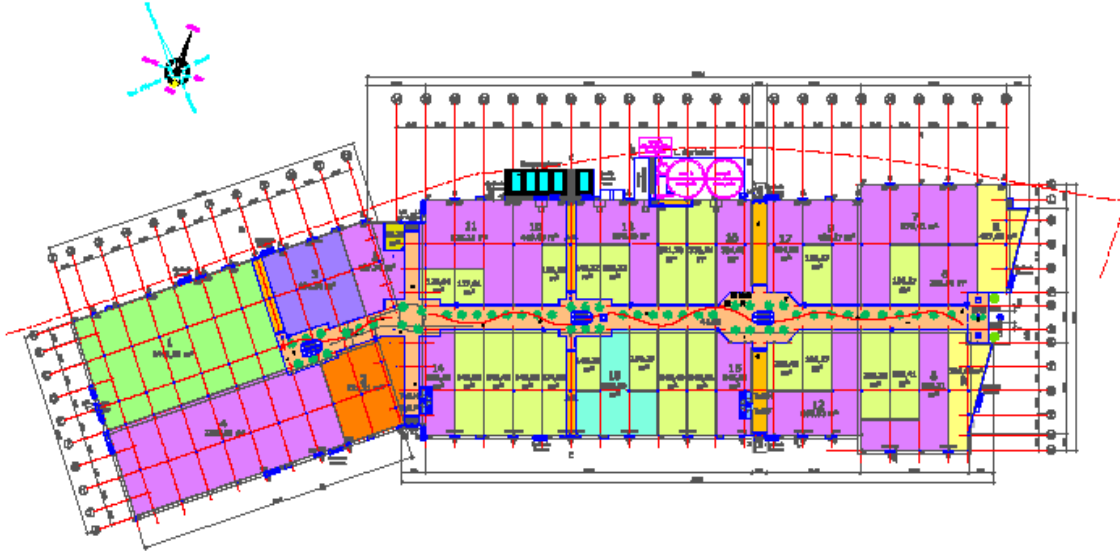


Figure 1: Project map

The construction of the new commercial complex will involve an area of 25.000 m² dedicated to the world of dwelling: a commercial area of 20.000 m² surrounded by a promenade area 3.000m². Parking areas will also be built around the building.

2. SITE DESCRIPTION

2.1. CLIMATIC CONDITIONS

The commercial complex studied is located in Perpignan, in the south of France. The climate is Mediterranean, and the site is characterized by:

- Winter base temperature of -4°C
- Summer base temperature of 31°C

Figure 2 illustrates temperature and precipitation profiles in Perpignan for winter and summer periods.

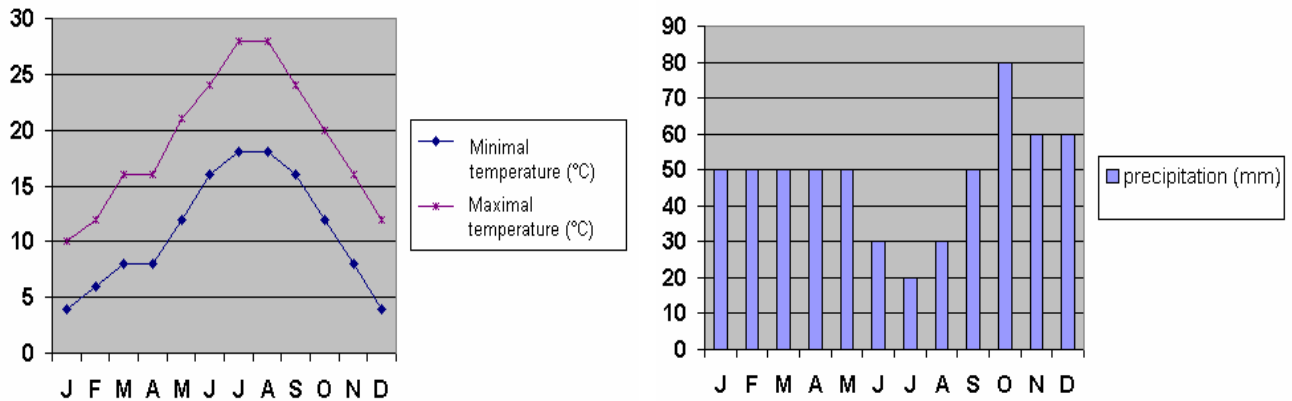


Figure 2 Temperature profile and precipitation (Perpignan)

2.2. ENERGY PRICE

The Energy prices presented thereafter are valid till August 2007.

Gas

Gas price is made up of two components: a fixed component corresponding to the subscription fee and a variable component depending on the energy consumption. It should be noted that two energy consumption rates are defined according to the season: winter or summer

Table 1: gas prices

Gas prices (B2S)		
Subscription	Winter	Summer
756 €	3,562 c€/kWh PCS	3,030 c€/kWh PCS

Electricity

The price of electricity includes a first variable share that corresponds to subscription fees and is proportional to the installed power, and a second variable share proportional to the amount to energy consumed. Several electricity consumption rates are defined depending on the season and on time (normal, peak, off-peak hours) as presented in table 3

Table 2: electricity prices

Electricity prices (green A5 LU)			
Subscription €/ kW	Time	Winter c€/kWh	Summer c€/kWh
68,64	PH	9,695	2,586
	NH	5,535	2,586
	OPH	3,714	1,643

2.3. MAPS, GRAPHS OF THE ENERGY NEEDS

The evaluation of the shopping mall energy needs is an essential step since it allows us to size the geothermal installation.

2.3.1 Study hypothesis.

2.3.1.1 Building characteristics

The shopping complex includes 39 shops, 1 day nursery, 2 restaurants and 1 promenade. All of these areas will be treated as a single zone characterized by its own heat losses and gains. The design of heat pumps depends on the energy need of each zone. Its design power is at least equal to the highest energy need (heating and cooling).

A previous study, led by BECICE, has allowed the description of all zones in terms of area, volume and set point temperatures as presented in table 3.

Table 3 Building characteristics

	Living space	Volume	Winter Temperature set point	Summer Temperature set point
Shops	18817 m ²	107258 m ³	19 °C	26 °C
Day nursery	60 m ²	344 m ³	19 °C	26 °C
Restaurants	854 m ²	3844 m ³	19 °C	26 °C
Promenade	3345 m ²	25086 m ³	19 °C	-
Total area	23077 m ²	136532 m ³		

Fresh air entering the shopping center is preheated by the Rooftops of the promenade zone. Hence, it's already warm when it penetrates into the other defined zones.

2.3.1.2 Zones characteristics:

Heating and cooling demands for each zone have been evaluated, as well as the emitters size and power implemented.

Table 4: Zones characteristics

	Habitable space	Volume	Heating demand	Cooling demand	Number of HP	Implemented Heating power	Implemented cooling power
Shop 1	2442,7 m ³	13923,3 m ³	33,7 kW	128,4 kW	12	230,2 kW	178,8 kW
Shop 2	751,3 m ³	4282,4 m ³	9,6 kW	39,3 kW	4	76,7 kW	59,6 kW
Shop 3	805,6 m ³	4591,6 m ³	11,0 kW	42,3 kW	4	76,7 kW	59,6 kW
Shop 4	2253,0 m ³	12842,2 m ³	31,3 kW	118,4 kW	11	211,0 kW	163,9 kW
Shop 5	427,8 m ³	2438,3 m ³	5,7 kW	22,4 kW	3	57,5 kW	44,7 kW
Shop 6	383,9 m ³	2188,3 m ³	3,7 kW	19,8 kW	2	38,4 kW	29,8 kW
Shop 7	973,4 m ³	5548,4 m ³	13,9 kW	51,3 kW	5	95,9 kW	74,5 kW
Shop 8	589,2 m ³	3358,5 m ³	9,4 kW	31,2 kW	3	57,5 kW	44,7 kW
Shop 9	485,2 m ³	2765,5 m ³	6,9 kW	25,5 kW	3	57,5 kW	44,7 kW
Shop 10	459,7 m ³	2620,0 m ³	6,5 kW	24,2 kW	3	57,5 kW	44,7 kW
Shop 11	825,1 m ³	4703,1 m ³	12,0 kW	43,5 kW	4	76,7 kW	59,6 kW
Shop 12	665,5 m ³	3793,5 m ³	9,9 kW	35,1 kW	4	76,7 kW	59,6 kW
Shop 13	599,1 m ³	3414,6 m ³	9,0 kW	31,6 kW	3	57,5 kW	44,7 kW
Shop 14	357,0 m ³	2034,8 m ³	4,9 kW	18,8 kW	2	38,4 kW	29,8 kW
Shop 15	345,9 m ³	1971,8 m ³	4,6 kW	18,1 kW	2	38,4 kW	29,8 kW
Shop 16	385,0 m ³	2194,4 m ³	5,0 kW	20,2 kW	2	38,4 kW	29,8 kW
Shop 17	385,0 m ³	2194,4 m ³	5,0 kW	20,2 kW	2	38,4 kW	29,8 kW
Shop 18	596,7 m ³	3401,0 m ³	9,0 kW	31,5 kW	3	57,5 kW	44,7 kW
Shop 19	340,4 m ³	1940,0 m ³	4,4 kW	17,8 kW	2	38,4 kW	29,8 kW
Shop 20	340,4 m ³	1940,3 m ³	4,4 kW	17,8 kW	2	38,4 kW	29,8 kW
Shop 21	340,3 m ³	1939,6 m ³	4,4 kW	17,8 kW	2	38,4 kW	29,8 kW
Shop 22	275,0 m ³	1567,4 m ³	3,6 kW	14,4 kW	2	38,4 kW	29,8 kW
Shop 23	145,2 m ³	827,8 m ³	1,4 kW	7,5 kW	1	19,2 kW	14,9 kW
Shop 24	196,4 m ³	1119,3 m ³	1,9 kW	10,1 kW	1	19,2 kW	14,9 kW
Shop 25	340,4 m ³	1940,3 m ³	4,4 kW	17,8 kW	2	38,4 kW	29,8 kW
Shop 26	340,3 m ³	1939,6 m ³	4,4 kW	17,8 kW	2	38,4 kW	29,8 kW
Shop 27	205,4 m ³	1171,0 m ³	2,0 kW	10,6 kW	1	19,2 kW	14,9 kW
Shop 28	196,4 m ³	1119,3 m ³	1,9 kW	10,1 kW	1	19,2 kW	14,9 kW
Shop 29	289,4 m ³	1649,4 m ³	2,8 kW	15,0 kW	2	38,4 kW	29,8 kW
Shop 30	289,4 m ³	1649,6 m ³	2,8 kW	15,0 kW	2	38,4 kW	29,8 kW
Shop 31	196,4 m ³	1119,3 m ³	1,9 kW	10,1 kW	1	19,2 kW	14,9 kW
Shop 32	196,4 m ³	1119,3 m ³	1,9 kW	10,1 kW	1	19,2 kW	14,9 kW
Shop 33	336,7 m ³	1919,4 m ³	4,0 kW	17,6 kW	2	38,4 kW	29,8 kW
Shop 34	321,2 m ³	1830,8 m ³	4,2 kW	16,8 kW	2	38,4 kW	29,8 kW
Shop 35	188,2 m ³	1072,9 m ³	1,8 kW	9,7 kW	1	19,2 kW	14,9 kW
Shop 36	145,2 m ³	827,8 m ³	1,4 kW	7,5 kW	1	19,2 kW	14,9 kW
Shop 37	156,7 m ³	893,1 m ³	1,5 kW	8,1 kW	1	19,2 kW	14,9 kW
Shop 38	117,0 m ³	667,0 m ³	1,1 kW	6,0 kW	1	19,2 kW	14,9 kW
Shop 39	129,6 m ³	738,9 m ³	1,3 kW	6,7 kW	1	19,2 kW	14,9 kW
	16817,3 m³	107258,3 m³	249,1 kW	986,6 kW	103	1 975,5 kW	1 534,7 kW
day nursery 30	60,3 m ³	343,7 m ³	1,1 kW	3,2 kW	1	19,2 kW	14,9 kW
	60,3 m³	343,7 m³	1,1 kW	3,2 kW	1	19,2 kW	14,9 kW
Restaurant 41	396,6 m ³	1784,7 m ³	7,8 kW	58,5 kW	6	115,1 kW	89,4 kW
Restaurant 42	457,6 m ³	2059,3 m ³	7,5 kW	67,2 kW	7	134,3 kW	104,3 kW
	854,2 m³	3 844,0 m³	15,3 kW	125,8 kW	13	249,3 kW	193,7 kW
Promenade	3344,6 m³	25086,2 m³	100,2 kW	376,0 kW	3 (Roof top)	604,3 kW	470,0 kW
	23076,6 m³	136532,2 m³	365,6 kW	1 491,6 kW	120	2 848,3 kW	2 213,3 kW

2.3.1.3 Emitters characteristics:

Brands and models of actual devices are known thanks to BECICE. The emitters installed in the commercial complex (Shops, restaurants and day nursery) are reversible heat pumps using water loops (LENNOX FWHK 16).

Efficiencies of these devices depend on both the evaporator and condenser temperatures. Hence, the heat pump performances can be assessed accordingly with evaporator and condenser temperatures profiles.

▪ For the Heating operation

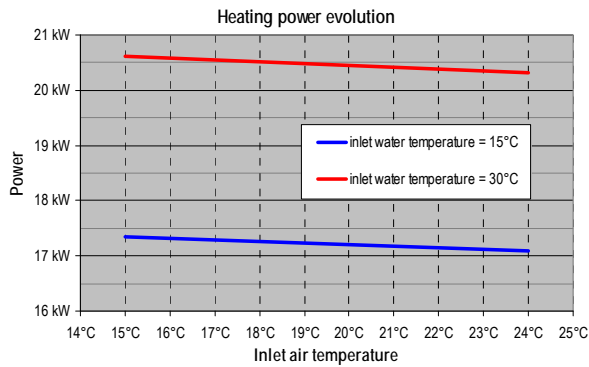


Figure 3 Heating power evolution

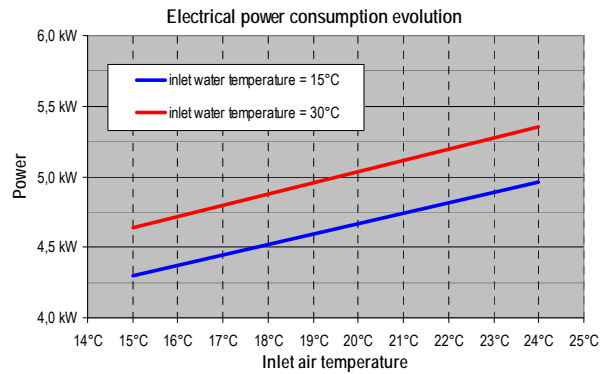


Figure 4 Electrical power consumption evolution

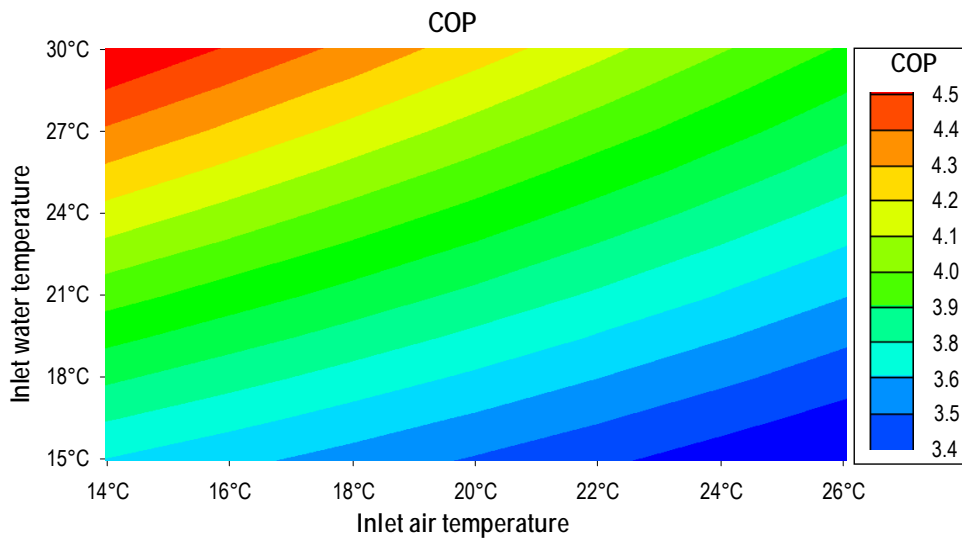


Figure 5 Evolution of the Heat Pump COP

▪ Cooling operation

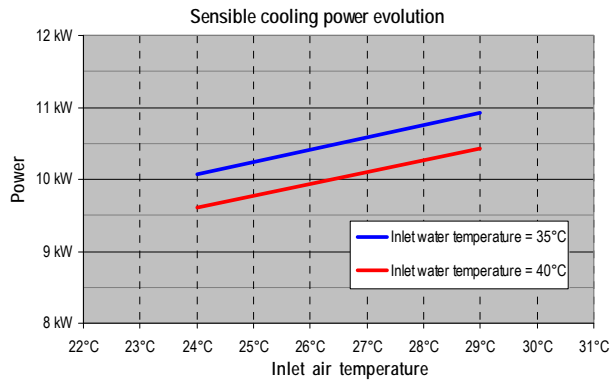


Figure 6 Sensible cooling power evolution

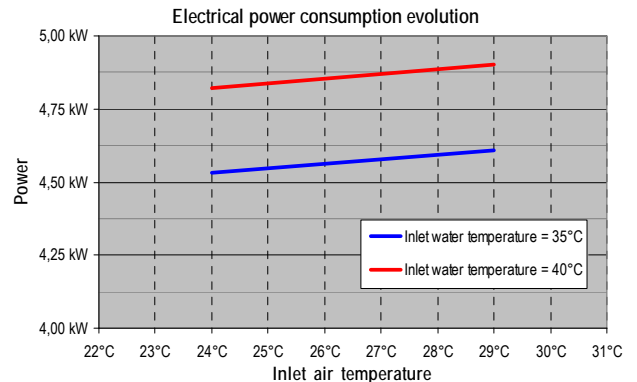


Figure 7 Electrical power consumption evolution

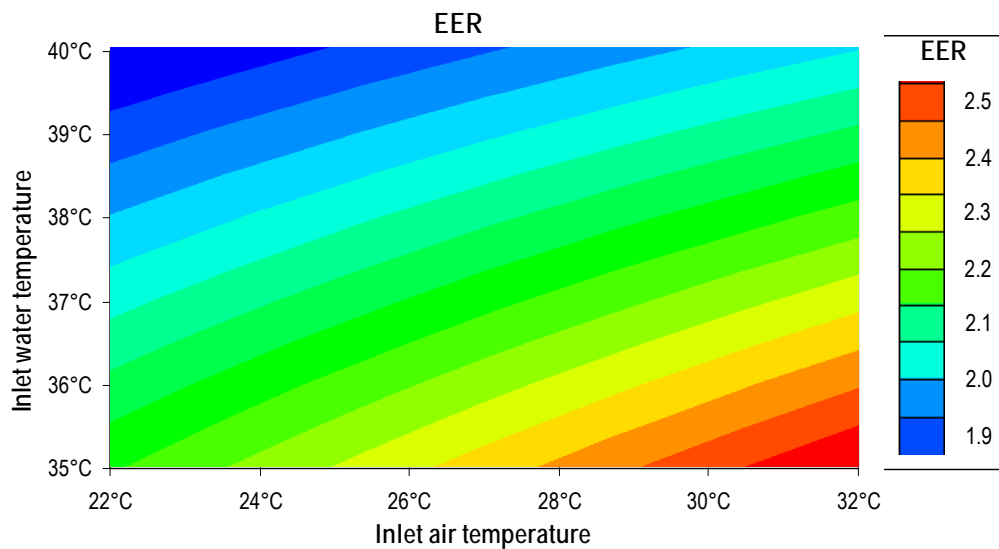


Figure 8 Evolution of the Heat Pump EER

Concerning the Promenade, emitters are rooftops LENNOX FHK 120 and 170.

Operation hypothesis:

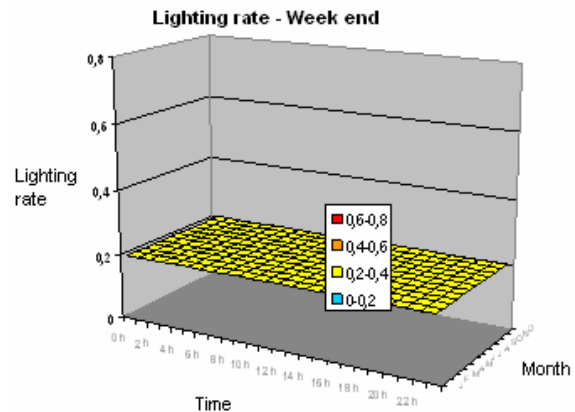
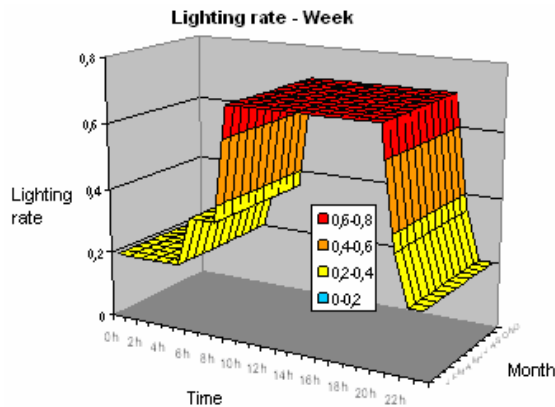
The operation hypothesis includes

- Temperatures set points, with start and stop gaps and a temperature decrease during the night.
- Lighting power implemented and its use rate according to the hours of the day, the month and the type of day (weekday or weekend)
- The occupancy with a maximal value which is balanced according to the hour of the day, the month and the type of day (weekday or weekend).
- Solar gains,
- Ventilation, flow rates by people and minimal flow rate.
- Monday till Saturday are considered as « weekdays » whereas only Sundays are considered as « weekends ».
- Internal gains calculations are based on the RT2005 analysis led by BECICE.

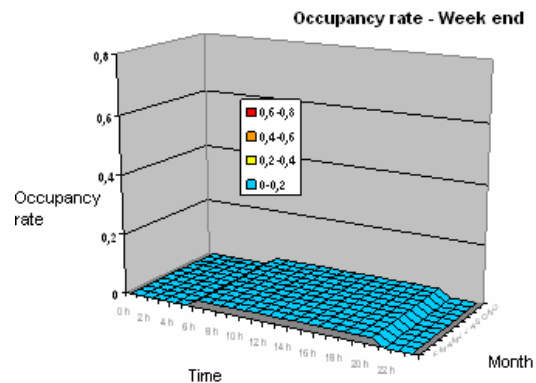
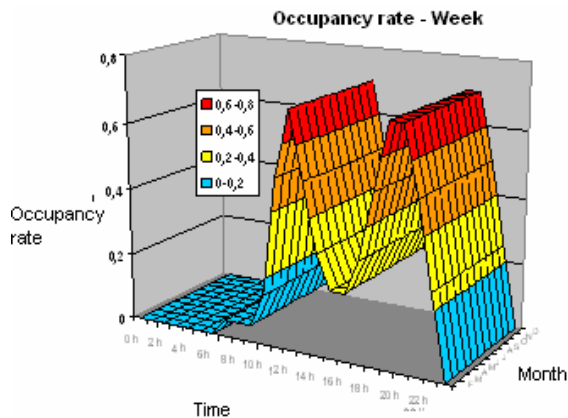
“Shops and Day nursery” zone

The same hypotheses are assumed for both the commercial area and the nursery day and are stated as follow:

- Heating temperature set points: 19°C with a starting gap of 0°C and a stopping gap of 3°C,
- A temperature decrease of 2°C between 23:00 and 6:00 during the week and the entire weekend.
- Cooling temperature set points: 26°C with a starting gap of 1°C and a stopping gap of 2°C,
- Lighting power implemented: 12 W/m² of living space. The lighting rate depends on the period:



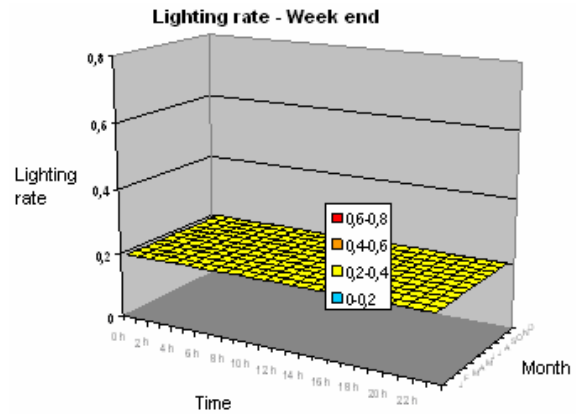
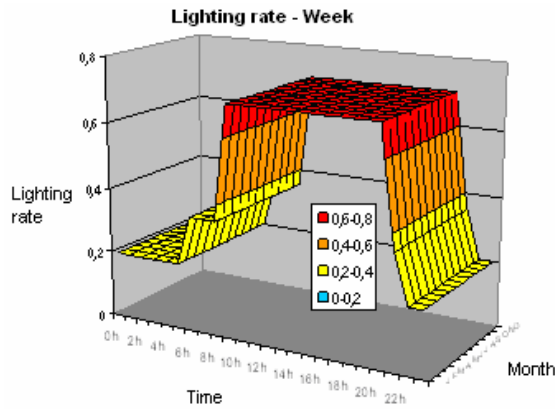
- Maximal occupancy: 1 people per 8 m² (habitable space)
- Occupancy rate:



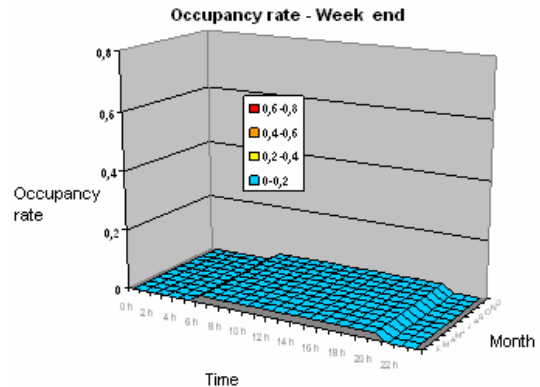
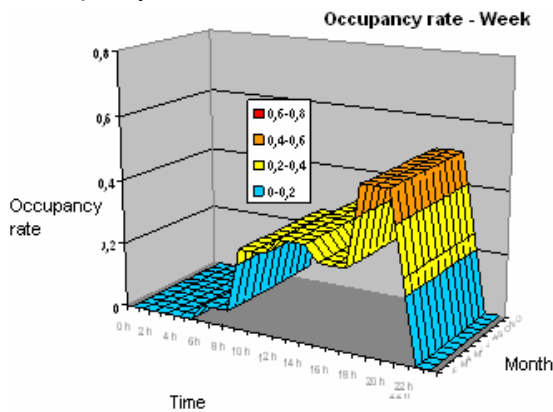
- Maximal solar gains : 20 W/m² of living space, gains are evaluated on an hourly basis ,
- Ventilation 18 m³/h of fresh air with a minimal value equal to 20 % of the maximal ventilation.

« Restaurant » zone

- Heating temperature settings: 19°C with a starting gap of 0°C and a stopping gap of 3°C,
- A temperature decrease of 2°C between 23 and 6 during the week and all times during the week end.
- Cooling temperature settings: 26°C with a starting gap of 1°C and a stopping gap of 2°C,
- Lighting power implemented: 12 W/m² of habitable space. The lighting rate depends on the period:



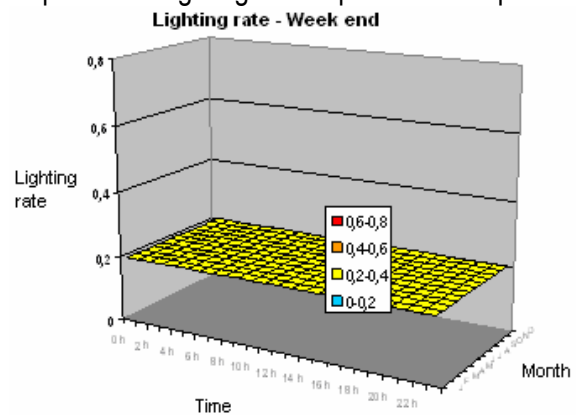
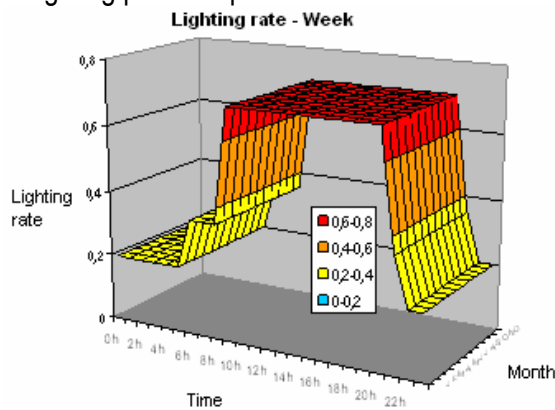
- Maximal solar gains : 20 W/m² of living space, gains are evaluated on an hourly basis
- Maximal occupancy: 1 person per 8 m² (living space)
- Occupancy rate:



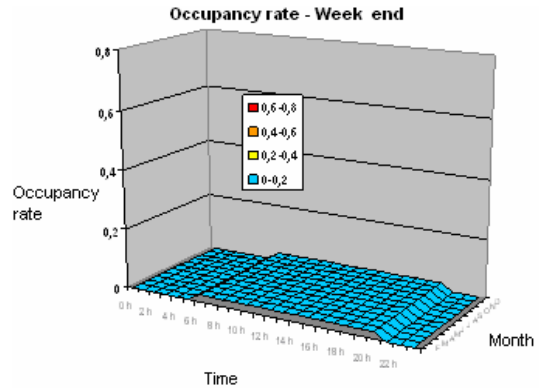
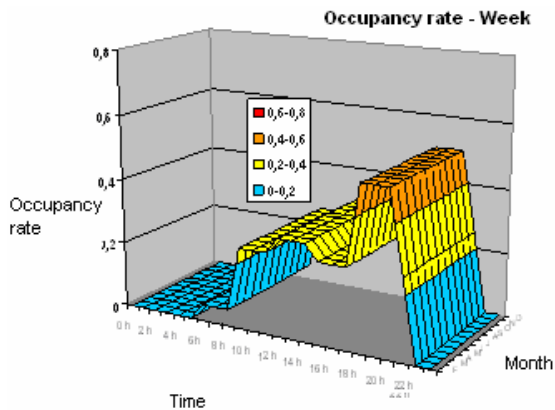
- Gain from appliances : 100 W/person
- Ventilation 30 m³/h of fresh air with a minimal value equal to 20 % of the maximal ventilation.

« Promenade » zone:

- Heating temperature set points: 19°C with a starting gap of 0°C and a stopping gap of 3°C,
- A temperature decrease of 2°C between 23:00 and 6:00 during the week and all the weekend.
- Cooling temperature set points: 26°C with a starting gap of 1°C and a stopping gap of 2°C,
- Lighting power implemented: 12 W/m² of habitable space. The lighting rate depends on the period:



- Maximal occupancy: 1 person per 8 m² (habitable space)
- Occupancy rate:



- Maximal solar gains : 30 W/m² of habitable space, gains are calculated for on an hourly basis
- Ventilation 18 m³/h of fresh air with a minimal value equal to 20 % of the maximal ventilation.
- All the fresh air of the shopping mall is entering through this Zone.

2.3.1.4 Reference solution hypothesis

Emitters are installed on the water loop either to take calories from the loop and heat shopping areas, or to remove calories and cool shopping areas.

▪ Heating and cooling production

The reference solution described by BECICE consists of a water loop whose temperature is regulated by a gas boiler room and a number of dry air coolers.

Boiler room	Condensing gas boilers	390 kW
	Condensing boiler quantity	3
	Optimal efficiency	95,1% (LHV)
Dry air coolers	Dry air cooler power	780 kW
	Fans power	8x1.38 kW
	Air coolers quantity	5

The heating and cooling demands of the «Promenade zone» are covered by rooftops having the following characteristics:

- Heating production: hot water heat exchangers fed by gas boilers,
- Cooling production: air to air heat pump,

▪ Water loop

For an accurate simulation of the thermal system behavior, water loop characteristics must be known and especially the water loop volume. According to BECICE the water volume is of 30 m³.

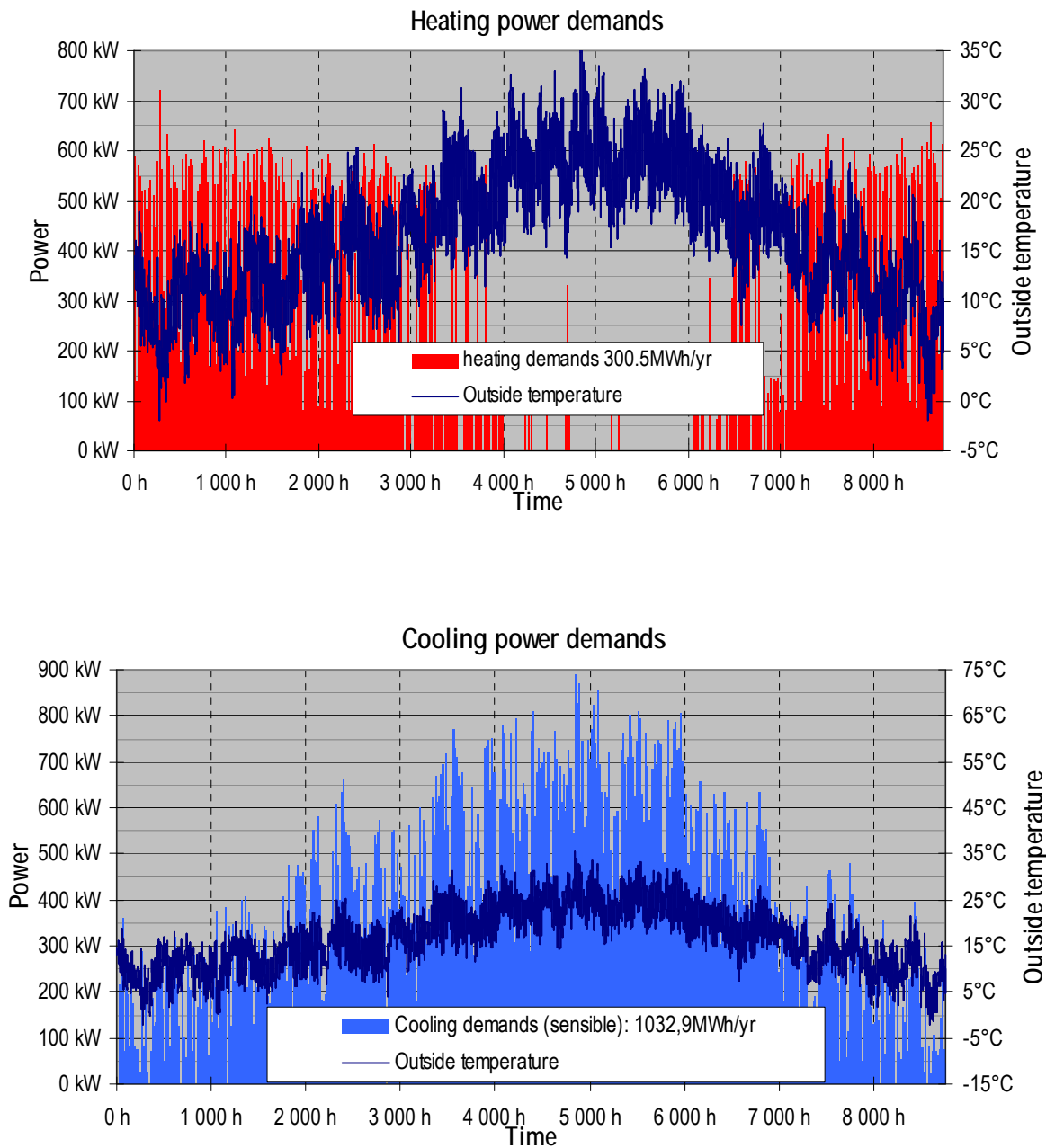
The maximal flow rate obtained by summing up all emitters flow rates is equal to 225 m³/h.

2.3.2 Energy demands

The previously stated hypotheses and meteorological data have been used to evaluate the energy demand of each zone.

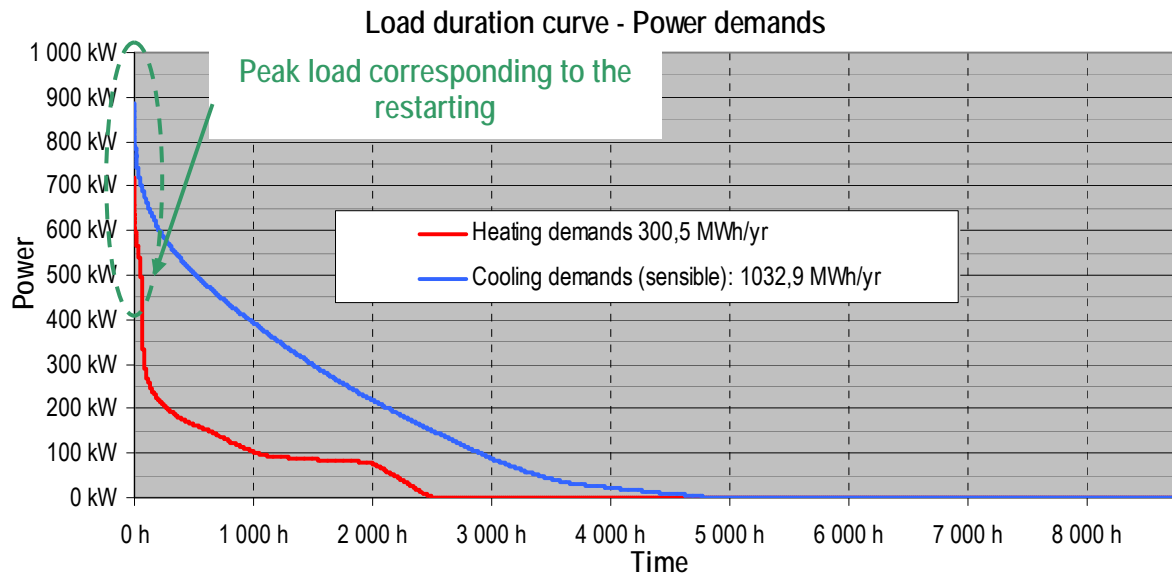
2.3.2.1 Power demand

The following graphs show dynamic power demands of the shops zone, restaurants and day nursery zone as well as outside temperature variations. These graphs stem from the dynamic thermal simulation of the shopping center, based on previously stated hypotheses.



Concerning heating power demands, the peak load corresponds to the morning restarting.

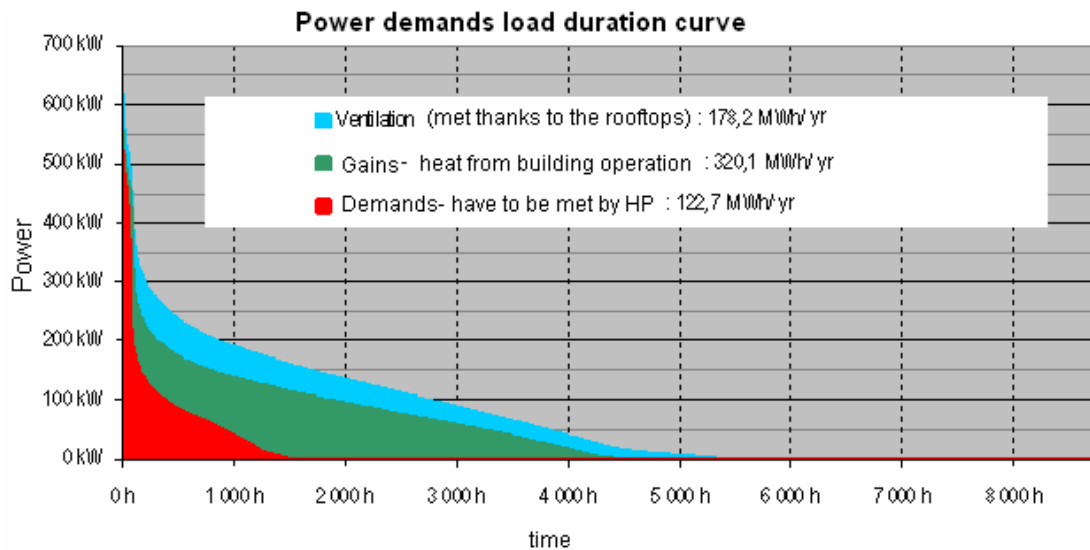
Following graphs illustrate the load curve for both heating and cooling needs of the shopping area, restaurants, day nursery and promenade area. These curves result from dynamic simulation.



Energy demands to achieve heating and cooling in the shopping centre are:

- Energy demands - heating purpose : 122,7 MWh_h/yr
- Energy demands - cooling purpose : 860,3 MWh_c/yr (sensible)

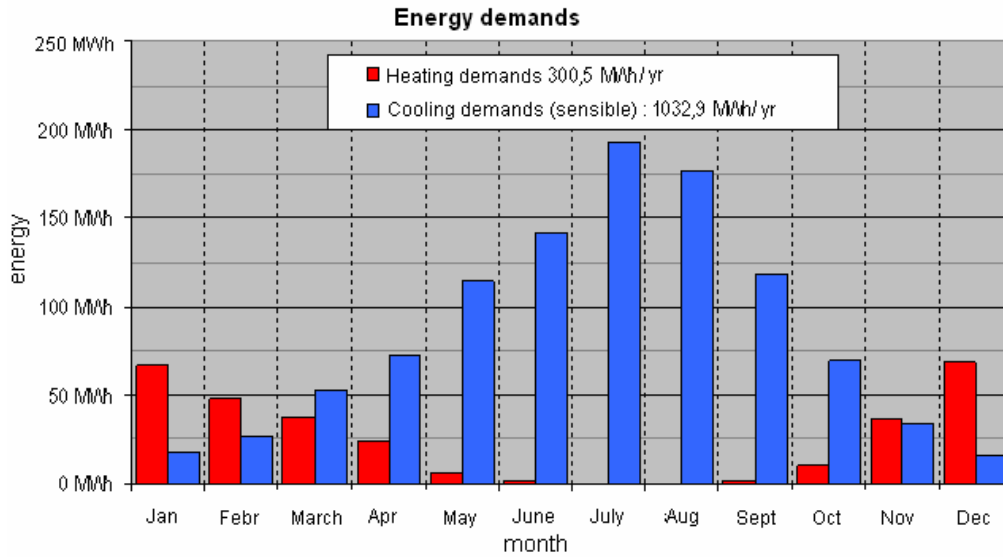
The following graph shows the total demands distribution between actual demands covered by local HP, heat gains and demands corresponding to ventilation load covered by the promenade zone.



2.3.2.2 Energy demands:

▪ Global energy demands

The following graph shows monthly energy demands over a year.



It is obvious that cooling demands are higher than heating demands due to Mediterranean climatic conditions and high heat gains. Following tables demonstrate the distribution between heating demands and cooling demands for each zone.

•Heating demand by zone

	January	February	March	April	May	June	July	August	Septemb	October	Novemb	Decemb	Sum
Shop 1	3,60 MWh	2,68 MWh	2,03 MWh	1,28 MWh	0,30 MWh	0,04 MWh	0,02 MWh	0,00 MWh	0,07 MWh	0,49 MWh	1,87 MWh	3,78 MWh	16,17 MWh
Shop 2	0,99 MWh	0,72 MWh	0,55 MWh	0,34 MWh	0,08 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,13 MWh	0,48 MWh	1,02 MWh	4,33 MWh
Shop 3	1,17 MWh	0,87 MWh	0,66 MWh	0,42 MWh	0,10 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,16 MWh	0,60 MWh	1,23 MWh	5,25 MWh
Shop 4	3,36 MWh	2,49 MWh	1,90 MWh	1,20 MWh	0,28 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,06 MWh	0,46 MWh	1,73 MWh	3,51 MWh	15,06 MWh
Shop 5	0,58 MWh	0,44 MWh	0,33 MWh	0,21 MWh	0,05 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,08 MWh	0,30 MWh	0,62 MWh	2,64 MWh
Shop 6	0,30 MWh	0,22 MWh	0,16 MWh	0,11 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,03 MWh	0,14 MWh	0,31 MWh	1,30 MWh
Shop 7	1,58 MWh	1,18 MWh	0,92 MWh	0,56 MWh	0,13 MWh	0,02 MWh	0,01 MWh	0,00 MWh	0,03 MWh	0,21 MWh	0,83 MWh	1,65 MWh	7,13 MWh
Shop 8	1,13 MWh	0,83 MWh	0,65 MWh	0,40 MWh	0,11 MWh	0,02 MWh	0,00 MWh	0,00 MWh	0,03 MWh	0,16 MWh	0,59 MWh	1,18 MWh	5,10 MWh
Shop 9	0,74 MWh	0,55 MWh	0,42 MWh	0,27 MWh	0,06 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,10 MWh	0,39 MWh	0,79 MWh	3,36 MWh
Shop 10	0,70 MWh	0,52 MWh	0,40 MWh	0,25 MWh	0,06 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,10 MWh	0,37 MWh	0,73 MWh	3,15 MWh
Shop 11	1,34 MWh	1,00 MWh	0,76 MWh	0,48 MWh	0,12 MWh	0,02 MWh	0,01 MWh	0,00 MWh	0,03 MWh	0,18 MWh	0,70 MWh	1,41 MWh	6,03 MWh
Shop 12	1,15 MWh	0,87 MWh	0,67 MWh	0,42 MWh	0,10 MWh	0,02 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,17 MWh	0,61 MWh	1,22 MWh	5,26 MWh
Shop 13	1,03 MWh	0,77 MWh	0,59 MWh	0,37 MWh	0,09 MWh	0,02 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,14 MWh	0,54 MWh	1,07 MWh	4,64 MWh
Shop 14	0,53 MWh	0,40 MWh	0,30 MWh	0,19 MWh	0,05 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,07 MWh	0,28 MWh	0,56 MWh	2,40 MWh
Shop 15	0,49 MWh	0,37 MWh	0,28 MWh	0,18 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,07 MWh	0,25 MWh	0,51 MWh	2,19 MWh
Shop 16	0,52 MWh	0,39 MWh	0,29 MWh	0,18 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,07 MWh	0,26 MWh	0,54 MWh	2,31 MWh
Shop 17	0,52 MWh	0,39 MWh	0,29 MWh	0,18 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,07 MWh	0,26 MWh	0,54 MWh	2,31 MWh
Shop 18	1,02 MWh	0,76 MWh	0,58 MWh	0,36 MWh	0,09 MWh	0,02 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,14 MWh	0,54 MWh	1,07 MWh	4,61 MWh
Shop 19	0,46 MWh	0,34 MWh	0,25 MWh	0,16 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,23 MWh	0,47 MWh	2,02 MWh
Shop 20	0,46 MWh	0,34 MWh	0,26 MWh	0,16 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,23 MWh	0,47 MWh	2,02 MWh
Shop 21	0,46 MWh	0,34 MWh	0,25 MWh	0,16 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,23 MWh	0,47 MWh	2,02 MWh
Shop 22	0,38 MWh	0,28 MWh	0,21 MWh	0,14 MWh	0,03 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,05 MWh	0,19 MWh	0,39 MWh	1,69 MWh
Shop 23	0,11 MWh	0,08 MWh	0,06 MWh	0,04 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,12 MWh	0,49 MWh
Shop 24	0,16 MWh	0,11 MWh	0,08 MWh	0,05 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,07 MWh	0,16 MWh	0,66 MWh
Shop 25	0,46 MWh	0,34 MWh	0,26 MWh	0,16 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,23 MWh	0,47 MWh	2,02 MWh
Shop 26	0,46 MWh	0,34 MWh	0,25 MWh	0,16 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,23 MWh	0,47 MWh	2,02 MWh
Shop 27	0,16 MWh	0,12 MWh	0,08 MWh	0,06 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,08 MWh	0,17 MWh	0,69 MWh
Shop 28	0,16 MWh	0,11 MWh	0,08 MWh	0,05 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,07 MWh	0,16 MWh	0,66 MWh
Shop 29	0,22 MWh	0,17 MWh	0,12 MWh	0,08 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,11 MWh	0,24 MWh	0,97 MWh
Shop 30	0,22 MWh	0,17 MWh	0,12 MWh	0,08 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,11 MWh	0,24 MWh	0,97 MWh
Shop 31	0,16 MWh	0,11 MWh	0,08 MWh	0,05 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,07 MWh	0,16 MWh	0,66 MWh
Shop 32	0,16 MWh	0,11 MWh	0,08 MWh	0,05 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,07 MWh	0,16 MWh	0,66 MWh
Shop 33	0,37 MWh	0,27 MWh	0,21 MWh	0,13 MWh	0,03 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,05 MWh	0,19 MWh	0,39 MWh	1,65 MWh
Shop 34	0,44 MWh	0,32 MWh	0,25 MWh	0,16 MWh	0,04 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,22 MWh	0,45 MWh	1,95 MWh
Shop 35	0,15 MWh	0,11 MWh	0,08 MWh	0,05 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,07 MWh	0,15 MWh	0,63 MWh
Shop 36	0,11 MWh	0,08 MWh	0,06 MWh	0,04 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,12 MWh	0,49 MWh
Shop 37	0,12 MWh	0,09 MWh	0,07 MWh	0,04 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,06 MWh	0,13 MWh	0,53 MWh
Shop 38	0,09 MWh	0,07 MWh	0,05 MWh	0,03 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,04 MWh	0,09 MWh	0,39 MWh
Shop 39	0,10 MWh	0,07 MWh	0,05 MWh	0,03 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,01 MWh	0,05 MWh	0,11 MWh	0,43 MWh
day nursery40	0,15 MWh	0,11 MWh	0,09 MWh	0,05 MWh	0,01 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,00 MWh	0,02 MWh	0,08 MWh	0,15 MWh	0,67 MWh
Restaurant 41	0,61 MWh	0,46 MWh	0,36 MWh	0,23 MWh	0,07 MWh	0,03 MWh	0,01 MWh	0,00 MWh	0,03 MWh	0,10 MWh	0,31 MWh	0,64 MWh	2,67 MWh
Restaurant 42	0,50 MWh	0,37 MWh	0,30 MWh	0,19 MWh	0,07 MWh	0,03 MWh	0,01 MWh	0,01 MWh	0,04 MWh	0,10 MWh	0,25 MWh	0,53 MWh	2,39 MWh
Promenade	38,98 MWh	27,91 MWh	22,27 MWh	13,82 MWh	3,37 MWh	1,01 MWh	0,21 MWh	0,07 MWh	0,94 MWh	6,13 MWh	23,02 MWh	40,05 MWh	177,73 MWh
Total	66,33 MWh	48,28 MWh	37,76 MWh	23,57 MWh	5,67 MWh	1,42 MWh	0,31 MWh	0,08 MWh	1,46 MWh	9,88 MWh	37,04 MWh	68,73 MWh	300,53 MWh

•Cooling demand by zone.

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Shop 1	1,36 MWh	2,40 MWh	5,20 MWh	7,34 MWh	11,28 MWh	13,75 MWh	18,03 MWh	16,56 MWh	11,37 MWh	6,87 MWh	3,03 MWh	1,20 MWh	98,39 MWh
Shop 2	0,49 MWh	0,83 MWh	1,71 MWh	2,35 MWh	3,53 MWh	4,26 MWh	5,53 MWh	5,10 MWh	3,52 MWh	2,21 MWh	1,02 MWh	0,43 MWh	30,99 MWh
Shop 3	0,45 MWh	0,81 MWh	1,74 MWh	2,44 MWh	3,73 MWh	4,54 MWh	5,93 MWh	5,47 MWh	3,74 MWh	2,29 MWh	1,02 MWh	0,40 MWh	32,55 MWh
Shop 4	1,24 MWh	2,21 MWh	4,80 MWh	6,77 MWh	10,38 MWh	12,68 MWh	16,62 MWh	15,30 MWh	10,47 MWh	6,34 MWh	2,80 MWh	1,06 MWh	90,68 MWh
Shop 5	0,25 MWh	0,44 MWh	0,93 MWh	1,30 MWh	1,98 MWh	2,41 MWh	3,16 MWh	2,90 MWh	1,99 MWh	1,21 MWh	0,55 MWh	0,22 MWh	17,32 MWh
Shop 6	0,44 MWh	0,61 MWh	1,08 MWh	1,38 MWh	1,90 MWh	2,23 MWh	2,82 MWh	2,61 MWh	1,86 MWh	1,26 MWh	0,70 MWh	0,40 MWh	17,26 MWh
Shop 7	0,51 MWh	0,92 MWh	2,04 MWh	2,90 MWh	4,48 MWh	5,48 MWh	7,20 MWh	6,62 MWh	4,53 MWh	2,73 MWh	1,16 MWh	0,43 MWh	39,00 MWh
Shop 8	0,23 MWh	0,47 MWh	1,10 MWh	1,62 MWh	2,62 MWh	3,28 MWh	4,37 MWh	4,01 MWh	2,70 MWh	1,54 MWh	0,61 MWh	0,20 MWh	22,77 MWh
Shop 9	0,24 MWh	0,45 MWh	0,99 MWh	1,42 MWh	2,21 MWh	2,72 MWh	3,58 MWh	3,29 MWh	2,24 MWh	1,34 MWh	0,58 MWh	0,21 MWh	19,28 MWh
Shop 10	0,23 MWh	0,43 MWh	0,95 MWh	1,35 MWh	2,10 MWh	2,57 MWh	3,39 MWh	3,12 MWh	2,12 MWh	1,27 MWh	0,55 MWh	0,19 MWh	18,28 MWh
Shop 11	0,41 MWh	0,76 MWh	1,69 MWh	2,39 MWh	3,75 MWh	4,63 MWh	6,10 MWh	5,62 MWh	3,82 MWh	2,26 MWh	0,96 MWh	0,33 MWh	32,73 MWh
Shop 12	0,30 MWh	0,58 MWh	1,31 MWh	1,90 MWh	3,00 MWh	3,73 MWh	4,93 MWh	4,52 MWh	3,06 MWh	1,80 MWh	0,74 MWh	0,25 MWh	26,13 MWh
Shop 13	0,27 MWh	0,52 MWh	1,19 MWh	1,72 MWh	2,71 MWh	3,34 MWh	4,43 MWh	4,07 MWh	2,76 MWh	1,62 MWh	0,67 MWh	0,23 MWh	23,53 MWh
Shop 14	0,19 MWh	0,35 MWh	0,76 MWh	1,07 MWh	1,65 MWh	2,00 MWh	2,64 MWh	2,42 MWh	1,66 MWh	1,00 MWh	0,44 MWh	0,17 MWh	14,36 MWh
Shop 15	0,20 MWh	0,36 MWh	0,76 MWh	1,06 MWh	1,60 MWh	1,95 MWh	2,55 MWh	2,34 MWh	1,61 MWh	0,99 MWh	0,44 MWh	0,18 MWh	14,05 MWh
Shop 16	0,24 MWh	0,41 MWh	0,86 MWh	1,20 MWh	1,80 MWh	2,18 MWh	2,84 MWh	2,62 MWh	1,80 MWh	1,12 MWh	0,50 MWh	0,21 MWh	15,79 MWh
Shop 17	0,24 MWh	0,41 MWh	0,86 MWh	1,20 MWh	1,80 MWh	2,18 MWh	2,84 MWh	2,62 MWh	1,80 MWh	1,12 MWh	0,50 MWh	0,21 MWh	15,79 MWh
Shop 18	0,26 MWh	0,52 MWh	1,17 MWh	1,70 MWh	2,70 MWh	3,33 MWh	4,42 MWh	4,06 MWh	2,75 MWh	1,61 MWh	0,67 MWh	0,23 MWh	23,43 MWh
Shop 19	0,21 MWh	0,37 MWh	0,76 MWh	1,06 MWh	1,59 MWh	1,93 MWh	2,50 MWh	2,31 MWh	1,59 MWh	0,98 MWh	0,46 MWh	0,18 MWh	13,96 MWh
Shop 20	0,21 MWh	0,37 MWh	0,77 MWh	1,06 MWh	1,59 MWh	1,93 MWh	2,50 MWh	2,31 MWh	1,59 MWh	0,98 MWh	0,46 MWh	0,18 MWh	13,96 MWh
Shop 21	0,21 MWh	0,37 MWh	0,76 MWh	1,06 MWh	1,59 MWh	1,93 MWh	2,50 MWh	2,31 MWh	1,59 MWh	0,98 MWh	0,46 MWh	0,18 MWh	13,95 MWh
Shop 22	0,16 MWh	0,28 MWh	0,60 MWh	0,84 MWh	1,28 MWh	1,55 MWh	2,02 MWh	1,86 MWh	1,28 MWh	0,79 MWh	0,35 MWh	0,14 MWh	11,17 MWh
Shop 23	0,16 MWh	0,23 MWh	0,41 MWh	0,52 MWh	0,72 MWh	0,84 MWh	1,06 MWh	0,99 MWh	0,70 MWh	0,47 MWh	0,27 MWh	0,15 MWh	6,52 MWh
Shop 24	0,23 MWh	0,31 MWh	0,55 MWh	0,70 MWh	0,97 MWh	1,14 MWh	1,44 MWh	1,34 MWh	0,95 MWh	0,64 MWh	0,36 MWh	0,20 MWh	8,83 MWh
Shop 25	0,21 MWh	0,37 MWh	0,77 MWh	1,06 MWh	1,59 MWh	1,93 MWh	2,50 MWh	2,31 MWh	1,59 MWh	0,98 MWh	0,46 MWh	0,18 MWh	13,96 MWh
Shop 26	0,21 MWh	0,37 MWh	0,76 MWh	1,06 MWh	1,59 MWh	1,93 MWh	2,50 MWh	2,31 MWh	1,59 MWh	0,98 MWh	0,46 MWh	0,18 MWh	13,95 MWh
Shop 27	0,24 MWh	0,33 MWh	0,57 MWh	0,74 MWh	1,02 MWh	1,20 MWh	1,51 MWh	1,40 MWh	0,99 MWh	0,67 MWh	0,38 MWh	0,21 MWh	9,24 MWh
Shop 28	0,23 MWh	0,31 MWh	0,55 MWh	0,70 MWh	0,97 MWh	1,14 MWh	1,44 MWh	1,34 MWh	0,95 MWh	0,64 MWh	0,36 MWh	0,20 MWh	8,83 MWh
Shop 29	0,33 MWh	0,46 MWh	0,81 MWh	1,03 MWh	1,42 MWh	1,68 MWh	2,12 MWh	1,97 MWh	1,40 MWh	0,94 MWh	0,53 MWh	0,30 MWh	12,98 MWh
Shop 30	0,33 MWh	0,46 MWh	0,81 MWh	1,03 MWh	1,42 MWh	1,68 MWh	2,12 MWh	1,97 MWh	1,40 MWh	0,94 MWh	0,53 MWh	0,30 MWh	12,98 MWh
Shop 31	0,23 MWh	0,31 MWh	0,55 MWh	0,70 MWh	0,97 MWh	1,14 MWh	1,44 MWh	1,34 MWh	0,95 MWh	0,64 MWh	0,36 MWh	0,20 MWh	8,83 MWh
Shop 32	0,23 MWh	0,31 MWh	0,55 MWh	0,70 MWh	0,97 MWh	1,14 MWh	1,44 MWh	1,34 MWh	0,95 MWh	0,64 MWh	0,36 MWh	0,20 MWh	8,83 MWh
Shop 33	0,26 MWh	0,41 MWh	0,82 MWh	1,10 MWh	1,61 MWh	1,93 MWh	2,47 MWh	2,28 MWh	1,59 MWh	1,02 MWh	0,50 MWh	0,24 MWh	14,22 MWh
Shop 34	0,20 MWh	0,34 MWh	0,71 MWh	0,99 MWh	1,50 MWh	1,81 MWh	2,37 MWh	2,18 MWh	1,50 MWh	0,92 MWh	0,42 MWh	0,17 MWh	13,10 MWh
Shop 35	0,22 MWh	0,30 MWh	0,52 MWh	0,68 MWh	0,93 MWh	1,10 MWh	1,38 MWh	1,28 MWh	0,91 MWh	0,61 MWh	0,34 MWh	0,20 MWh	8,45 MWh
Shop 36	0,16 MWh	0,23 MWh	0,41 MWh	0,52 MWh	0,72 MWh	0,84 MWh	1,06 MWh	0,99 MWh	0,70 MWh	0,47 MWh	0,27 MWh	0,15 MWh	6,52 MWh
Shop 37	0,18 MWh	0,25 MWh	0,44 MWh	0,56 MWh	0,77 MWh	0,91 MWh	1,15 MWh	1,06 MWh	0,76 MWh	0,51 MWh	0,28 MWh	0,16 MWh	7,04 MWh
Shop 38	0,13 MWh	0,19 MWh	0,33 MWh	0,42 MWh	0,58 MWh	0,68 MWh	0,86 MWh	0,80 MWh	0,57 MWh	0,38 MWh	0,21 MWh	0,12 MWh	5,25 MWh
Shop 39	0,15 MWh	0,21 MWh	0,36 MWh	0,46 MWh	0,64 MWh	0,75 MWh	0,95 MWh	0,88 MWh	0,62 MWh	0,42 MWh	0,24 MWh	0,13 MWh	5,82 MWh
Day nursery 40	0,02 MWh	0,04 MWh	0,10 MWh	0,15 MWh	0,26 MWh	0,33 MWh	0,45 MWh	0,41 MWh	0,27 MWh	0,15 MWh	0,06 MWh	0,02 MWh	2,26 MWh
Restaurant 41	2,55 MWh	2,78 MWh	4,03 MWh	4,75 MWh	6,23 MWh	6,97 MWh	8,69 MWh	8,60 MWh	6,46 MWh	5,05 MWh	3,46 MWh	2,45 MWh	62,03 MWh
Restaurant 42	3,30 MWh	3,49 MWh	4,92 MWh	5,69 MWh	7,32 MWh	8,10 MWh	9,99 MWh	9,90 MWh	7,51 MWh	5,99 MWh	4,27 MWh	3,18 MWh	73,65 MWh
Promenade	0,00 MWh	0,03 MWh	1,42 MWh	4,06 MWh	12,75 MWh	20,41 MWh	34,95 MWh	29,89 MWh	15,90 MWh	4,11 MWh	0,75 MWh	0,00 MWh	124,27 MWh
Total	17,93 MWh	26,54 MWh	52,40 MWh	72,77 MWh	114,25 MWh	142,27 MWh	192,80 MWh	176,62 MWh	118,16 MWh	69,48 MWh	33,51 MWh	16,20 MWh	1032,93 MWh

3. ENERGY USE

3.1. FINANCIAL CONDITIONS

The following tables show energy costs for the reference solution.

Reference (gas+air coolers)				
			Energy	Cost
Electricity (EDF price list 15/08/2007)	Green tariff A5 LU	Air coolers	11 MWhe	323 €/yr
		Promenade cooling	53 MWhe	1 383 €/yr
	Blu or yellow tariff	Tenants HP	594 MWhe	36 453 €/yr
Gas (GDF price list)	Tariff B2S	Loop heating	25 MWh HHV	1 636 €/yr
		Promenade rooftops	250 MWh HHV	8 699 €/yr
Cost				48 495 €/yr
GHG emissions :				99,1 tCO2eq/yr

	Annual consumption	Global cost	Average cost
Electricity	658 MWh per year	38 159 € per year	58 € / MWh
Gas	275 MWh per year	10 335 € per year	38 € / MWh

3.2. TECHNICAL CONDITIONS

For a constant temperature water loop, every occupant, depending on its needs can either:

- cool its space by rejecting calories of the cooled space
- or heat its space by taking calories from the water loop.

The water loop must have a variable flow rate in order to reduce auxiliaries energy consumption for non-full load conditions.

The heating/cooling system will function during working hours of the commercial mall fixed by the mall manager. The main purpose of the thermal system is to regulate the temperature of the water loop in order to:

- evacuate excess calories during summer periods
- supply necessary calories during winter periods

All occupants must install a heat pump connected to the water loop.

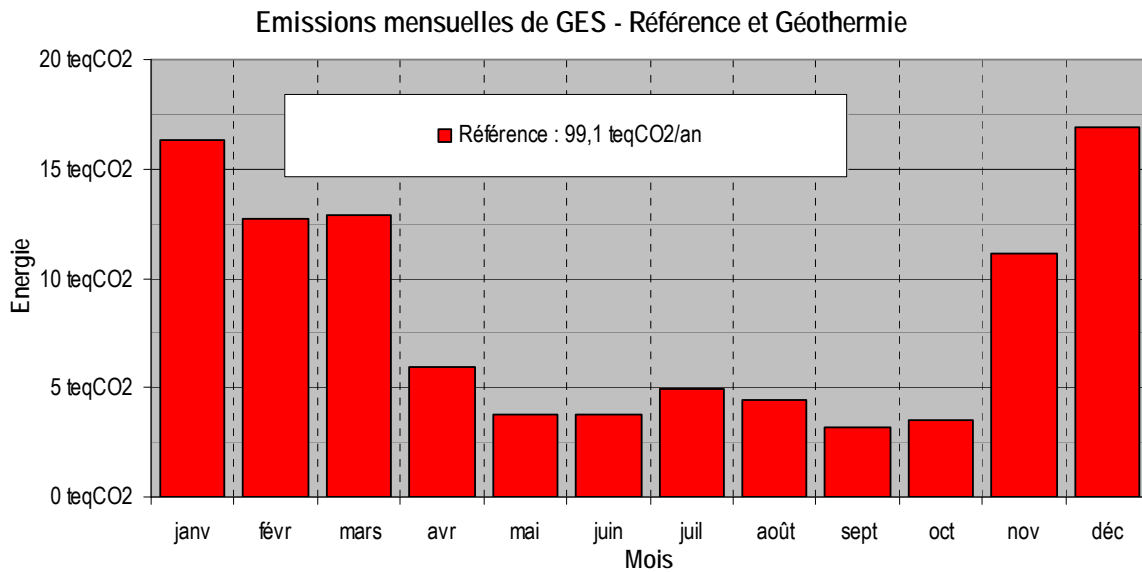
3.3. CO₂ FIGURES

GHG emissions have been calculated based on ratios defined by ADEME for each energy type. These ratios are presented in table 5.

Table 5

	Electricity (kg.MWh)	Gas (kg/MWh (LHV))
Winter	180	230.8
Summer	40	230.8

According to these ratios and to energy consumptions of each solution, GHG emissions are determined monthly. The following graph shows monthly GHG emissions for the reference solution.



The reference solution produces 99,1 Tons CO₂ equivalent a year.

4. MAIN CONCLUSIONS

Obviously, cooling demands (1 033 MWh per year) are much higher than heating demands (300 MWh per year) due to Mediterranean climatic conditions and large available heat gains: from lighting, people and sunshine.

As a standard solution, gas boilers will cover the heating demand and heat pumps coupled with air coolers will cover the cooling demand. This solution will allow global emissions of greenhouse gases of 99 tons CO₂ equivalent a year.