EUROPEAN COMMISSION

DIRECTORATE-GENERAL FOR ENERGY

SAVE II Programme

Energy Savings by CHCP plants in the Hotel Sector

Energy Audits - Portugal

May 2001

CONTENTS

1. Selection of hotels in Portugal

An important part of the project was to conduct energy audits on a typical sample of hotels that cover the minimum criteria of CHCP installations in Portugal. This is a description of the selection process, and the result of the energy audits

In Portugal it was chosen to use data from a recent study sponsored by the Portuguese Directorate General for Energy (DGE, 1999) which analysed the energy consumption on 4 and 5 star hotels all over the country. The new audits for the cHose project were therefore targeted to 3 star hotels and to hotel-apartments. As an extreme case, one state-inn ("Pousada") was also chosen although it was smaller than the typical hotel for the study and had a different consumption pattern. The reason for including the "Pousada" was due to the categories' high occupation rates, which makes the possibility of cost-effectiveness for a CHCP system probable.

The approach was to choose a set of hotels and hotel-apartments from different climate regions, but placed in districts where minimum occupation rates are reasonable (>30%). The hotels were also preferably in three different size classes (in number of rooms), namely around 100, 200 and 300, and smaller only if they included a swimming pool.

The obtained list was filtered according to the exclusion criteria defined by the consortium, type of climate in the region and type of air-conditioning system, resulting in the following set of chosen hotels:

Table 1.1. Selected hotels in Portugal

Cases	Location	Type	Rooms	Building year/renov.	Activities	Other
1	Porto	Business 4 star	112	1973	Restaurant Conference rooms	
2	Lisbon	Business (hotel-apartment)	134 single-room apartments	1996	Swimming-pool (outdoor) Shopping area	
3	Lisbon	Business/Tourism 3 star	96 rooms	1956	Hair-dresser Laundry, 2 Restaurants	
4	Cascais	Business (hotel-apartment) 4 star	162 apartments	1994	2 swim-pools (1 indoor) Health-club Discotheque, Laundry	
5	Porto	Business 5 star	238	>1980	Restaurant, Bar, Conference rooms	
6	Coimbra	Business (hotel-apartment) 4 star	126 + 12 suites	1994	Restaurant Swimming-pool	
7	Vila Real	Business and tourism 3 star	116	1984 /1991	Swimming-pool Restaurant Discotheque, Laundry	
8	Beja	Tourism	35	?	Swimming-pool Restaurant	Old monastery
9	Portimão	Tourism (hotel-ap.) 4 star	74 (ap); 76 rooms	1989	Swimming-pool Restaurant	
10	Vilamoura	Tourism 5 star	387	1987	Rest., Bar, Grill, Swim-pool, Health-club, conference rooms	
11	Lisboa	Business – Tourism 3 star	252	1990	Restaurant Conference rooms	

Table 1.2 Selected hotels in Portugal – Statistics

Cases	Room occupation rate	Meals per day	Conference room occupation rate	Laundry per day	Other
1	38% (Bed Oc.)	133	N/A	-	
2	38% (Bed Oc.)	-	N/A	-	
3	73%	22	3%	213 kg[(1)]	
4	72%	64	33%	276 kg	
5	36% (Bed. Oc.)	326	N/A	-	
6	61%	77	25%	-	
7	65%	143	29%	347 kg	
8	38%	32	3%	168 kg	
9	74%	76	-	179 kg	
10	44% (Bed. Oc.)	1382	-	2555 kg	
11	71%	33	90%	-	

[1] *Total over 365 days*

2. Energy usage in hotels

Energy conservation measures

The main opportunities for energy conservation are identified on the following list:

- Adjustments in the contract with the electric utility
- Use of low head showers
- Replacement of incandescent lamps by CFL
- Installation of a automatic key-switch for rooms and apartments
- Peak-demand controller
- Maintenance of boilers
- Load shift of some electric equipment, namely laundry's machines
- Installation of automatic switch-off for lights in the apartment halls
- Replacement of single-sheet glasses by double glasses
- Correction of losses on doors
- Automatic switch-off for convectors on window openings
- Better isolation of some spots in the network
- Maintenance of heat exchangers
- Pre-treatment of feed water
- Maintenance of solar panels
- Installation of an EMS.
- Repair or installation of a reactive power compensation system
- Installation of "free-cooling" systems when possible

[1] Total over 365 days

In the following table a summary of energy end-uses characteristics (installed electrical, heating and cooling capacity, power peak load and energy consumption per type of energy demand) of the audited hotels is shown.

Table 2.1. Characteristics of energy end-use

Case	Type of energy demand	Installed capacity,	Peak load,	Energy
			kW and peak month	**MWh**
1	Electricity	800 kVA	310 (Jun.)	1006
	Heat	1026 kW		1444
	Cooling	154.8 kW		48
2	Electricity	1250 kVA	240 (Jun, Jul, Nov, Dec)	1236
	Heat	749 kW		693
	Cooling	150 kW		
3	Electricity (cool. inc.)	250 kVA	150.89 (Aug.)	462.64
	Heat	646 kW		816.51
	Cooling	77 kW		
4	Electricity (cool. inc.)	800 kVA	291 (Nov.)	1054.4
	Heat	466 kW		689,9
	Cooling	769 kW		
5	Electricity (cool. inc.)	1600 kVA	628 (Jul.)	2315
	Heat	3720 kW		1465
	Cooling	512.5 kW		256
6	Electricity (cool. inc.)	630 kVA	177 (Aug.)	520.6
	Heat	650 kW		666.9
	Cooling	100 kW		
7	Electricity (cool. inc.)	200 kW (LV)[2]	198 (Jul.)	753.4
	Heat	800 kW		1211.3
	Cooling	240 kW		
8	Electricity (cool. inc.)	500 kVA	198 (Set.)	693.5
	Heat	593 kW		928.7
	Cooling	98 kW		
9	Electricity (cool. inc.)	240 kW (LV)	147 (Set.)	161.34
	Heat	621 kW		429.126
	Cooling	100 kW		
10	Electricity (cool. inc.)	1000 kVA	1165 (Oct.)	4220
	Heat	2581 kW		3561
	Cooling	966 kW		734
11	Electricity (HVAC. inc.)	1000 kVA	382 (Dec.)	1529
	Heat and cooling (Rev. heat-pumps)	134 kW		783

[2] Low Voltage connection. The indicated power is the contracted with the utility.

2.1 Specific energy consumption (SEC)

2.2

The specific energy consumption (SEC) of the hotels (energy uses per m2 and year and per room) is shown in the following table and figure.

Table 2.2 Primary source, use of energy [MWh per year] and specific use [kWh/m2 and year]

			Energy consumption			Specific cons.	
Hotel	area	rooms	Thermal	Electricity	Total	kWh/m^2	MWh/room
1	5513	114	1444	1007	2451	444.596	21.502
2	7695	134	693	1236	1929	250.666	14.395
3	3157	96	817	463	1279	405.179	13.324
4	13500	162	690	1054	1744	129.207	10.767
5	16781	238	2101	2315	4416	263.155	18.555
6	11986	138	667	521	1188	99.074	8.605
7	4856	116	1211	753	1965	404.592	16.937
8	4487	35	929	694	1622	361.533	46.349
9	3670	76	161	429	590	160.890	7.769
10	30791	399	3561	4220	7781	252.704	19.501
11	8914	252	190	1529	1720	192.909	6.824

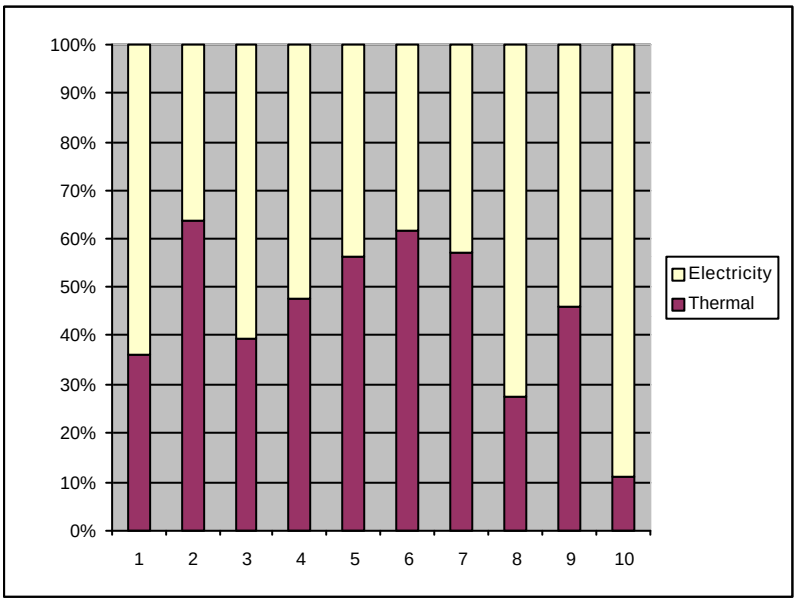


Figure 1 - Energy source in each case study

Case studies – Systems installed and End-use of energy

Case 1

Systems installed

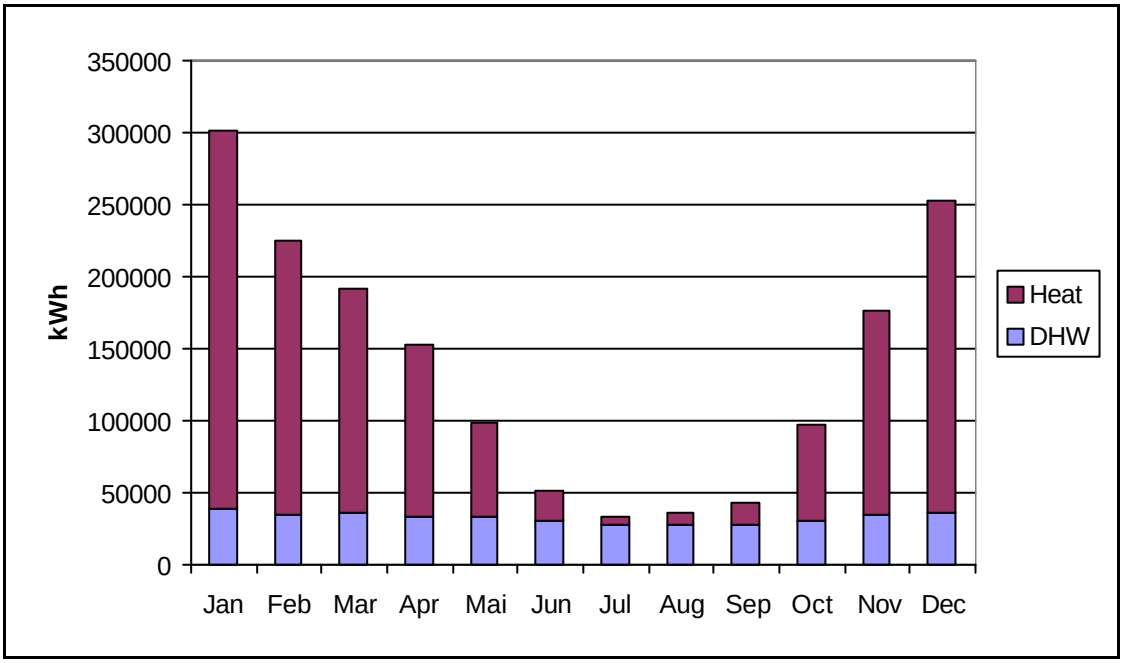
The heat for space heating and sanitary hot water is produced in two boilers burning residual fuel oil, one with 581 kW and the other with 465 kW. The pollutant emission is normal for the used fuel and the measured efficiency was 79% and 83%.

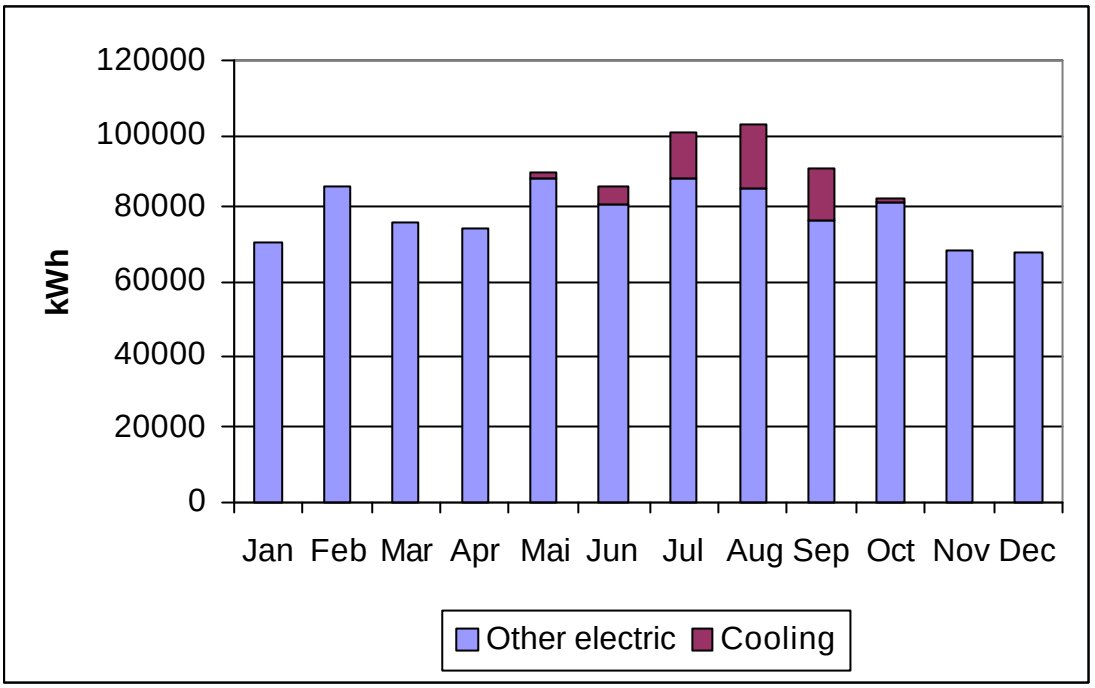
The only end-uses for gas (propane) were the kitchen appliances.

The chilled water for climate cooling is produced in two 74.4 kW electric chillers, screw type and air-cooled. There is no "free cooling" system.

The hotel has a backup generator of 250 kVA

End-use of energy – Energy Profiles

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Other electric
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Case 2

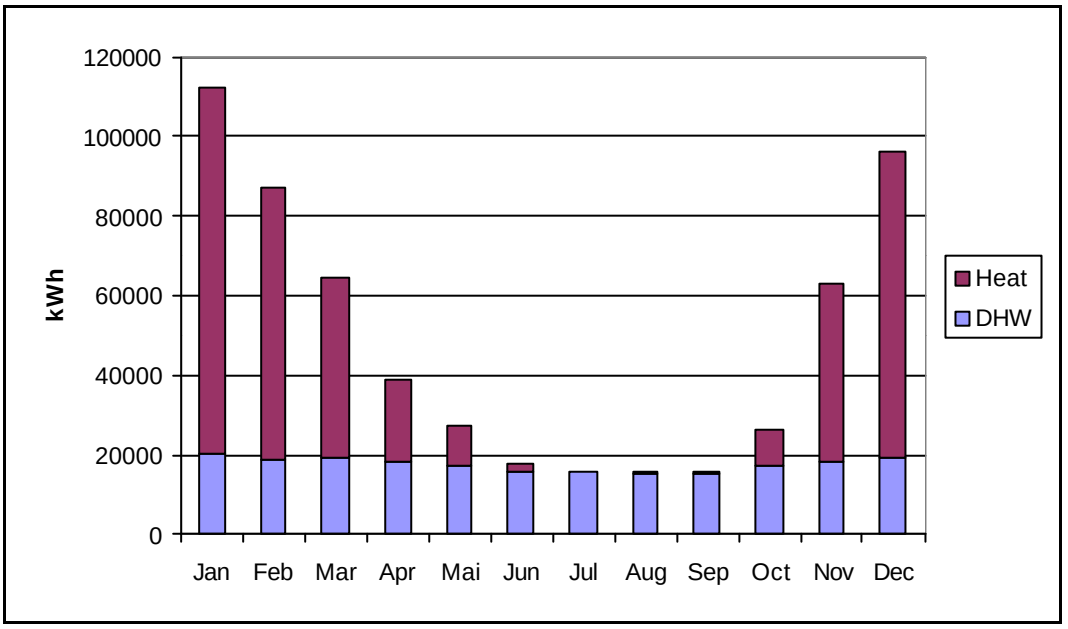
Systems installed

Six atmospheric boilers are use for space heating and hot water production with a total power of 774 kW, burning propane from the gas network[3]. The equipment is in a good state, without corrosion traces and the water of the primary circuit is clear. The measured efficiencies of the burners were low (75%), due to bad regulation of the burners. Hot water is stored in two 4000 litre tanks.

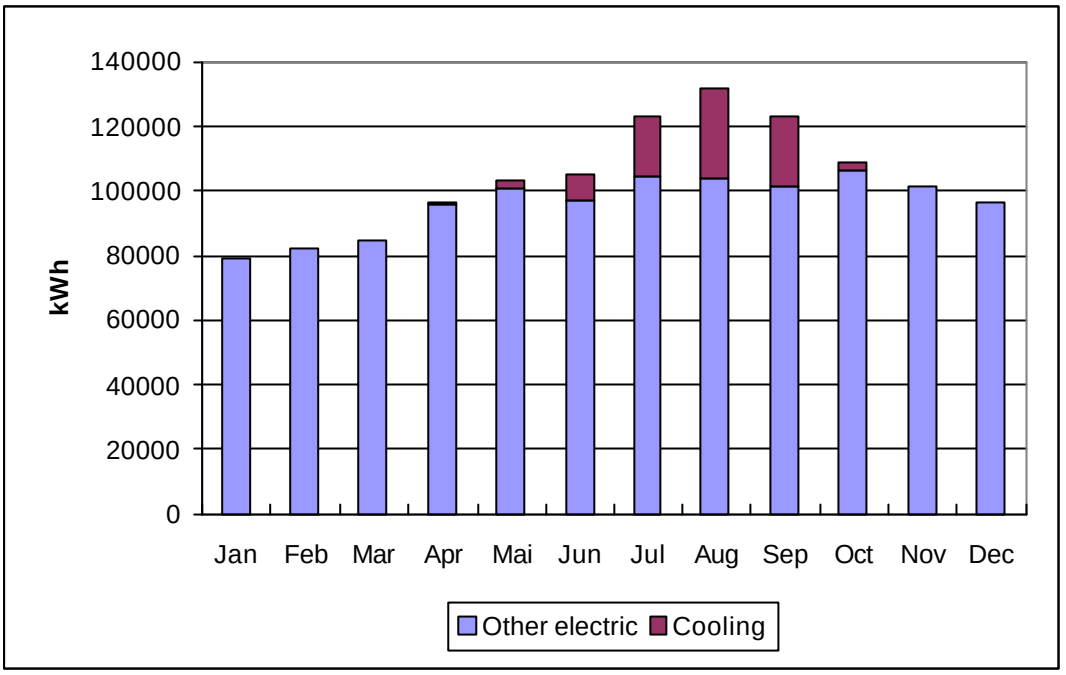
Climate cooling is produced in two electric chillers. The distribution network inside the hotel is on two pipes which prevents the simultaneous use of space heating and cooling, although the hotel thermal plant also supplies a small shopping centre with separate piping.

Electricity uses include lighting, the HVAC auxiliary systems, lifts and the chillers consumption. The hotel does not have a restaurant, but each apartment has a small kitchen with electric appliances.

End-use of energy – Energy Profiles



[3] Until recently Lisbon had a propane gas distribution network that is being replaced by the Natural Gas network.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Cooling

Case 3

Systems installed

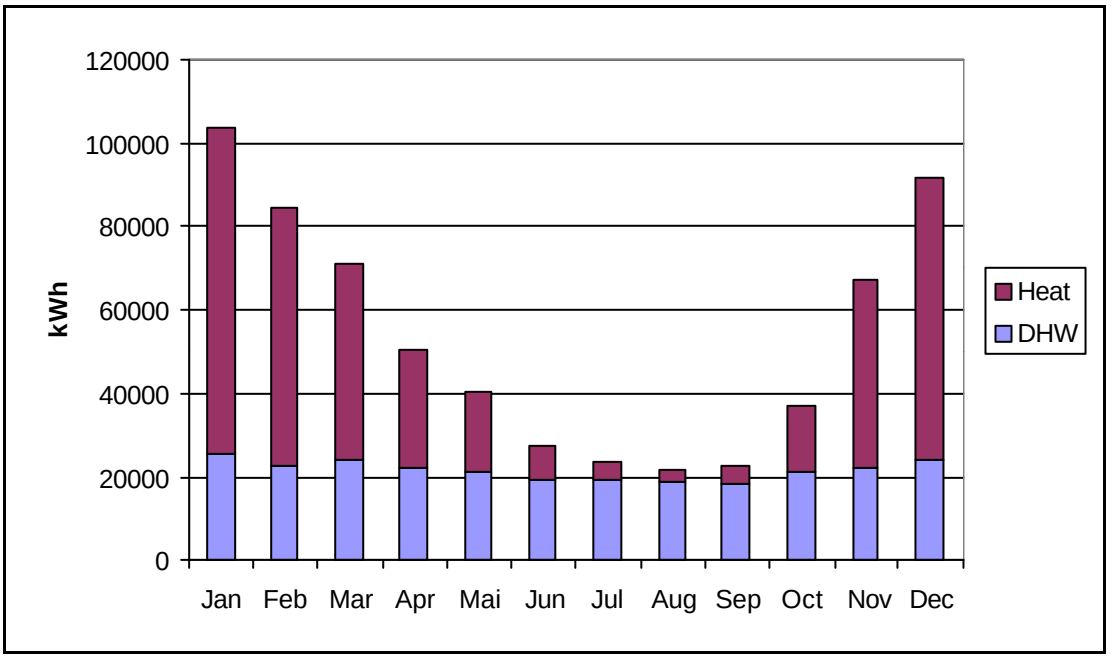
Two tubular boilers, each with 323kW are used for space heating and hot water production. They are currently burning Natural Gas but during the period covered by the data, the fuel source was the gas distributed by the network in Lisbon (propane). The equipment is in from 1995 and in good condition. The measured efficiency was 81%. Emission of pollutants is under standard values. There is no feed-water pre-treatment. Hot water is stored in four tanks with a total capacity of 1740 litre, considered too low for winter periods.

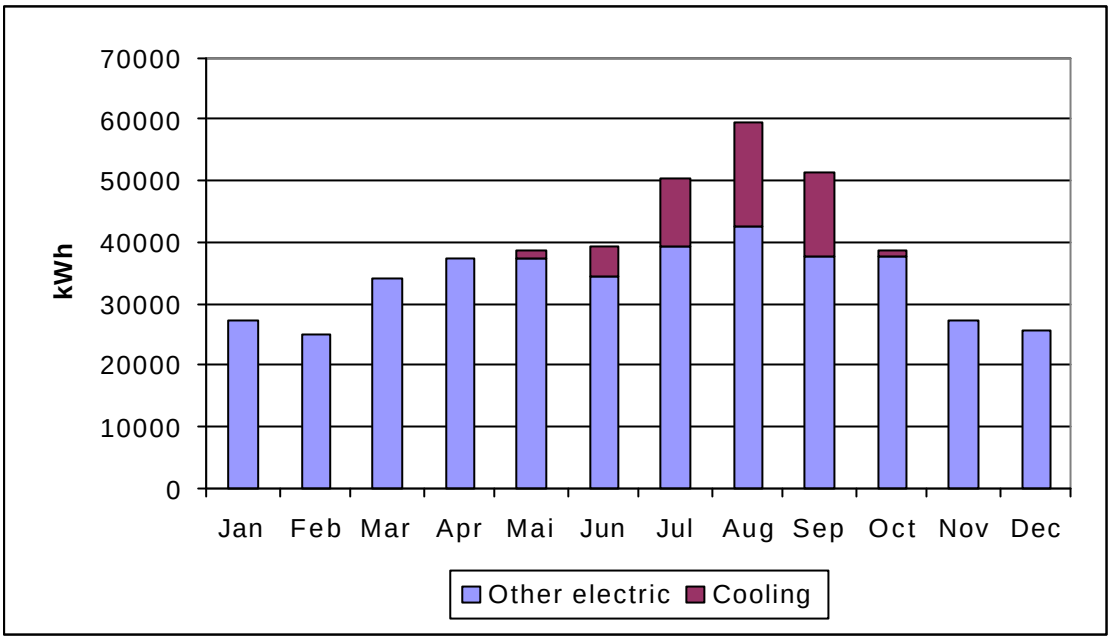
Climate cooling is produced in one 77 kW electric chiller. The network inside the building is on two pipes, preventing the simultaneous use of heating and cooling. There is no "free-cooling" system, which could reduce energy consumption during mild seasons with the input of fresh-air, but it is difficult to install one on a building with the age of this hotel without significant works.

Electricity end-uses include: lighting of the public areas; laundry; service kitchen; the external restaurant; the consumption in rooms including lighting; the lifts; and several other end-uses that were impossible to segregate. In the latter are the HVAC auxiliary systems included (thermal plant) as well as the hotel bar.

The hotel has a service restaurant and an external restaurant explored by a third party. The hotel supplies the electricity consumption of the latter.

End-use of energy – Energy Profiles

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Case 4

Systems installed

Part of the space-heating and sanitary hot water is produced with two boilers burning propane, regulated for 80º C, each with 233kW. The equipment is 15 years old and is in a good condition. However, the measured efficiency is low (74%) and the emission of pollutants could be lower with the burner correctly tuned. There are some failures in isolation of pipes that lead to losses. There are three tanks for storage of SHW with a total capacity of 6000 litre.

Solar energy is used and accounts for 17% of hot water production which is used mainly for the indoor swimming-pool

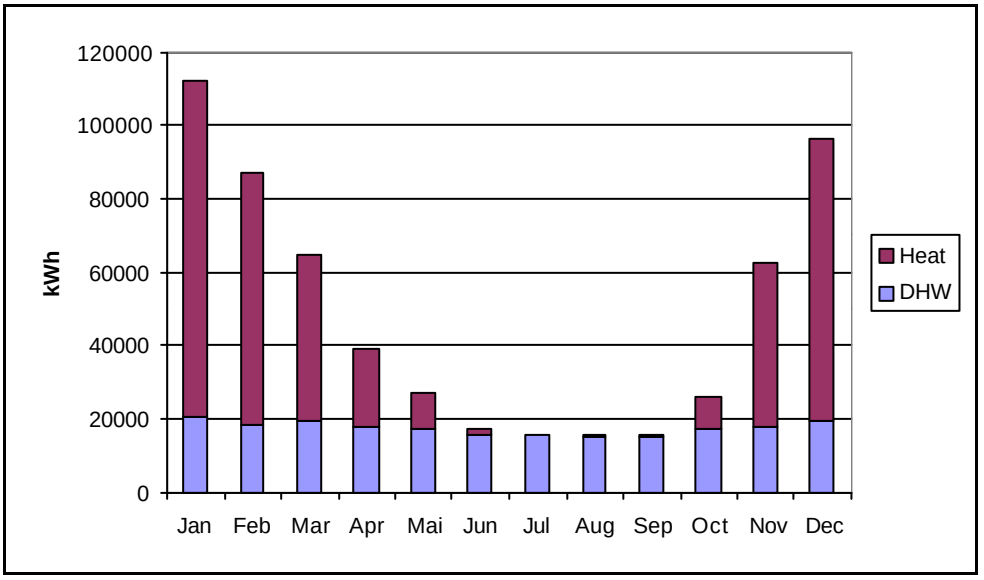
An important share of the space heating and almost all the climate cooling is produced in 209 reversible heat-pumps, 15 with 14.24 kW and 194 with 2.18 kW. Only a small part of the climate cooling, corresponding to the conference rooms, is produced in a centralised manner, although there are two electric chillers, one with 565kW and the other with 164 kW. The small split units were installed recently replacing the use of the chillers. The reason for this was not explained.

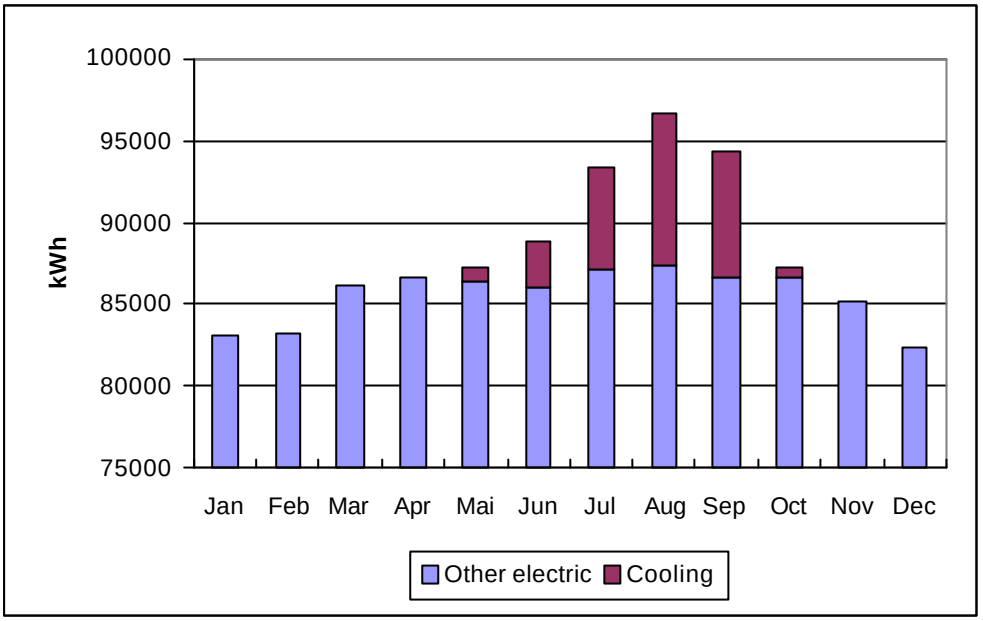
The network inside the building is on two pipes, which prevents the simultaneous use of space heating and cooling. There is no "free-cooling" system and its implementation now would force significant civil works.

Due to the generalised use of electricity for acclimatisation purposes, the main share of its use (71%) is for HVAC and lighting of common areas (non-segregated circuits). The remaining end-uses by order of magnitude are the apartments, thermal plant, kitchen and lifts.

The hotel has a backup generator with 208 kVA.

End-use of energy – Energy Profiles

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Cooling

Case 5

Systems installed

Two 1860 kW boilers produce hot water for space heating and Sanitary hot water. The boilers were burning thick and thin fuel by the time of the audit. The equipment is 15 years old and is in a good condition. There were no traces of corrosion and the isolation is good.

The burners were correctly tuned and the pollutants emission was under the average values for the fuel used. The measured efficiency was around 80%.

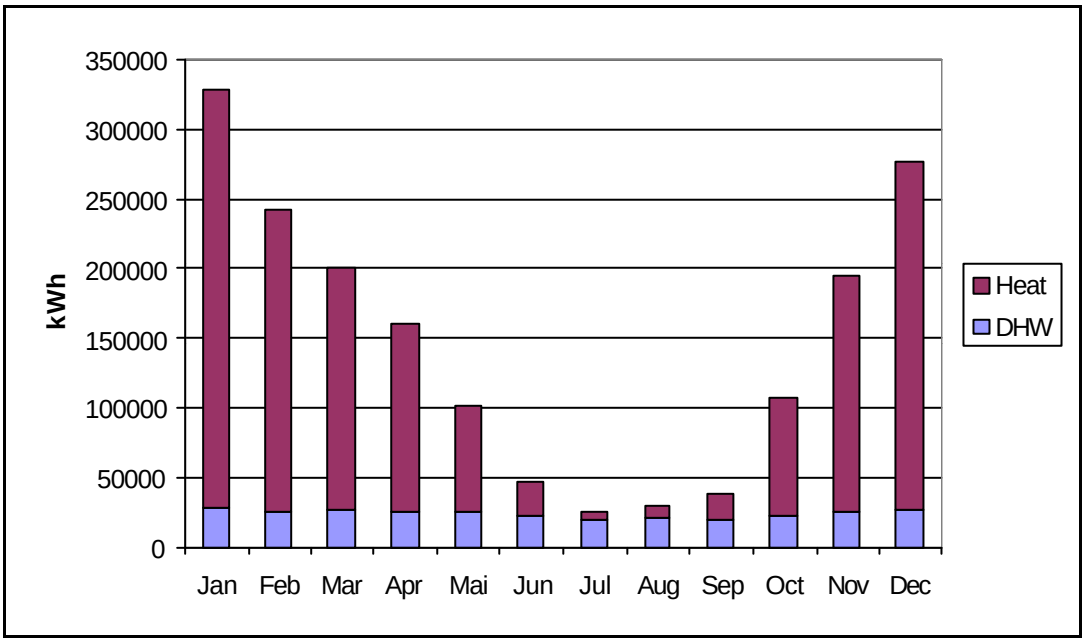
The hot water is stored in tanks with a total capacity of 24 cubic metre.

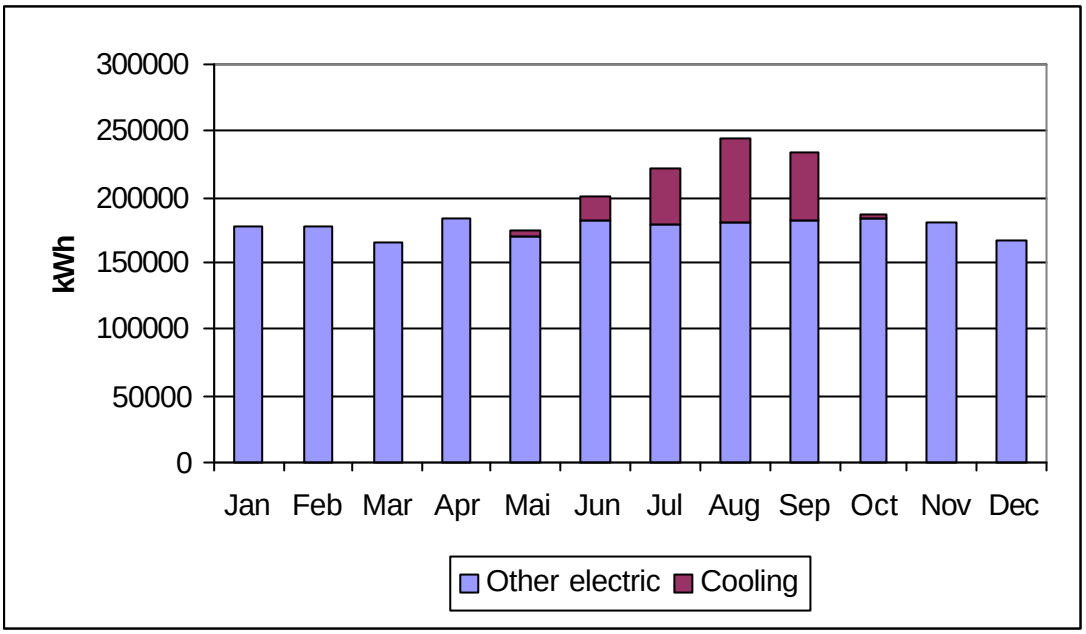
The chilled water for space cooling is produced in two chillers with a total power of 501.2 kW. One of them has a heat recovery system for pre-heating Sanitary Hot Water. The network is on two pipes.

Three main areas share a big part of the electric consumption: HVAC, SHW, kitchen and lighting, being the natural target for conservation measures.

The hotel has a backup generator of 272 kVA

End-use of energy – Energy Profiles

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Case 6

Systems installed

Two boilers with 325kW each produce hot water for space heating and sanitary hot water. The fuel used is Natural Gas. There is a third boiler burning diesel oil for backup purposes. The equipment is 23 years old but is in a good condition. The burners are incorrectly tuned which cause efficiency to be lower than it could be (79%) and a higher emission of pollutants, namely CO. There is no treatment of the feed-water, which may lead to future problems.

The hot water is stored in three tanks with a total capacity of 12000 litre, perhaps insufficient for a severe winter. A better tuning of the burners and a better isolation of some parts of the piping may reduce this problem.

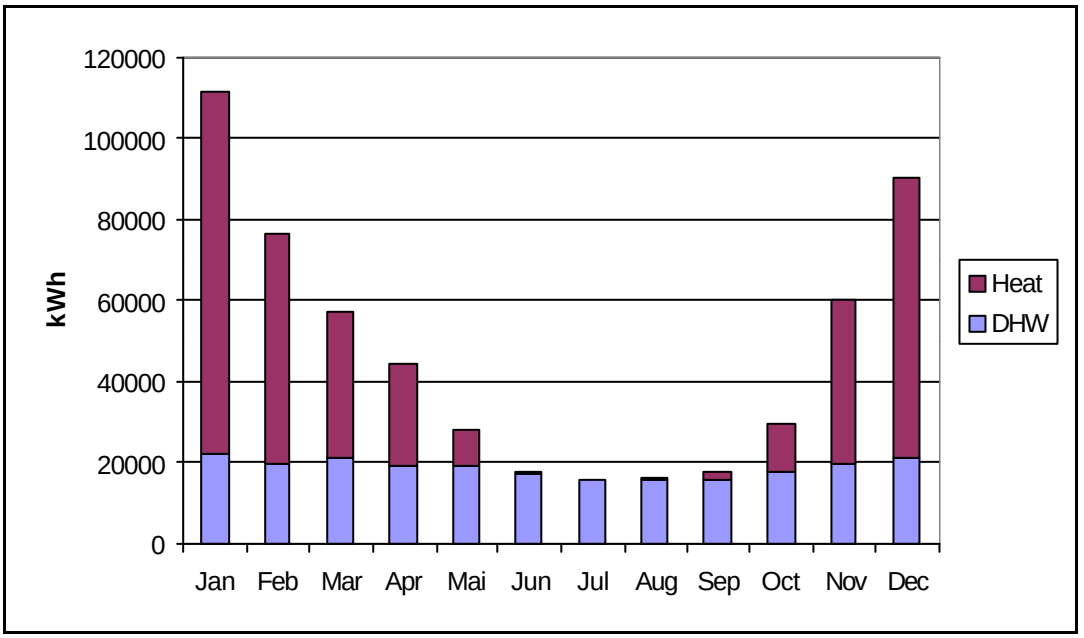
The climate cooling is produced in two chillers with 100 kW, although there are 4 small air-conditioned units (reversible heat pumps) each with 4.27 kW. Again there is no "free-cooling" system, missing a good opportunity for saving energy during mild seasons.

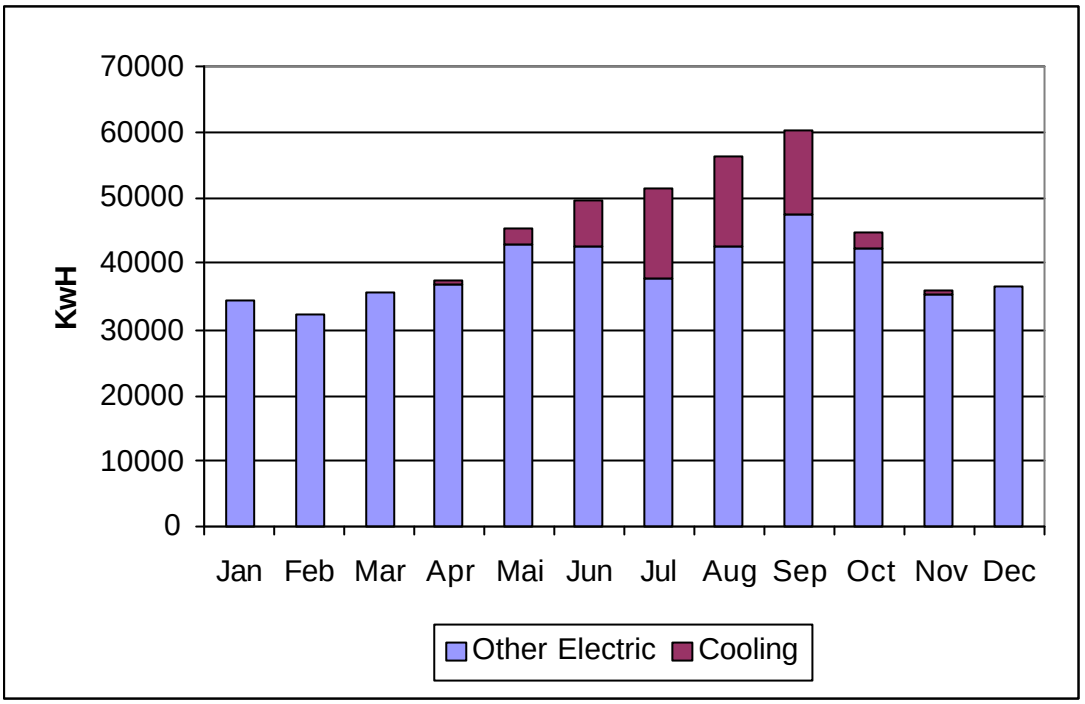
The network inside the hotel is also on two pipes, preventing the simultaneous use of heating and cooling.

The main use of electricity is for lighting of common areas. The kitchen and the rooms are other important uses so are the HVAC auxiliary systems and the lifts.

There is a backup generator of 150 kVA.

End-use of energy – Energy Profiles

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Case 7

Systems installed

The hot water for space heating and sanitary use is produced in 2 of 4 installed boilers (two are backup units) of 200 kW each burning LPG. The boilers are regulated for a water temperature of 70ºC. The measured efficiency is high (95%) but the exhaust contains too much pollutants, namely CO and CO2. There are deficiencies on the piping isolation that contributes to losses.

The hot water is stored in six tanks of 1000 litre each seem to be reasonable to the normal occupation of the hotel in winter but could be insufficient if this occupation was higher.

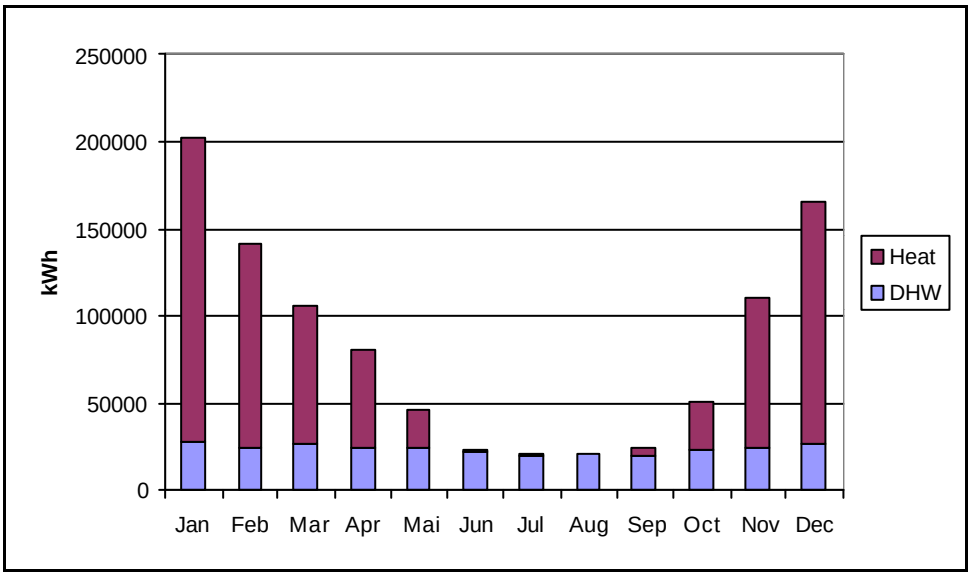
There are solar panels for heating water, but they are used only for the swimming pool, which seems to be an insufficient use for the money invested.

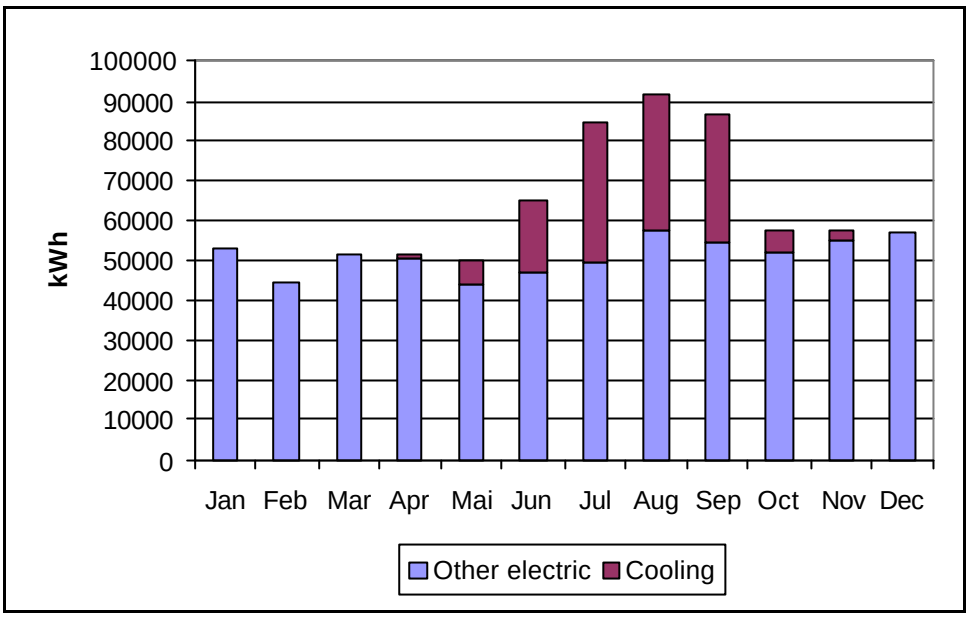
Climate cooling is based on two 120 kW chillers. The network is on two pipes for the rooms and on 4 pipes to the conference rooms, restaurant and other common areas, allowing in this case the occurrence simultaneous heating and cooling of different areas.

The main uses of electricity are climate cooling on the cooling season and lighting. This latter consumption is has had some attention as the low number of incandescent lamps shows (20%). However, the current use of Halogen lamps in areas where lights are on for a long period leads still to a possibility of energy savings by replacing with CFL.

There is a backup generator of 100 kVA.

End-use of energy – Energy Profiles

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Case 8

Systems installed

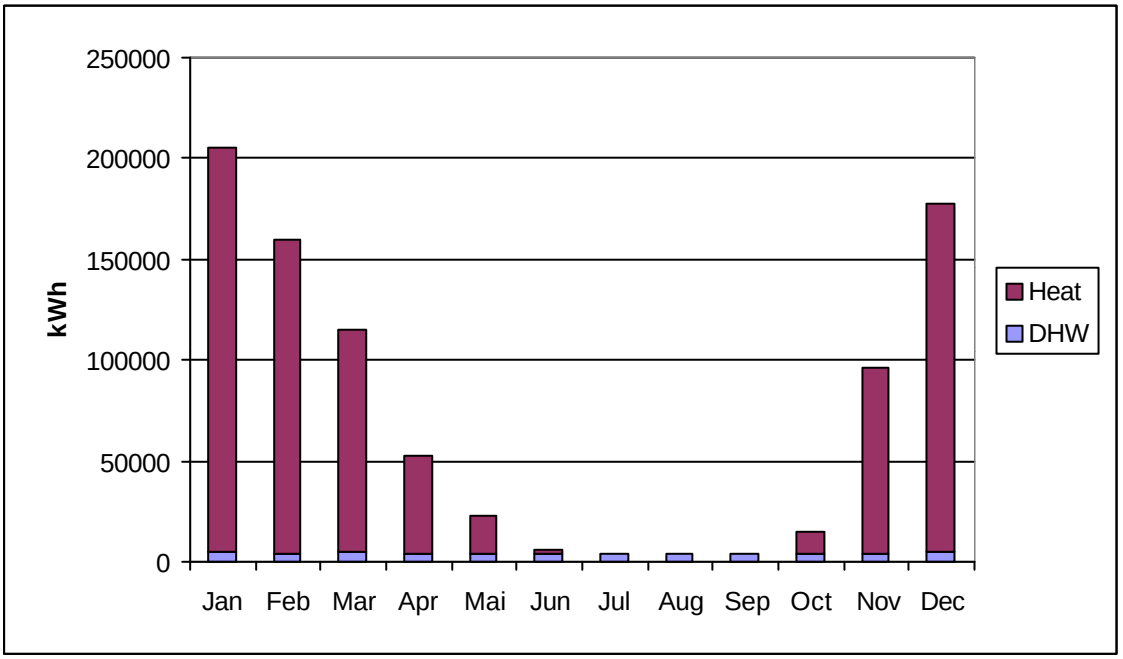
Two boilers of 296.5 kW each produce hot water at 75ºC for space heating and sanitary uses. The measured efficiency is high (94 – 95%) and the emission of pollutants is low, except for NOx. There are small deficiencies in the piping isolation, especially in the laundry hot water pipes. The SHW is stored in a 2500 litre tank.

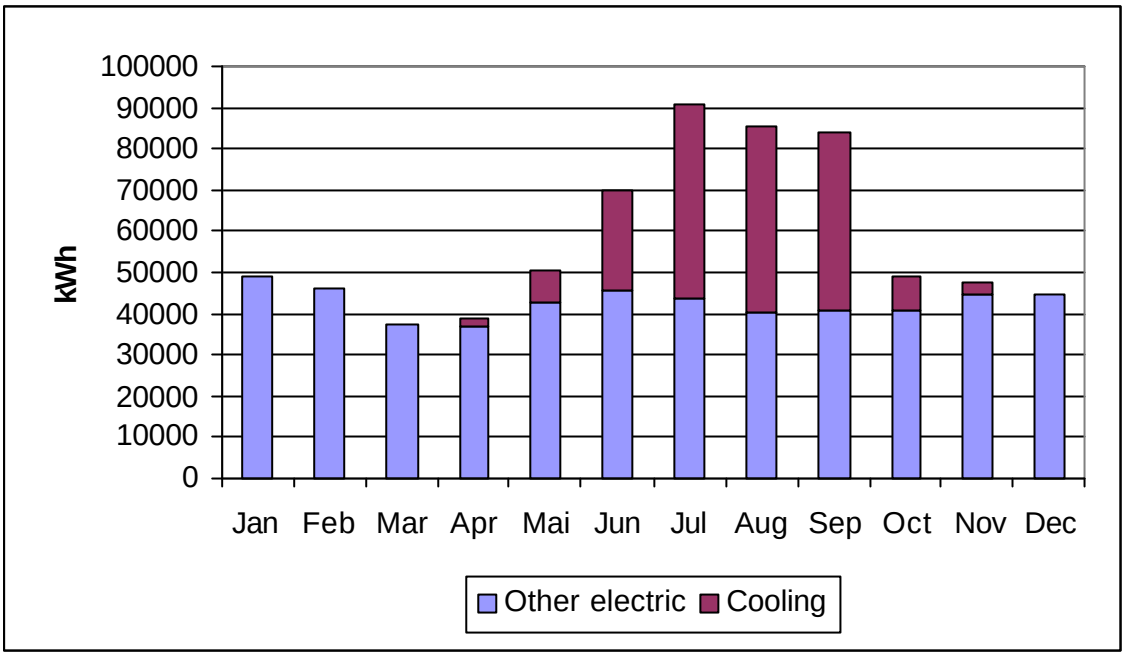
The chilled water for climate cooling is produced in two 49 kW chillers. The network is on two pipes which prevents the simultaneous use of heating and cooling.

The most important electricity uses are for cooling, which contributes for a big increase in consumption during summer, and for lighting, although the latter is in a good share due to the outdoor lamps used for enhancing the night view of the monument. The use of incandescent lamps is in this case difficult to change due to aesthetic reasons

There is a backup generator of 295 kVA

End-use of energy – Energy Profiles

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Case 9

Systems installed

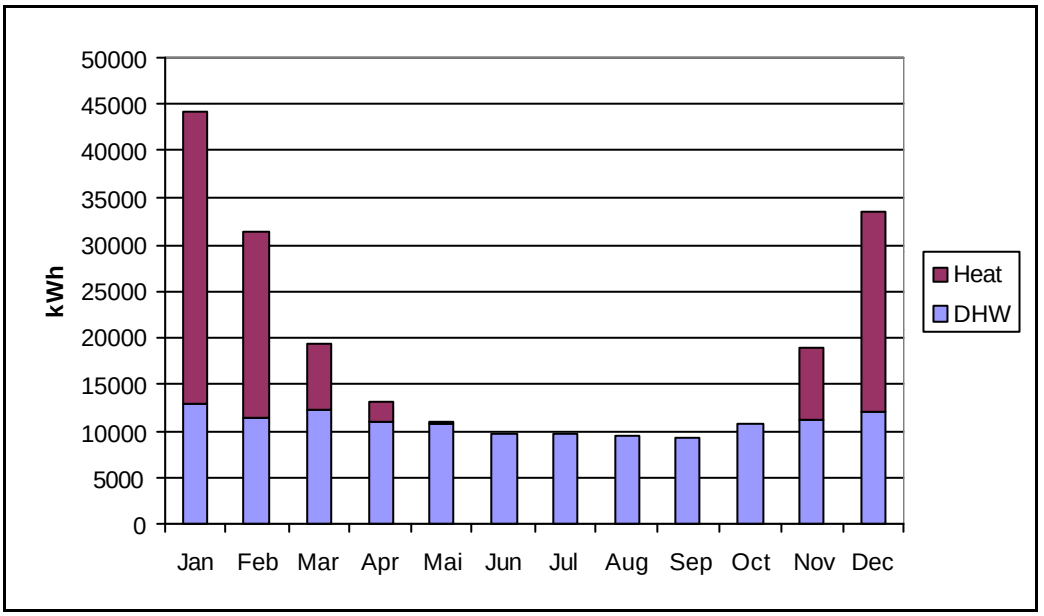
The heat for space heating and SHW is produced in two boilers, one with 421 kW and the other with 200 kW, burning LPG. There were problems in the exhaust that caused a low efficiency in the smaller boiler (88%). The measured efficiency of the main boiler was 95.4%. There is no treatment of the feed water, which has caused corrosion in some accessories and may lead to future efficiency problems. There are also 79 m^2 of solar panels for water heating purposes. The SHW is stored in 4 tanks of 3000 litre each, which are sufficient during winter.

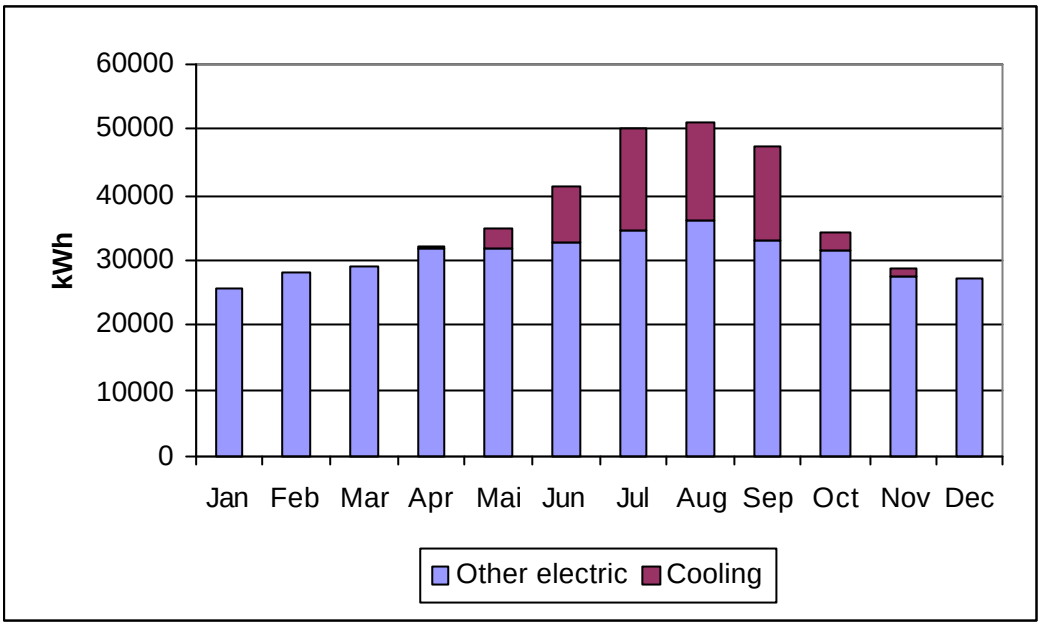
There are 4 chillers for climate cooling, although only two are effectively used. The general conditions of the chillers are bad and it was impossible to read the ratings.

Besides climate cooling, electricity uses are mainly inside the apartments, lighting, the laundry and kitchen. Lighting has as usual an important share of the consumption, although in this case there is a good taking of natural light conditions and also there was some care in installing low energy consumption lamps. It includes also the consumption of a mobile phone re-transmitter installed in the roof.

There is a backup generator of 200 kVA

End-use of energy – Energy Profiles

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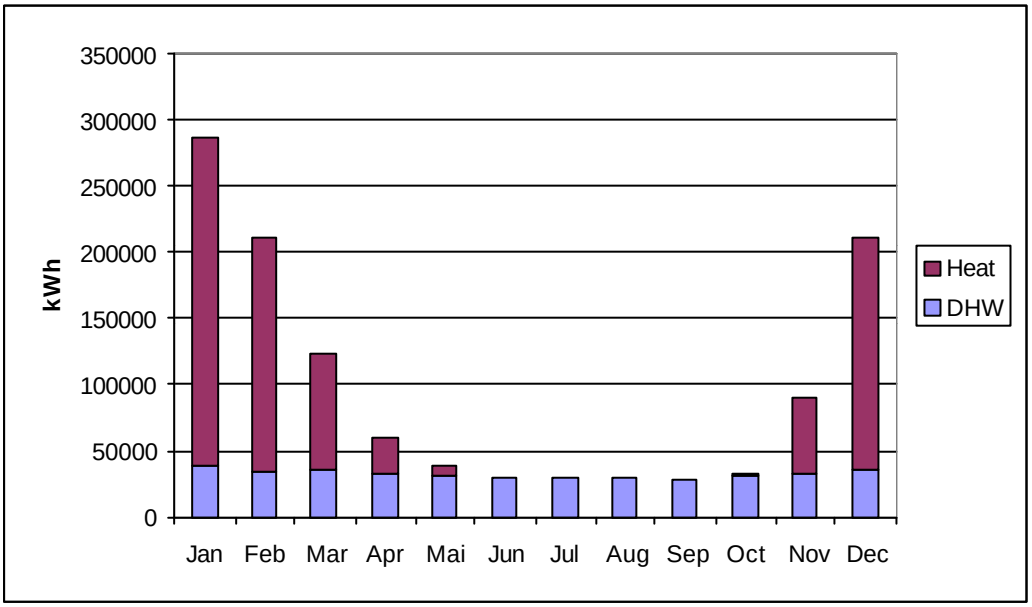
Case 10

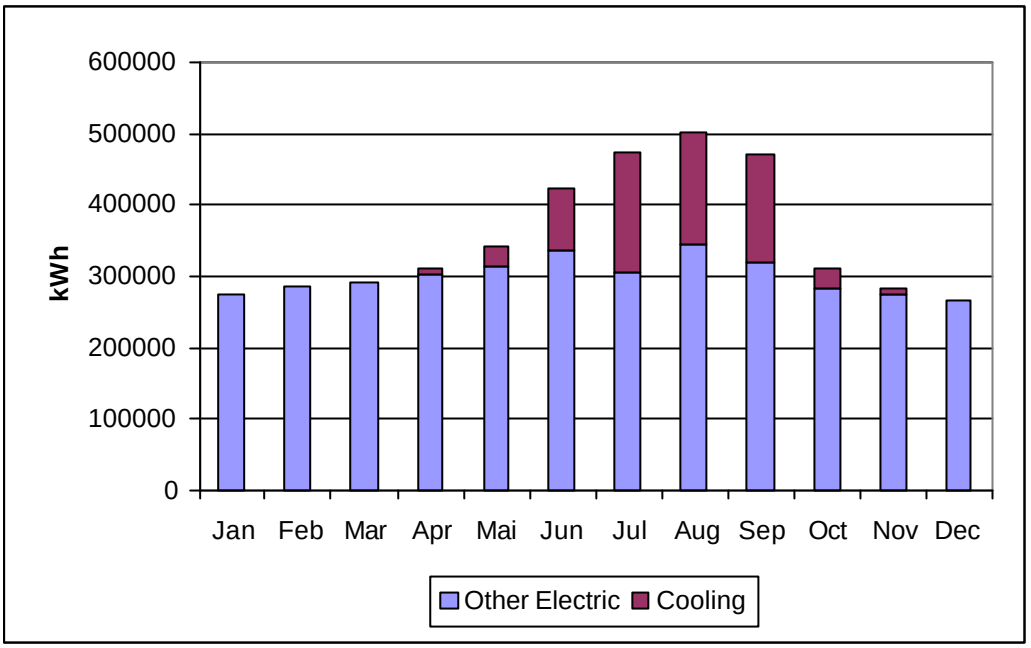
Systems installed

There are three boilers for hot water production, one of 1162.79 kW burning propane another one of the same power burning oil, and a third one of 581.4 kW burning oil. Only the propane fuel is used in normal conditions. The hot water is used for space heating and sanitary uses. The measured efficiency for the running boiler is 81.2 %. Globally there are problems with the piping due to corrosion although there is a feed-water treatment using reverse osmosis.

Steam is produced in another set of boilers for use in the laundry. Again there are two boilers, each with 581,4 kW, but only one is commonly used, burning propane. The other is used in rare situations and burns oil.

End-use of energy – Energy Profiles

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Case 11

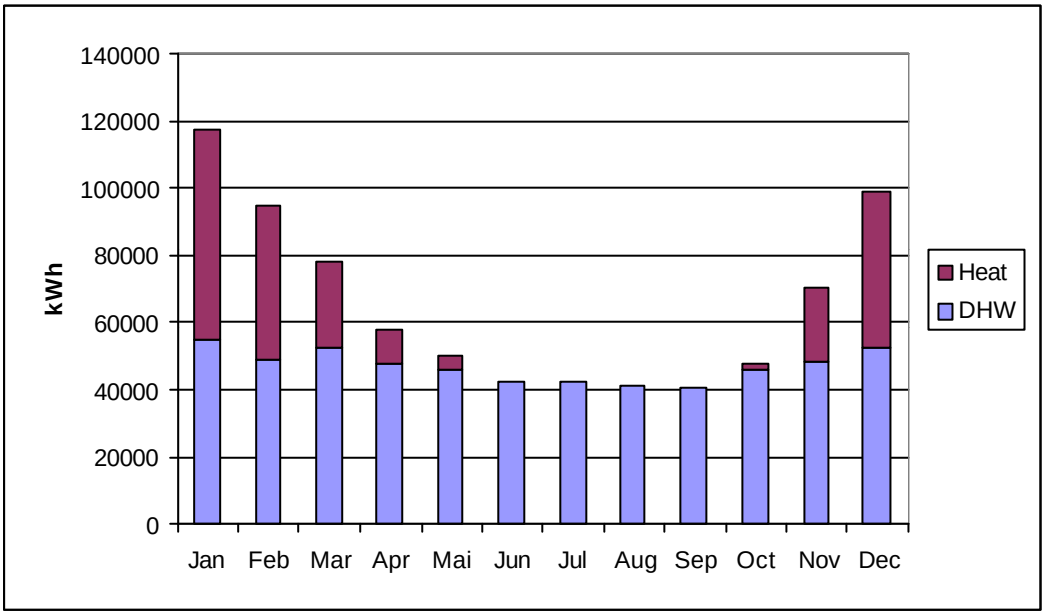
Systems installed

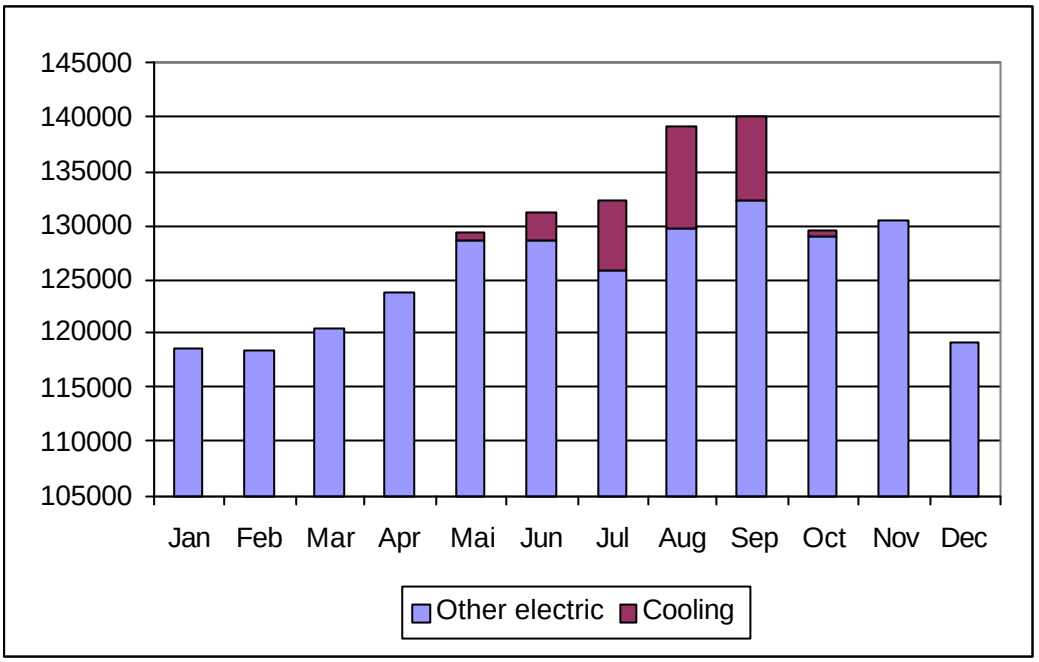
The heat for space heating and SHW is produced on a centralised manner in two heat pumps. The kitchen has it's own heat pump. At the time of the audit there was a resistance bank serially connected for adjusting the water temperature to the setting point. There are, however, plans for the installation of a natural gas boiler. The SHW is stored in two tanks with total capacity of 5000 litre.

The climate cooling is produced in the same reversible heat pumps. The conference rooms and suites have their own air-conditioned units.

Due to the use of electricity for acclimatisation and SHW purposes, this is of course the bigger electricity end-use. Lighting is as usual important.

The hotel has a 325 kVA backup generator.

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