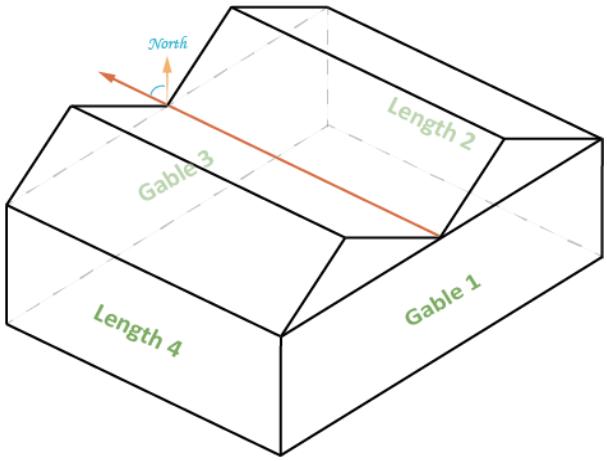
Hortinergy

Energy and climate analysis for greenhouse project

Project name : **Semi closed greenhouse in S** Date: 11/01/2021

Scenario :	Referance
Site:	
Latitude [°] =	43.75
Longitude [°] =	4.45
Altitude [m] =	30

Version: 2.1



A. Project parameters

1. Greenhouse design

Length (m)	100
Span – chapel width (m)	4
Width (m)	100
Area (m²)	10 000
Roof height (m)	7.8
Gutter height (m)	7
Greenhouse type	saw tooth

	Roof	Gable 1	Length 2	Gable 3	Length 4
Cover	4mm clear glass	4mm clear glass	4mm clear glass	4mm clear glass	4mm clear glass
Frame percentage	10	10	10	10	10
Screen number	2	1	1	1	1
Screen 1 type	Black out	Black out	Black out	Black out	Black out
Shade %	99	99	99	99	99
Energy saving %	65	70	70	70	70
Screen 2 type	Thermal	-	-	-	-
Shade %	13	-	-	-	-
Energy saving %	47	-	-	-	-
Screen 3 type	-				
Shade %	-				
Energy saving %	-				

2. Crop production

Type of crop	Tomato
Cultivation starting date	2020-12-05
End of cultivation	2021-11-15
Seedling age	4 weeks at transplantation

3. Climate management

a. Period and temperature setting

	Temperature setting (°C)		
	day	**pre-night**	**post-night**
Period 1			
2020-12-05 2021-11-15	20	16	18
Periode 2			
- -	-	-	-
Period 3			
- -	-	-	-
Period 4			
- -	-	-	-
Period 5			
- -	-	-	-
Period 6			
- -	-	-	-

b. Morning revival

Morning revival	No
Solar radiation	0 W/m²
Temperature increase	0 °C/h

c. Humidity set

Humidity regulation:	Water deficit (vapour pressure deficit)

Period	Unit	Min	Max
Day	g water / kg dry air	2	8
Night	g water / kg dry air	2	8

d. Day / Night switch - screen regulation

Screen use

	Roof	Gable 1	Length 2	Gable 3	Length 4
Screen number	2	1	1	1	1
Screen 1 type	Black out	Black out	Black out	Black out	Black out
Regulation	Black out				
Screen 2 type	Thermal	-	-	-	-
Regulation	Thermal				
Screen 3 type	-				
Regulation	-				

d1. Day / Night switch - thermal screen regulation

Regulation type	Solar radiation
Minimum solar radiation	100 W/m²
Min Delta temperature in/out	-

d2. Shade screen regulation

Regulation type	Solar radiation
Minimum solar radiation	0 W/m²
Shade screen as thermal	0

d3. Black out regulation

Beginning	End	Hours/day Solar Radiation
2021-12-05	2022-11-05	8
Black out as thermal	no	

5. Cooling, humidification and semi-closed systems

Semi-closed greenhouse:	Yes
Nb air tubes par chapel:	3
Air recirculat. rate (m^3/m^2 h)	12

Air flow

Air flow max rate (m^3/m^2 h):	70

Fan specification

Max air flow /fan (m^3/h fan)	10000

Electricity consumtion per fan according to air flow percentage (Watt)	
100%	1000
75%	600
50%	400
25%	250

Humidification and cooling:	Pad
Max evoporating capacity (m3/h):	15
Pad thickness (mm)	200
Pad height (cm)	200
Pad lengh (% of gable)	95
Flush (%)	50
Temperature of water (°C)	0
Distance between pad and fan (m)	-

Temperature sets and regulation	
Cooling temperature (°C):	28
Vent opening temp. (°C):	32
Priority:	Humidification

Electricty cost (€/MWh)	100

6. Closed greenhouse

Closed greenhouse	no

	day	night
Cooling temperature (°C)	-	-

7. Assimilation Light

Assimilation Light impl.	Yes
Type of Light	LED
Light management	DLI

	LED	HPS
Input power (µmol/ s m²)	300	-
Efficiency (µmol/J)	2.50	-

		Hours of lighting		
	Total DLI (Mol/Day/m²)	Hour light switch on	Hour light switch off	Outside light level above light switch off (W/m²)
Jan	20	-	-	-
Feb	20	-	-	-
Mar	20	-	-	-
Apr	20	-	-	-
May	20	-	-	-
Jun	20	-	-	-
Jul	20	-	-	-
Aug	20	-	-	-
Sep	20	-	-	-
Oct	20	-	-	-
Nov	20	-	-	-
Dec	20	-	-	-

8. Heat production

Dimensionning User defined (advanced parameters)

Heating	Main	Auxiliary
Energy source	CHP - recovery heat	Gas
Unit price (€/MWh)	10	50
Maximum power	500	3 000
Condensor	Yes	No
Max yield (%)	100	95

Main energy period	Start	End
Date	2020-12-05	2021-11-15

Distribution yield (%)	95

Buffer tank	Yes (advanced parameters)
Volume (m^3)	300
Height (m)	10
Insulation (cm)	20
Temperature differance	40 (°C) between heat production and emission

Electricty cost (€/MWh)	100

9. Outdoor climate

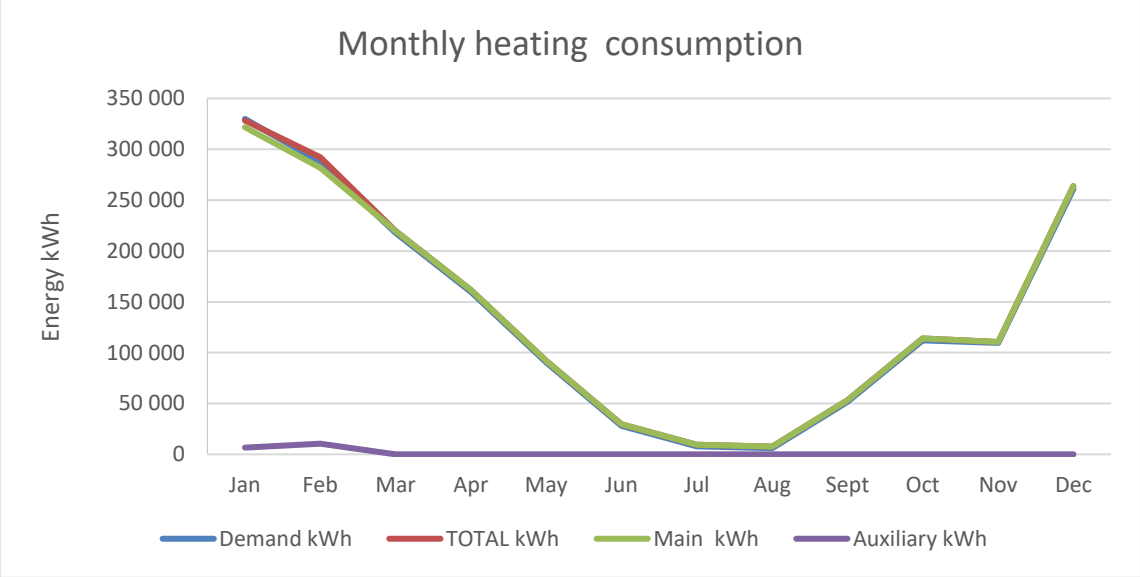
Month	Average outdoor temperature (°C)	Mimimum outdoor temperature (°C)	Maximum outdoor temperature (°C)	External average relative humidity (%)	External average global solar radiation (kWh/ m² day)
Januray	6.9	-2.6	17.0	70	1.61
February	7.4	-2.0	16.9	65	2.47
March	10.8	1.3	22.9	62	3.90
April	13.7	5.2	25.7	63	5.07
May	17.7	8.2	29.7	62	6.20
June	22.2	11.8	33.7	57	7.00
July	25.1	15.3	35.2	51	7.00
August	24.5	14.9	35.9	54	6.04
September	19.8	10.9	30.5	62	4.58
October	15.9	6.8	26.1	71	2.86
November	10.4	1.7	21.7	75	1.71
December	7.5	-1.9	18.0	72	1.37
Average/ Min /Max	15.2	-2.6	35.9	64	4.16

B. Energy consumption

1. Annual heating cost and energy consumption

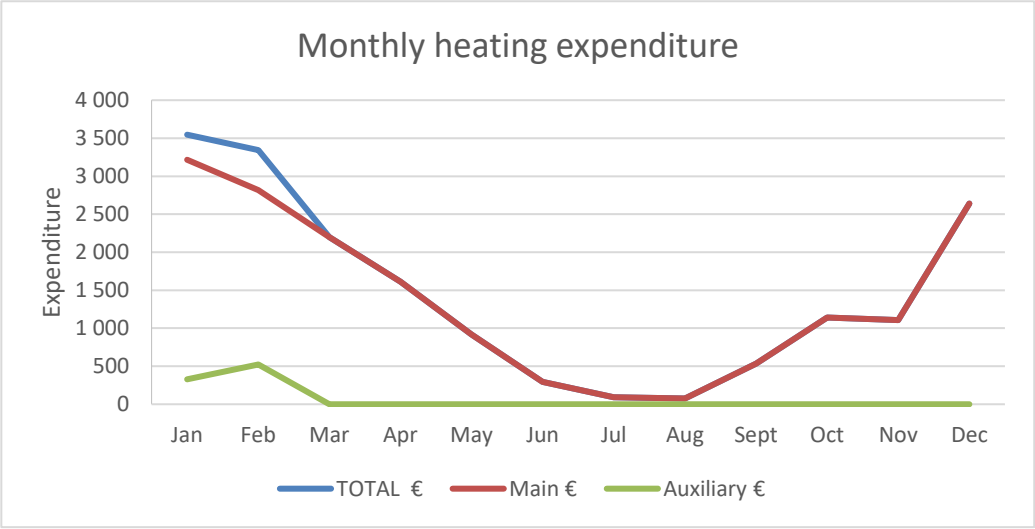
	Total	Main	Auxiliary
Energy source		CHP - recovery heat	Gas
Unit price (€/MWh)		10	50
Expenditure (€)	17 505	16 652	853
€ /m²	1.8	1.7	0.1
Main vs Auxiliary (cost %)		95%	5%
Consumption MWh	1 682	1 665	17
Consumpt. / unit (kWh/m²)	168	167	2
Main vs Auxiliary (energy %)		99%	1%

2. Monthly heating consumption



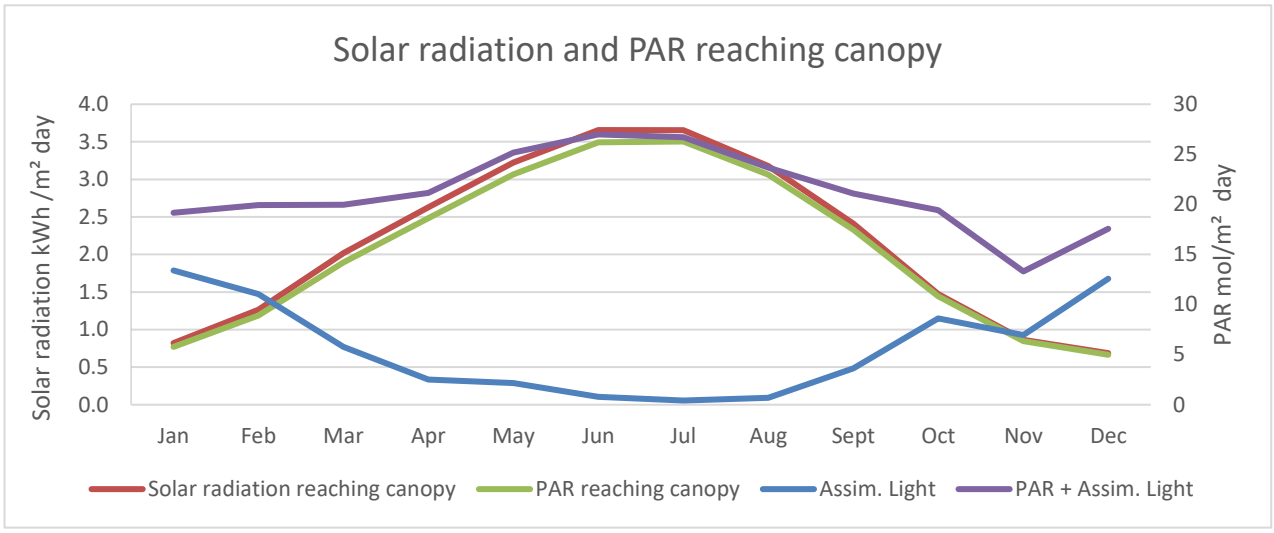
	Demand kWh	TOTAL kWh	Main kWh	Auxiliary kWh
Jan	329 878	328 224	321 622	6 602
Feb	287 361	292 289	281 826	10 463
Mar	217 970	219 873	219 873	0
Apr	159 673	161 463	161 463	0
May	90 220	91 966	91 966	0
Jun	28 000	29 570	29 570	0
Jul	7 887	9 429	9 429	0
Aug	6 042	7 606	7 606	0
Sept	51 684	53 326	53 326	0
Oct	112 129	113 932	113 932	0
Nov	109 690	110 590	110 590	0
Dec	261 008	263 873	263 873	0
Total	**1 661 543**	**1 682 141**	**1 665 076**	**17 065**

3. Monthly heating expenditure



	TOTAL €	Main €	Auxiliary €
Jan	3 546	3 216	330
Feb	3 341	2 818	523
Mar	2 199	2 199	0
Apr	1 615	1 615	0
May	920	920	0
Jun	296	296	0
Jul	94	94	0
Aug	76	76	0
Sept	533	533	0
Oct	1 139	1 139	0
Nov	1 106	1 106	0
Dec	2 640	2 640	0
Total	**17 505**	**16 652**	**853**

4. Solar radiation and PAR reaching canopy



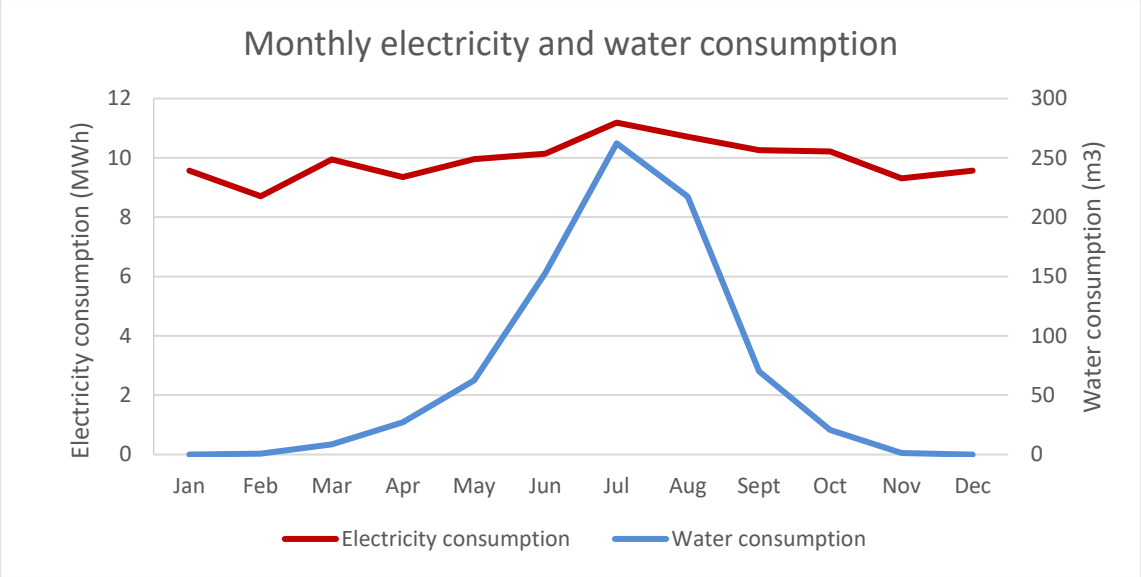
	External	Internal reaching canopy			
	Solar radiation	Solar radiation	PAR	Assim. Light	PAR + Assim. Light
	kWh/ m² day	kWh/ m² day	mol/m² day	mol/m² day	mol/m² day
Jan	1.61	0.82	5.77	13.40	19.17
Feb	2.47	1.27	8.90	11.05	19.94
Mar	3.90	2.02	14.20	5.77	19.98
Apr	5.07	2.63	18.63	2.51	21.14
May	6.20	3.22	23.00	2.17	25.18
Jun	7.00	3.66	26.21	0.80	26.99
Jul	7.00	3.65	26.28	0.42	26.70
Aug	6.04	3.18	22.98	0.70	23.68
Sept	4.58	2.41	17.46	3.63	21.10
Oct	2.86	1.47	10.81	8.62	19.43
Nov	1.71	0.86	6.35	6.96	13.31
Dec	1.37	0.69	4.99	12.57	17.56
Average	**4.15**	**2.16**	**15.46**	**5.72**	**21.18**

5. Pad & wall, fog and cooling systems

5.1 Pad & wall and semi-closed

Electricity	
Electricity (€/MWh)	100
Energy (MWh)	118.9
kWh/m²	11.9
Expenditure (€)	11 892
€ /m²	1.19

Water	
m^3	824
m^3/m^2	0.08



	Electricity		Water	
	MWh	kWh/m²	m^3	l/m²
Jan	9.6	1.0	0	0.0
Feb	8.7	0.9	1	0.1
Mar	9.9	1.0	9	0.9
Apr	9.4	0.9	27	2.7
May	10.0	1.0	63	6.3
Jun	10.1	1.0	153	15.3
Jul	11.2	1.1	262	26.2
Aug	10.7	1.1	217	21.7
Sept	10.3	1.0	70	7.0
Oct	10.2	1.0	21	2.1
Nov	9.3	0.9	1	0.1
Dec	9.6	1.0	0	0.0
Total	**118.9**	**11.9**	**824**	82.4

Semi-closed greenhouse: estimation for sensible and latent needs - beta version

	Latent dehumidification for heating	Sensible heating	Latent dehumidification for heating	Sensible heating
	kWh	kWh	kWh/m²	kW/m²
Jan	5 014	324 864	1	32
Feb	2 958	284 403	0	28
Mar	4 918	213 051	0	21
Apr	7 180	152 493	1	15
May	8 495	81 725	1	8
Jun	5 621	22 379	1	2
Jul	1 884	6 004	0	1
Aug	1 954	4 088	0	0
Sept	5 852	45 832	1	5
Oct	7 607	104 522	1	10
Nov	8 319	101 371	1	10
Dec	5 323	255 685	1	26
Total	**65 125**	**1 596 418**	**7**	**160**

5.2 Closed greenhouse: estimation for sensible and latent needs

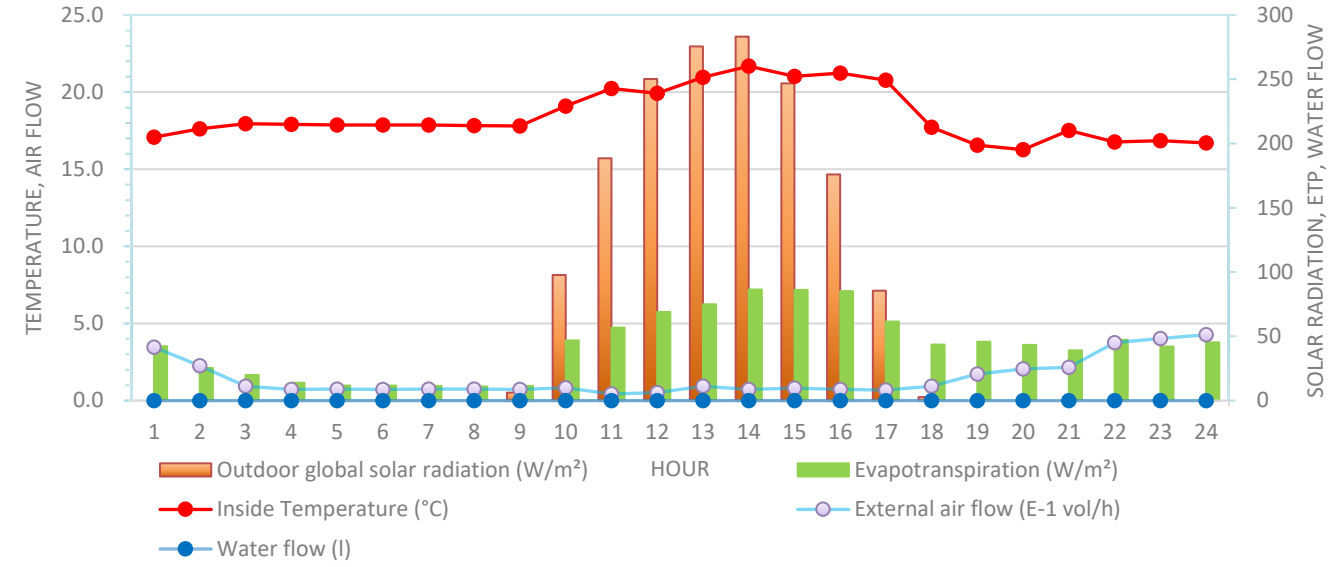
	Cooling needs (sensible)	Cooling needs (Latent)	Cooling needs (Total)	
	MWh	MWh	MWh	kWh/m²
Jan	-	-	-	-
Feb	-	-	-	-
Mar	-	-	-	-
Apr	-	-	-	-
May	-	-	-	-
Jun	-	-	-	-
Jul	-	-	-	-
Aug	-	-	-	-
Sept	-	-	-	-
Oct	-	-	-	-
Nov	-	-	-	-
Dec	-	-	-	-
Total	**-**	**-**	**-**	**-**

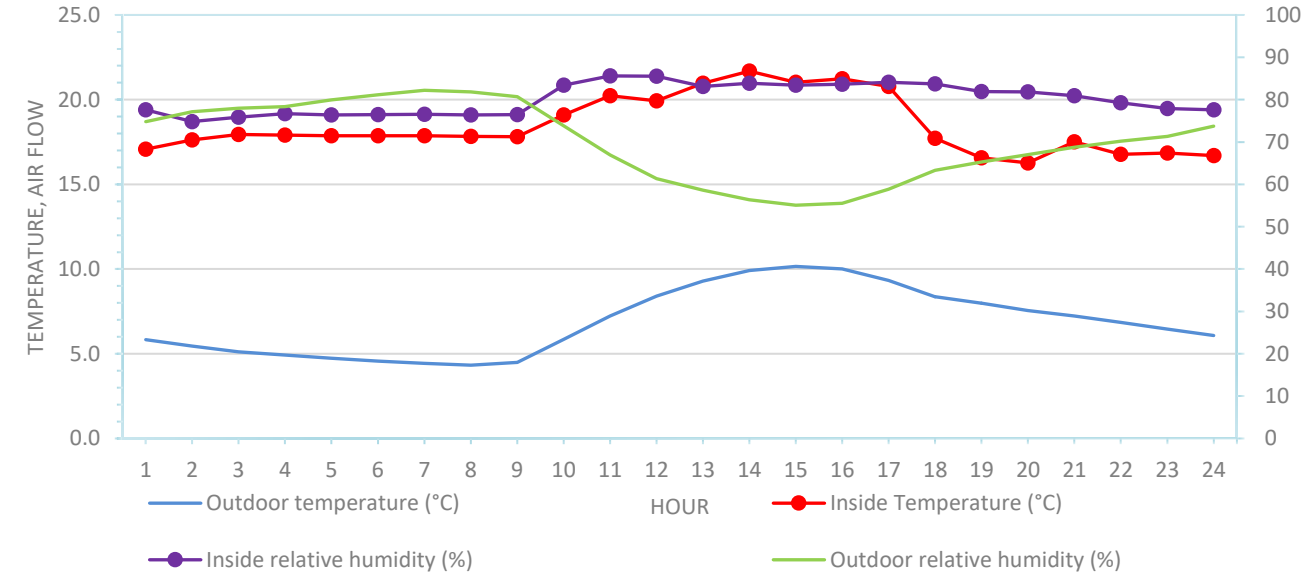
6. Assimilation Light

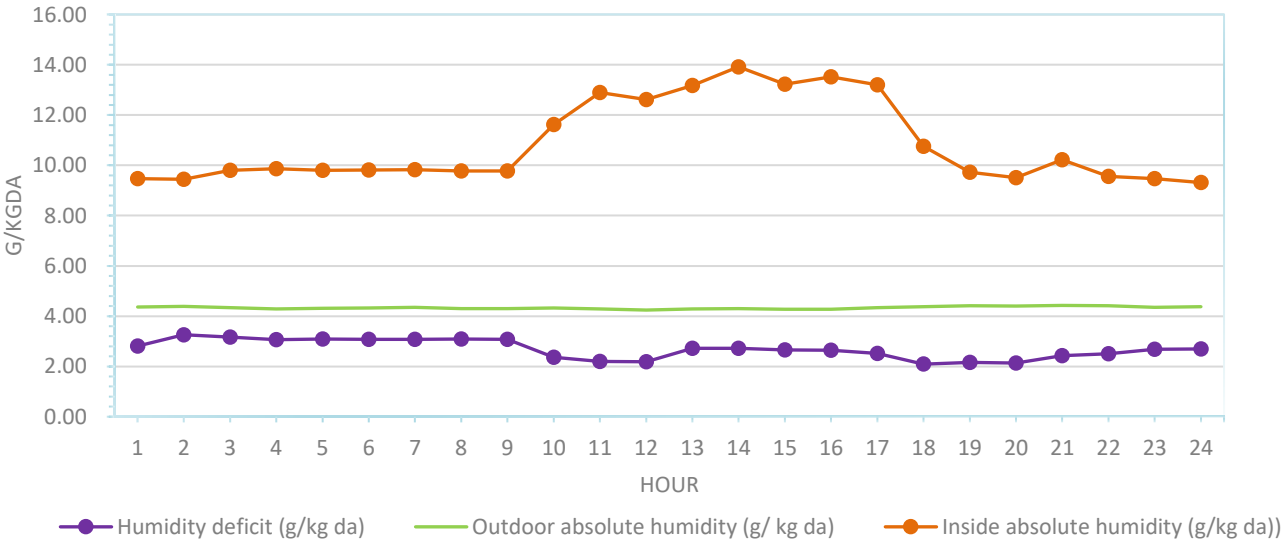
	Electricity consumption		Expenditure	
	MWh	kWh/m²	€	€/m²
Jan	433.2	43.3	43 320.0	4.3
Feb	349.2	34.9	34 920.0	3.5
Mar	265.2	26.5	26 520.0	2.7
Apr	162.0	16.2	16 200.0	1.6
May	70.8	7.1	7 080.0	0.7
Jun	28.8	2.9	2 880.0	0.3
Jul	19.2	1.9	1 920.0	0.2
Aug	31.2	3.1	3 120.0	0.3
Sept	85.2	8.5	8 520.0	0.9
Oct	236.4	23.6	23 640.0	2.4
Nov	331.2	33.1	33 120.0	3.3
Dec	265.2	26.5	26 520.0	2.7
Total	**2 277.6**	**227.8**	**227 760.0**	**22.8**

7. Inner climate

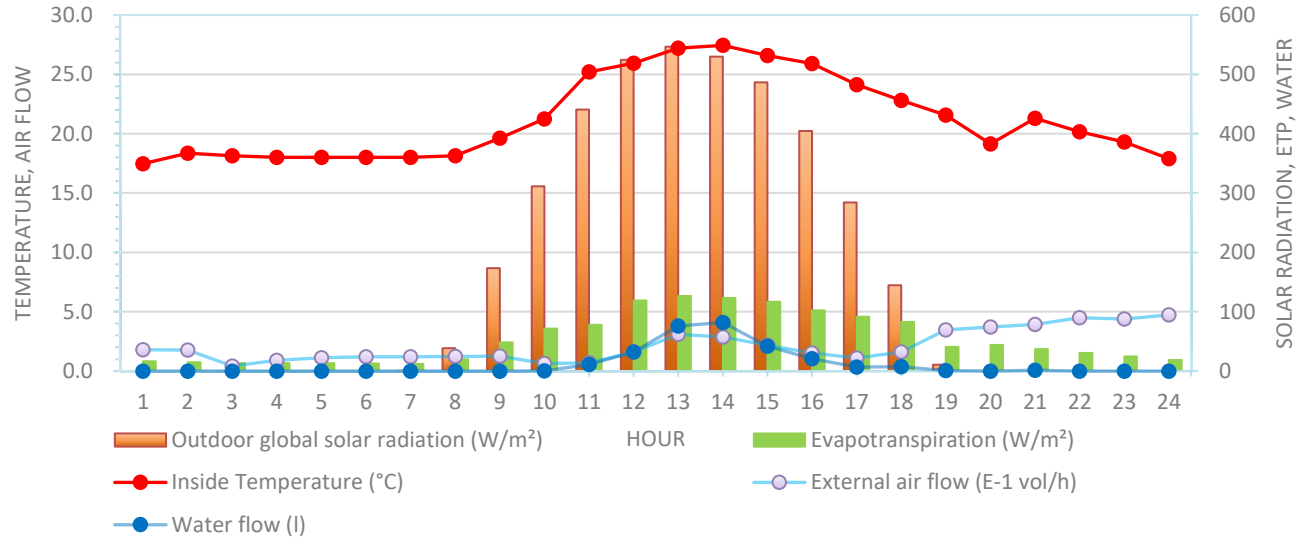
A. Inner climate for an average day in January

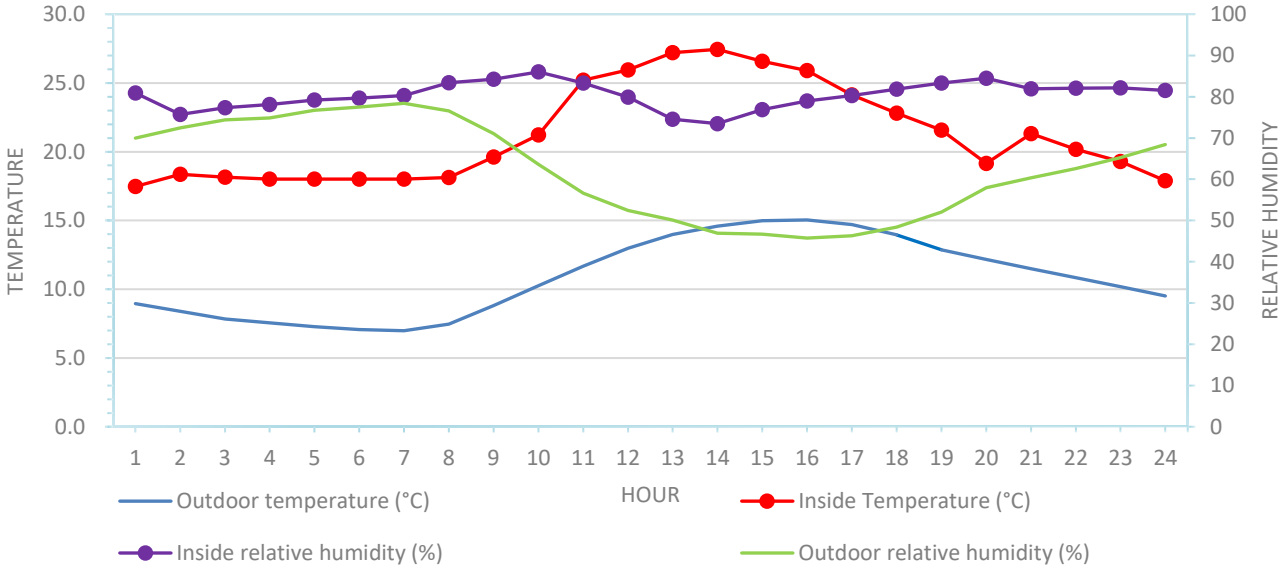


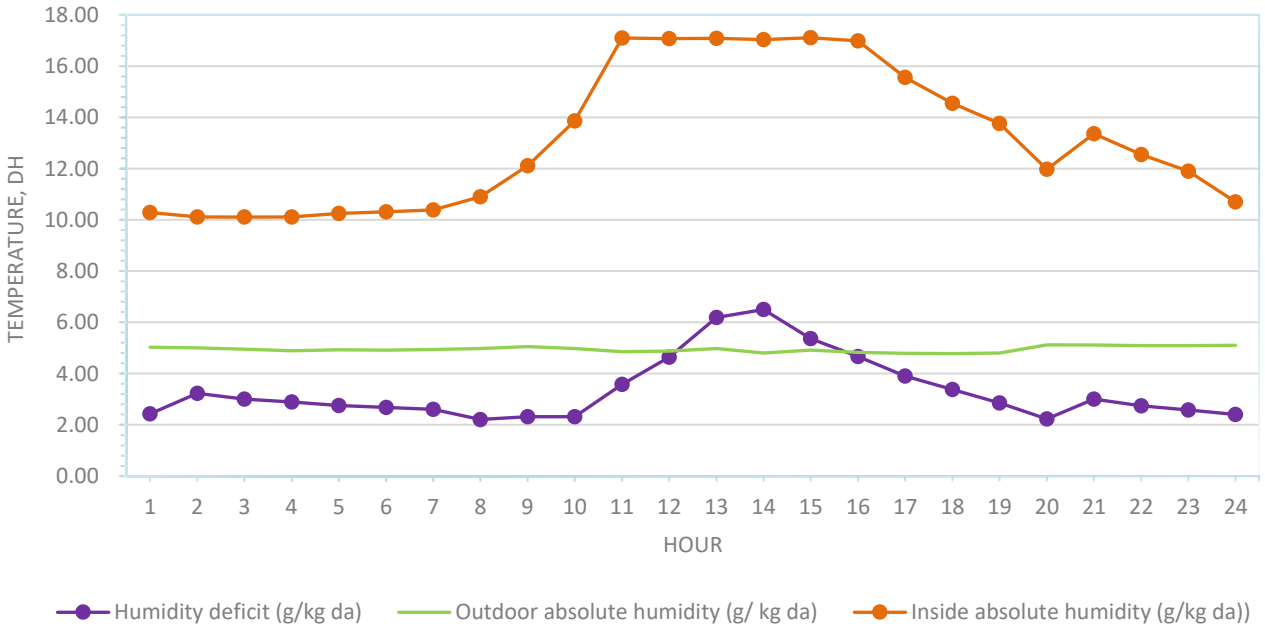




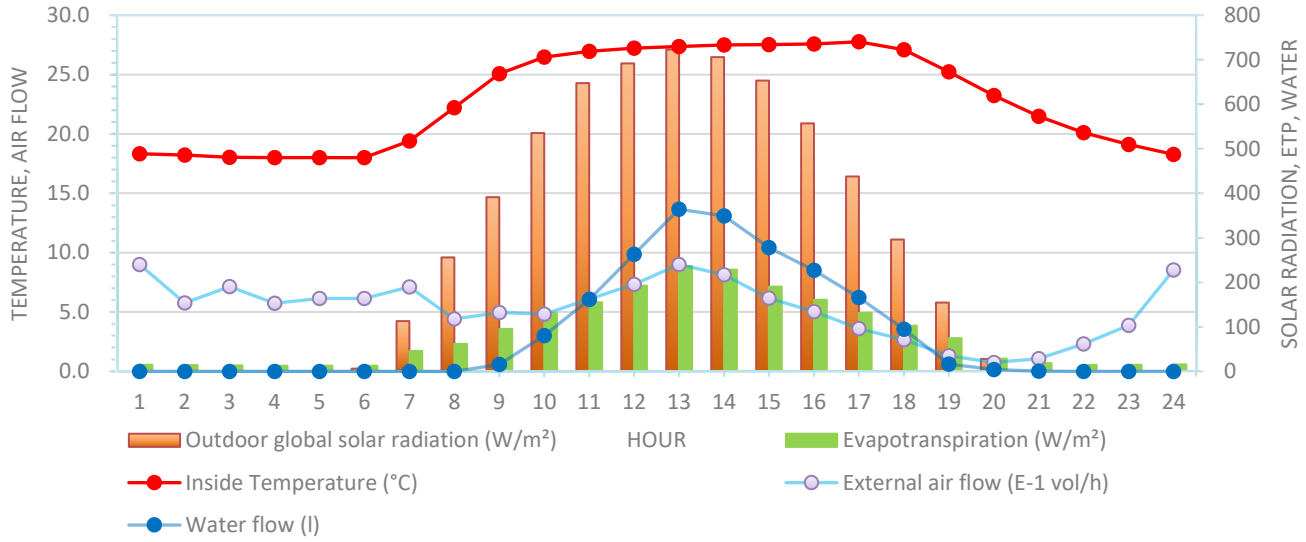
B. Inner climate for an average day in March

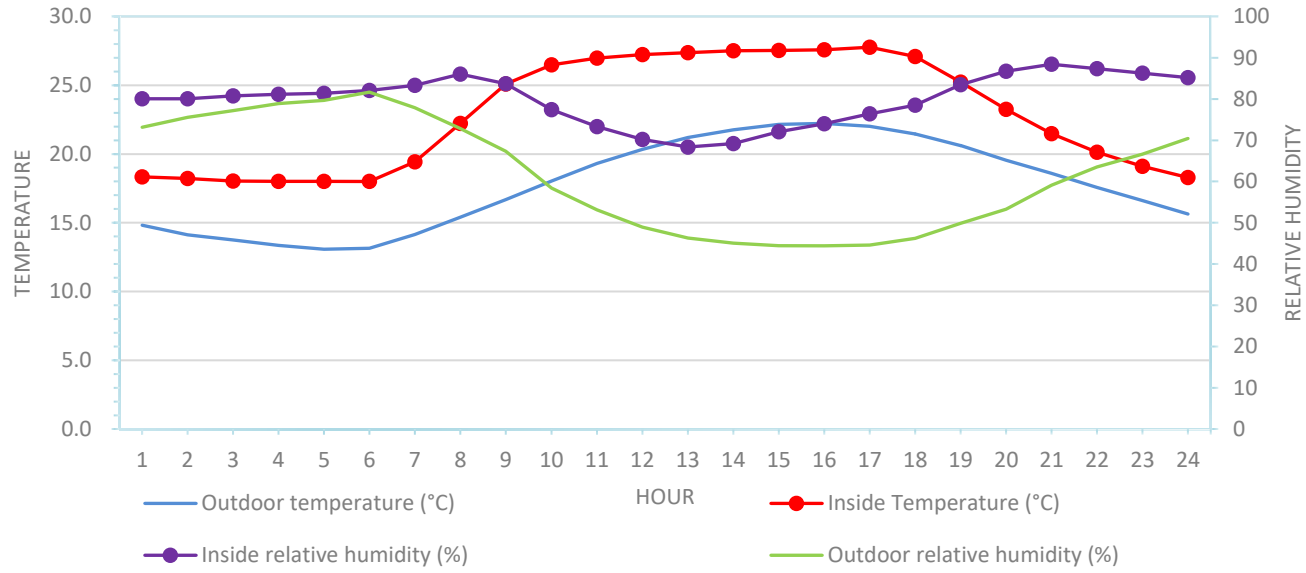


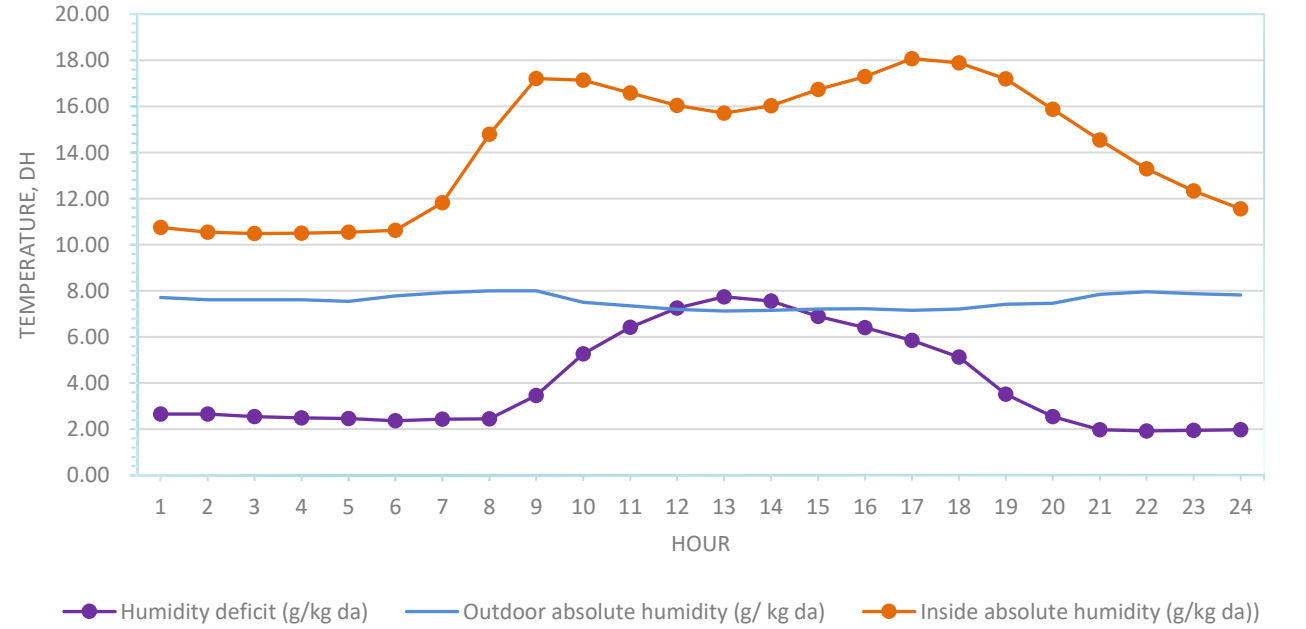




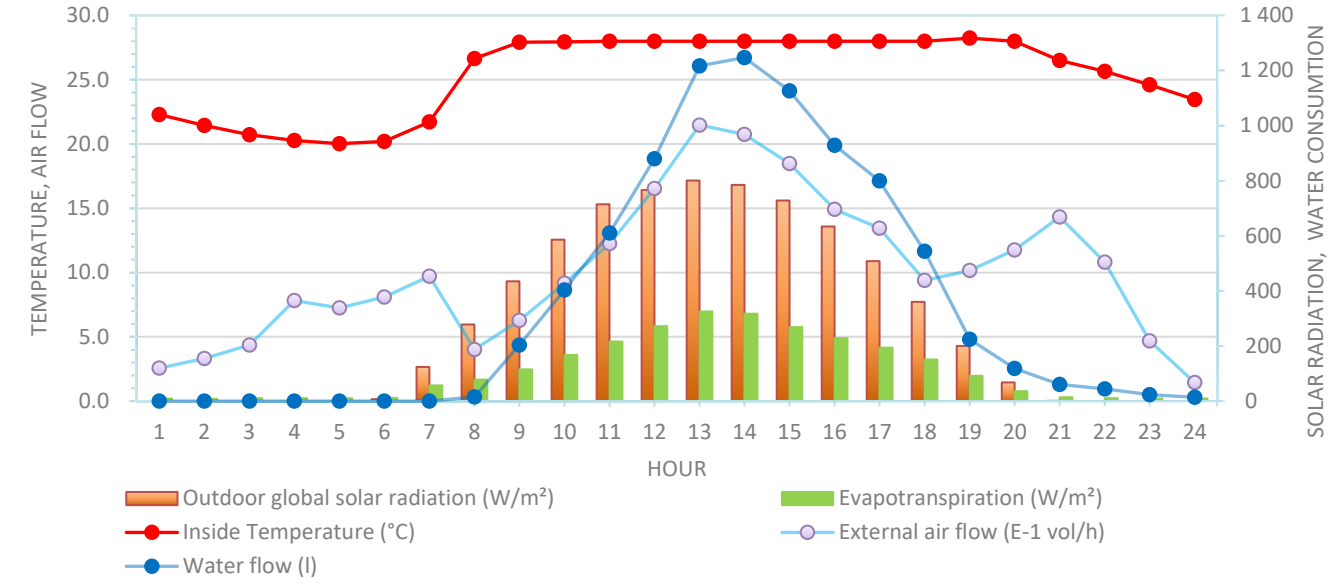
C. Inner climate for an average day in May

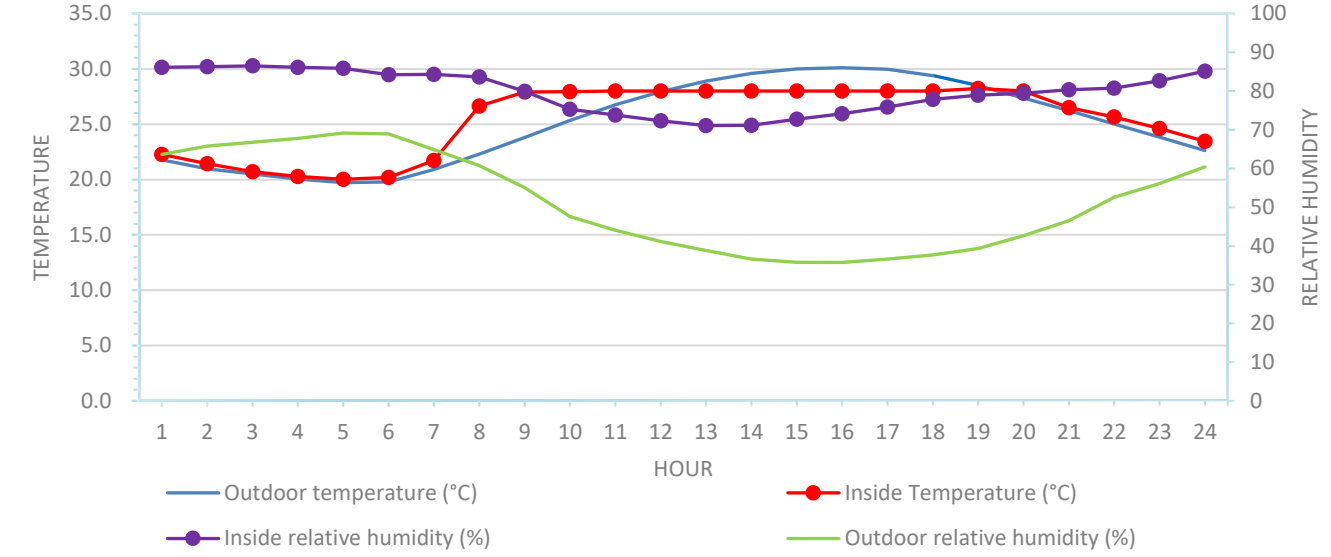


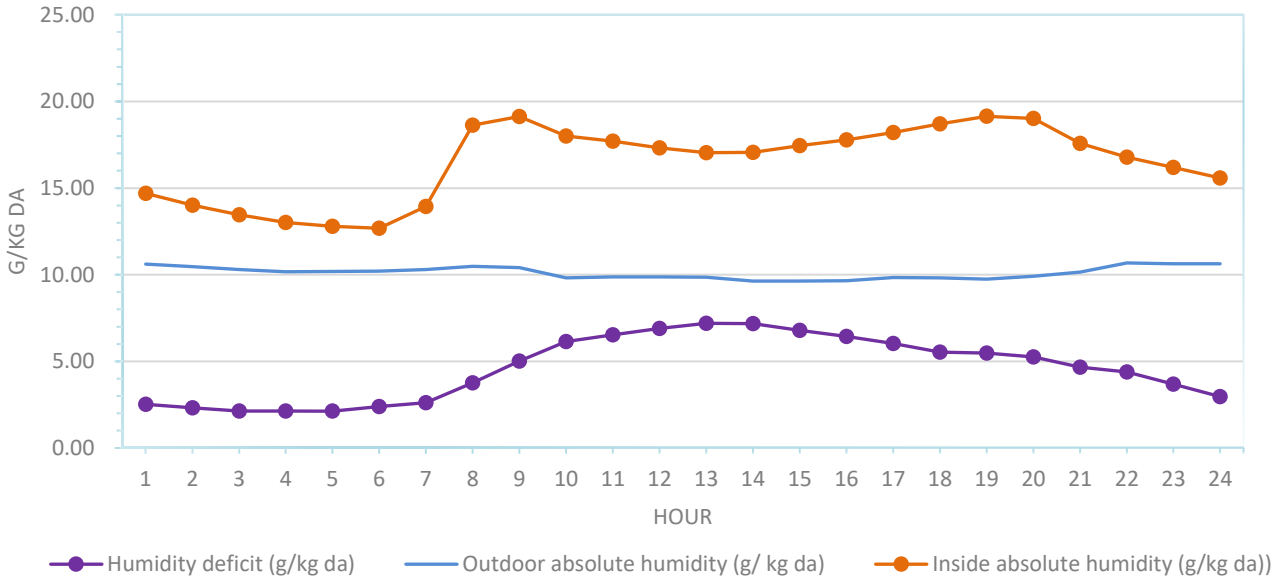




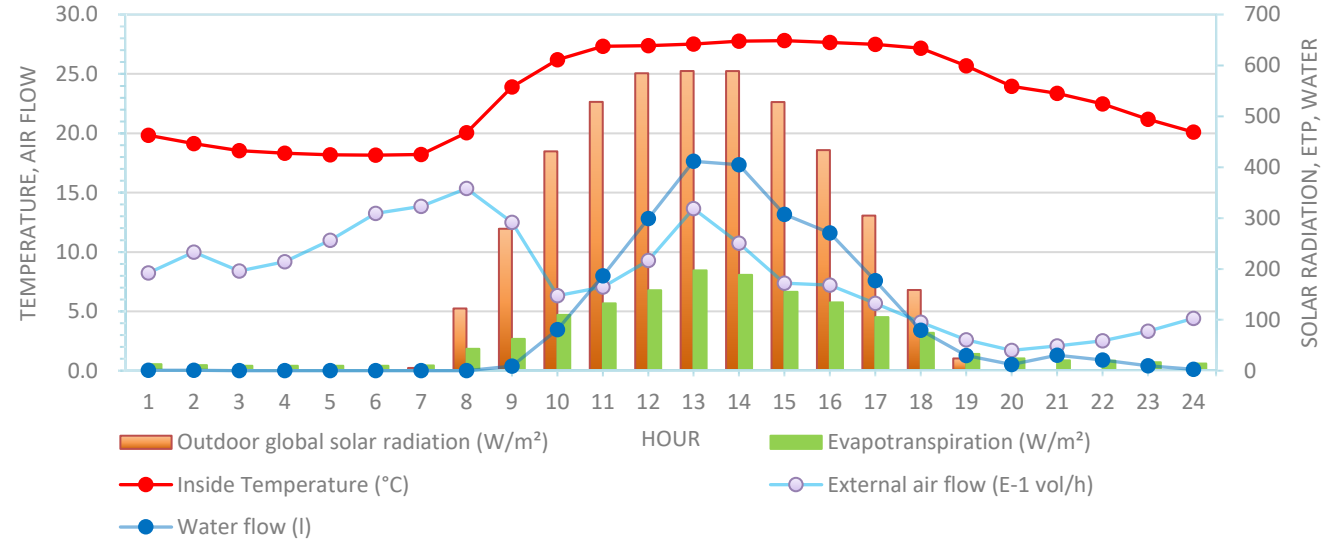
D. Inner climate for an average day in July

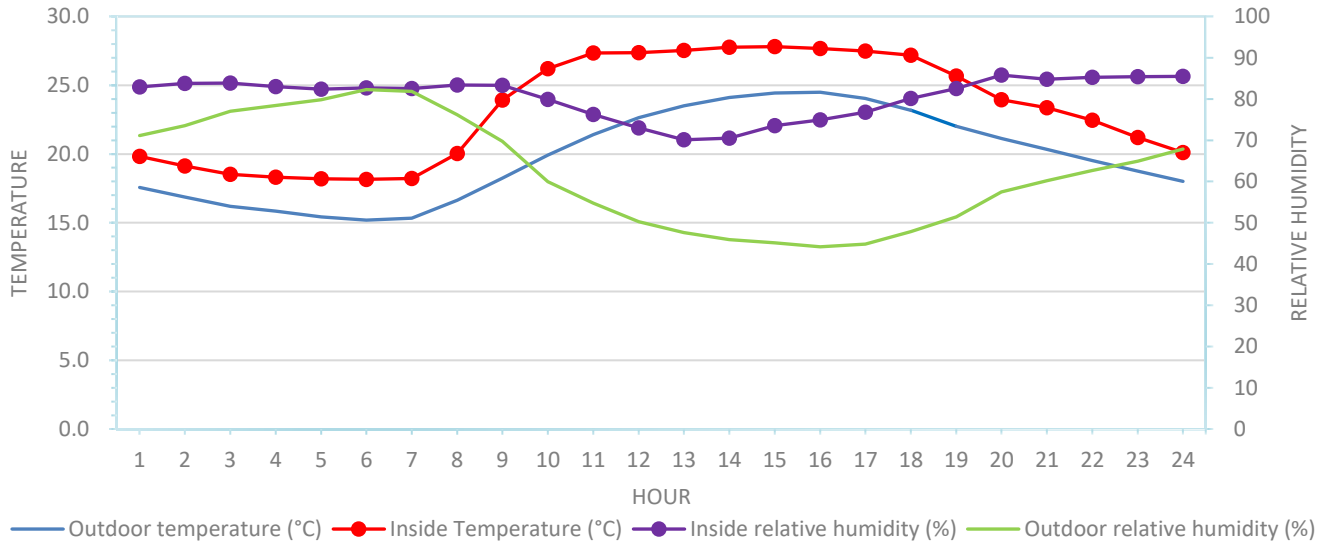


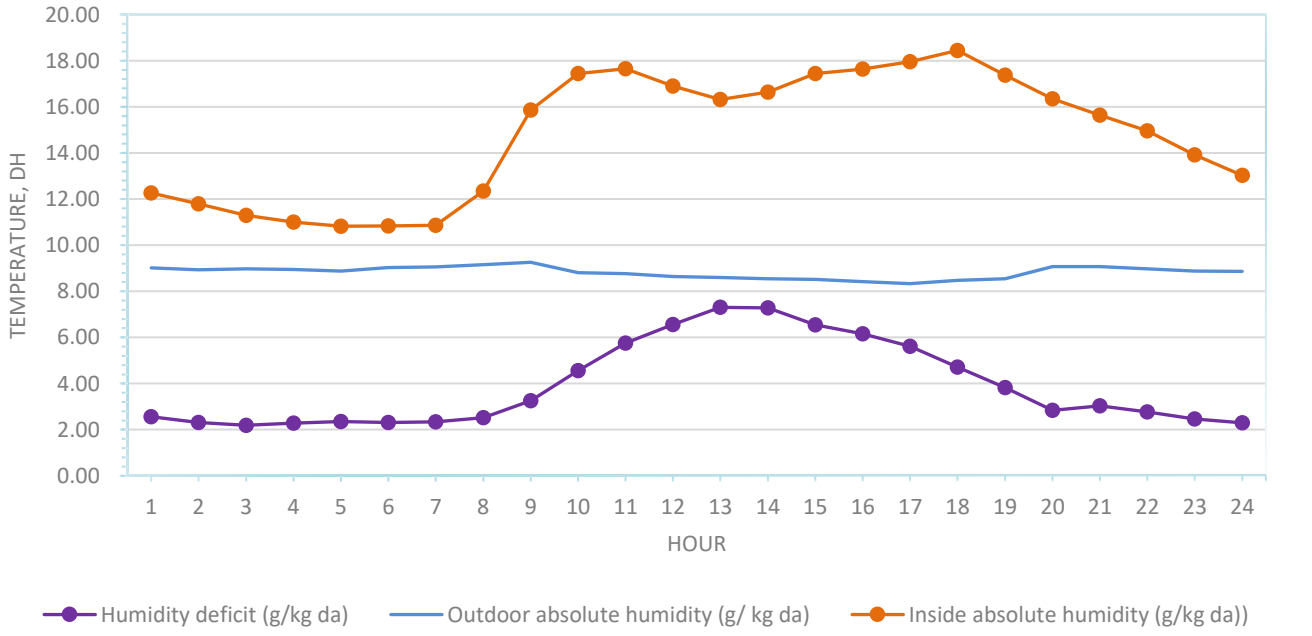




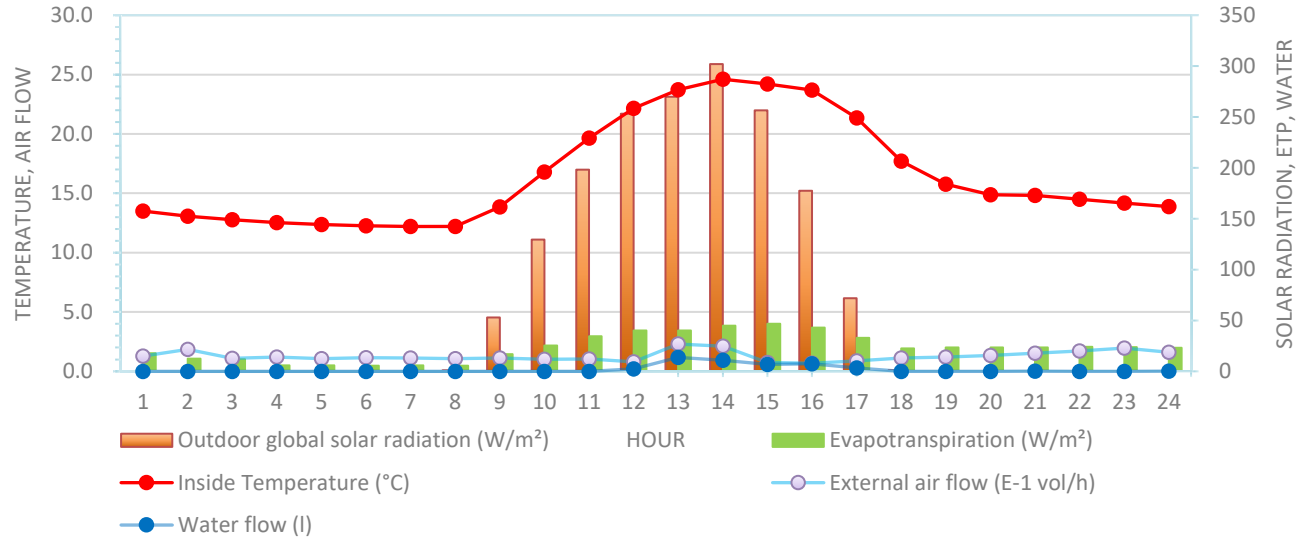
E. Inner climate for a typical day in September

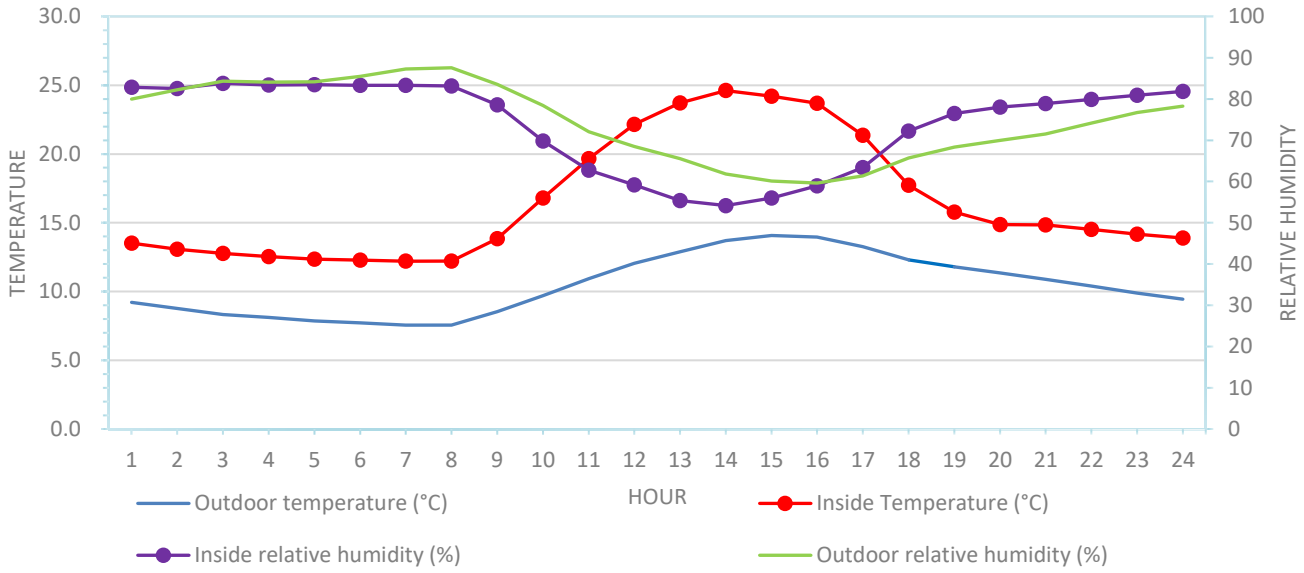


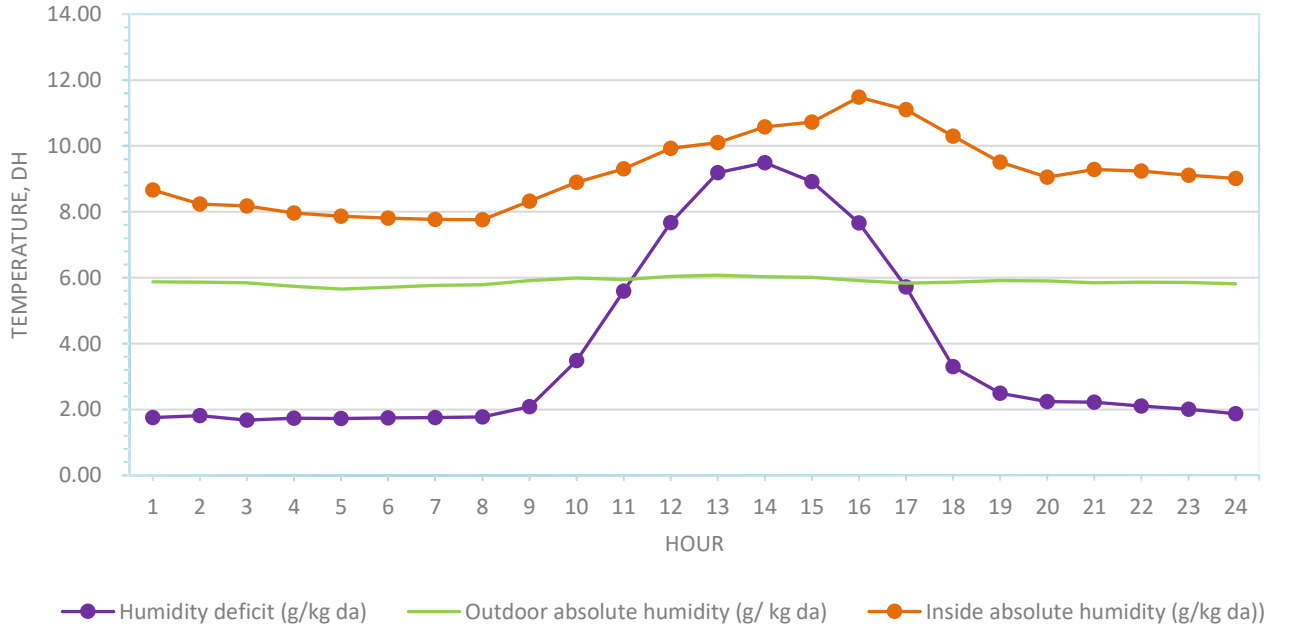




F. Inner climate for an average day in November

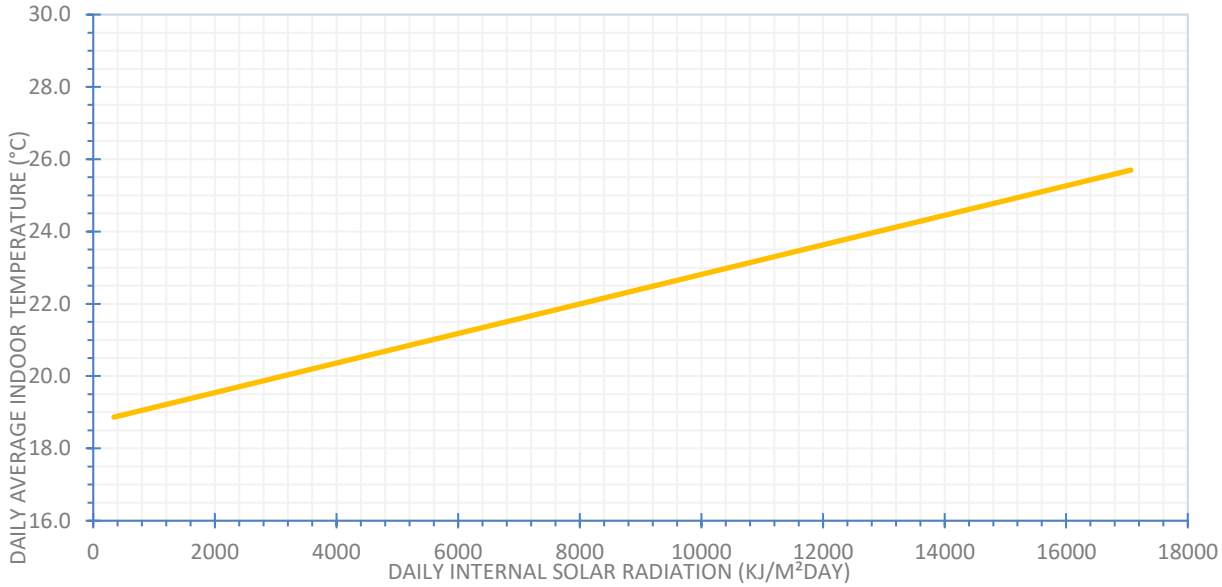




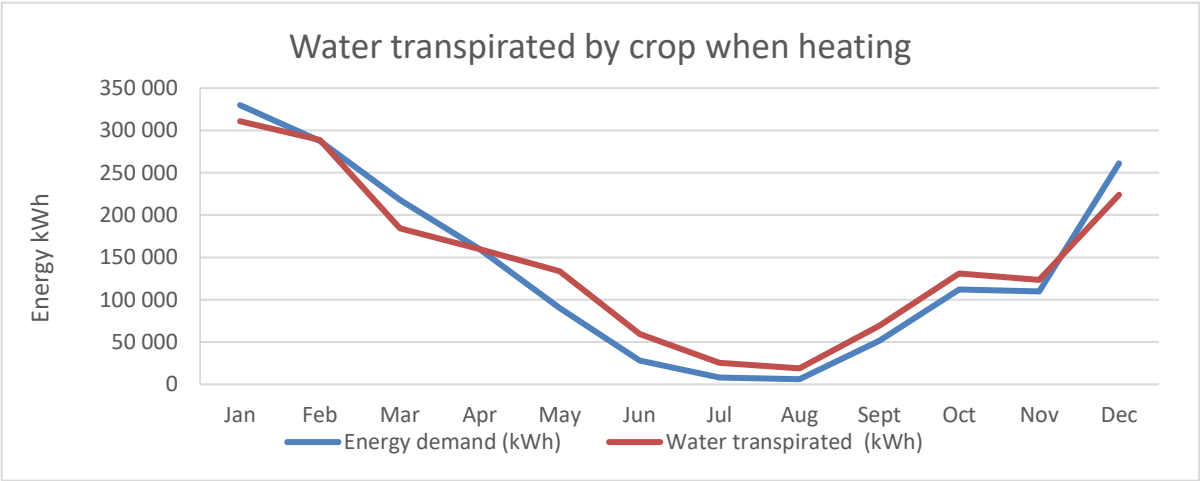


8. Climate control and risks management

Daily correlation between internal solar radiation and average indoor temperature

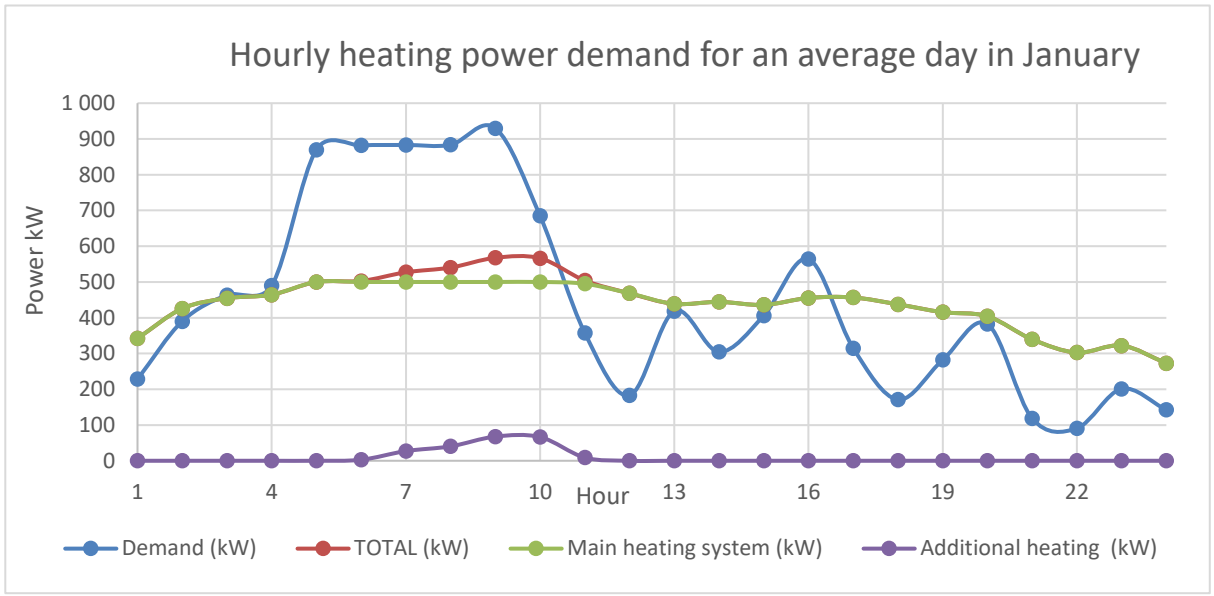


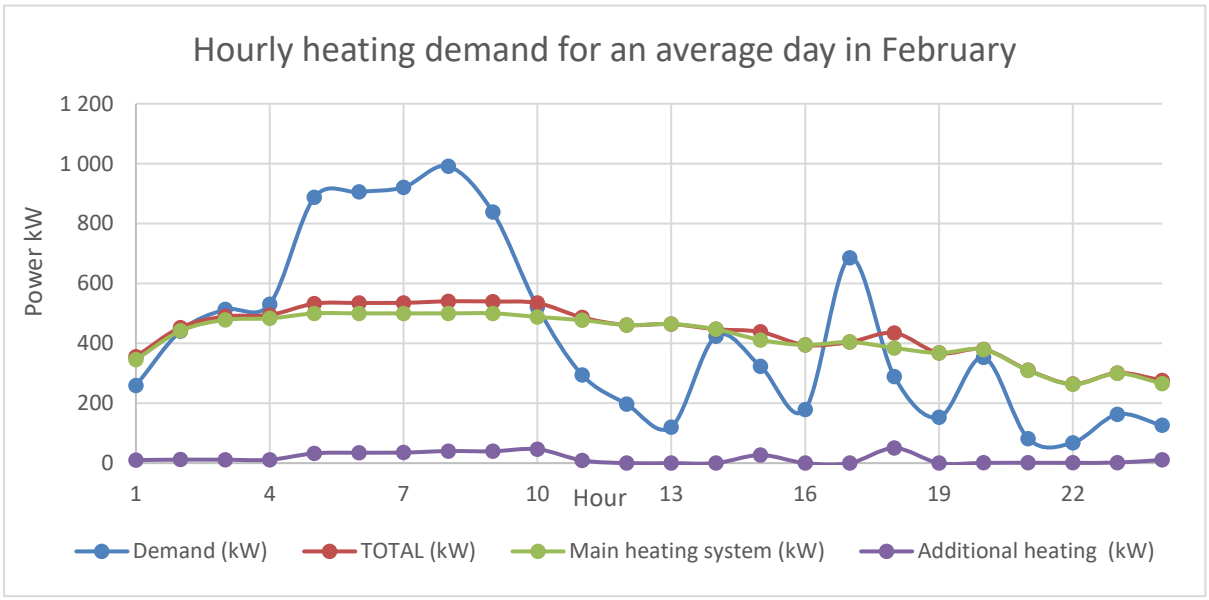
9. Water transpirated by crop when heating

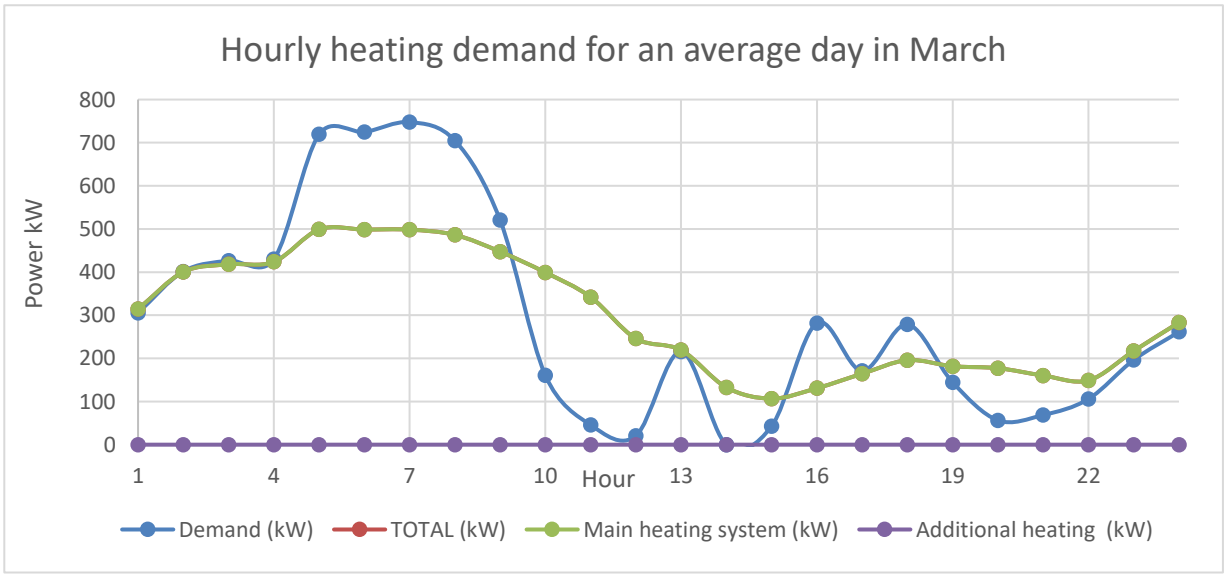


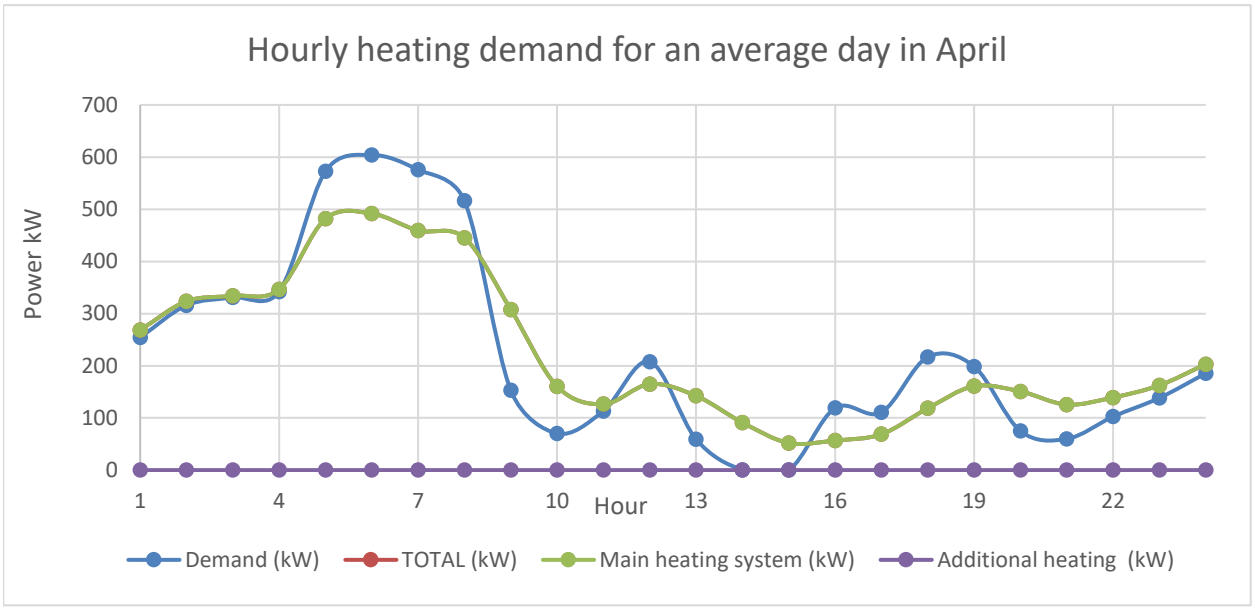
	Demand kWh	Water transpirated	
		kWh	%
Jan	329 878	310 845	94%
Feb	287 361	288 568	100%
Mar	217 970	184 171	84%
Apr	159 673	159 821	100%
May	90 220	133 769	148%
Jun	28 000	59 581	213%
Jul	7 887	25 291	321%
Aug	6 042	18 863	312%
Sept	51 684	69 160	134%
Oct	112 129	130 951	117%
Nov	109 690	123 207	112%
Dec	261 008	223 962	86%
Total	**1 661 543**	**1 728 189**	**104%**

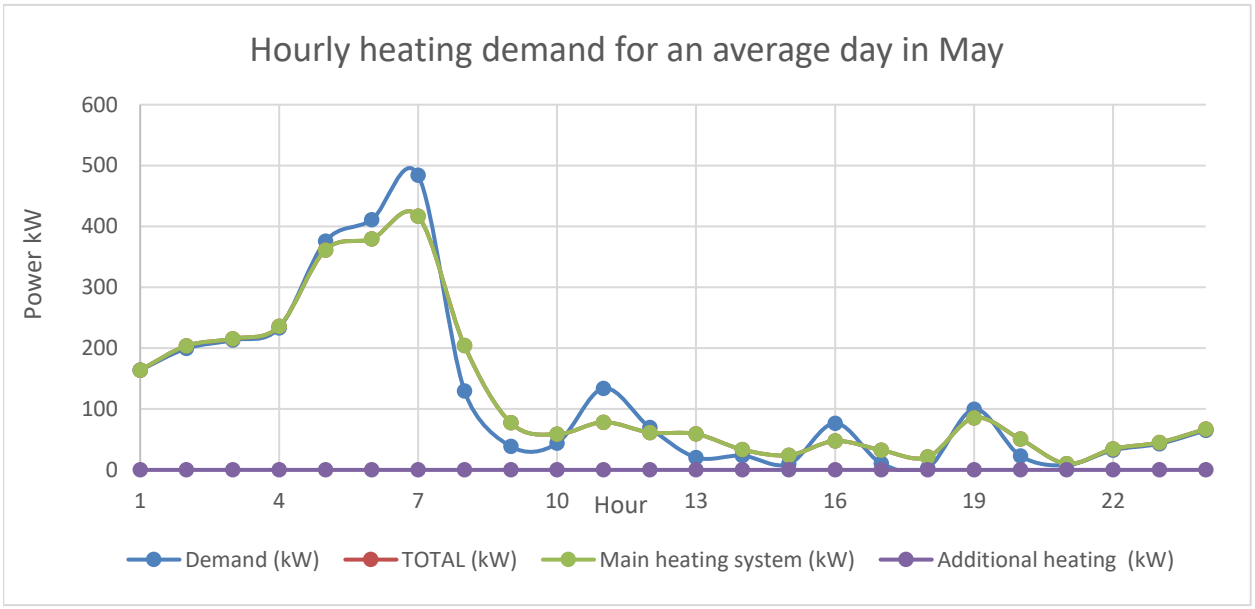
10. Daily energy consumption

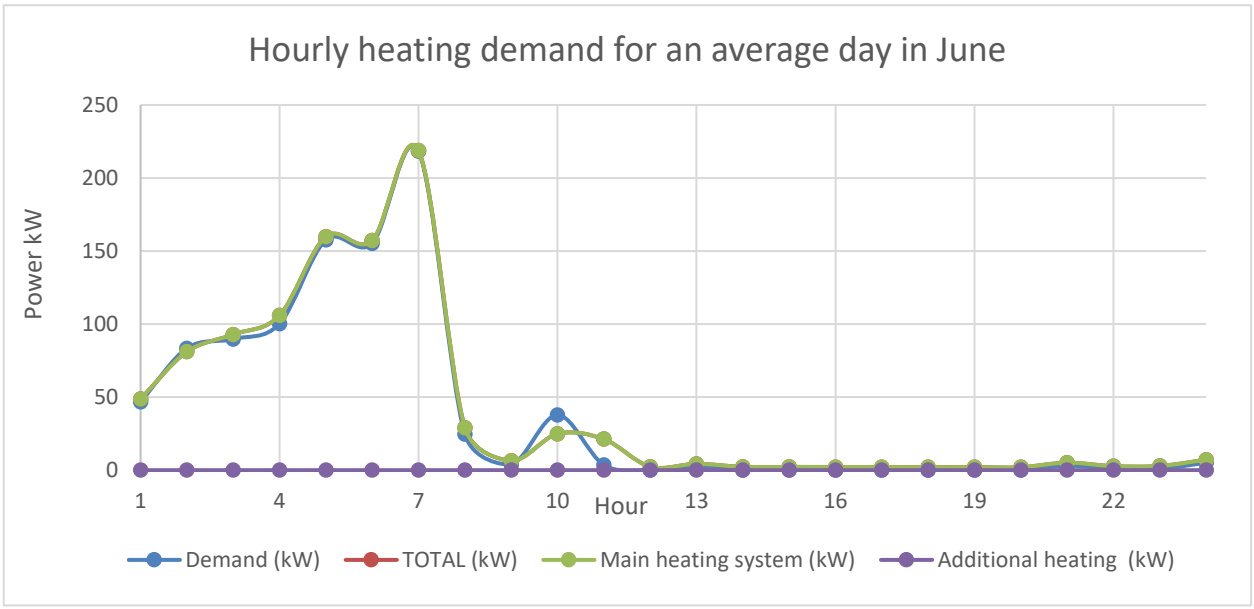


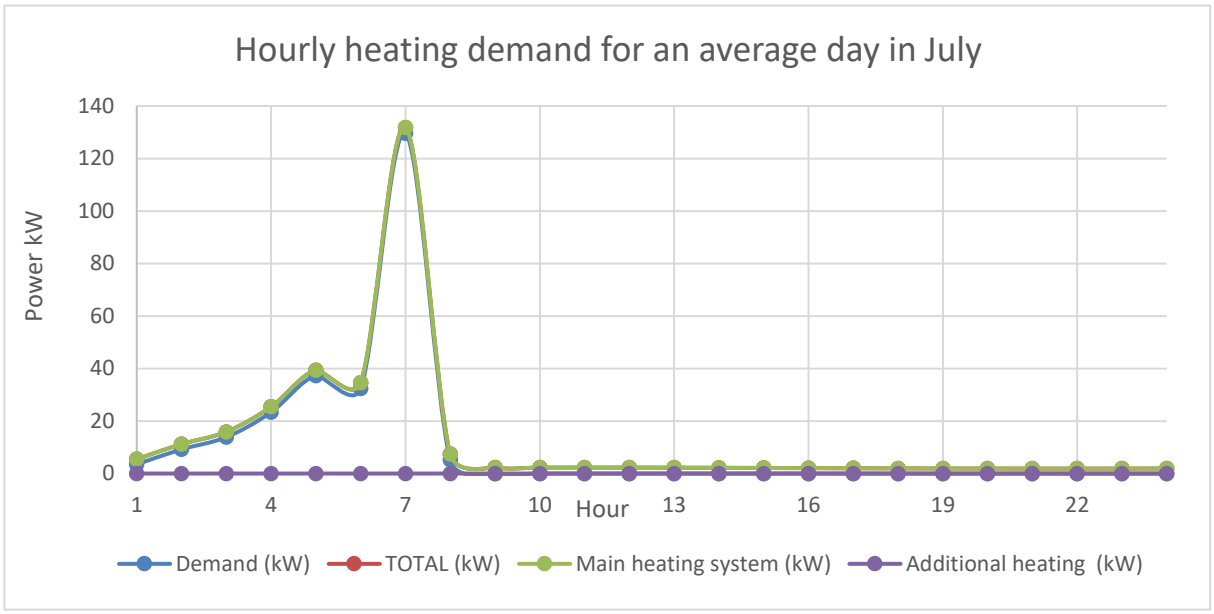


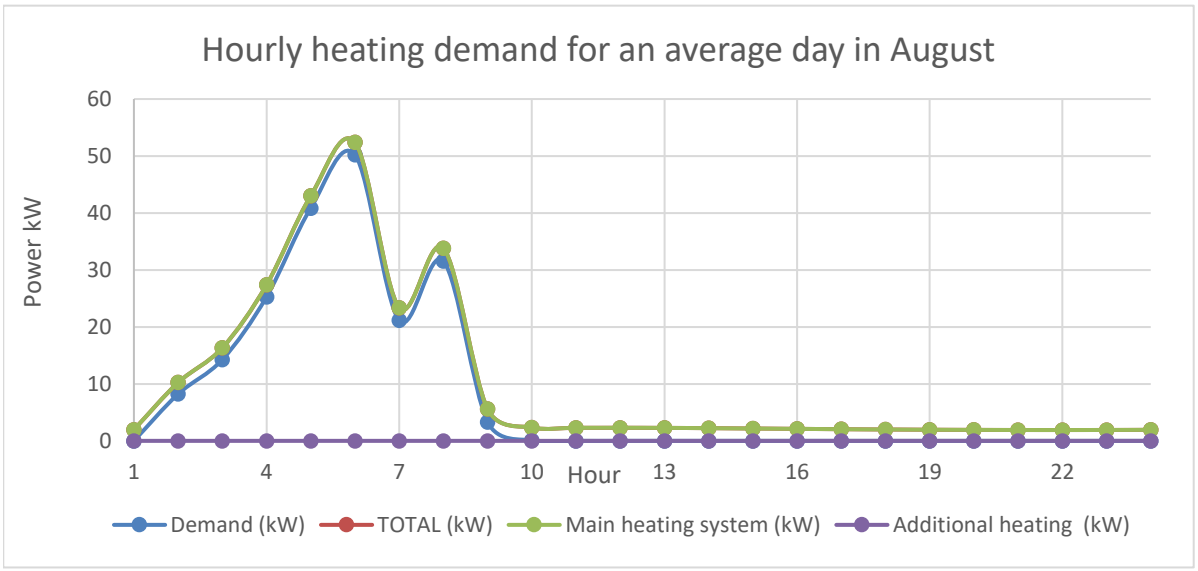


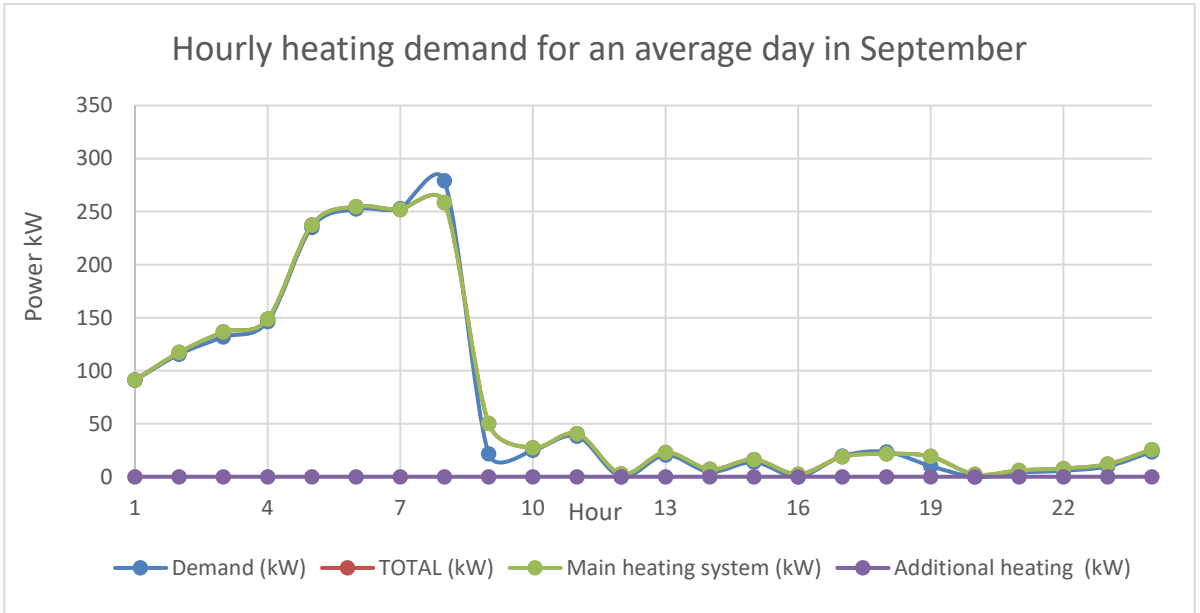

Hourly heating demand for an average day in April
Power kW
700
600
500
400
300
200
100
0
1
4
7
10
13
16
19
22
Hour
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)

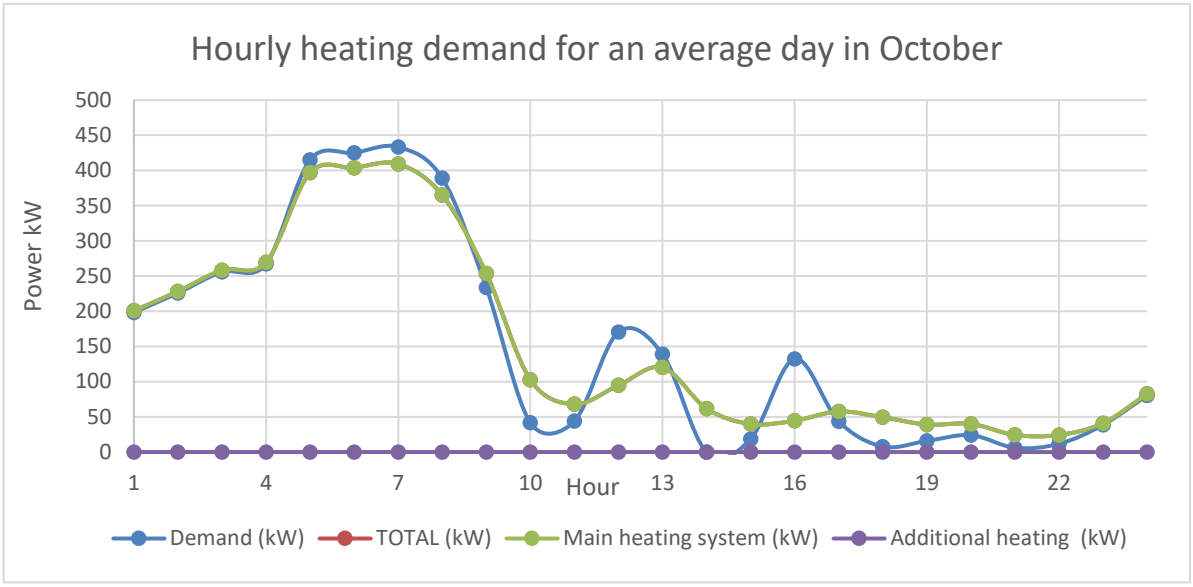

Hourly heating demand for an average day in May
Power kW
600
500
400
300
200
100
0
1
4
7
10
13
16
19
22
Hour
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)

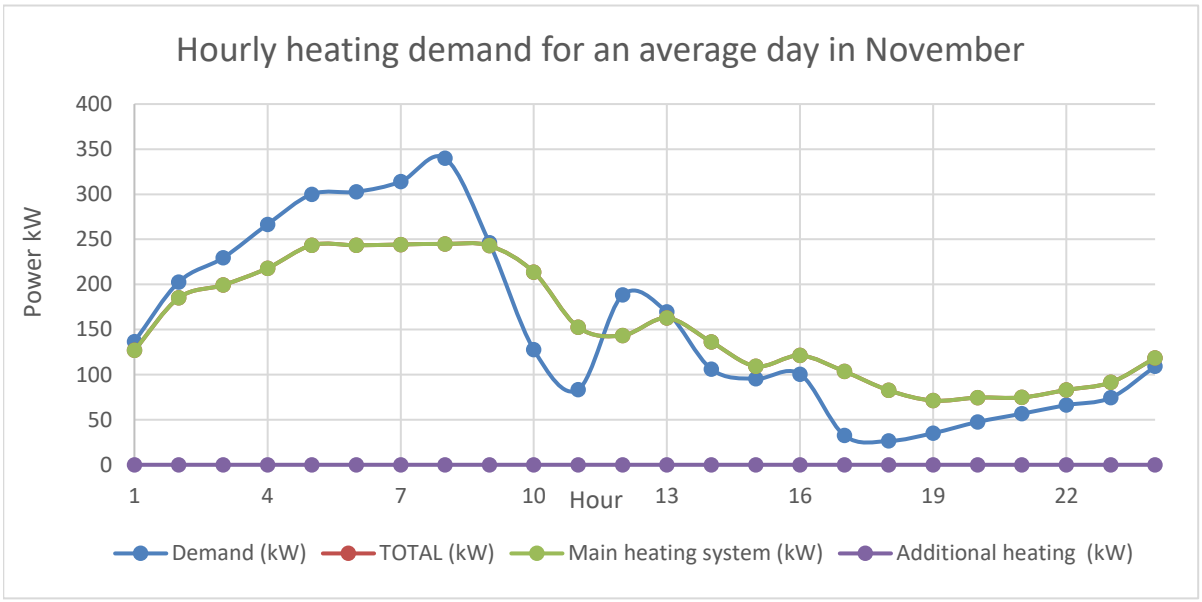

Hourly heating demand for an average day in June
Power kW
250
200
150
100
50
0
1
4
7
10
13
16
19
22
Hour
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)

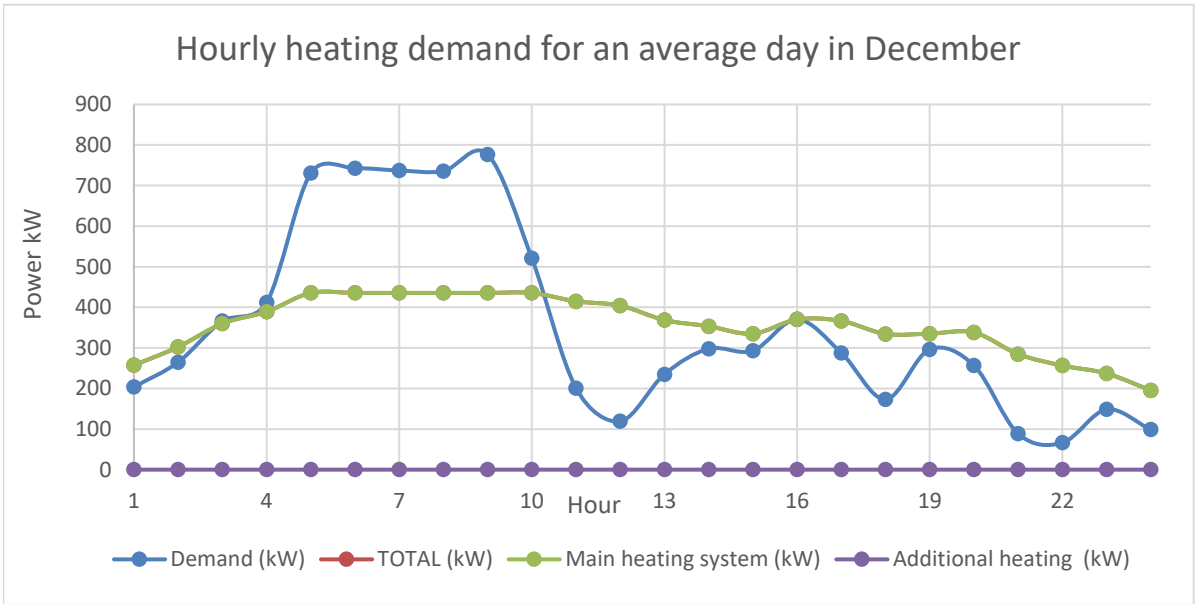

Hourly heating demand for an average day in July
Power kW
140
120
100
80
60
40
20
0
1
4
7
10
Hour
13
16
19
22
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)


Hourly heating demand for an average day in August
Power kW
60
50
40
30
20
10
0
1
4
7
10
Hour
13
16
19
22
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)

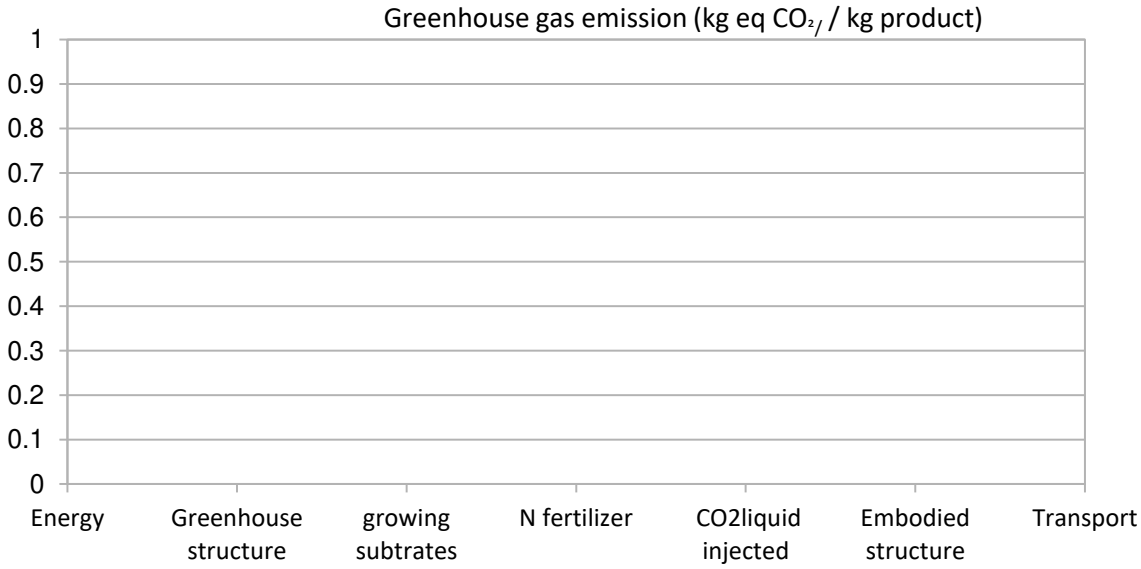

Hourly heating demand for an average day in September
Power kW
350
300
250
200
150
100
50
0
1
4
7
10
Hour
13
16
19
22
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)


Hourly heating demand for an average day in October
Power kW
500
450
400
350
300
250
200
150
100
50
0
1
4
7
10
13
16
19
22
Hour
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)


Hourly heating demand for an average day in November
Power kW
400
350
300
250
200
150
100
50
0
1
4
7
10
13
16
19
22
Hour
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)


Hourly heating demand for an average day in December
Power kW
900
800
700
600
500
400
300
200
100
0
1
4
7
10
13
16
19
22
Hour
Demand (kW)
TOTAL (kW)
Main heating system (kW)
Additional heating (kW)

11. Greenhouse gas emission estimation



Total gas emissions for production: 0.000 kg CO_2 /kg product

Item	t eqCO2/ greenhouse	%	g eqCO2/kg product
Energy	-	-	-
Greenhouse structure	-	-	-
growing subtrates	0.00	-	-
N fertilizer	0.00	-	-
CO2liquid injected	0.00	-	-
Transport	0.00	-	-
Total	**0.00**	**0%**	**0.000**

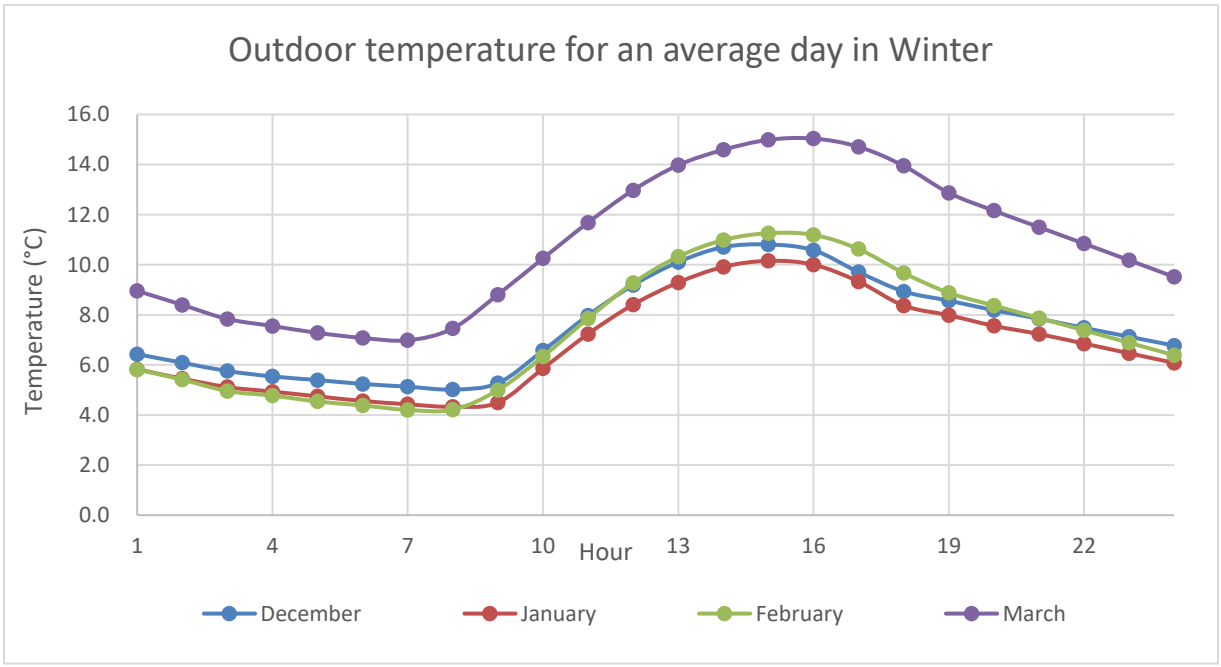
Energy detail

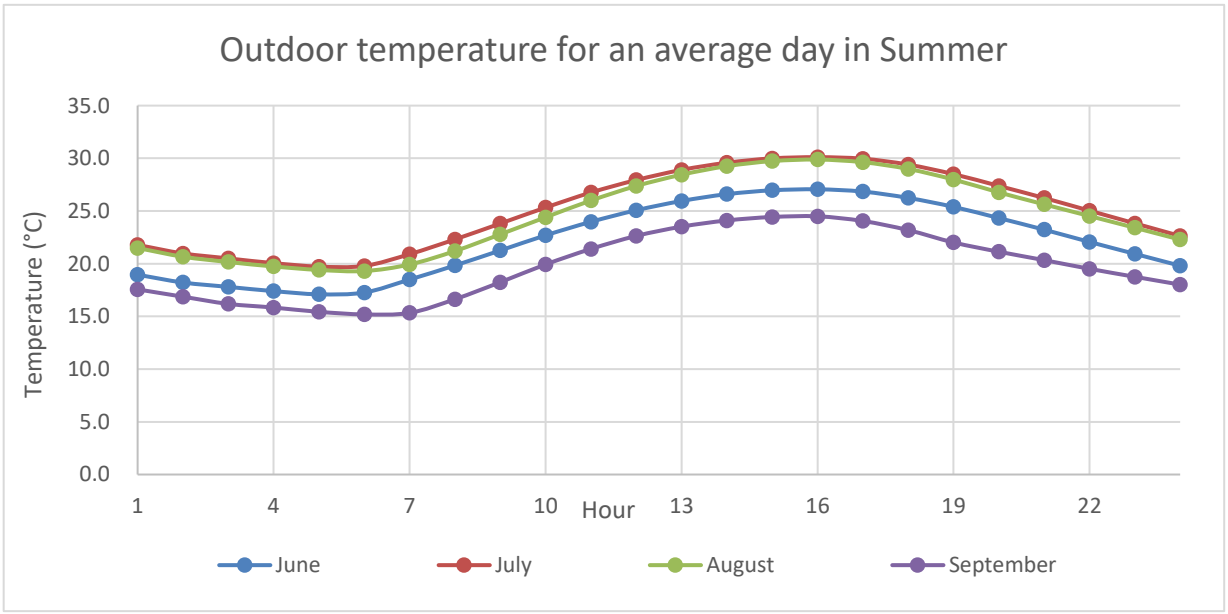
Energy	t eqCO2/ greenhouse	%	g eqCO2/kg product
Main	-	-	-
Additional	-	-	-
Electricty	155.05	100%	-
Total	**155.05**	**100%**	**-**

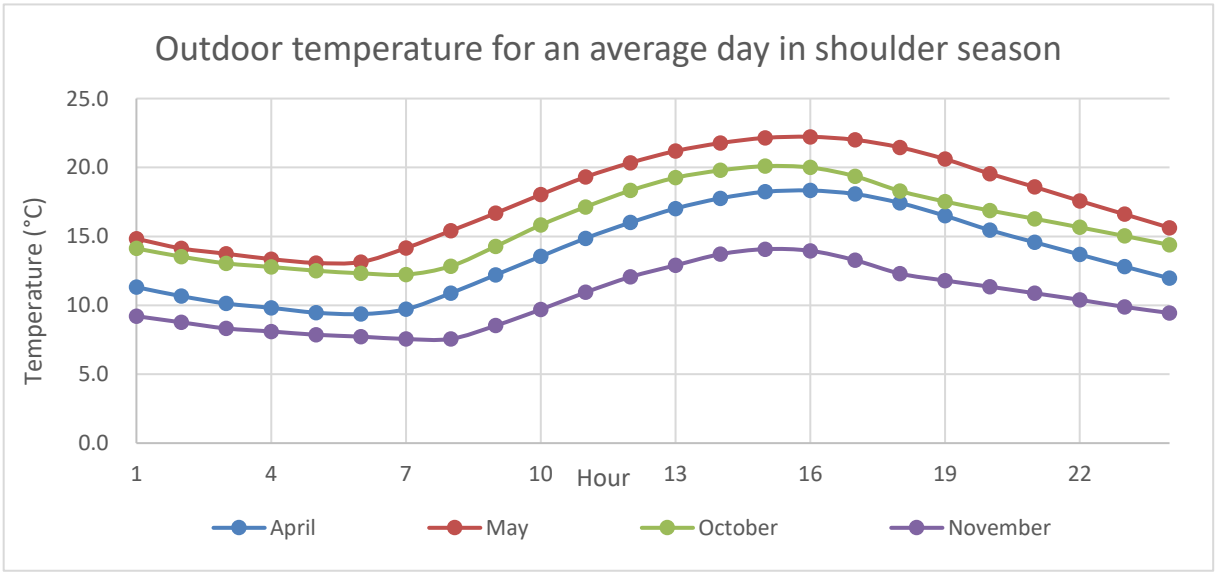
Transport detail

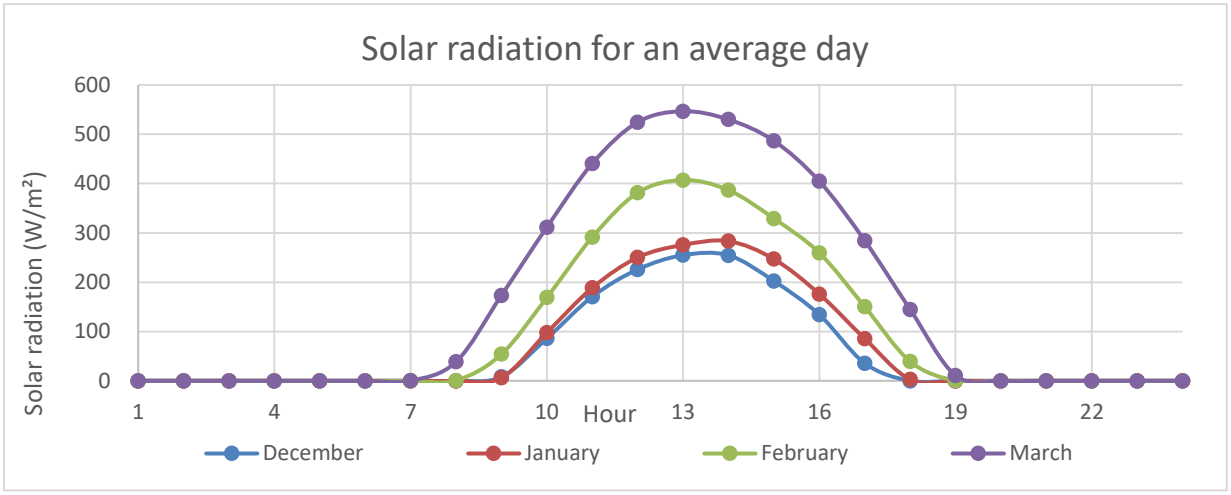
Ytem	km	t eqCO2/ greenhouse	%	g eqCO2/kg product
truck <3,5T	0	0.00	-	-
truck 7,5T	0	0.00	-	-
truck 12T	0	0.00	-	-
truck 40T	0	0.00	-	-
medium-haul aircraft	0	0.00	-	-
long-haul aircraft	0	0.00	-	-
container ship	0	0.00	-	-
Total	0	0.00	-	-

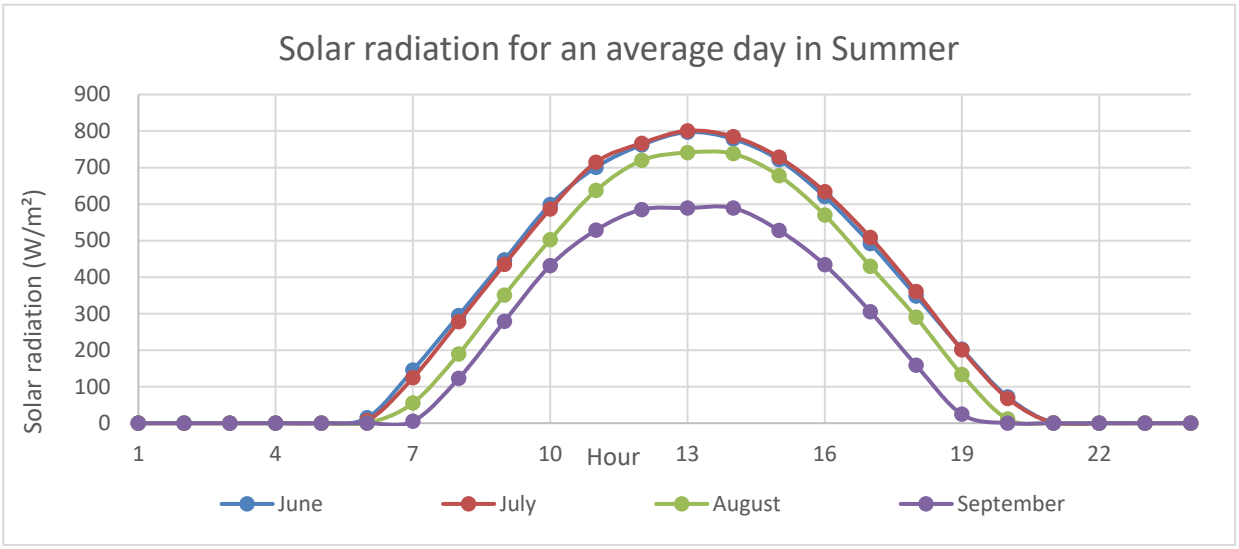
12. Outdoor climate

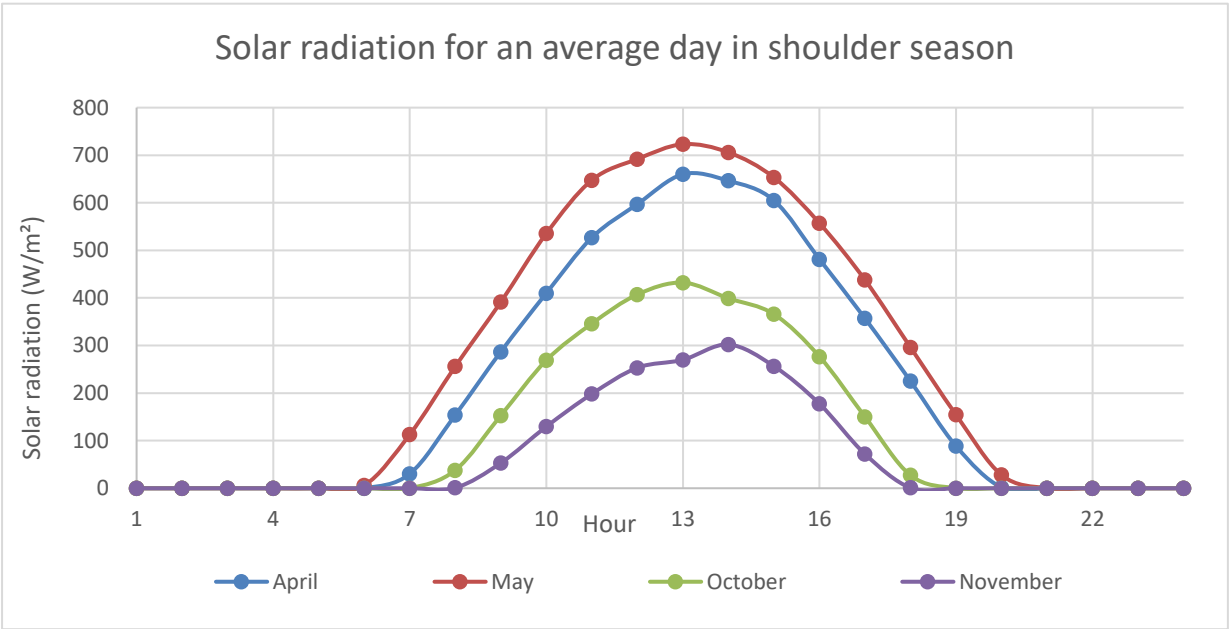












Contact: contact@hortinergy.com