D6.1 Appendix D Summary Sheet

D6.1 Appendix D Details

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D6.1 Appendix D HUSA Chamartín hotel: Short Description

This document describes the demonstration building HUSA Chamartín Hotel.

Keywords: HUSA, Chamartín, hotel, Madrid, demonstration building

Table of Contents

List of Figures

List of Tables

Appendix D: Husa Chamartin Hotel. Madrid (Spain)

HUSA Chamartín Hotel is a four stars hotel located in Madrid, Spain. The hotel has a capacity of 387 rooms and his area is 35.000 m^2.

Figure 1: HUSA Chamartín Hotel location

HUSA Chamartín Hotel is located closed to Chamartín Railway Station and 16 floors, 9 of this dedicated to accommodation. It was originally built for offices, but change for hotel use during construction.

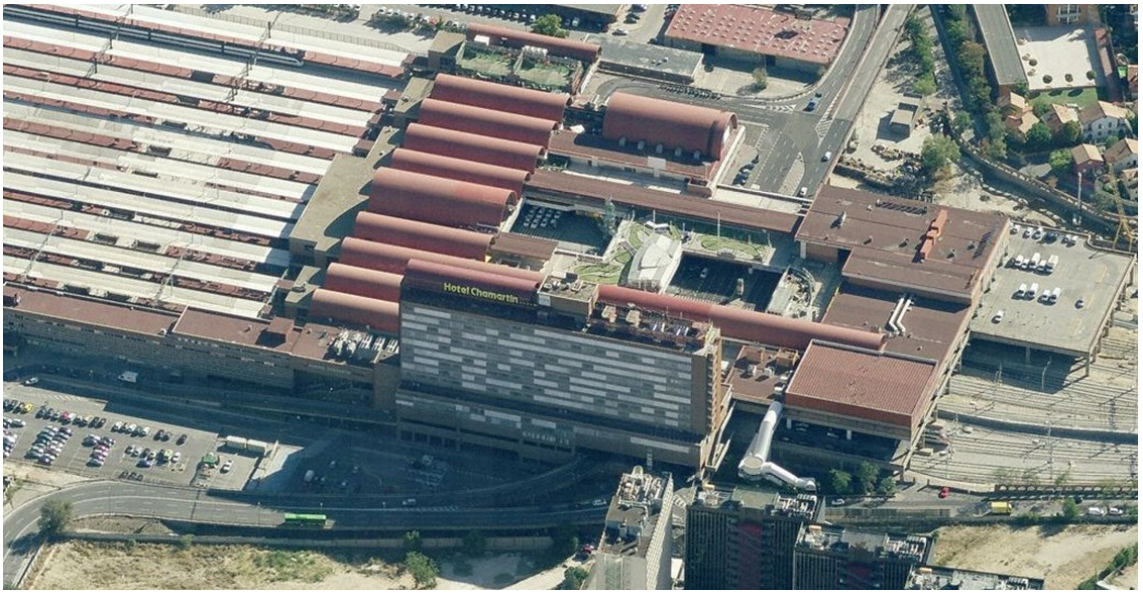


Figure 2: Aereal view of HUSA Chamartín Hotel and Railway Station

1.1 General building information

HUSA Chamartín Hotel (HCH) is located in Madrid, the capital of Spain, with over 3.250.000 inhabitants, in the center of Spain.

The city of Madrid is located over the Manzanares river basin and a few kilometers from the Sierra Guadarrama, at an altitude of 667 meters.

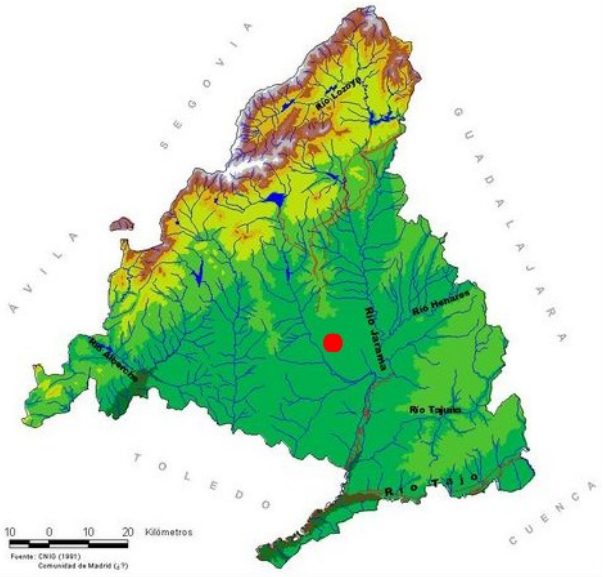


Figure 3: Hydrographic map of the Madrid Region

Madrid's climate is Mediterranean-continental type influenced bay urban conditions. Winters are cold, with temperatures below 4-5 ° C, frequent frost and snow. Summers are hot with averages around 24 ° C in July and August, with highs, on time and in batch, can reach 35 ° C.

The daily oscillation is important in the urban fringe, but is reduced in the center of the city by the anthropogenic effect. The annual temperature range is high (19 degrees) due to the large distance to the sea and altitude.

The annual rainfall is above 400 mm, with very marked minimum in summer (dry four months, from June to September) and large area oscillations between NW area, far more rainy, and the SE area is more arid.

Table 1: General information of HUSA Chamartin building

Name	HUSA Chamartín Hotel	Envelopment area	12.873m^2
Address	Agustín de Foxá Street	Glazed area	4.737m^2 (37%)
City / Post code	Madrid/ 28036	From factor (S/V)	0.437
Country	Spain	Heated Area (m^2)	15.875m^2
Contact Person	Javier Martín	Heated Volume (m^3)	44.450m^3
e-mail of contact person	javier.martin@dalkia.es	Cooled Area (m^2)	15.875m^2
Location (coordinates)	Latitude: 40º 28' 19" N Longitude: 3º 41' 0" W	Cooled Volume (m^3)	44.450m^3
Orientation	N S W E	Heating degree days (15.5ºC)	1.471
Altitude (m)	667	Cooling degree days (15.5ºC)	1.443

Year of construction	1.982	Average power consumption (kWh/m^{2}a)	n.a.
Typology of building	Hotel	Average thermal consumption (kWh/m^{2}a)	
Floors	16	Heating system	Gas boilers Fancoils
Built area	34.834 m^2	Cooling system	Chiller Fancoils
Net usable area	28.935 m^2	DHW system	Gas boilers

Table 2: Climate values for Madrid

	T (ºC)	TM (ºC)	Tm (ºC)	R (mm)	RH (%)	DR (d)	DN (d)	DT (d)	DF (d)	DH (d)	DD (d)	I (h/mo)
Jan	6.1	9.7	2.6	37	71	6	1	0	5	6	8	148
Feb	7.9	12.0	3.7	35	65	6	1	0	4	3	6	157
Mar	10.7	15.7	5.6	26	54	5	0	1	2	1	7	214
Apr	12.3	17.5	7.2	47	55	7	0	1	1	0	5	231
May	16.1	21.4	10.7	52	54	8	0	3	0	0	4	272
Jun	21.0	26.9	15.1	25	46	4	0	3	0	0	8	310
Jul	24.8	31.2	18.4	15	39	2	0	3	0	0	16	359
Aug	24.4	30.7	18.2	10	41	2	0	2	0	0	14	335
Sep	20.5	26.0	15.0	28	50	3	0	2	0	0	9	261
Oct	14.6	19.0	10.2	49	64	6	0	1	1	0	6	198
Nov	9.7	13.4	6.0	56	70	6	0	0	5	1	7	157
Dec	7.0	10.1	3.8	56	74	7	1	0	6	4	7	124
Total	14.6	19.4	9.7	436	57	63	4	16	24	16	97	2769

T: monthly average temperature; TM: monthly average of highest daily temperatures; Tm: monthly average of lowest daily temperatures; R: monthly average of rainfall; RH: monthly average of relative humidity; DR: monthly average of rainy days (rainfall ≥ 1mm); DN: monthly average of snow days; DT: monthly average of storm days; DF: monthly average of foggy days; DH: monthly average of frost days; DD: monthly average of cloudless days; I: monthly average of sunny hours.

2 Building use: distribution and occupancy

HUSA Chamartín Hotel has a rectangular plan with sixteen floors. In the ground floor there are offices and storage room.

Figure 4: Floor +0.00 plan

Table 3: HCH building distribution / usage floor +0.00

Zone	Floor	Useful area (m^2)	H. (m)	Vol. (m^3)	% cond.	Occ. (pax)	Cond. services
Storage room	0	225.05	3.00	675.15	0%	-	-
Air conditioning units room	0	27.05	3.00	81.15	0%	-	-
Office	0	55.05	3.00	165.15	0%	3	-
Bathroom 01	0	6.80	3.00	20.4	0%	-	-
Bathroom 02	0	6.80	3.00	20.4	0%	-	-
Waste room	0	8.55	3.00	25.65	0%	-	-
Hall + hallway	0	117.72	3.00	353.16	0%	-	-

In the first floor there are changing rooms and laundry.

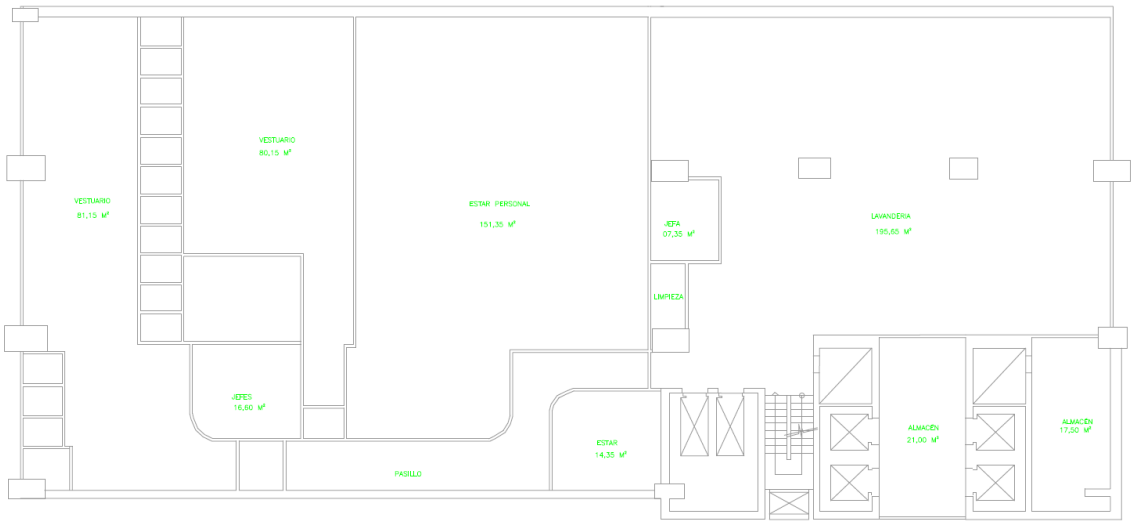


Figure 5: Floor +3.30 plan

Table 4: HCH building distribution / usage floor +3.30

Zone	Floor	Useful area (m^2)	H. (m)	Vol. (m^3)	% cond.	Occ. (pax)	Cond. services
Changing room 01	1	81.15	3.00	243.45	0%	-	-
Changing room 02	1	80.15	3.00	240.45	0%	-	-
Changing room 03	1	16.60	3.00	49.8	0%	-	-
Living room	1	151.35	3.00	454.05	0%	-	-
Laundry	1	203.15	3.00	609.45	0%	-	-
Storage room 01	1	17.50	3.00	52.5	0%	-	-
Storage room 02	1	21.00	3.00	63	0%	-	-
Hall + hallway	1	143.68	3.00	431.04	0%	-	-

In the second floor there is the hotel access.

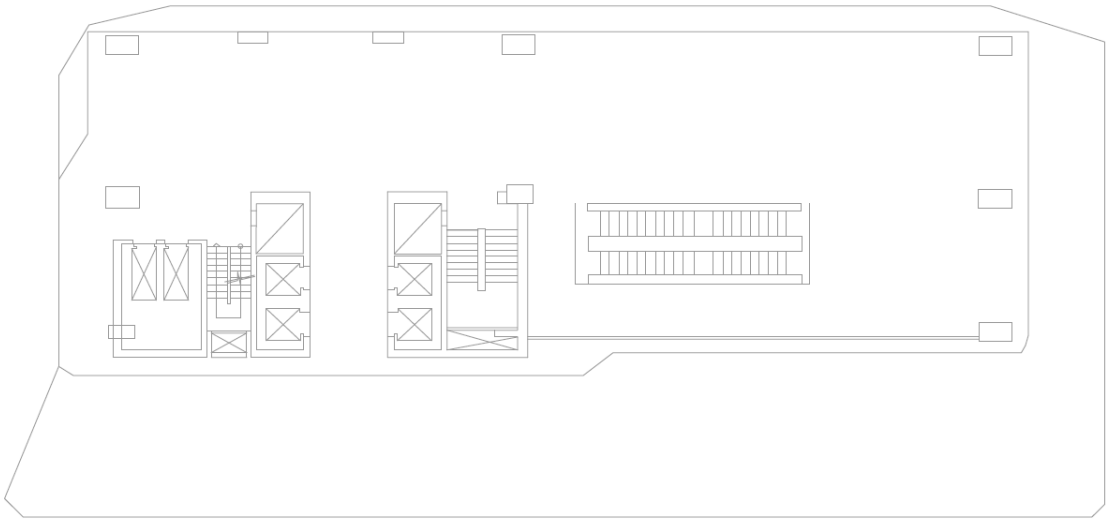


Figure 6: Floor +6.60 plan

Table 5: HCH building distribution / usage floor +6.60

Zone	Floor	Useful area (m^2)	H. (m)	Vol. (m^3)	% cond.	Occ. (pax)	Cond. services
Hall + hallway	2	80.50	3.00	241.15	100%	-	AHU

In the third floor there are offices.

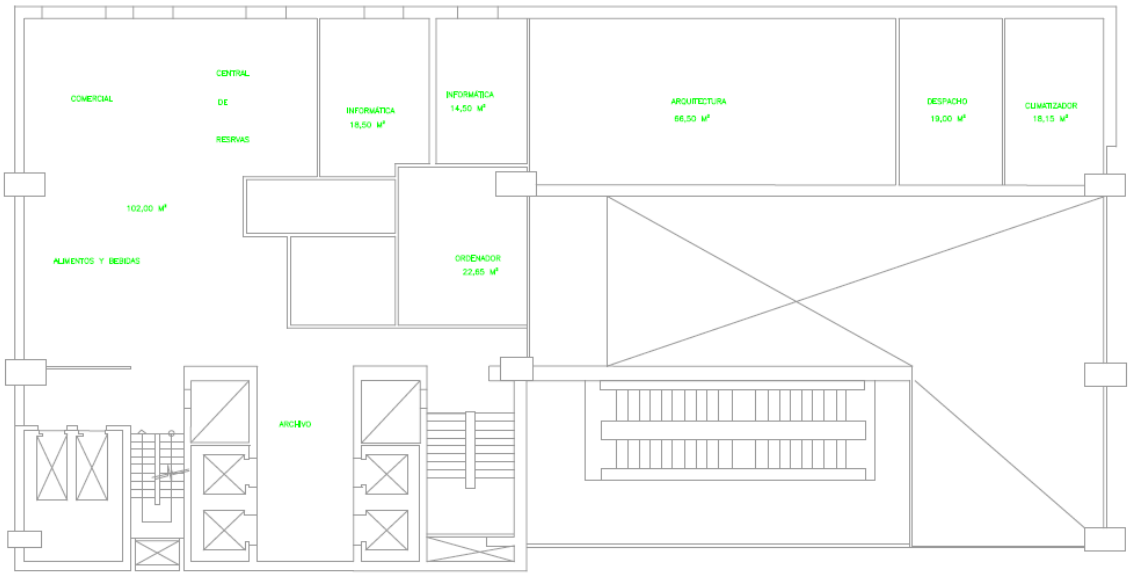


Figure 7: Floor +9.90 plan

Table 6: HCH building distribution / usage floor +9.90

Zone	Floor	Useful area (m^2)	H. (m)	Vol. (m^3)	% cond.	Occ. (pax)	Cond. services
Office 01	3	102.00	3.00	306.00	100%	-	AHU
Office 02	3	18.50	3.00	55.50	100%	-	AHU
Office 03	3	14.50	3.00	43.50	100%	-	AHU
Office 04	3	66.50	3.00	199.50	100%	-	AHU
Office 05	3	19.00	3.00	57	100%	-	AHU
Office 06	3	18.15	3.00	54.45	100%	-	AHU
Office 07	3	22.65	3.00	67.95	100%	-	AHU
Hall + hallway	3	156.80	3.00	470.4	100%	-	AHU

In the fourth floor there are offices, meeting rooms, bar and restaurant.

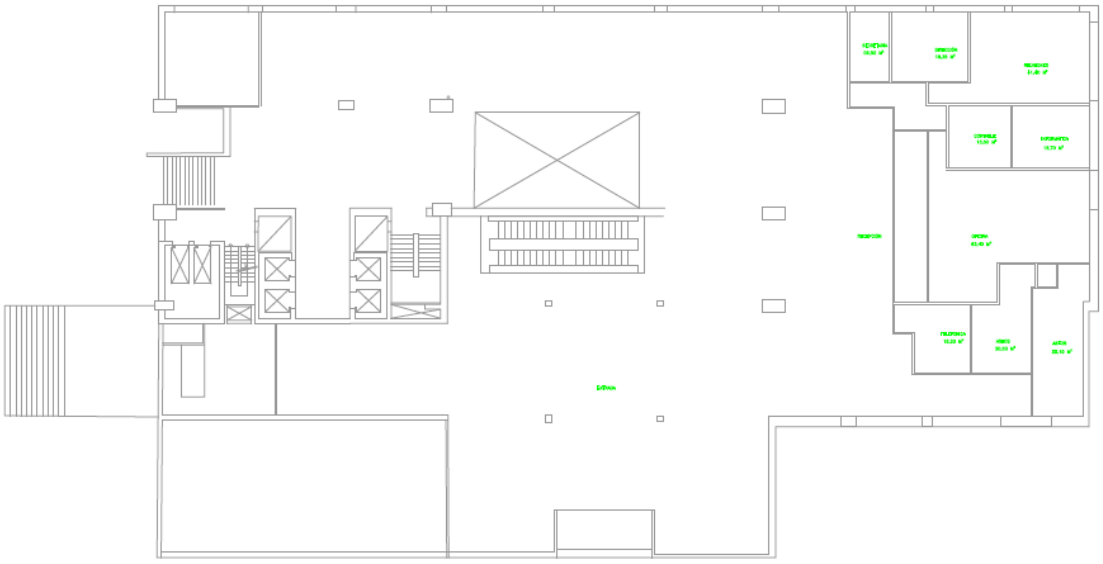


Figure 8: Floor +13.05 plan

Table 7: HCH building distribution / usage floor +13.05

Zone	Floor	Useful area (m^2)	H. (m)	Vol. (m^3)	% cond.	Occ. (pax)	Cond. services
Office 01	4	9.50	3.00		100%	-	AHU
Office 02	4	18.35	3.00		100%	-	AHU

Office 03	4	41.40	3.00		100%	-	AHU
Office 04	4	13.50	3.00		100%	-	AHU
Office 05	4	16.70	3.00		100%	-	AHU
Office 06	4	63.40	3.00		100%	-	AHU
Office 07	4	15.20	3.00		100%	-	AHU
Bathroom 01	4	20.50	3.00		100%	-	AHU
Bathroom 02	4	25.15	3.00		100%	-	AHU
Bar	4	90.30	3.00		100%	-	AHU
Restaurant	4	130.68	3.00		100%	-	AHU
Hall + hallway	4	964.26	3.00		100%	-	AHU

In the fifth floor there are meeting rooms and kitchen mainly.

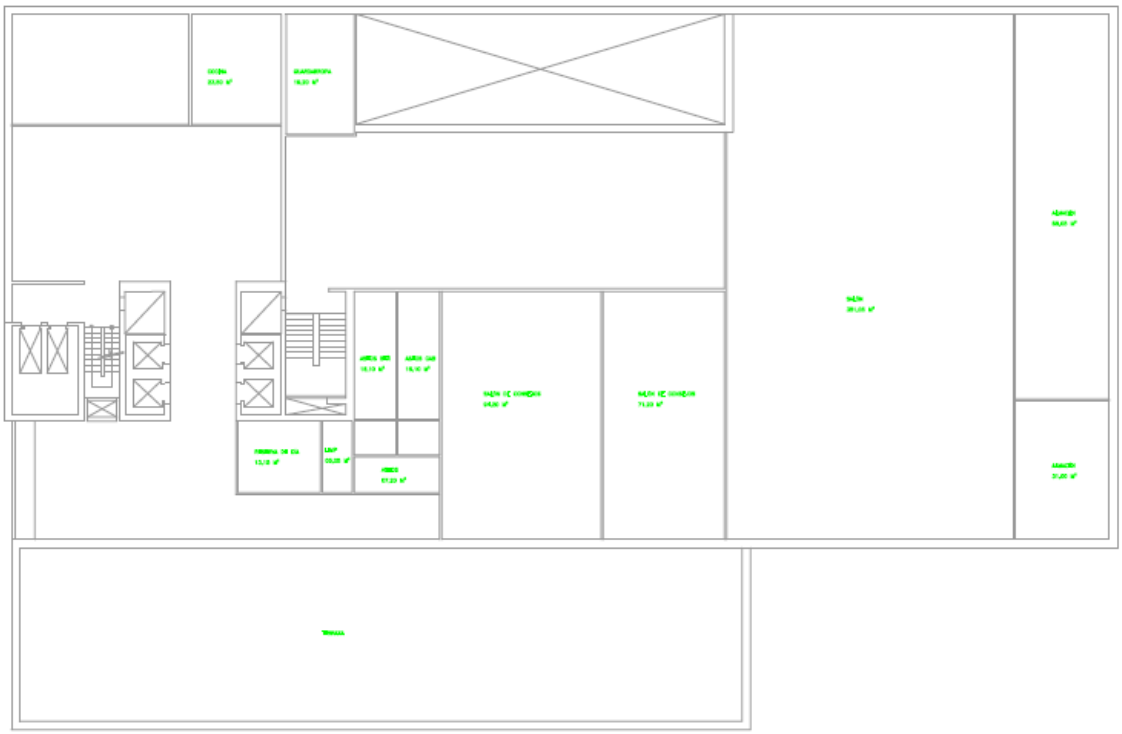


Figure 9: Floor +16.35 plan

Table 8: HCH building distribution / usage floor +16.35

Zone	Floor	Useful area (m^2)	H. (m)	Vol. (m^3)	% cond.	Occ. (pax)	Cond. services
Meeting room 01	5	351.05	3.00	1053.15	100%	-	AHU
Meeting room 02	5	71.20	3.00	213.60	100%	-	AHU

Meeting room 03	5	94.20	3.00	282.60	100%	-	AHU
Storage room 01	5	88.05	3.00	264.15	100%	-	AHU
Storage room 02	5	31.00	3.00	93	100%	-	AHU
Bathroom 01	5	16.10	3.00	48.3	0%	-	-
Bathroom 02	5	16.10	3.00	48.3	0%	-	-
Bathroom 03	5	7.20	3.00	21.6	0%	-	-
Wardrobe	5	19.20	3.00	57.6	0%	-	-
Kitchen	5	70.92	3.00	212.76	0%	-	-
Hall + hallway	5	526.38	3.00	1579.15	100%	-	AHU

In the sixth floor there are no rooms, is the technical floor.

Figure 10: Floor +19.25 plan

Table 9: HCH building distribution / usage floor +19.25

Zone	Floor	Useful area (m^2)	H. (m)	Vol. (m^3)	% cond.	Occ. (pax)	Cond. services
Technical floor	6	1250	3.00	3750	0%	-	-

In the floors 7 to 16 there are rooms.

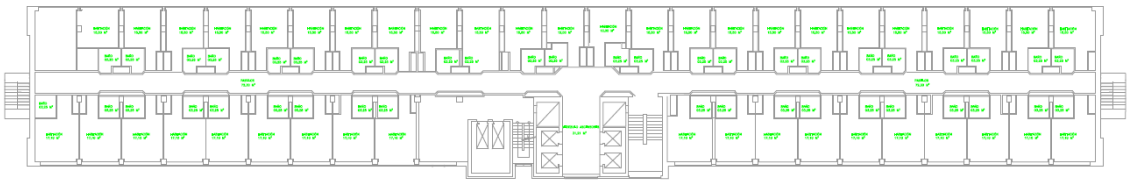


Figure 11: Floor 7 to 16 plan

Table 10: HCH building distribution / usage floor 7 to 16

Zone	Floor	Useful area	H. (m)	Vol. (m^3)	% cond.	Occ. (pax)	Cond. services

		(m^2)					
Rooms 01 to 24	7 – 16	18.75	3.00	56.25	100%	1 - 2	FANCOILS
Rooms 25 - 43	7 – 16	20.35	3.00	61.05	100%	1 - 2	FANCOILS
Hallway	7 – 16	144.60	3.00	433.80	100%	-	AHU
Hall	7 – 16	31.21	3.00	93.63	100%	-	AHU

Table 11: Building daily occupation profile of HUSA Chamartin building[1]

Hour	1	2	3	4	5	6	7	8	9	10	11	12
Mon-Fri	1	1	1	1	1	1	1	1	1	1	1	1
Weekend	1	1	1	1	1	1	1	1	1	1	1	1
Hour	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Mon-Fri	1	1	1	1	1	1	1	1	1	1	1	1
Weekend	1	1	1	1	1	1	1	1	1	1	1	1

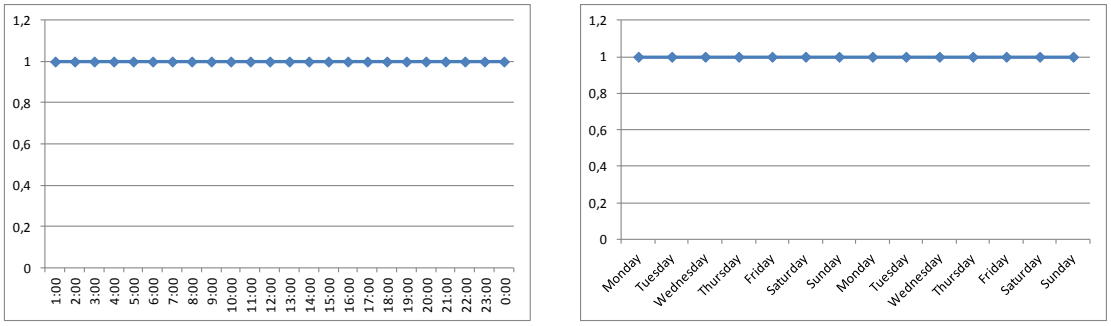


Figure 12: Building daily occupation

Table 12: Building yearly occupation profile of HUSA Chamartin building

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
Mon-Fri	1	1	1	1	1	1	1	1	1	1	1	1	1
Weekend	1	1	1	1	1	1	1	1	1	1	1	1	1
Week	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Mon-Fri	1	1	1	1	1	1	1	1	1	1	1	1	1
Weekend	1	1	1	1	1	1	1	1	1	1	1	1	1
Week	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
Mon-Fri	1	1	1	1	1	1	1	1	1	1	1	1	1
Weekend	1	1	1	1	1	1	1	1	1	1	1	1	1

[1] (Not occup.=0; partially occup.=1; occup.=2)

Week	40	41	42	43	44	45	46	47	48	49	50	51	52
Mon-Fri	1	1	1	1	1	1	1	1	1	1	1	1	1
Weekend	1	1	1	1	1	1	1	1	1	1	1	1	1

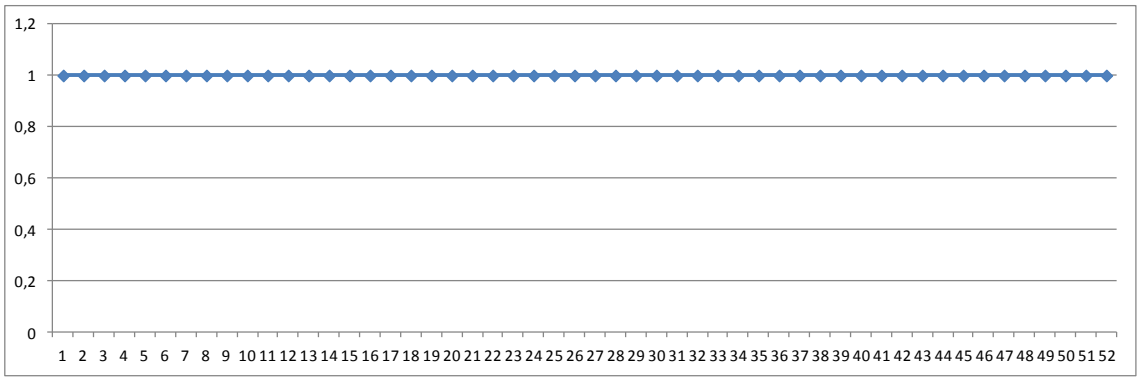


Figure 13: Building yearly occupation

3 Building characteristics

3.1 Envelope elements and thermal characteristics

Table 13: Construction elements of HUSA Chamartin building

Envelope Element	Description (material and thickness)	Total thick. (m)	U-Value ($W/m^2 K$)	Abs int. – abs ext	Details section'sketch from inner face to outer face
External wall	1 Brick 0,250 2 EPS 0,04 3 Brick 0,125 4 Plaster 0,005	0.415	0.44		
Internal wall	1 Plaster 0.005 2 Perforated brick 0.090 3 Plaster 0.005	0.100	2.13		
Roof	1 Concrete block 0,100 2 Concrete block 0,400 3 EPS 0.040 4Air cavity unventilated 0.100 5 Plaster 0,020	0.660	0.52		
Floor	1 Concrete 0.350 2 Concrete 0.100 3 Cement 0.005 4 Ceramic tile 0.010	0.465	2.50		

Table 14: Windows description of HUSA Chamartin building

Envelope Element	Description	U-Value (W/m^2K)	g	Details section sketch from inner face to outer face
Window	1 Vertical Blinds 2 Aluminium woodwork 3 Double glass 6+4	3.0	n.a.	

4 Energy flow

HUSA Chamartín Hotel has a system that can provide cold or heat. Boilers and chillers work against two storage tanks. Exchangers distributed heat or cold to the AHU and fan coils circuits.

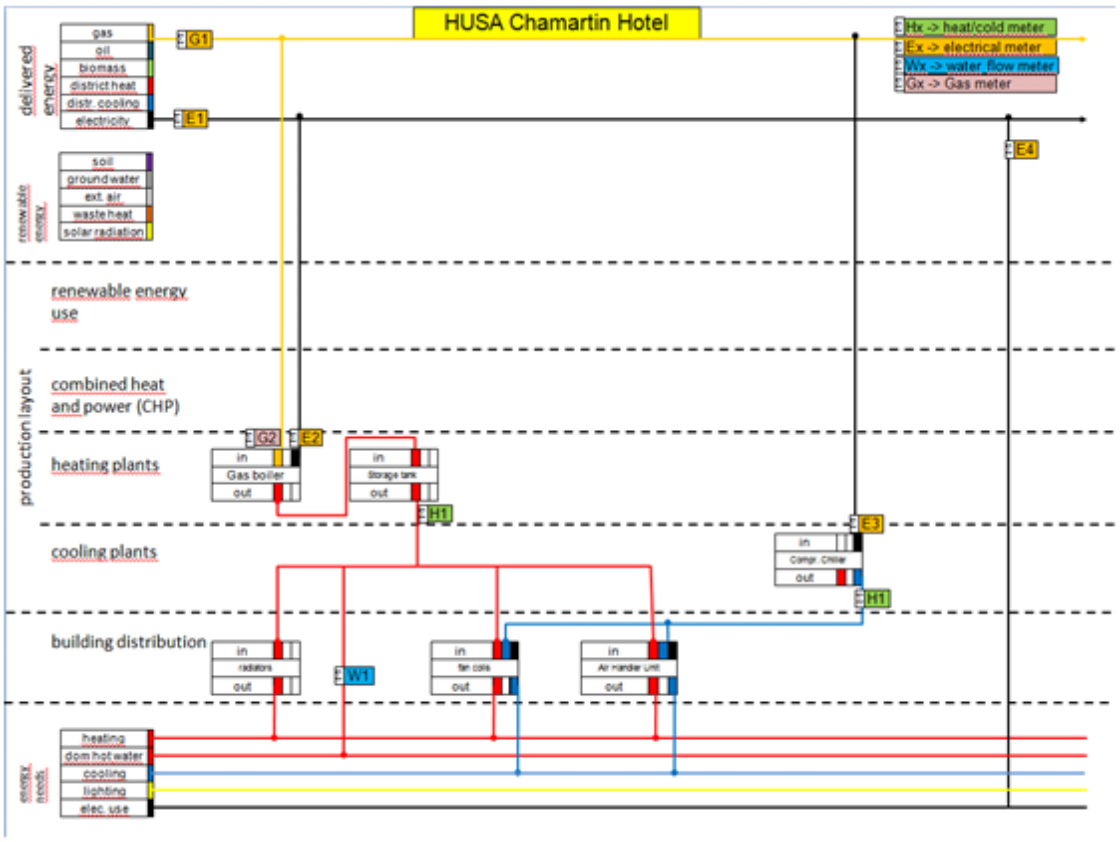


Figure 14: Energy flow

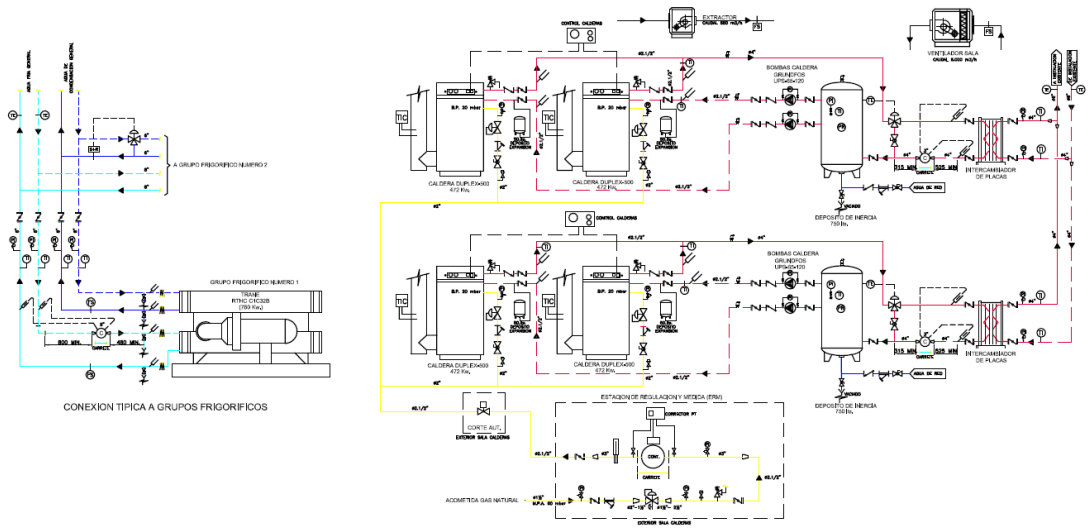
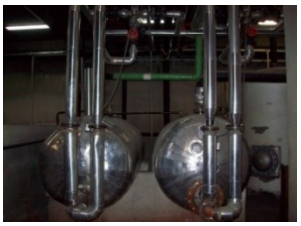


Figure 15: Hydraulic scheme for heating and cooling system

Table 15: Energy flow elements of HUSA Chamartin building

HVAC PLANT	Installed system	Nº units	Picture
Heating	**Gas Boiler** ADISA DUPLEX 500 Heating Power: 472kW Max. temperature: 110ºC Working pressure: 6bar	4	
Cooling	**Chiller** TRANE RTHC C1C32B Cooling power: 780kW	2	
Storage	**Heat storage** Volume: 750 l	2	
DHW	**Accumulators** Volume: 5.000 l	2	
Terminal Units	**Fancoils**	387	
	Radiators	460	

5 Energy supply and use

5.1 Electricity supply and consumption

Table 16: Information about electricity supply of HUSA Chamartin building

Energy supplier (Name of organization)	IBERDROLA					
Tariff						
Nº tariff periods	6					
Periods	1	2	3	4	5	6
Contrated power (kW)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
€/kW	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
€/kWh	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

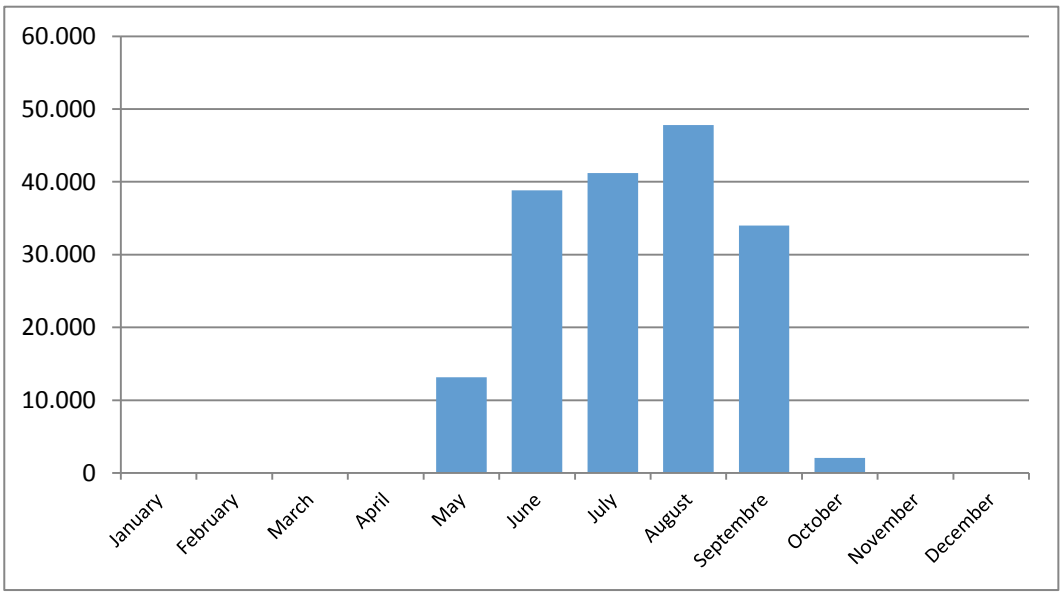


Figure 16: Electricity consumption for cooling system

Table 17: Electricity consumption of HUSA Chamartin building

	Jan	Feb	Mar	Apr	May	Jun
kWh	0	0	0	0	13.139	38.827
€	0	0	0	0	647,75	1.914,17
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	41.214	47.784	34.009	2.054	0	0
€	2.031,85	2.355,75	1.676,64	101,26	0	0

Total (kWh): 177.027

Total (€): 8.727,42

5.2 Fuel supply and consumption

Table 18: Information about fuel supply of HUSA Chamartin building

Energy supplier (Name of organization)	
Contratred energy/flow	-
Tariff	n.a.
Nº tariff periods	n.a.
€/kWh	Variable
€/kWh Special Tax Hydrocarbon	n.a.

Table 19: Gas consumption of HUSA Chamartin building

	Jan	Feb	Mar	Apr	May	Jun
kWh	545.301	553.857	413.607	387.112	254.965	115.961
€	37.773,16	19.473,19	16.313,63	18.068,09	12.031,50	5.492,08
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	101.558	112.703	118.817	181.889	389.828	295.194
€	4.850,38	5.430,28	5.722,85	8.741,77	18.713,66	14.179,74

Total (kWh): 3.470.792

Total (€): 166.790,33

6 Building Management System

HUSA Chamartín Hotel is provided with a monitoring and control system in the boilers and chillers rooms. The system only has control over energy production and is located in boilers/chillers rooms. The variable to control energy production is the return temperature.

6.1 Energy generation monitoring and control

There is commercial software developed by TREND for visualization features of their control system. The application can display real-time operating variables.

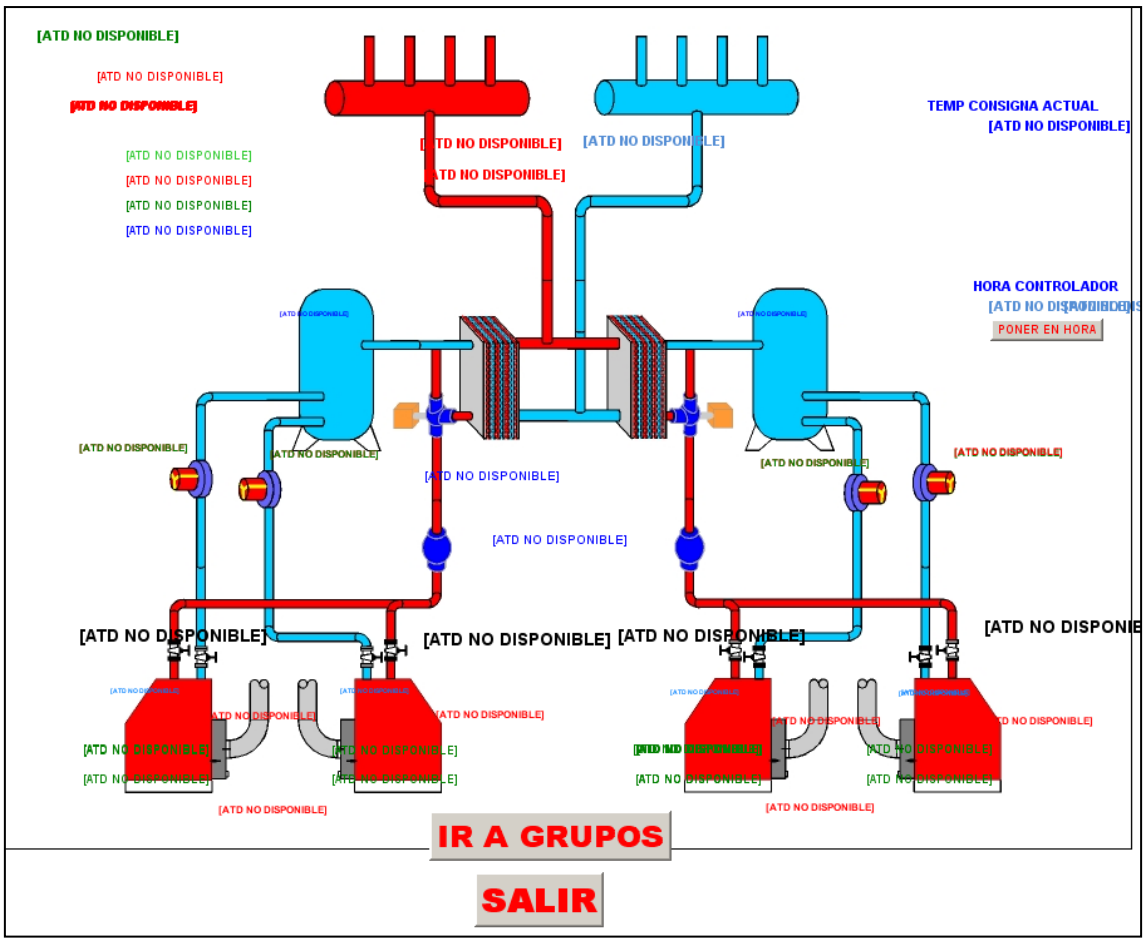


Figure 17: Heat production management of HCH

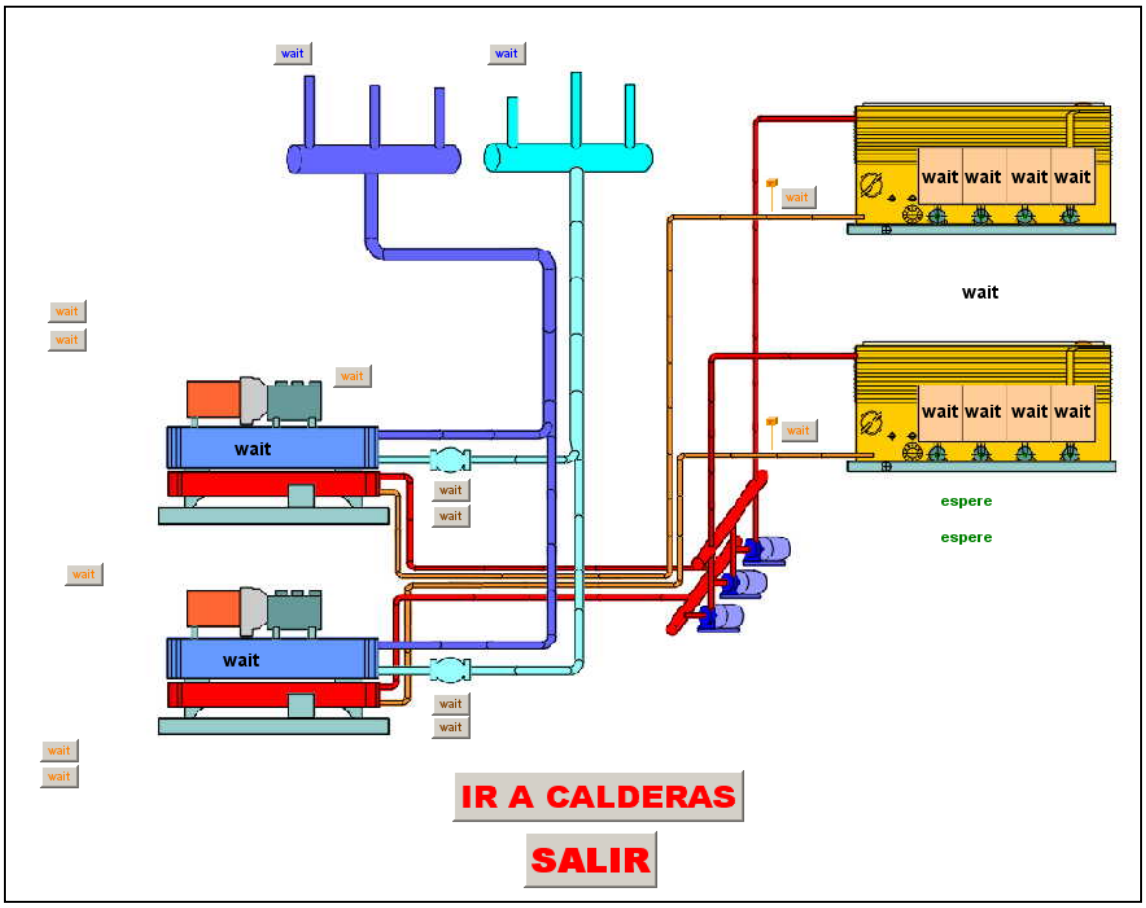


Figure 18: Cold production management of HCH

Table 20: BMS installed devices and power balance of HUSA Chamartin building

Device	Model	Manufacturer	Power (W)	Voltage (V)
Controller	IQ 221	TREND CONTROLS	10	230
Controller	IQ 222	TREND CONTROLS	10	230
Controller	IQ 223	TREND CONTROLS	10	230
Controller	IQ 228	TREND CONTROLS	10	230
Temperature sensor	TB/TI	TREND CONTROLS		
External Temperature sensor	TB/TI	TREND CONTROLS		
Energy meter		SIEMENS		
Energy meet		CIRCUTOR		

6.2 Control strategies

6.2.1 Heating and cooling system

Control strategy for heating systems is based on external temperature and regulated by return temperature in each circuit.

Table 21: Systems level control strategies of HUSA Chamartin building

Heating System	Programming	WINTER: 1st OCT – 1st MAY
	Days	EVERY DAY
	Set points	Depend external temperature
	Scheduling	00:00 h – 23:59 h
Cooling System	Programming	SUMMER: 1st MAY – 1st OCT
	Days	EVERY DAY
	Set points	Depend external temperature
	Scheduling	00:00 h – 23:59 h

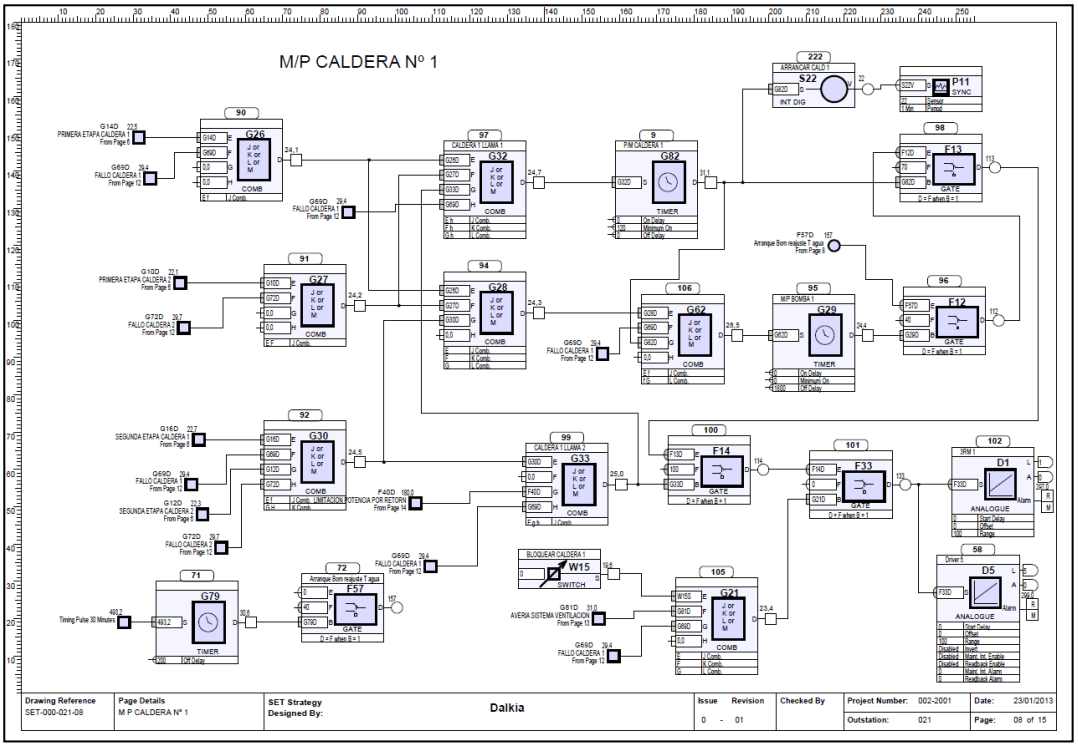


Figure 19: Strategy for boiler start

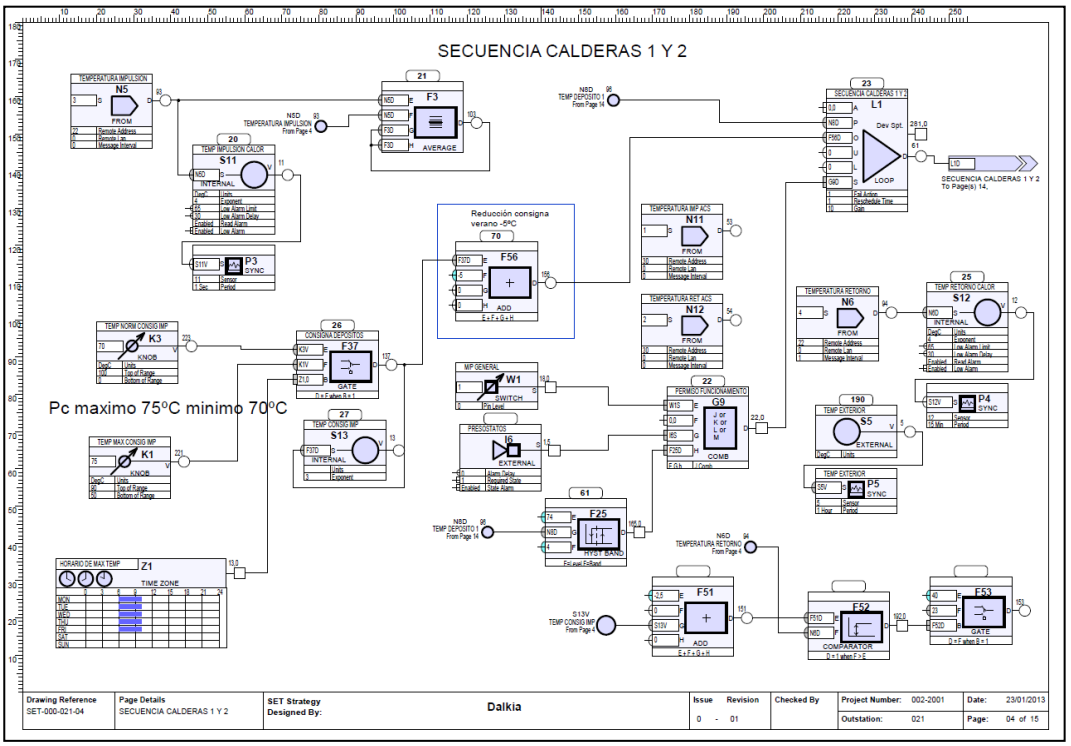


Figure 20: Strategy for boilers sequencing

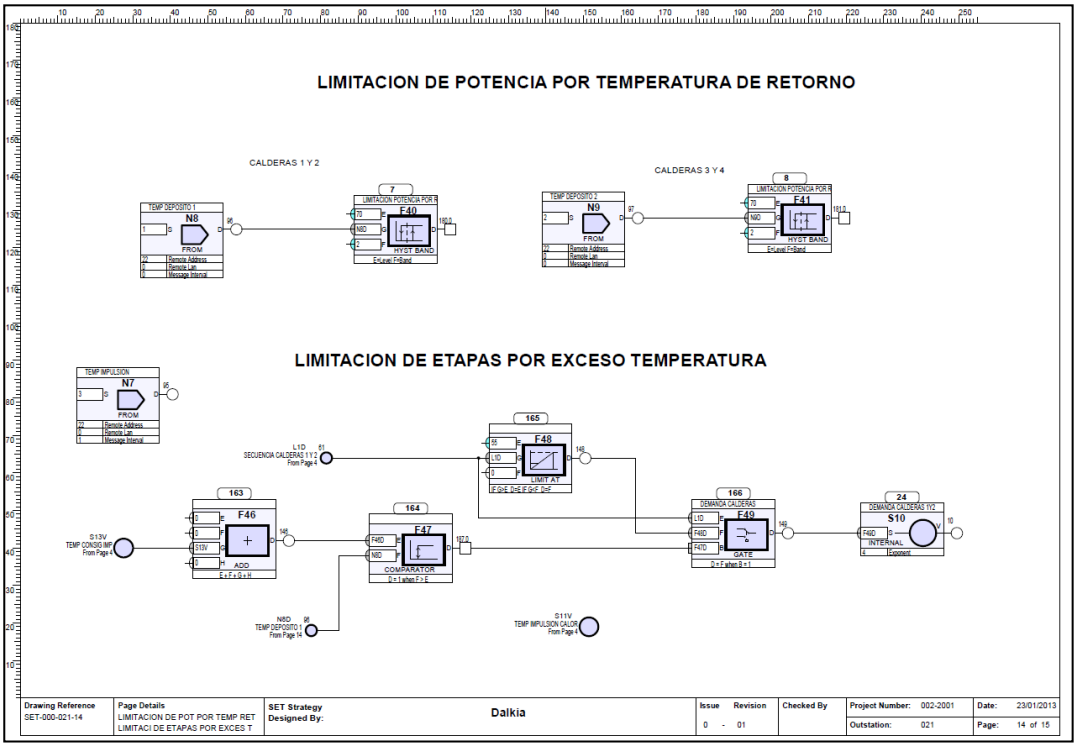


Figure 21: Strategy for boiler power limitation

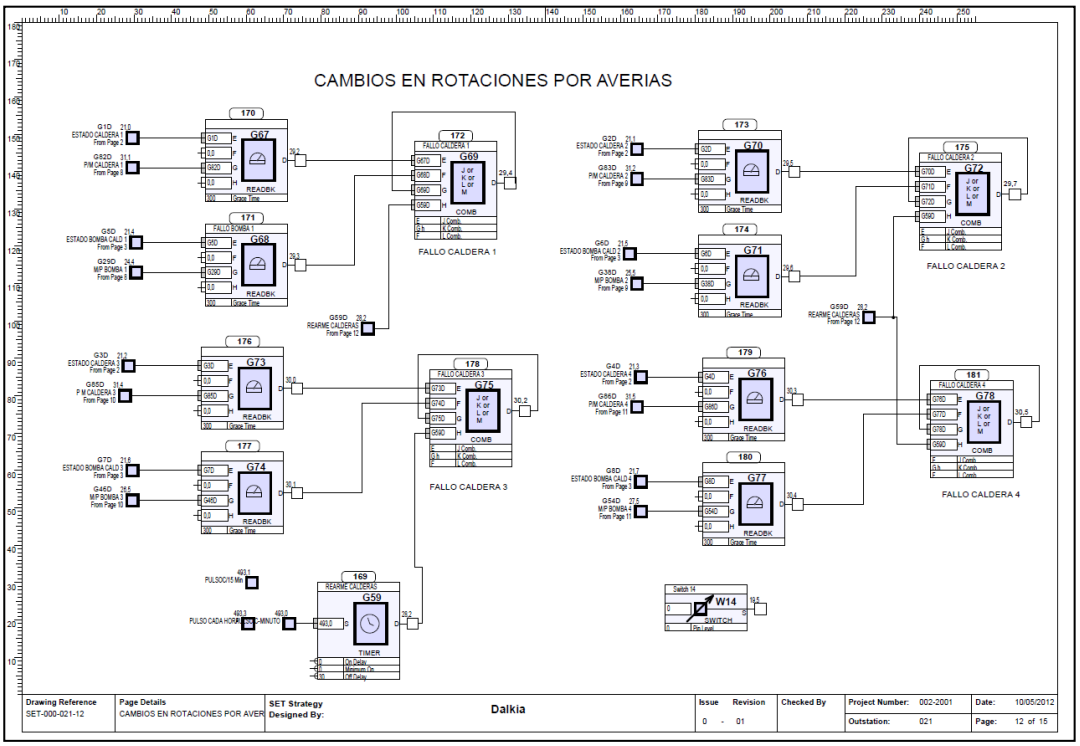


Figure 22: Strategy for boilers rotation by impairments

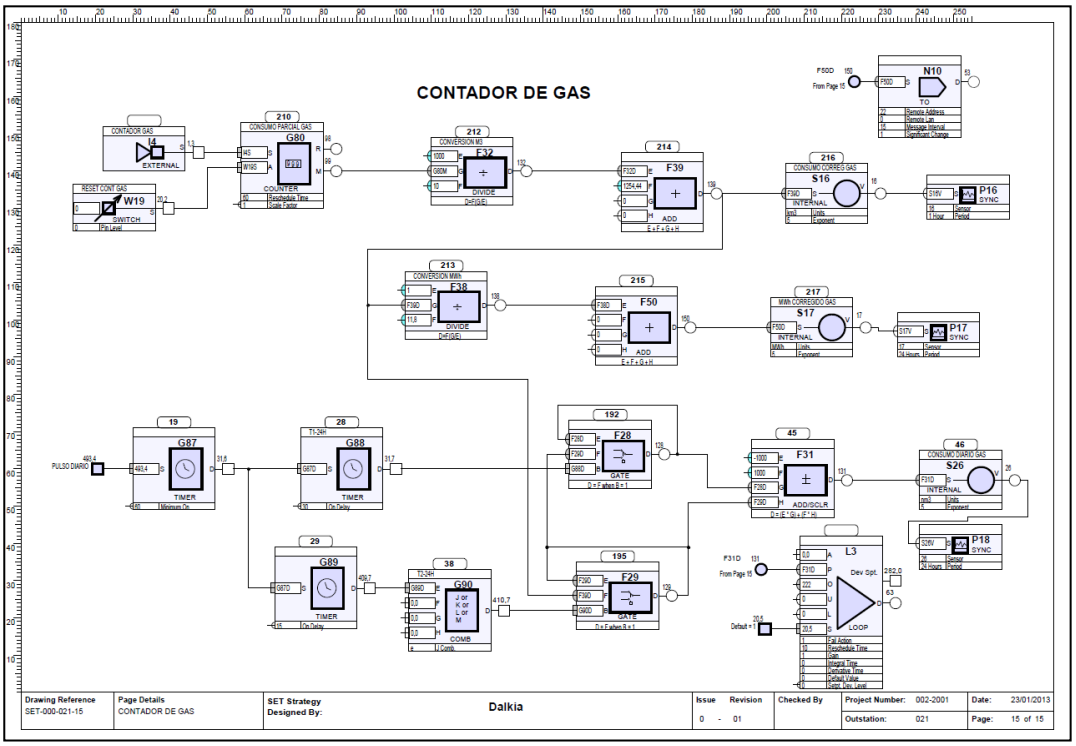


Figure 23: Strategy for gas meter

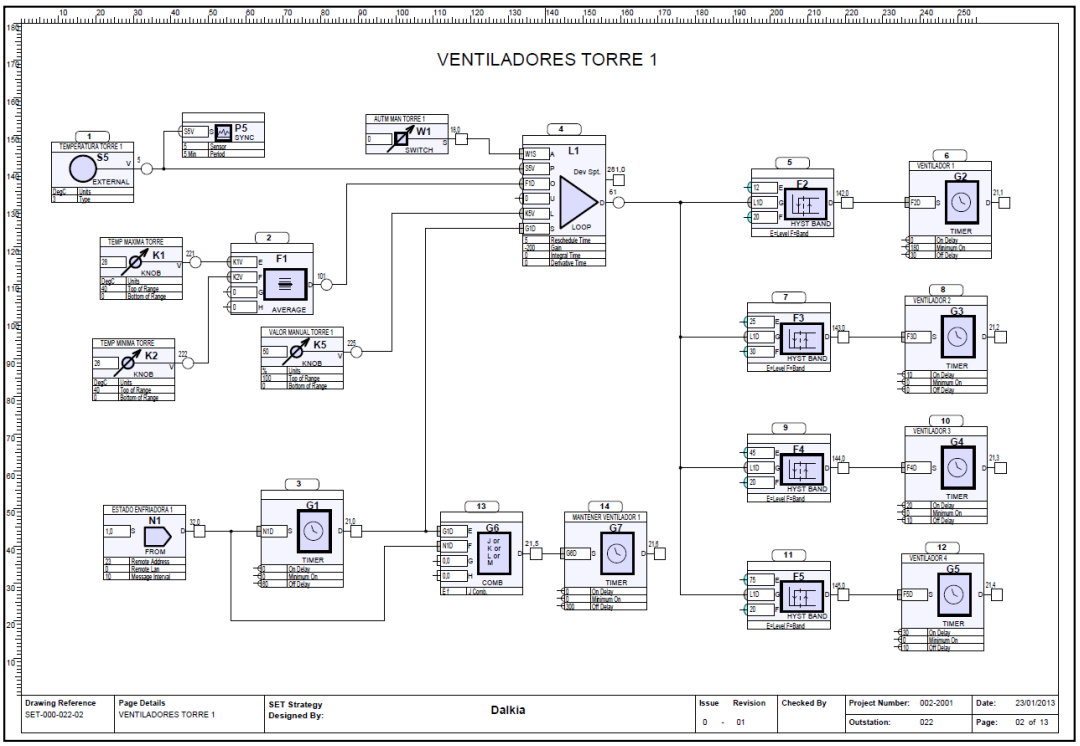


Figure 24: Strategy for fan tower

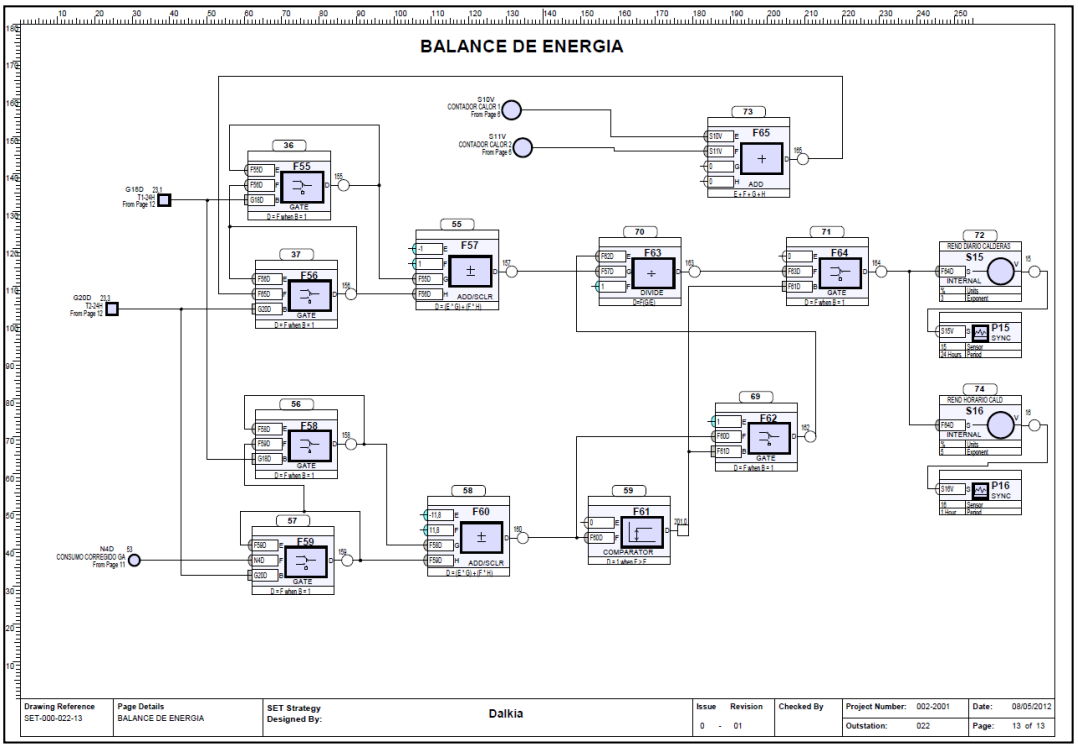


Figure 25: Strategy for energy balance

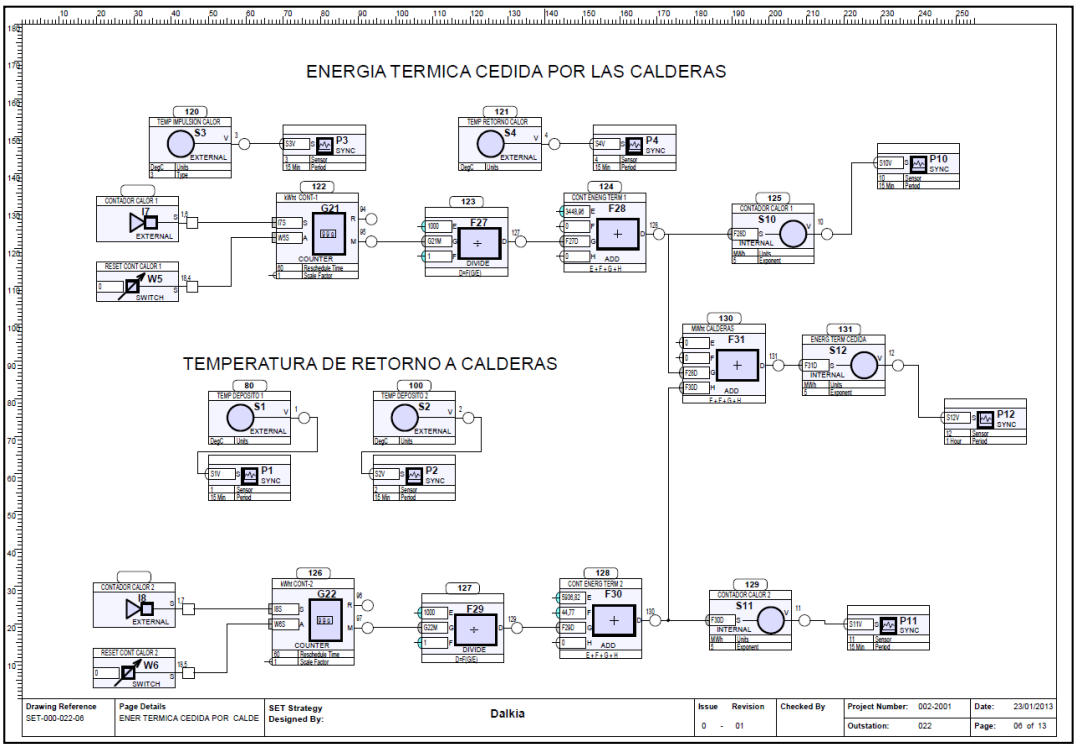


Figure 26: Strategy for boilers thermal energy

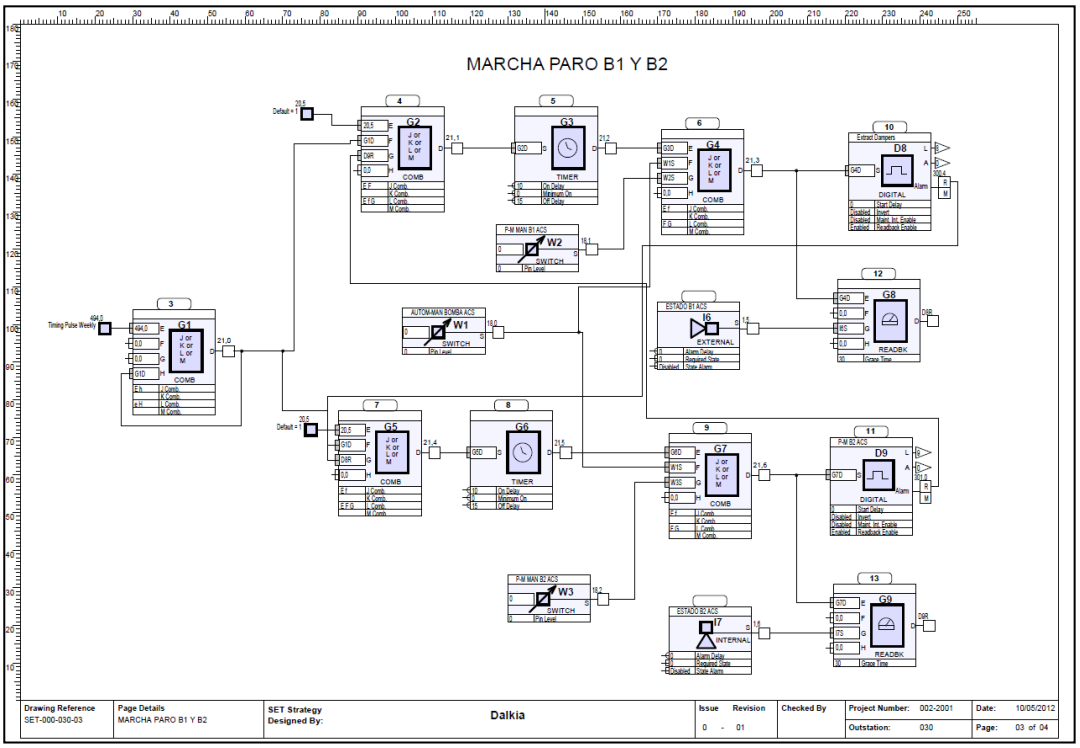


Figure 27: Strategy for DHW pumps starts

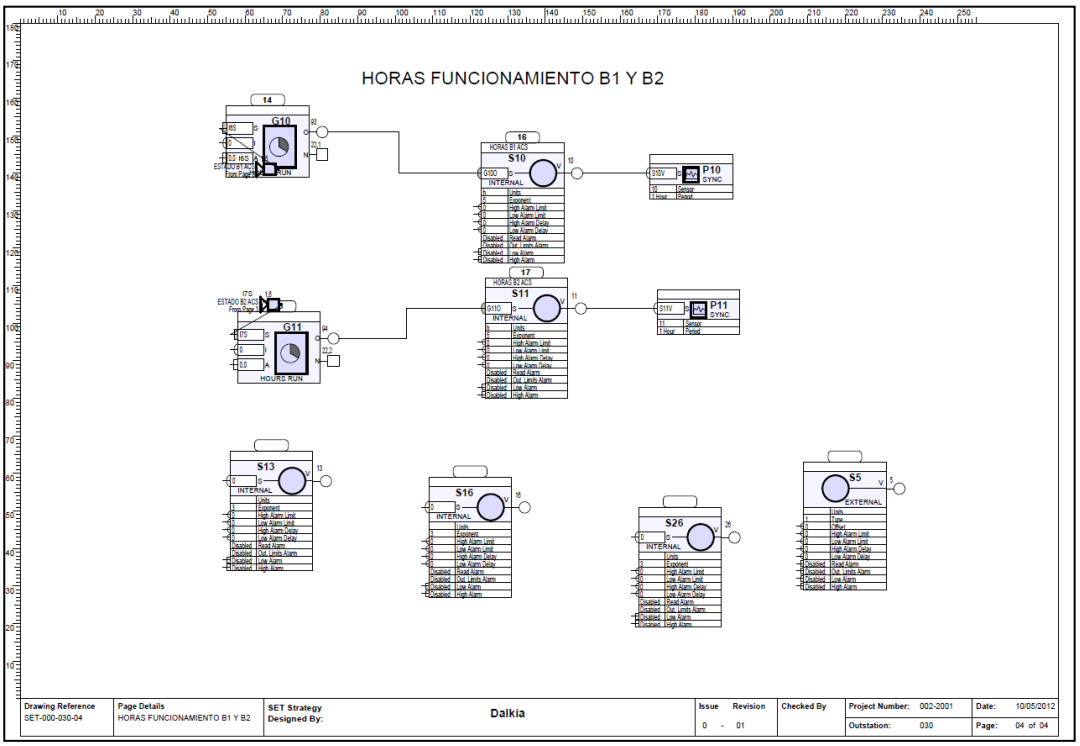


Figure 28: Strategy for DHW pumps operating hours

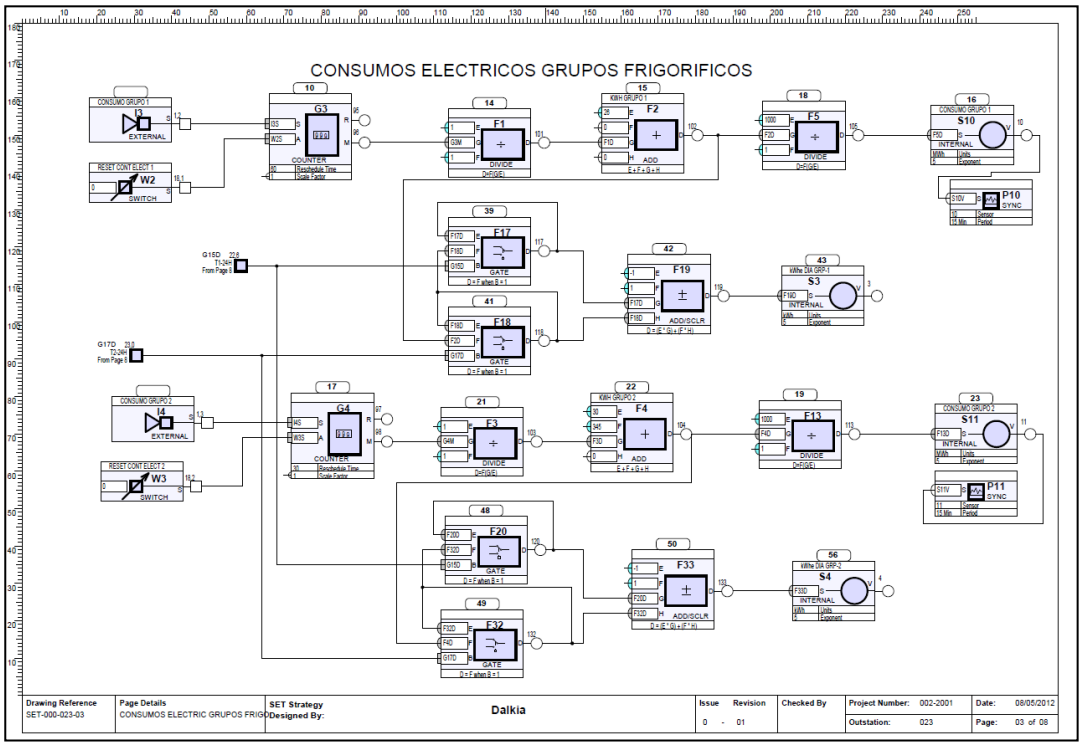


Figure 29: Strategy for cooling units' electrical consumption

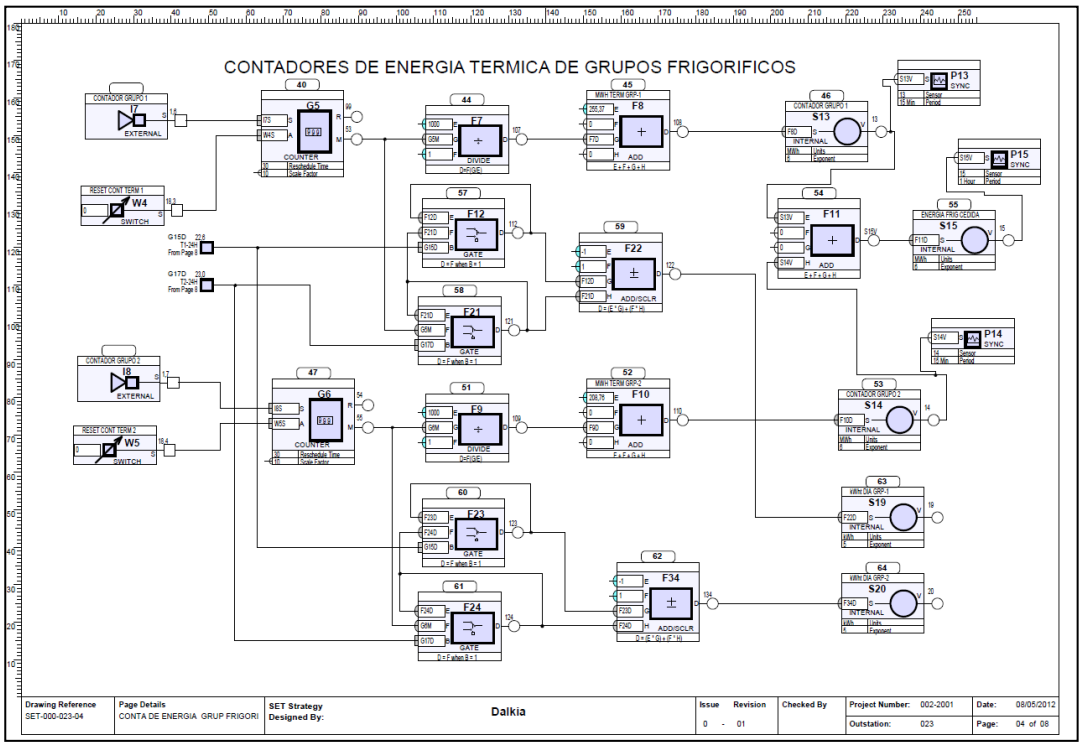


Figure 30: Strategy for cooling units thermal energy counters

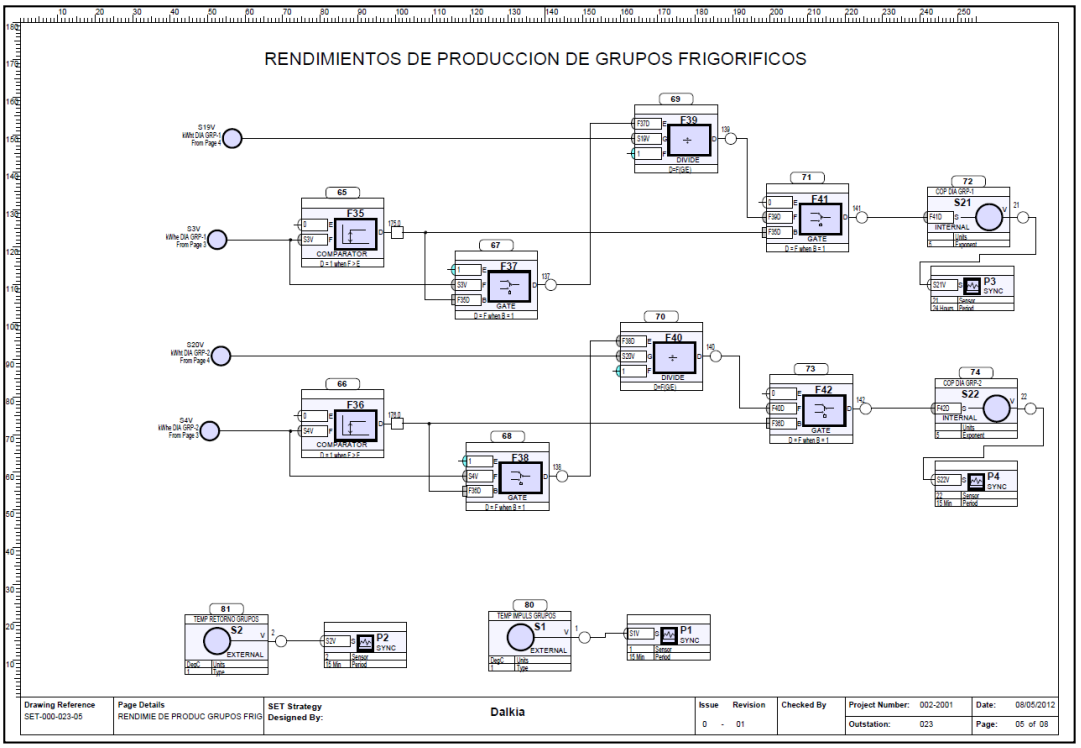


Figure 31: Strategy for cooling units' production yields

6.2.2 Generation level existing control

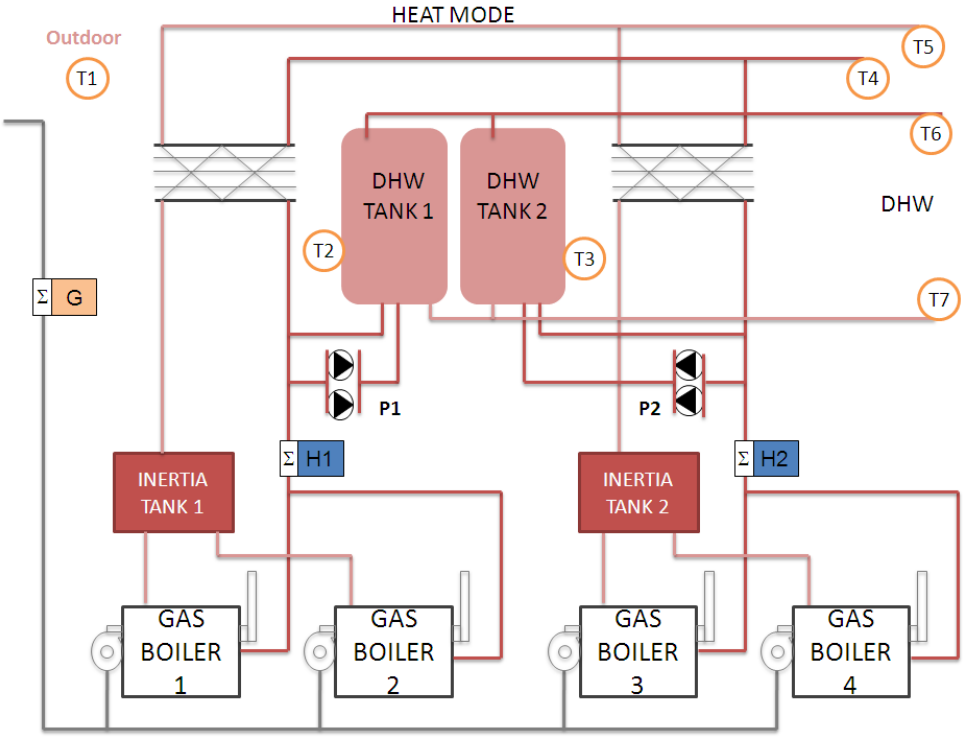


Figure 32: Heat generation scheme

Table 22: Boiler related sensors

System	ID	Description	Unit
Boiler	T1	Outdoor temperature	°C
	T2	DHW Tank 1 temperature	°C
	T3	DHW Tank 2 temperature	°C
	T4	Heat Supply temperature from boiler	°C
	T5	Heat Return temperature to boiler	°C
	T4	DHW Supply temperature	°C
	T5	DHW Return temperature	°C
	P1	Pump 1 DHW	On - Off
	P2	Pump 2 DHW	On - Off
	H1	Heat meter 1	Mw/h
	H2	Heat meter 2	Mw/h

Table 23: Boiler related control

System	ID	Description	Control
Boiler	Boilers On - Off	The permission to start and stop the boilers is managed by schedule.	Schedule Heat Schedule DHW
	P1	Pump DHW Tank 1	On → If set point is low than temperature in DHW Tank 1
	P2	Pump DHW Tank 2	On →If set point is low than temperature in DHW Tank 1

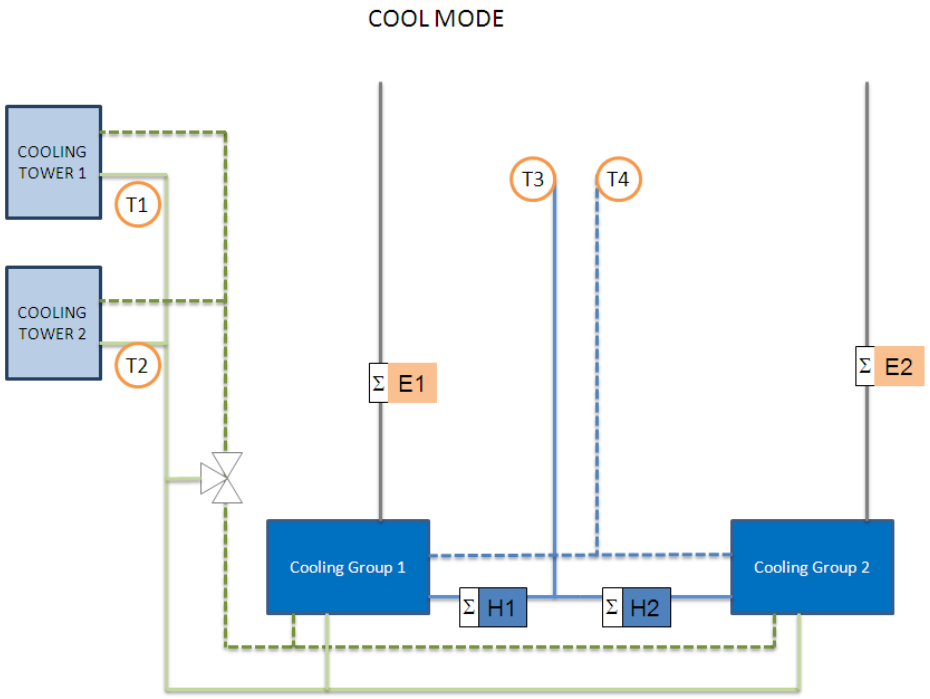


Figure 33: Cooling generation scheme

Table 24: Chiller related sensors

System	ID	Description	Unit
Chiller	T1	Cooling tower 1 temperature	°C
	T2	Cooling tower 2 temperature	°C
	T3	Discharge chiller 1 temperature	°C
	T4	Discharge chiller 2 temperature	°C
	H1	Heat meter 1	Mw/h

	H2	Heat meter 2	Mw/h
	E1	Electric meter 1	Mw/h
	E2	Electric meter 2	Mw/h

Table 25: Chiller related control

System	ID	Description	Control
Chiller	Chillers On - Off	The permission to start and stop the chillers is managed by schedule.	Schedule Cool Mode

7 Historical data: existing data base

7.1 Existing data base

There is no database in HUSA Chamartin building.

7.2 Existing historical variables

Table 26: Consumed energy parameters of HUSA Chamartin building

Consumed Energy				
Concept	**Application**		**Measurement[2]**	**Monitoring point and location**
Fossil fuel (biomass, natural gas, etc.)	Heating	Y	F+HC	Boilers room
	Cooling	N		
	DHW	Y	F+HC	Boilers room
Electricity	Heating			
	Cooling	Y	E+HC	Boilers room
	DHW			
	Ventilation	Y	E	Boilers room
	Lighting	Y	E	
	Appliances	Y	E	
District energy	District heating			
	District cooling			

Table 27: Delivered energy parameters of HUSA Chamartin building

Delivered energy				
Concept	**No.**		**Explanation**	**Unit**
Heating system	1	t_1	Boiler flow temperature	ºC
	2	t_2	Boiler return temperature	ºC
	3	t_3	Tank 1 temperature	ºC
	4	t_4	Tank 2 temperature	ºC
	5	E_1	Thermal energy meter Boiler1	Mw/h
	6	E_2	Thermal energy meter Boiler 2	Mw/h
	7	G_1	Boilers Gas meter	m^3
Cooling	8	t_5	Cooling Tower 1 temperature	ºC

[2] Electricity meter (E), Fuel meter (F), Water meter (W), Hot/cold water meter (HC), None (N)

system	9	t_6	Cooling Tower 2 temperature	ºC
	10	E_1	Thermal energy meter Cooling Unit 1	Mw/h
	11	E_2	Thermal energy meter Cooling Unit 2	Mw/h
	12	W_1	Electrical meter Cooling Unit 1	Mw/h
	13	W_2	Electrical meter Cooling Unit 2	Mw/h
Domestic Hot Water	14	t_7	Domestic Hot Water flow temperature	ºC
	15	t_8	Domestic Hot Water return temperature	ºC

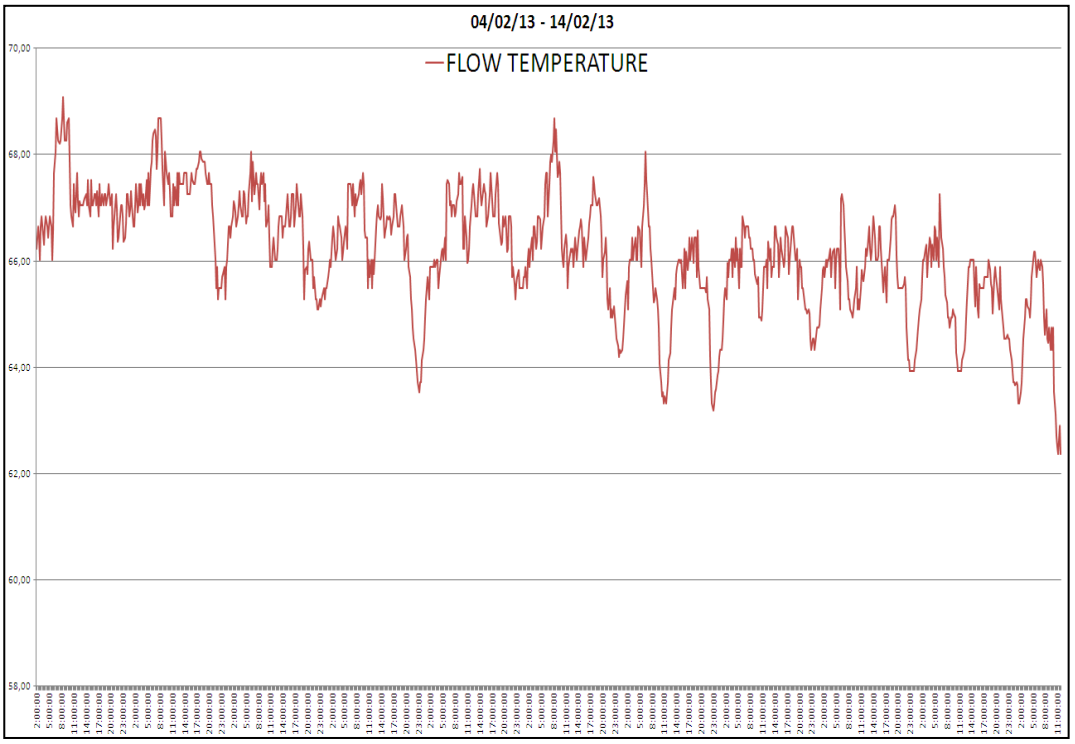


Figure 34: Boiler flow temperature

Table 28: Indoor ambient parameters of HUSA Chamartin building

Indoor ambient parameters				
Concept	**Measurement**		**Quantity**	**Monitoring point and location**
Indoor conditions	Temperature	N		
	Relative humidity	N		
	Illumination level	N		
	CO_2 concentration	N		

	Occupancy	N		
	Window status	N		

8 External data sources: weather data

There is an external temperature sensor in a boiler room.

Table 29: Outdoor ambient parameters of HUSA Chamartin building

Outdoor ambient parameters				
Concept	**No.**		**Explanation**	**Unit**
Outdoor ambient param.	1	t_{ext}	Ambient temperature	ºC