Inputs

Table 1: Inputs

Key	Description	Value	Units
loadSchedule	Schedule of loads	[object Object], [object Object], [object Object]	
nBuildings	Number of buildings	1	buildings
tPeak	Peak network flow temperature	65	°C
hHighPoint	System height		m
supplyCWS	CWS Supply		
tPriRtnDHW	DHW network return temperature	19	°C
profileDHW	DHW load profile	EST	
typeEmitter	Central heating emitter	underfloor	
connectionCH	Central heating connection	indirect	
tXPeak	External temperature at peak load	-5	°C
tPriRtnCH	Central heating network return temperature	35	°C
divCH	Central heating diversity	70	%
baseTemp	Base temperature	16	
degDaysAvg	Central heating degree-days	1749.5, 1884.5, 2023.9, 2167.9, 2316.2, 2467.9, 2623.5, 2782.4, 2944.3, 3108.6, 3275.4, 3444.9, 3615.7	°days
degDays	Central heating degree-days at base temperature	1850	°days
goBoilers	Boilers	true	
goASHP	Air Source Heat Pumps	true	
goHN	External Heat Network Supply	true	
goWSHP	Water Source Heat Pumps	false	
goReclaim	Cooling Source Heat Pumps	false	
goCHP	Combined Heat & Power	false	
goSolar	Solar Thermal	false	
boilerFuel	Boiler fuel type	gas	
boilerEmissions	Boiler Emissions	0.216	kgCO2/kWh
listBSizes	Available boiler outputs	30, 50, 75, 100, 250, 500, 750, 1000	kW
selectBoilers	Boiler selection	4 x 250	n x kW
tariffHP	Electrical Tariff	flat	
elecEmissions	Electrical Supply Emissions	0.233	kgCO2/kWh
substationType	Substation Type		
fridgeASHP	ASHP refrigerant	R744	
listASHPSizes	Available heat pump outputs	30	kW
selectASHP	ASHP selection	6 x 30	n x kW
vBuffer	Buffer volume	2000	litres

Table 1: Inputs (continued)

networkTempValve	Network temperature control valve		
pipeSizes	Schedule of pipes sizes	[object Object], [object Object], [object Object], [object Object], [object Object], [object Object], [object Object], [object Object], [object Object], [object Object], [object Object], [object Object]	
maxVelocity	Flow pipe sizing maximum velocity	1.5	m/s
minVelocity	Return pipe sizing minimum velocity	0.5	m/s
allowPipeDiff	Allow different flow and return pipe sizing		
goSave	Save design	false	

Calculations

Table 2: Calculations

key	Description	Value	Units
pPP	Average people per property	2.979	people
density	Average people per building (density)	444	people
kwDHWEst	Typical HIU rating for DHW	37.5	kW
peepDS439	People per standard DS439 property	2.3	people
eqPropDS439	Equivalent number of DS439 properties	193.043	properties
kwDS439	Peak DHW Load	509	kW
vPPEST	Volume DHW used per property per day	40	litres
vPHEST	Volume DHW used per person per day	28	litres
tRiseEST	Average temperature Rise on DHW	35	°C
vDHWEST	Volume drawn per day for DHW (tap)	18392	litres
kwhDHWEST	Energy used per day for DHW	751.006	kWh
vPDHW	Volume used per day for DHW (primary)	13993.913	litres
vBuffer9	Buffer Storage for DHW (based on 9%)	1259.452	litres
kwCH	Peak diversified (steady state) central heating load	422.1	kW
kwhCH	Energy used per day for CH	10130.4	kWh
vPCH	Volume used on peak load day for CH (primary)	289440	litres
kwhP24	Peak energy used per day	10881.405	kWh
vP24	Peak volume used per day (primary)	303433.913	litres
kwPeak	Peak load	931.1	kW
kwP24	Average 24h peak load	453.391	kW
m3hDHWPeak	Primary flow rate at peak DHW load	9.484	m3/h
m3hCHPeak	Primary flow rate at peak central heating load	12.06	m3/h
m3hPeak	Primary flow rate at peak load	21.544	m3/h
tPriRtnPeak	Primary return temperature at peak load	27.955	°C
tVWART24	Weighted primary return temperature on peak load day	34.262	°C
bufferkWh	Buffer storage peak energy content	86.438	kWh
boilerQty	Boiler quantity	4	boilers
boilerkW	Boiler unit power	250	kW
boilerkWPeak	Boiler peak power (n)	1000	kW
boilerkWxN1	Boiler power (n-1)	750	kW
ASHPQty	ASHP quantity	6	ASHPs
ASHPkW	ASHP unit power	30	kW
ASHPkWPeak	ASHP peak power (n)	180	kW
ASHPkWxN1	ASHP power (n-1)	150	kW
kWInPeak	Peak power available from all sources	1180	kW
kWxN1	Peak power available from (n-1) sources	930	kW
sparekW	Excess power availiable (n)	726.608	kW
oversizing	Oversizing (n)	160.261	%

Table 2: Calculations (continued)

ovsersizingN1	Oversizing (n-1)	105.12	%
dDaysCalc	Calculated degree days per year	1749.5	°days
dDaysPeak	Peak load day degree days	21	°days
eqDaysPeak	Annual days of full load heating	83.309	days
kwhCH365	Annual energy for central heating	212738	kWh
kwhDHW365	Annual energy for domestic hot water	274117	kWh
kwhUsed365	Annual energy utilised	486855	kWh
kwhDistLoss365	Annual distribution heat losses (est at 20%)	97371	kWh
kwh365	Annual energy required	584226	kWh
borePeak	Pipe bore at peak load and velocity	71.272	mm
dnMain	Nominal main line pipe size (max velocity)	DN80	
boreMain	Nominal main line pipe bore	73	mm
velocityPeak	Velocity at peak load using nominal size	1.429	m/s
borePeakMax	Maximum pipe bore at peak load and minimum velocity	123.447	mm
dnMainMax	Maximum main line pipe size (min velocity)	DN100	

DHW Loads

The following table shows DHW figures and buffer utilisation.

Table 3: Buffer Load Analysis

Hour	DHW %	DHW kWh	Buffer kWh
0:00	1.8	13.51	86.43
1:00	1.2	9.01	86.43
2:00	1	7.51	86.43
3:00	0.8	6	86.43
4:00	1.3	9.76	86.43
5:00	1.7	12.76	86.43
6:00	4.5	33.79	86.43
7:00	8.7	65.33	86.43
8:00	7.6	57.07	86.43
9:00	6.1	45.81	86.43
10:00	5.4	40.55	86.43
11:00	4.8	36.04	86.43
12:00	4.2	31.54	86.43
13:00	3.6	27.03	86.43
14:00	3.1	23.28	86.43
15:00	3.2	24.03	86.43
16:00	3.7	27.78	86.43
17:00	5.3	39.8	86.43
18:00	7.7	57.82	86.43
19:00	7.3	54.82	86.43
20:00	6.1	45.81	86.43
21:00	4.9	36.79	86.43
22:00	3.7	27.78	86.43
23:00	2.4	18.02	86.43

Historical Modelling

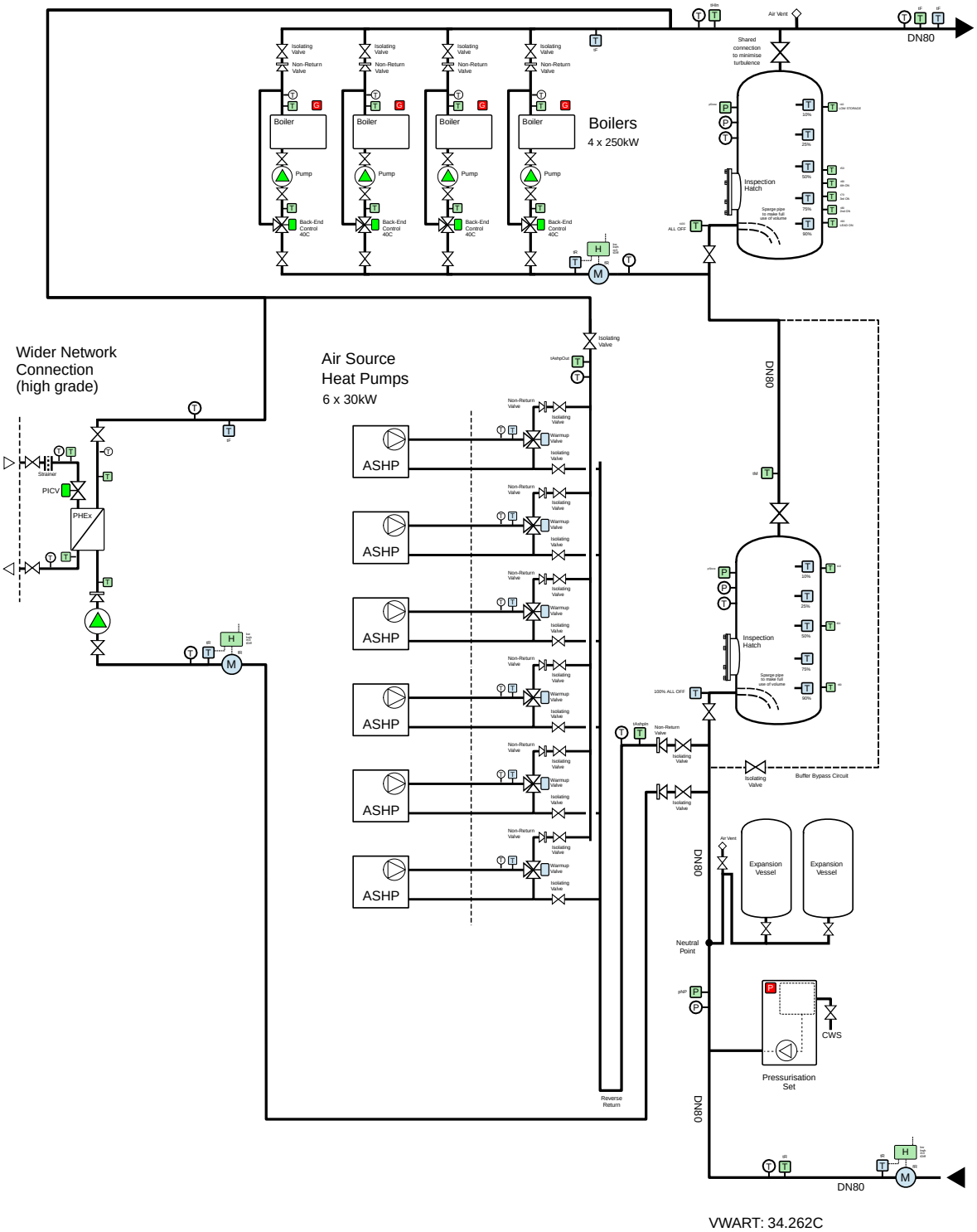
The following table shows energy use and generation for 2020 weather data.

Table 4: 2020 Load Analysis

Calculation	Value	Units
Base temperature used	16	°C
Degree days for 2020	1641	°days
Energy used in 2020	1066072	kWh
Energy used for DHW in 2020	274117	kW
Energy used for central heating in 2020	791955	kWh
Energy supplied via Gas Boilers in 2020	97321	kWh
Percentage via Gas Boilers in 2020	9.1	%
Assumed boiler efficiency	90	%
Energy input via Gas Boilers in 2020	108134.4	kWh
Emissions factor for gas	0.216	Kg CO2 / kWh
Carbon emissions for gas used in 2020	23357	Kg CO2
Energy supplied via Heat Pumps in 2020	968751	kWh
Percentage via Heat Pumps in 2020	90.8	%
Assumed COP for heat pumps	3	
Electrical input to Heat Pumps in 2020	322917	kWh
Emissions factor for electricity	0.233	Kg CO2 / kWh
Carbon emissions for electricity used in 2020	75239.6	Kg CO2
Total Carbon emissions in 2020	98596.6	Kg CO2

Plantroom Schematic

Pumping & Distribution



VWART: 34.262C

Control Points

The following table shows control points for the plantroom supply stage.

Table 5: Control Points - Supply

No.	Device	Group	Key	Type	Units	Description
1	supply	dat	tF	NTC 10k Input	degC	Network supply temperature
2	supply	dat	tR	NTC 10k Input	degC	Network return temperature
3	storeH	dat	t70	NTC 10k Input	degC	High grade buffer temperature, 70%
4	storeH	dat	t90	NTC 10k Input	degC	High grade buffer temperature, 90%
5	storeH	dat	t80	NTC 10k Input	degC	High grade buffer temperature, 80%
6	storeH	dat	t10	NTC 10k Input	degC	High grade buffer temperature, 10%
7	storeH	dat	pStore	0-10v Input	bar	High grade buffer pressure
8	storeH	dat	t60	NTC 10k Input	degC	High grade buffer temperature, 60%
9	storeH	dat	t50	NTC 10k Input	degC	High grade buffer temperature, 50%
10	boilers	meter	tR	M-Bus	degC	Boiler group metered return temperature
11	boilers	meter	kw	M-Bus	kW	Boiler group metered power
12	boilers	meter	kwh	M-Bus	kW	Boiler group metered historic energy
13	boilers	meter	m3	M-Bus	m3	Boiler group metered historic volume
14	boilers	meter	tDiff	M-Bus	degC	Boiler group metered temperature difference
15	boilers	meter	fR	M-Bus	m3/h	Boiler group metered flow rate
16	boilers	meter	tF	M-Bus	degC	Boiler group metered flow temperature
17	supply	dat	tHIn	NTC 10k Input	degC	Hot input temperature to high grade storage
18	storeH	dat	t100	NTC 10k Input	degC	High grade buffer temperature, 90%
19	supply	dat	tAshpIn	NTC 10k Input	degC	Temperature inlet to high grade heat pump array
20	supply	dat	tAshpOut	NTC 10k Input	degC	Temperature output from high grade heat pump array
21	storeL	dat	pStore	0-10v Input	bar	Low grade buffer pressure
22	storeL	dat	t90	NTC 10k Input	degC	Low grade buffer temperature, 90%
23	storeL	dat	t10	NTC 10k Input	degC	Low grade buffer temperature, 10%
24	storeL	dat	t50	NTC 10k Input	degC	Low grade buffer temperature, 50%
25	supply	dat	tM	NTC 10k Input	degC	Temperature at lower grade storage output
26	network	dat	pNP	0-10V Input	bar	Neutral point static pressure
27	supply	meter	tF	M-Bus	degC	Network metered flow temperature
28	supply	meter	tR	M-Bus	degC	Network metered return temperature
29	supply	meter	fR	M-Bus	m3/h	Network metered flow rate
30	supply	meter	kw	M-Bus	kW	Network metered power
31	supply	meter	kwh	M-Bus	kW	Network metered historic energy
32	supply	meter	m3	M-Bus	m3	Network metered historic volume
33	supply	meter	tDiff	M-Bus	degC	Network metered temperature difference
34	subSt	meter	tR	M-Bus	degC	Substation metered return temperature
35	subSt	meter	kw	M-Bus	kW	Substation metered power
36	subSt	meter	kwh	M-Bus	kW	Substation metered historic energy
37	subSt	meter	m3	M-Bus	m3	Substation metered historic volume
38	subSt	meter	tDiff	M-Bus	degC	Substation metered temperature difference
39	subSt	meter	fR	M-Bus	m3/h	Substation metered flow rate

Table 5: Control Points - Supply (continued)

40	subSt	meter	tF	M-Bus	degC	Substation metered flow temperature

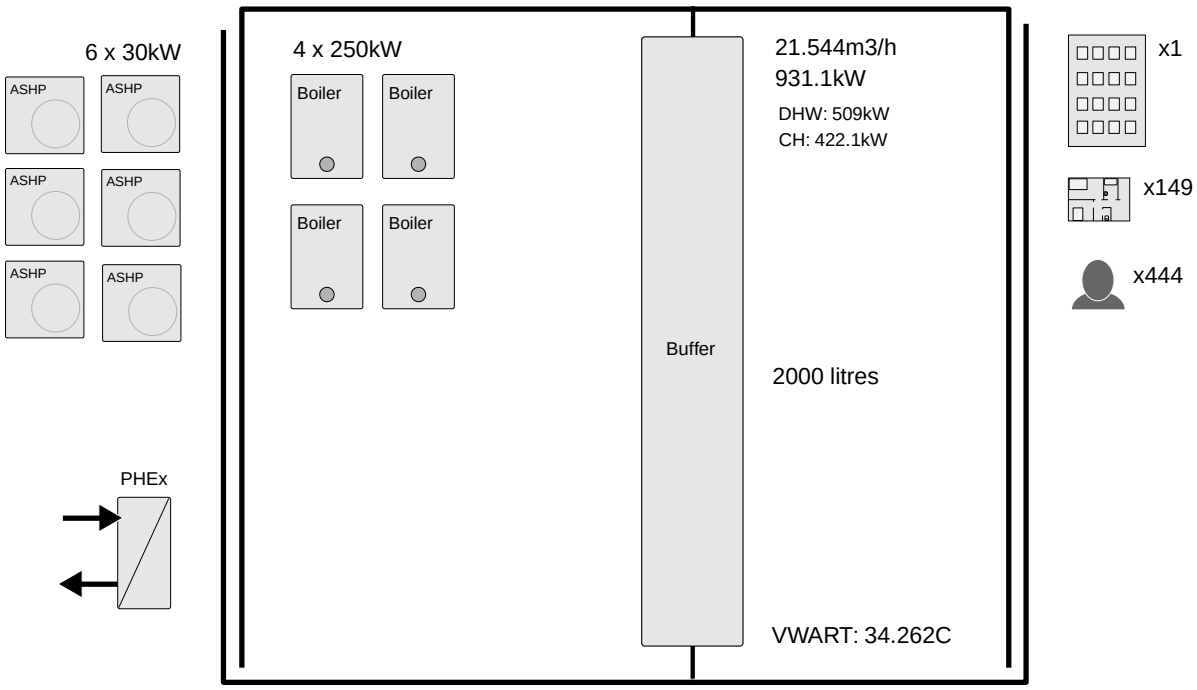
Plantroom Components

The following table shows components for the plantroom supply stage.

Table 6: Components - Supply

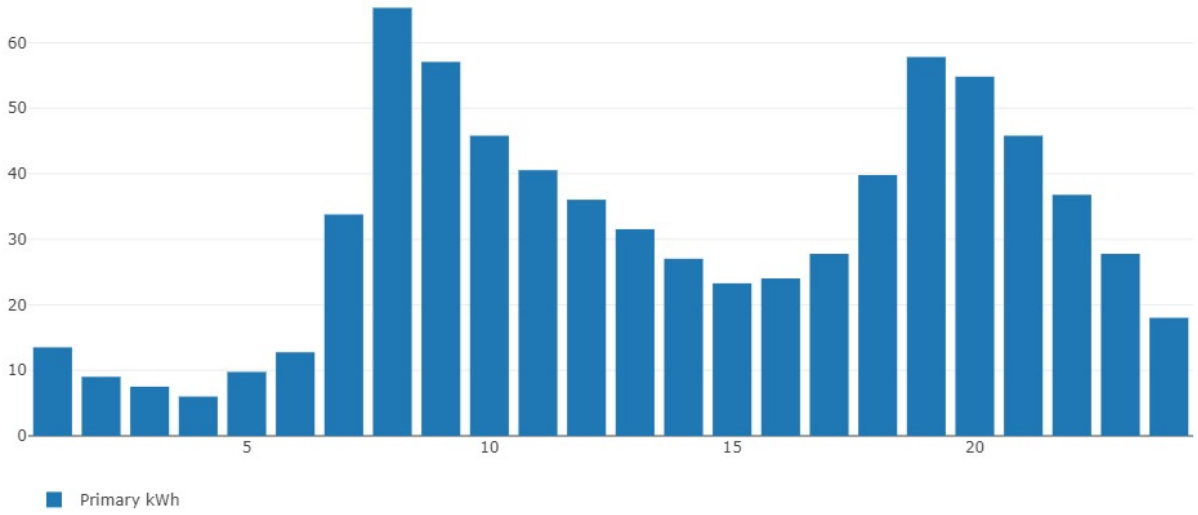
Item	Part ID	Qty	Title	Description
1	NTC10KPIPE100MM	15	NTC Pipe Temperature Sensor	NTC10K Thermistor Sensor for insertion mounting into pipework. Complete with 100mm pocket and cable gland.
2	LOADV1	4	Boiler Loading Valve	
3	BOILER250GAS	4	250kW Boiler (gas)	
4	BUFFER2000H	1	Buffer Store, 2000 litres	2000 litres, with DN80 flanged inlet/outlet connections. Sparge pipe fitted on cold inlet. See seperate schedule of boss positions.
5	NTC10KDEEP	9	NTC Storage Temperature Sensor	NTC10K Thermistor Sensor for insertion mounting into storage. Complete with 250mm pocket and cable gland.
6	ASHPTSDEEP	11	ASHP Storage Temperature Sensor	Heat pump temperature sensor for insertion mounting into storage. Complete with 250mm pocket and cable gland.
7	PS10	2	Pressure sensor, 0-10 bar.	Pressure sensor, 0-10 bar, 0-10v. Complete with cable gland.
8	EXPVESS	2	Expansion Vessel. litres	
9	PRESSSET1	1	Pressurisation Set	
10	HM-DN80	1	Heat Meter DN80 with M-Bus	

Topology

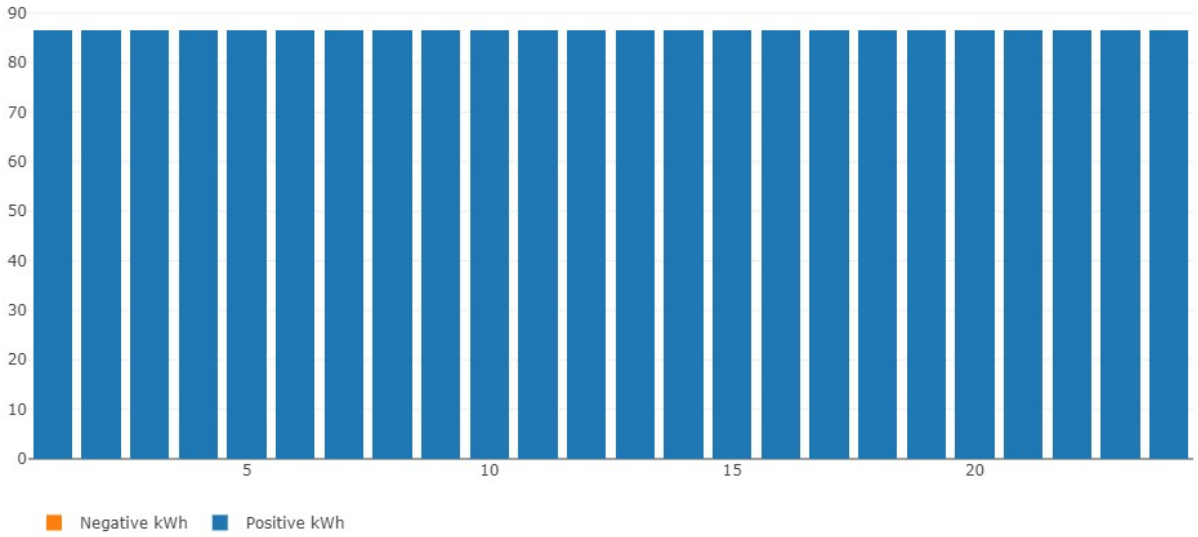

6 x 30kW
ASHP
ASHP
ASHP
ASHP
ASHP
ASHP
PHEx
4 x 250kW
Boiler
Boiler
Boiler
Boiler
Buffer
21.544m3/h
931.1kW
DHW: 509kW
CH: 422.1kW
2000 litres
VWART: 34.262C
x1
x149
x444

DHW Loads

The following graph shown the energy used for domestic hot water, for each hour of the day. This is the standard profile for domestic properties from the EST.

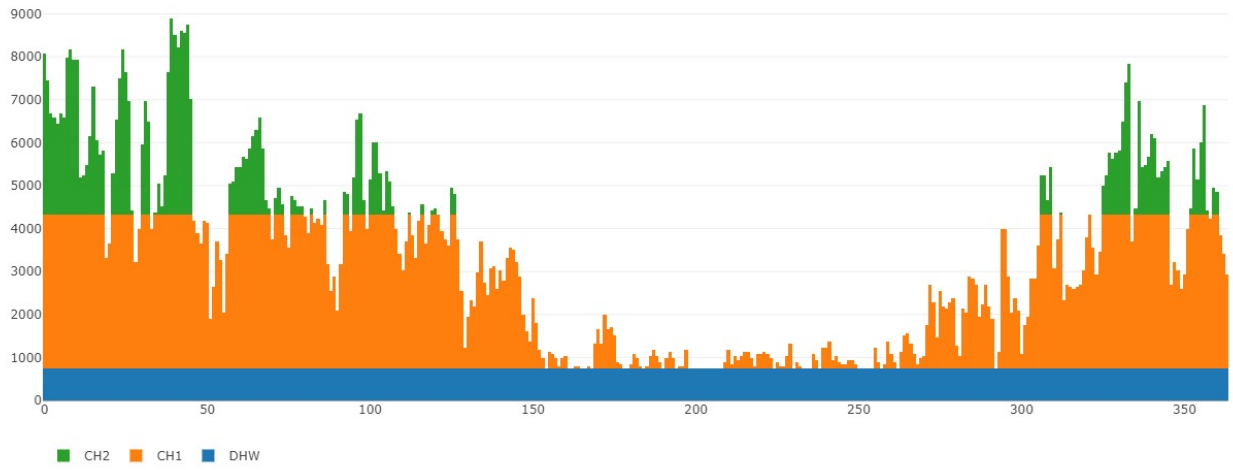


The following chart shows the energy stored in the buffer at the end of each hour, starting with an empty buffer. The storage must remain positive throughout the day.



Historical Modelling

The following chart shows the estimated loads for 2020 using historical degree day data.



The following chart shows the estimated loads for 2021 using historical degree day data.