

Project name : South France Example

Date: 25/01/2019

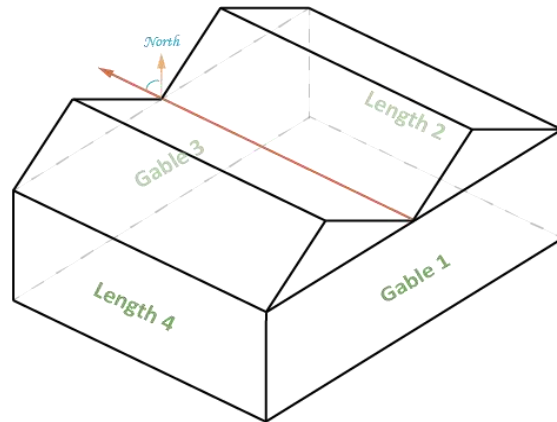
| | |
|-------------------|----------------|
| Scenario : | Semi closed V5 |
| Site: | |
| Latitude [°] = | 43.75 |
| Longitude [°] = | 4.45 |
| Altitude [m] = | 30 |

Version: 2.1

A. Project parameters

1. Greenhouse design

| | |
|--------------------------------|-----------|
| Length (m) | 100 |
| Span – chapel width (m) | 8 |
| Width (m) | 96 |
| Area (m²) | 9 600 |
| Roof height (m) | 7.8 |
| Gutter height (m) | 7 |
| Greenhouse type | saw tooth |
| Air leakage (vol/h) | 0.27 |
| Ground type | Classic |
| Path type | Concrete |
| Path ratio (%) | 10 |
| Cover transmission loss | 0 |



| | Roof | Gable 1 | Length 2 | Gable 3 | Length 4 |
|-------------------------|------------------------------|--------------------|--------------------|--------------------|--------------------|
| Cover | 4mm clear glass 2AR coatings | Polycarbonate 16mm | Polycarbonate 16mm | Polycarbonate 16mm | Polycarbonate 16mm |
| Frame percentage | 10 | 10 | 10 | 10 | 10 |
| Screen number | 2 | 0 | 0 | 0 | 0 |
| Screen 1 type | Thermal | - | - | - | - |
| Shade % | 13 | - | - | - | - |
| Energy saving % | 47 | - | - | - | - |
| Screen 2 type | Aluminium | - | - | - | - |
| Shade % | 40 | - | - | - | - |
| Energy saving % | 55 | - | - | - | - |
| Screen 3 type | - | - | - | - | - |
| Shade % | - | - | - | - | - |
| Energy saving % | - | - | - | - | - |

2. Crop production



| | |
|---------------------------|----------------------------|
| Type of crop | Tomato |
| Cultivation starting date | 2018-12-01 |
| End of cultivation | 2019-11-01 |
| Seedling age | 4 weeks at transplantation |

3. Climate management

a. Period and temperature setting

| | Temperature setting | |
|------------------|---------------------|-------|
| | day | night |
| Period 1 | | |
| 2018-12-01 | 20 | 18 |
| 2019-11-01 | | |
| Periode 2 | | |
| 2019-11-02 | 12 | 12 |
| 2019-11-30 | | |
| Period 3 | | |
| 0000-00-00 | 0 | 0 |
| 0000-00-00 | | |
| Period 4 | | |
| 0000-00-00 | 0 | 0 |
| 0000-00-00 | | |
| Period 5 | | |
| 0000-00-00 | 0 | 0 |
| 0000-00-00 | | |
| Period 6 | | |
| 0000-00-00 | 0 | 0 |
| 0000-00-00 | | |

b. Morning revival

| | |
|----------------------|----------------------|
| Morning revival | Yes |
| Solar radiation | 100 W/m ² |
| Temperature increase | 1 °C/h |

c. Humidity set

| | |
|----------------------|---|
| Humidity regulation: | Water deficit (vapour pressure deficit) |
|----------------------|---|

| Period | Unit | Min | Max |
|--------|----------------------|-----|-----|
| Day | g water / kg dry air | 1 | 8 |
| Night | g water / kg dry air | 1 | 8 |

d. Day / Night switch - screen regulation

Screen use

| | Roof | Gable 1 | Length 2 | Gable 3 | Length 4 |
|---------------|-----------------|---------|----------|---------|----------|
| Screen number | 2 | 0 | 0 | 0 | 0 |
| Screen 1 type | Thermal | - | - | - | - |
| Regulation | Thermal | | | | |
| Screen 2 type | Aluminium | - | - | - | - |
| Regulation | Thermal & shade | | | | |
| Screen 3 type | - | | | | |
| Regulation | - | | | | |

d1. Day / Night switch - thermal screen regulation

| | |
|------------------------------|--|
| Regulation type | Delta Temperature inside/outside and Solar radiation |
| Minimum solar radiation | 100 W/m ² |
| Min Delta temperature in/out | 15 °C |

d2. Shade screen regulation

| | |
|-------------------------|----------------------|
| Regulation type | Solar radiation |
| Minimum solar radiation | 700 W/m ² |
| Shade screen as thermal | yes |

d3. Black out regulation

| Beginning | End | Hours/day Solar Radiation |
|----------------------|-----|---------------------------|
| - | - | - |
| Black out as thermal | - | - |

5. Semi-closed greenhouse

| | |
|---|------|
| Semi-closed greenhouse: | Yes |
| Air flow max rate (m ³ /m ² h): | 74.0 |
| Nb air tubes par chapel: | 5 |

Fan specification

| | |
|---|--------|
| Max air flow /fan (m ³ /h fan) | 12 000 |
|---|--------|

| Electricity consumption per fan according to air flow percentage | |
|--|------|
| 100% | 1600 |
| 75% | 1200 |
| 50% | 800 |
| 25% | 300 |

| | |
|---|------|
| Air recirculat. rate (m ³ /m ² h) | 10.6 |
|---|------|

| | |
|---|-----|
| Humidification and cooling: | Pad |
| Water temperature (°C): | 14 |
| Max evoporating capacity (m ³ /h): | 0.5 |

| | |
|---------------------------|----------------|
| Priority: | Humidification |
| Cooling temperature (°C): | 26 |
| Vent opening temp. (°C): | 28 |
| Electricity cost (€/MWh) | 120 |

6. Heat production

Dimensioning User defined (advanced parameters)

| Heating | Main | Auxiliary |
|--------------------------|---------------------|------------|
| Energy source | CHP - recovery heat | Gas |
| Unit price (€/MWh) | 10 | 40 |
| Maximum power | 500 | 2 000 |
| Condensor | Yes | Yes |
| Max yield (%) | 95 | 95 |
| Main energy period | Start | End |
| Date | 2018-12-01 | 2019-11-30 |
| Distribution yield (%) | 90 | |
| Buffer tank | No | |
| Volume (m ³) | - | |
| Height (m) | - | |
| Insulation (cm) | - | |
| Temperature difference | - | |

7. Outdoor climate

| Month | Average outdoor temperature (°C) | Minimum outdoor temperature (°C) | Maximum outdoor temperature (°C) | External average relative humidity (%) | External average global solar radiation (kWh/ m ² day) |
|-------------------|----------------------------------|----------------------------------|----------------------------------|--|---|
| Januray | 6.6 | -3.4 | 15.2 | 71 | 1.78 |
| February | 7.5 | -1.3 | 17.8 | 66 | 2.62 |
| March | 10.8 | 0.4 | 21.6 | 60 | 4.03 |
| April | 13.6 | 5.3 | 24.7 | 63 | 5.40 |
| May | 18.1 | 8.6 | 29.9 | 62 | 6.31 |
| June | 22.4 | 12.8 | 34.3 | 56 | 7.33 |
| July | 24.6 | 14.9 | 34.0 | 52 | 7.47 |
| August | 24.3 | 15.6 | 35.8 | 55 | 6.02 |
| September | 19.4 | 11.0 | 29.7 | 63 | 4.70 |
| October | 15.9 | 7.0 | 25.4 | 73 | 2.80 |
| November | 10.2 | 1.3 | 19.8 | 74 | 2.01 |
| December | 6.8 | -2.5 | 16.9 | 72 | 1.55 |
| Average/ Min /Max | 15.0 | -3.4 | 35.8 | 64 | 4.34 |



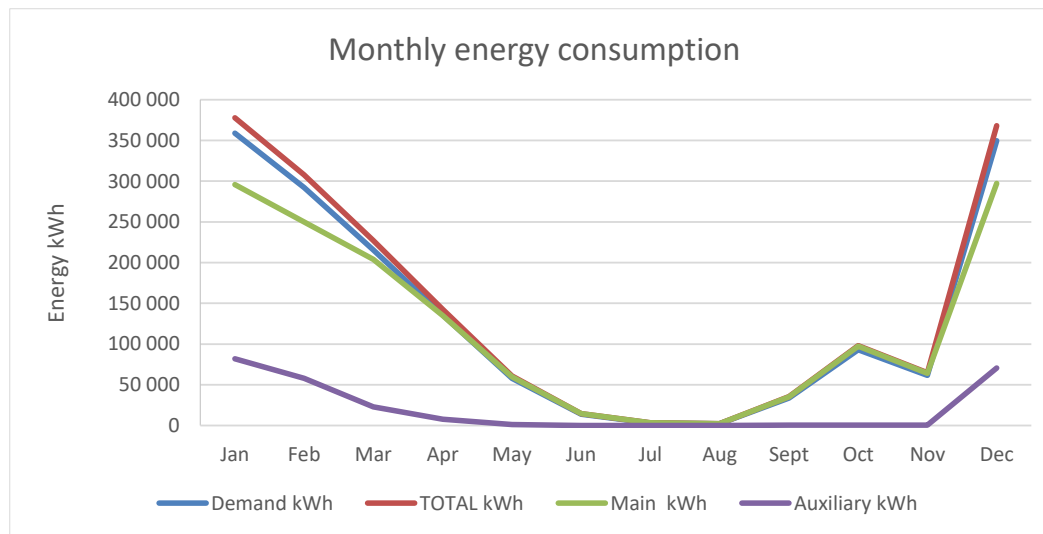
B. Energy consumption



1. Annual cost and energy consumption

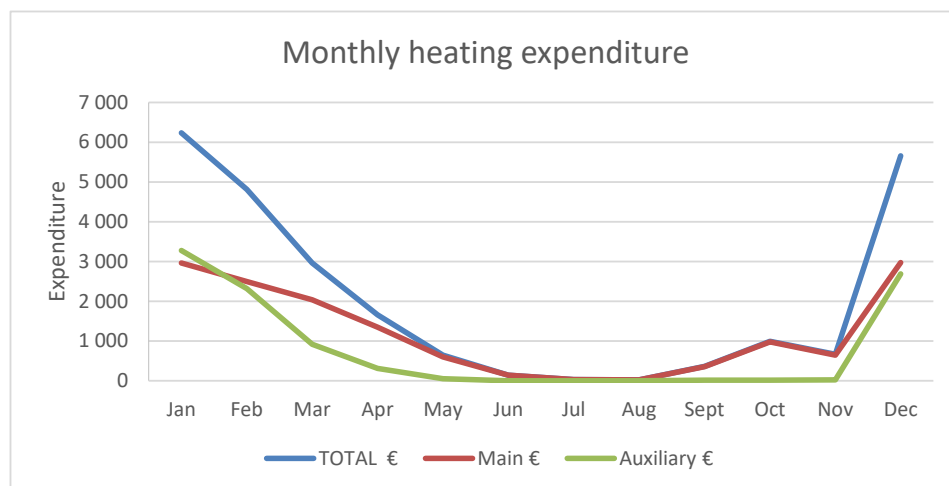
| | Total | Main | Auxiliary |
|--|--------|---------------------|-----------|
| Energy source | | CHP - recovery heat | Gas |
| Unit price (€/MWh) | | 10 | 40 |
| Expenditure (€) | 24 196 | 14 588 | 9 607 |
| €/m ² | 2.5 | 1.5 | 1.0 |
| Main vs Auxiliary (cost %) | | 60% | 40% |
| Consumption MWh | 1 702 | 1 459 | 240 |
| Consumpt. / unit (kWh/m ²) | 177 | 152 | 25 |
| Main vs Auxiliary (energy %) | | 86% | 14% |

2. Monthly heating consumption



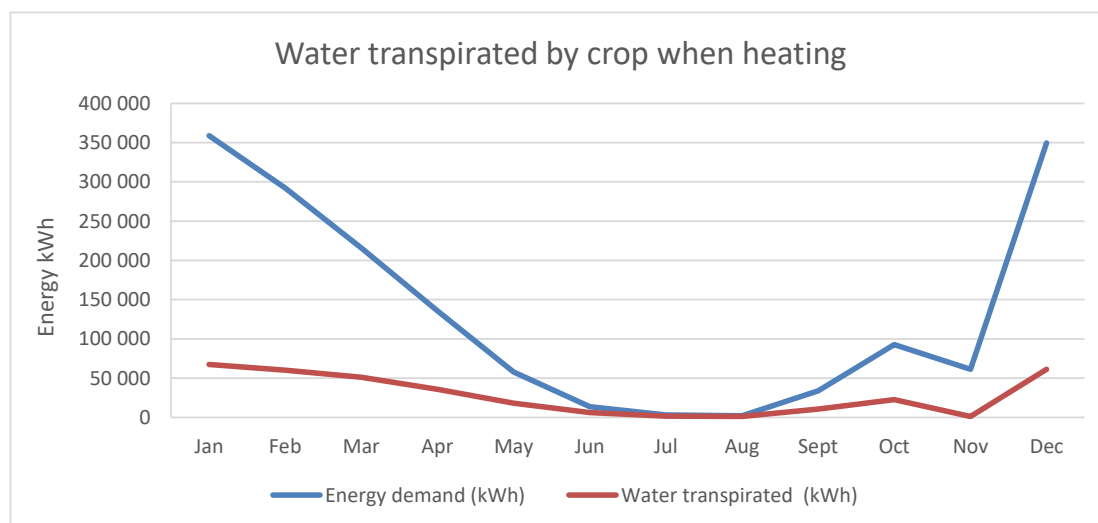
| | Demand kWh | TOTAL kWh | Main kWh | Auxiliary kWh |
|-------|------------|-----------|-----------|---------------|
| Jan | 358 919 | 377 810 | 295 886 | 81 924 |
| Feb | 292 305 | 307 690 | 249 794 | 57 895 |
| Mar | 215 650 | 227 000 | 203 981 | 23 020 |
| Apr | 135 528 | 142 661 | 134 939 | 7 722 |
| May | 57 838 | 60 882 | 59 668 | 1 214 |
| Jun | 13 687 | 14 408 | 14 408 | 0 |
| Jul | 3 097 | 3 260 | 3 260 | 0 |
| Aug | 2 125 | 2 237 | 2 237 | 0 |
| Sept | 33 821 | 35 601 | 35 265 | 336 |
| Oct | 92 993 | 97 887 | 97 502 | 385 |
| Nov | 61 484 | 64 720 | 64 194 | 525 |
| Dec | 349 543 | 367 940 | 297 246 | 70 693 |
| Total | 1 616 991 | 1 702 095 | 1 458 380 | 243 715 |

3. Monthly heating expenditure



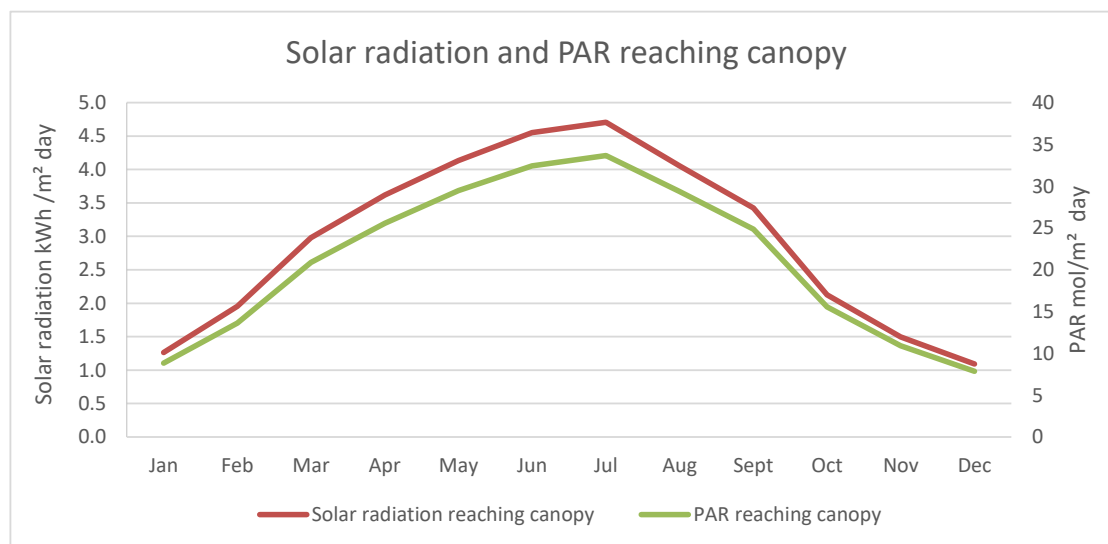
| | TOTAL € | Main € | Auxiliary € |
|-------|---------|--------|-------------|
| Jan | 6 236 | 2 959 | 3 277 |
| Feb | 4 814 | 2 498 | 2 316 |
| Mar | 2 961 | 2 040 | 921 |
| Apr | 1 658 | 1 349 | 309 |
| May | 645 | 597 | 49 |
| Jun | 144 | 144 | 0 |
| Jul | 33 | 33 | 0 |
| Aug | 22 | 22 | 0 |
| Sept | 366 | 353 | 13 |
| Oct | 993 | 977 | 15 |
| Nov | 664 | 643 | 21 |
| Dec | 5 659 | 2 973 | 2 686 |
| Total | 24 196 | 14 588 | 9 607 |

4. Water transpired by crop when heating



| | Demand kWh | Water transpired | |
|--------------|------------------|------------------|------------|
| | | kWh | % |
| Jan | 358 919 | 67 483 | 19% |
| Feb | 292 305 | 60 299 | 21% |
| Mar | 215 650 | 51 258 | 24% |
| Apr | 135 528 | 35 773 | 26% |
| May | 57 838 | 18 219 | 32% |
| Jun | 13 687 | 6 141 | 45% |
| Jul | 3 097 | 1 650 | 53% |
| Aug | 2 125 | 1 251 | 59% |
| Sept | 33 821 | 10 702 | 32% |
| Oct | 92 993 | 22 664 | 24% |
| Nov | 61 484 | 1 208 | 2% |
| Dec | 349 543 | 61 173 | 18% |
| Total | 1 616 991 | 337 819 | 21% |

5. Solar radiation and PAR reaching canopy

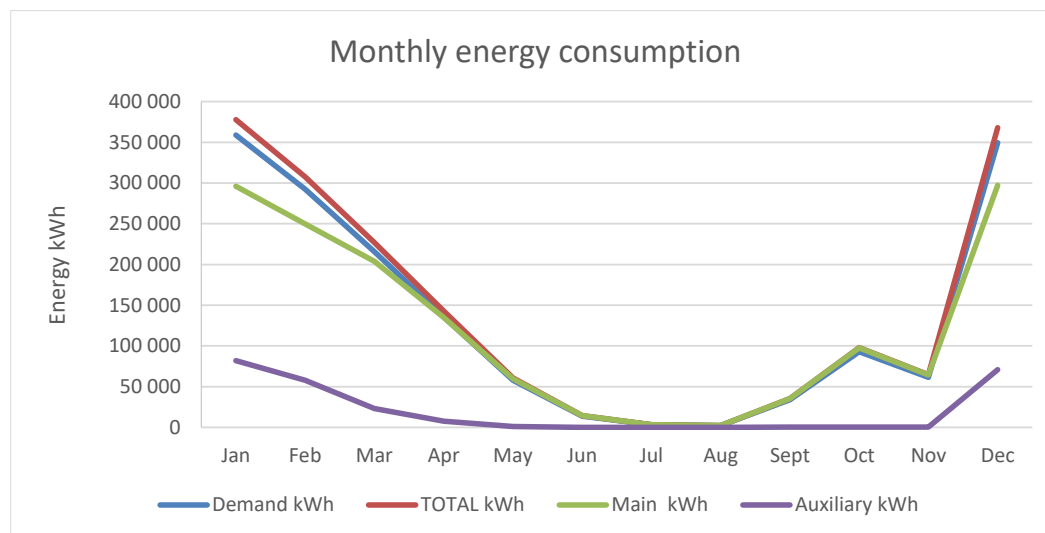


| | External | Internal reaching canopy | |
|----------------|--|--|-------------------------------|
| | Solar radiation kWh/ m ² day | Solar radiation kWh/ m ² day | PAR mol/m ² day |
| Jan | 1.78 | 1.26 | 8.83 |
| Feb | 2.62 | 1.95 | 13.63 |
| Mar | 4.03 | 2.98 | 20.90 |
| Apr | 5.40 | 3.62 | 25.58 |
| May | 6.31 | 4.13 | 29.46 |
| Jun | 7.33 | 4.55 | 32.44 |
| Jul | 7.47 | 4.71 | 33.67 |
| Aug | 6.02 | 4.05 | 29.35 |
| Sept | 4.70 | 3.42 | 24.84 |
| Oct | 2.80 | 2.13 | 15.56 |
| Nov | 2.01 | 1.50 | 10.91 |
| Dec | 1.55 | 1.09 | 7.86 |
| Average | 4.34 | 2.95 | 21.09 |

6. Semi closed greenhouse

| Electricity | |
|---------------------|--------|
| Electricity (€/MWh) | 120 |
| Energy (MWh) | 98.6 |
| kWh/m ² | 10.3 |
| Expenditure (€) | 11 835 |
| €/m ² | 1.23 |

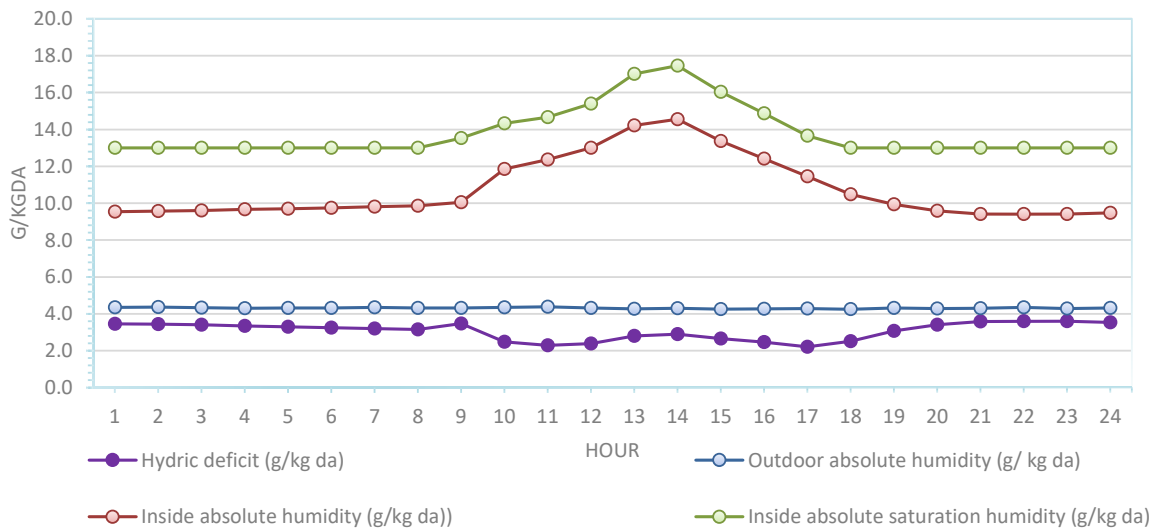
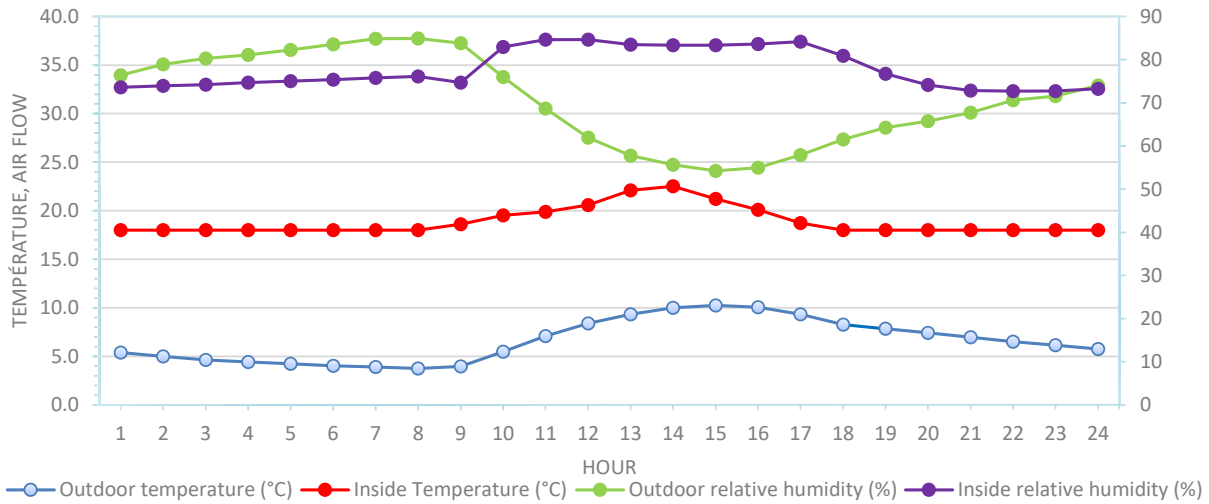
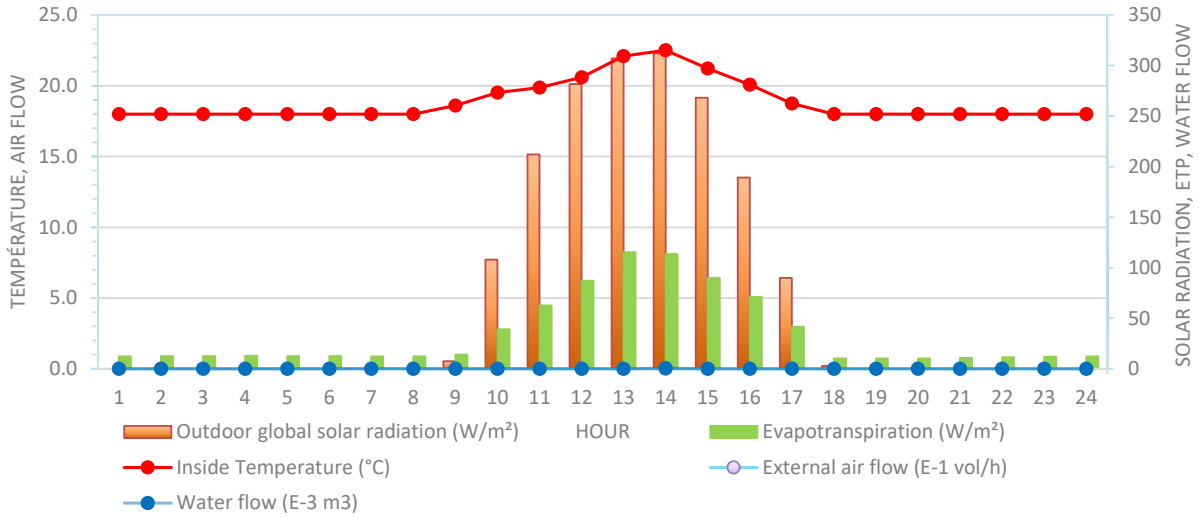
| Water | |
|--------------------------------|------|
| m ³ | 287 |
| m ³ /m ² | 0.03 |



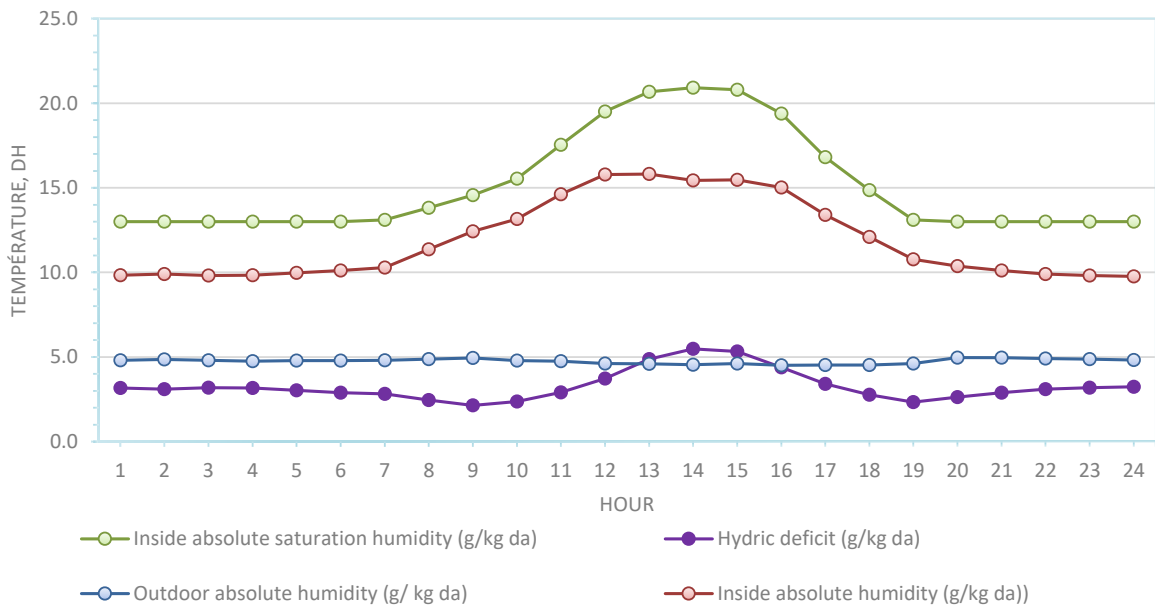
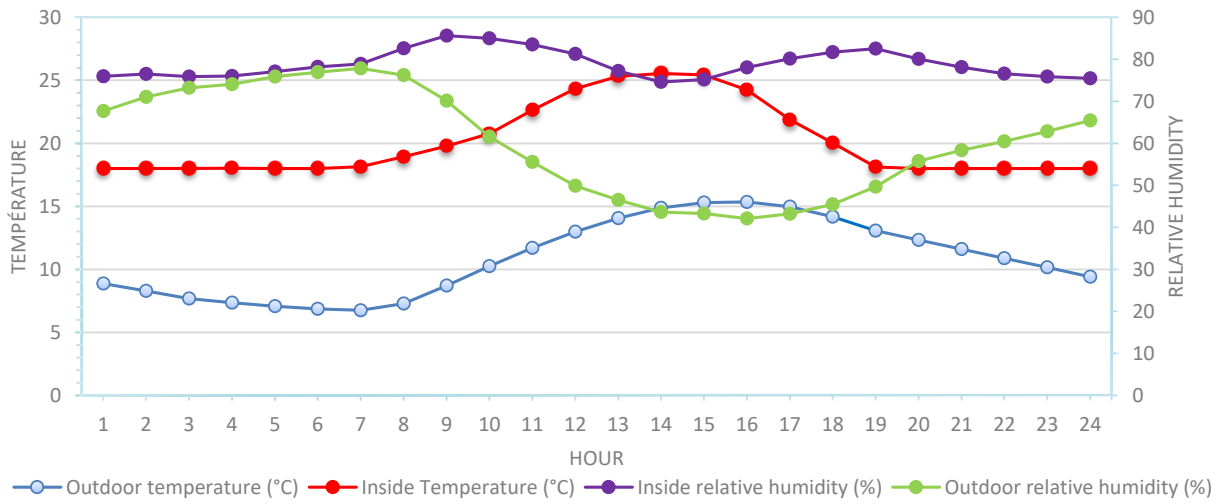
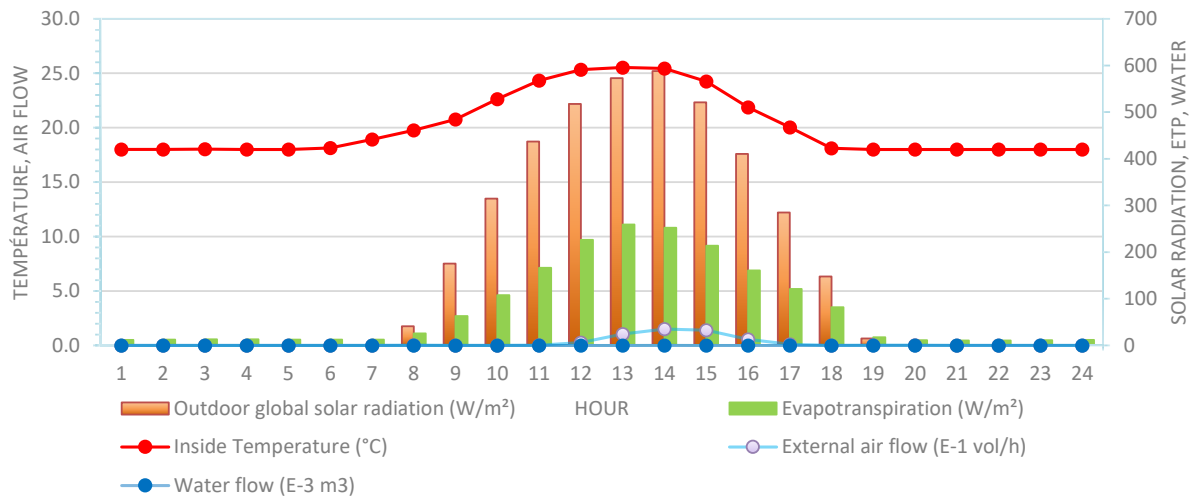
| | Electricity | | Water | |
|--------------|-------------|--------------------|----------------|------------------|
| | MWh | kWh/m ² | m ³ | l/m ² |
| Jan | 7.7 | 0.8 | 0 | 0.0 |
| Feb | 6.9 | 0.7 | 0 | 0.0 |
| Mar | 7.7 | 0.8 | 3 | 0.3 |
| Apr | 7.4 | 0.8 | 8 | 0.8 |
| May | 7.9 | 0.8 | 23 | 2.4 |
| Jun | 8.6 | 0.9 | 52 | 5.5 |
| Jul | 10.4 | 1.1 | 82 | 8.6 |
| Aug | 10.9 | 1.1 | 80 | 8.3 |
| Sept | 7.9 | 0.8 | 32 | 3.3 |
| Oct | 8.2 | 0.8 | 8 | 0.8 |
| Nov | 7.4 | 0.8 | 0 | 0.0 |
| Dec | 7.7 | 0.8 | 0 | 0.0 |
| Total | 98.6 | 10.3 | 287 | 29.9 |

7. Inner climate

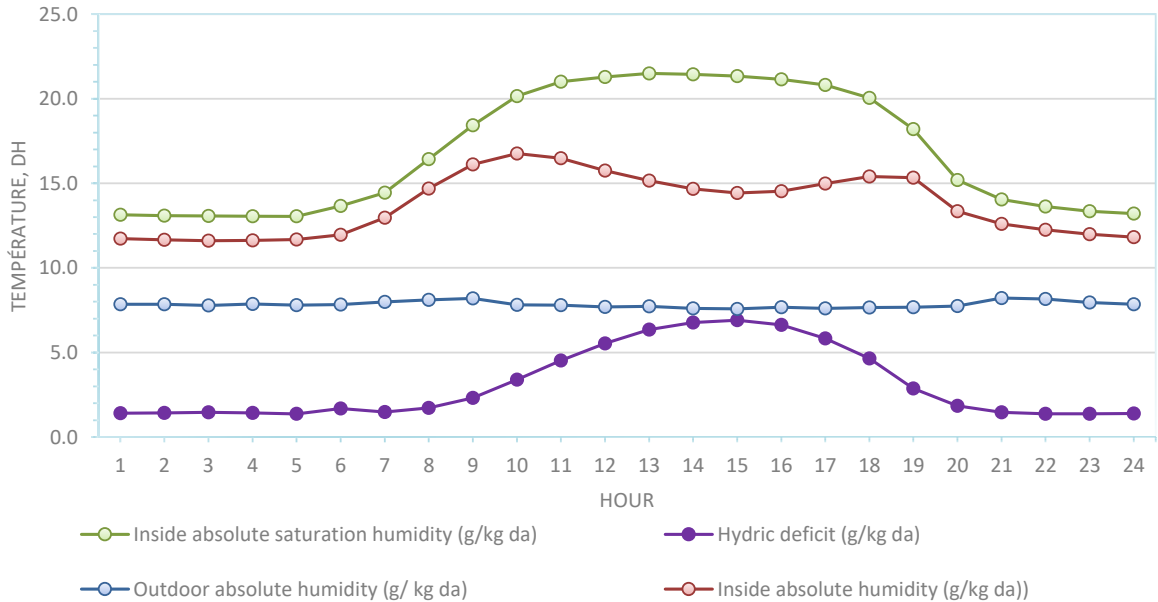
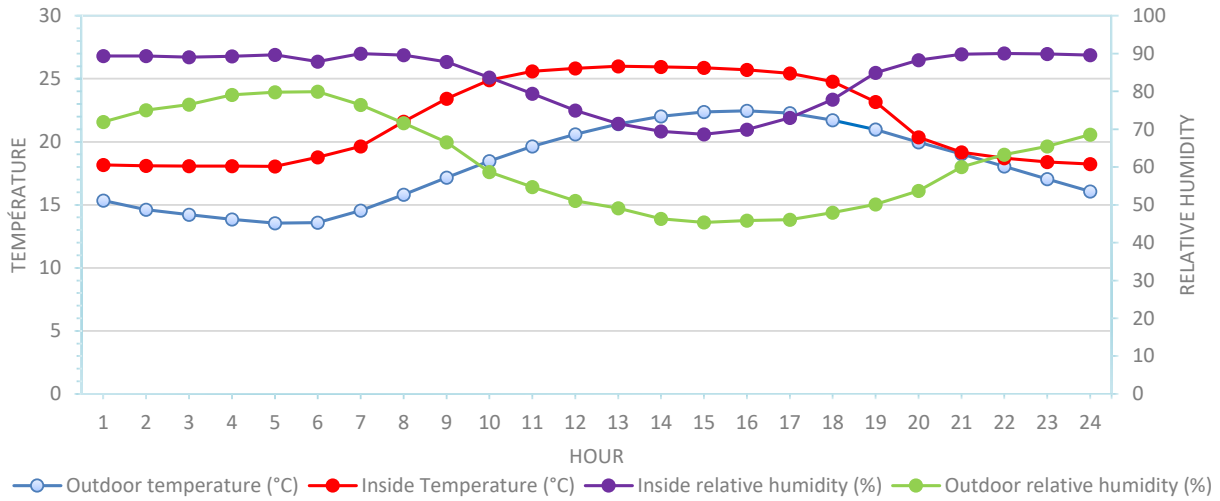
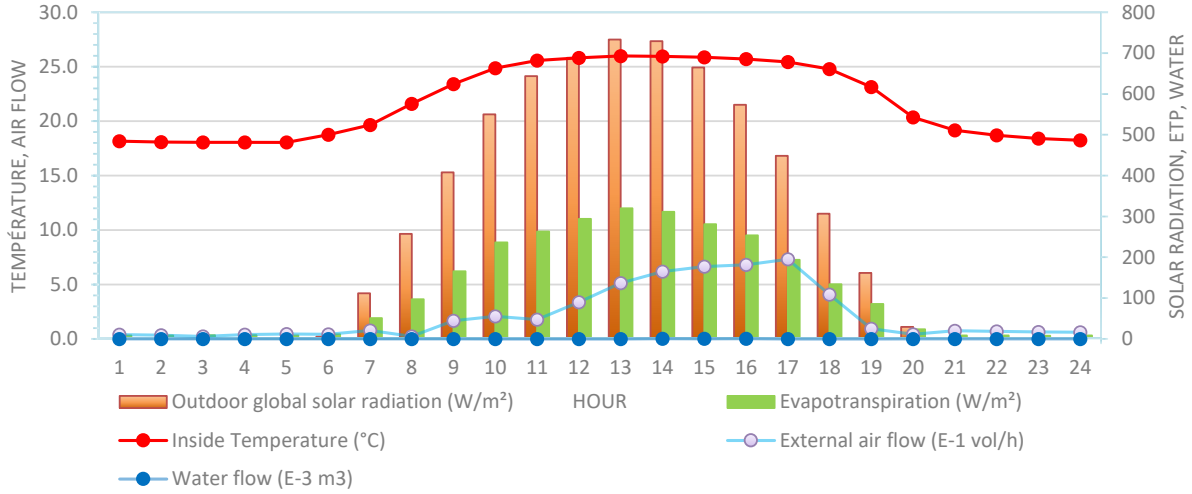
A. Inner climate for an average day in January



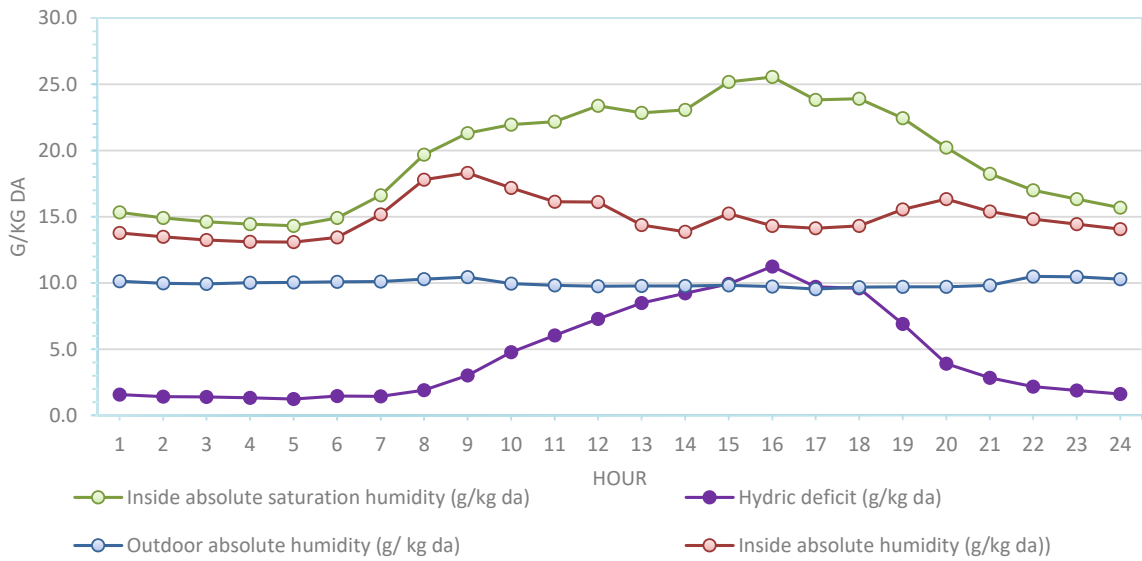
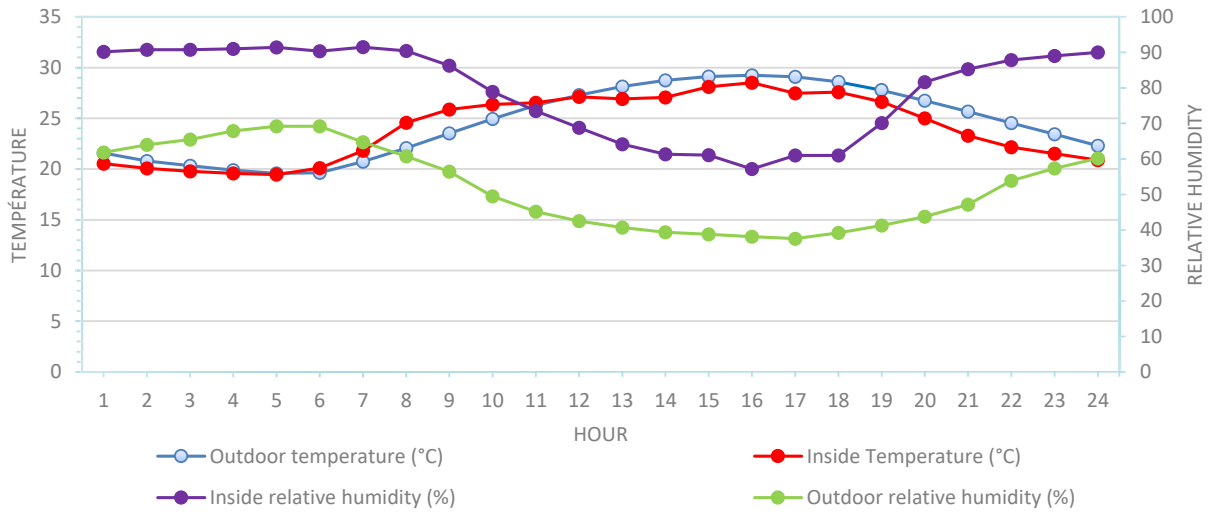
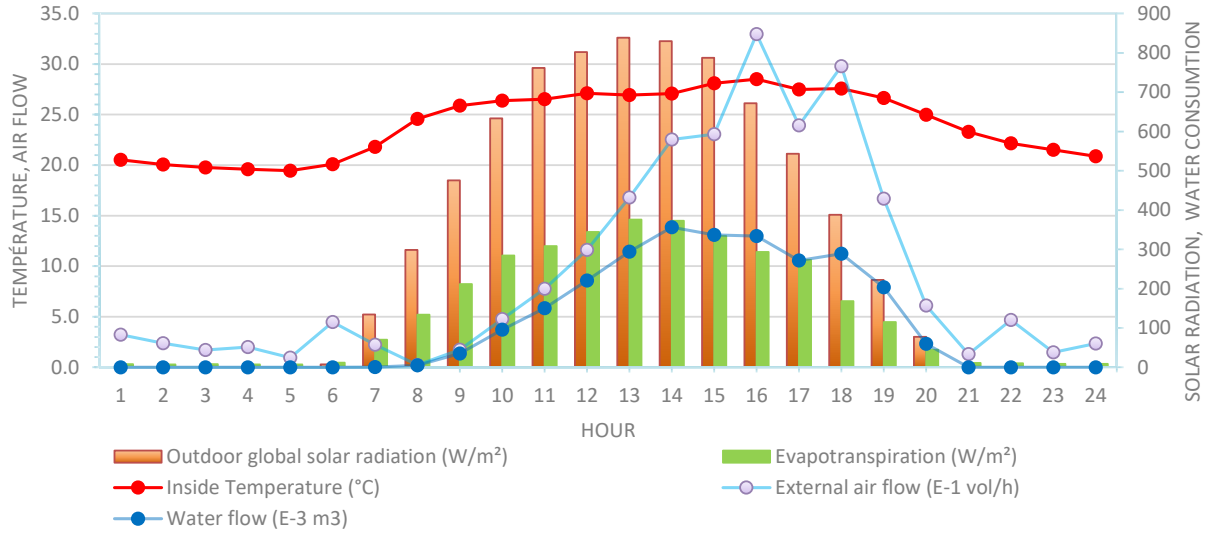
B. Inner climate for an average day in March



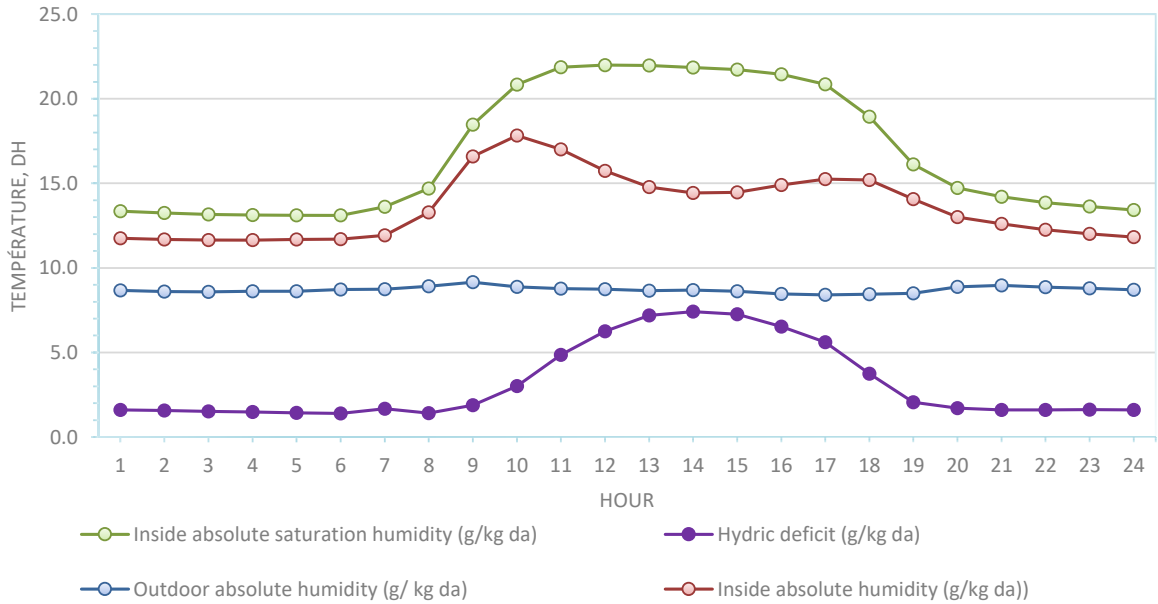
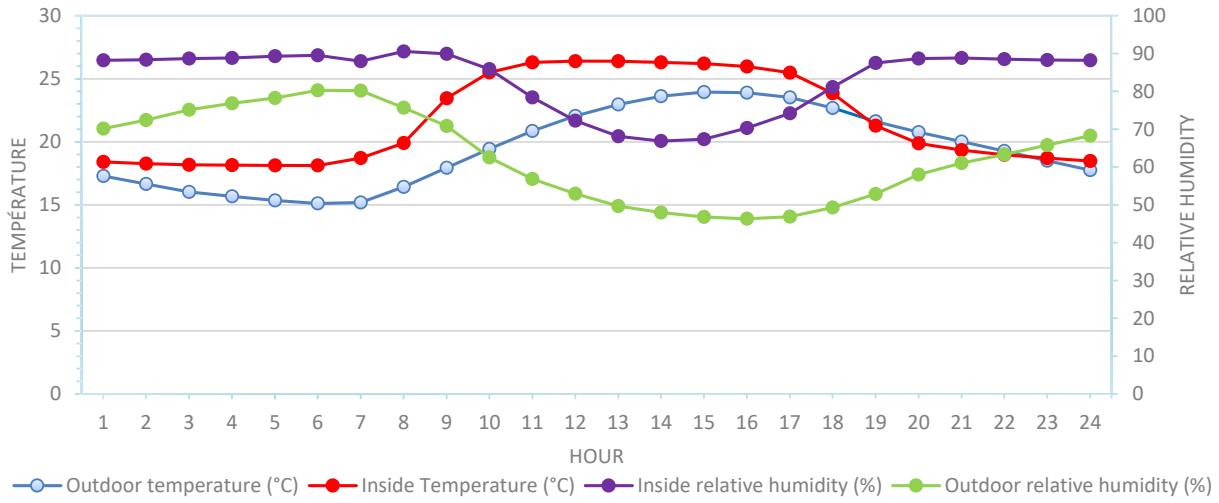
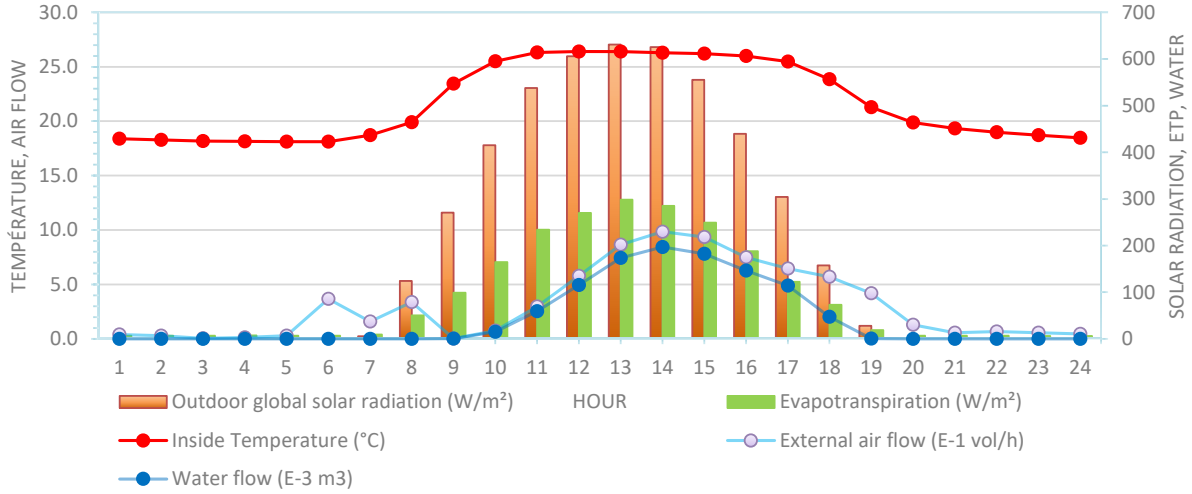
C. Inner climate for an average day in May



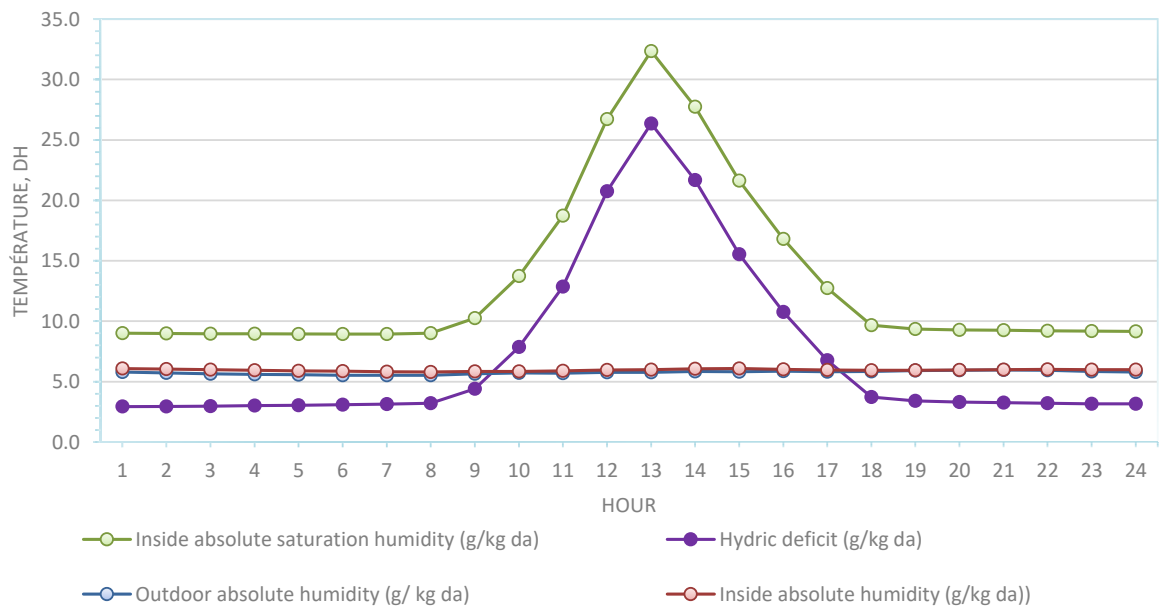
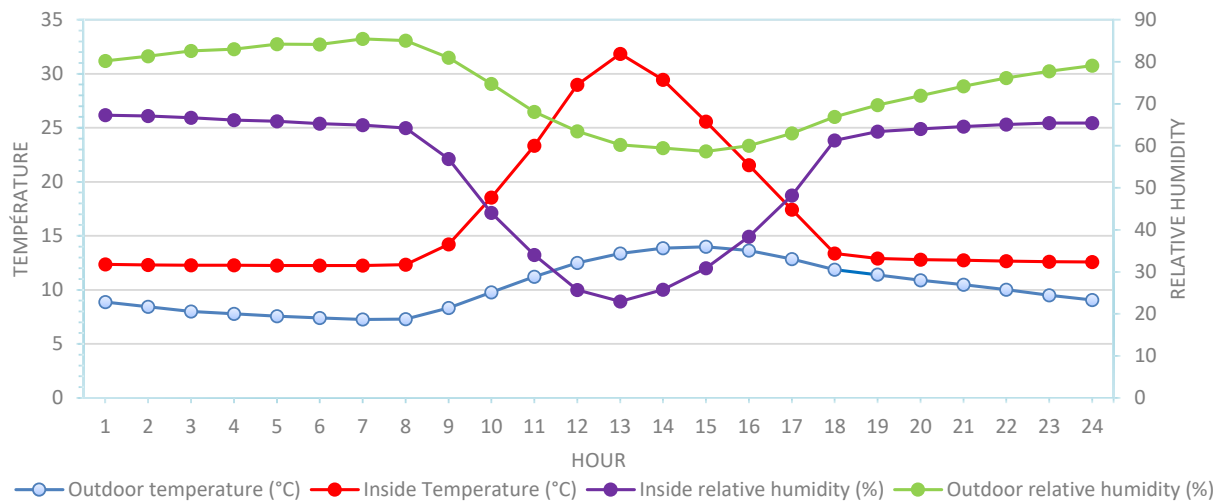
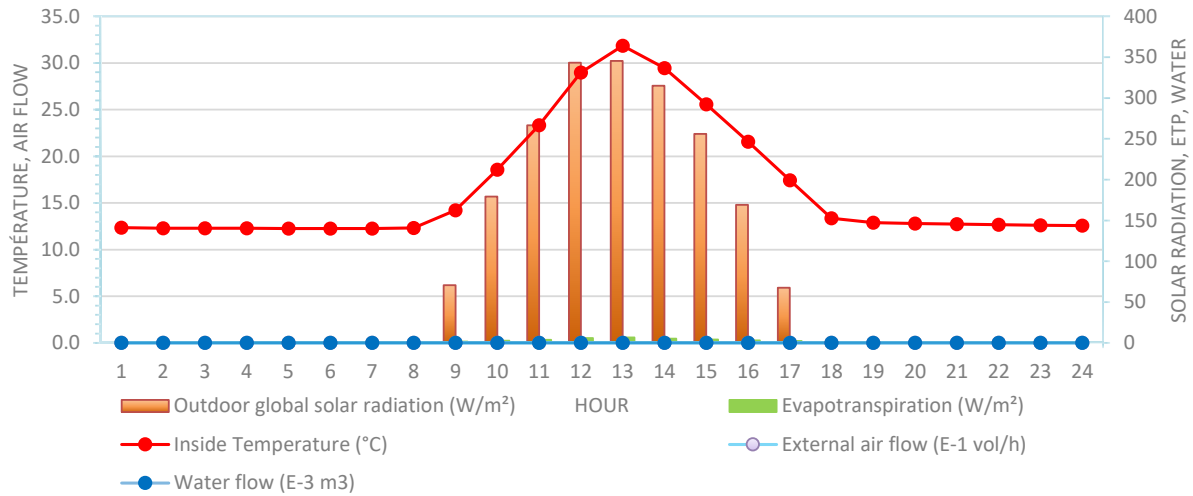
D. Inner climate for an average day in July



E. Inner climate for a typical day in September

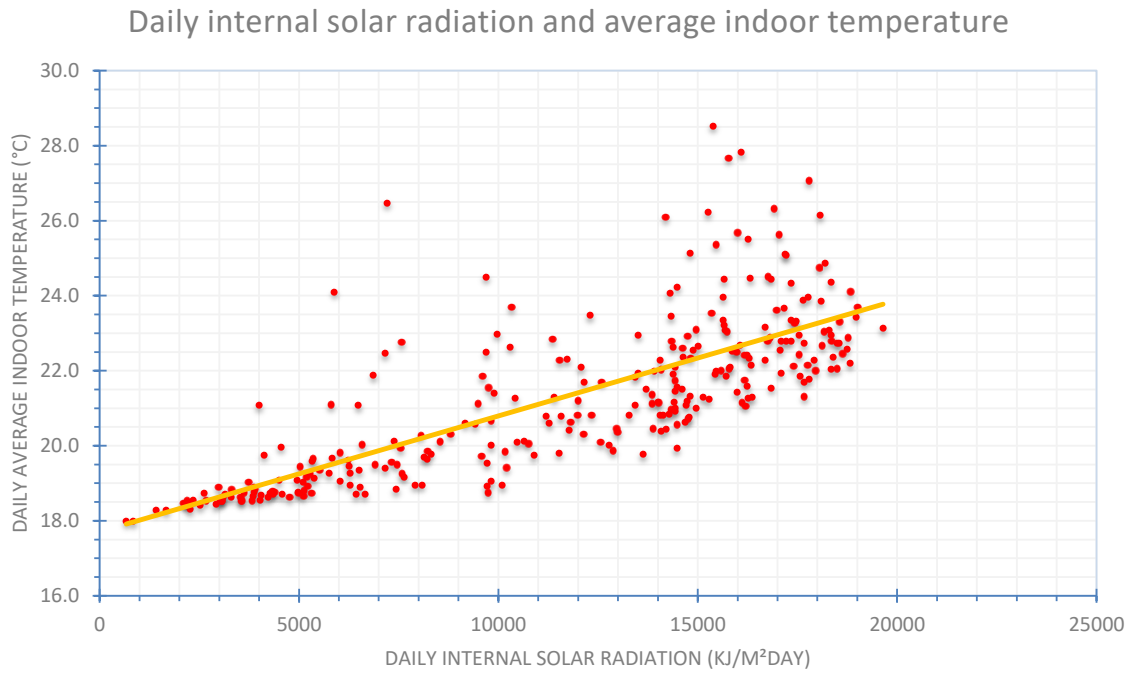


F. Inner climate for an average day in November

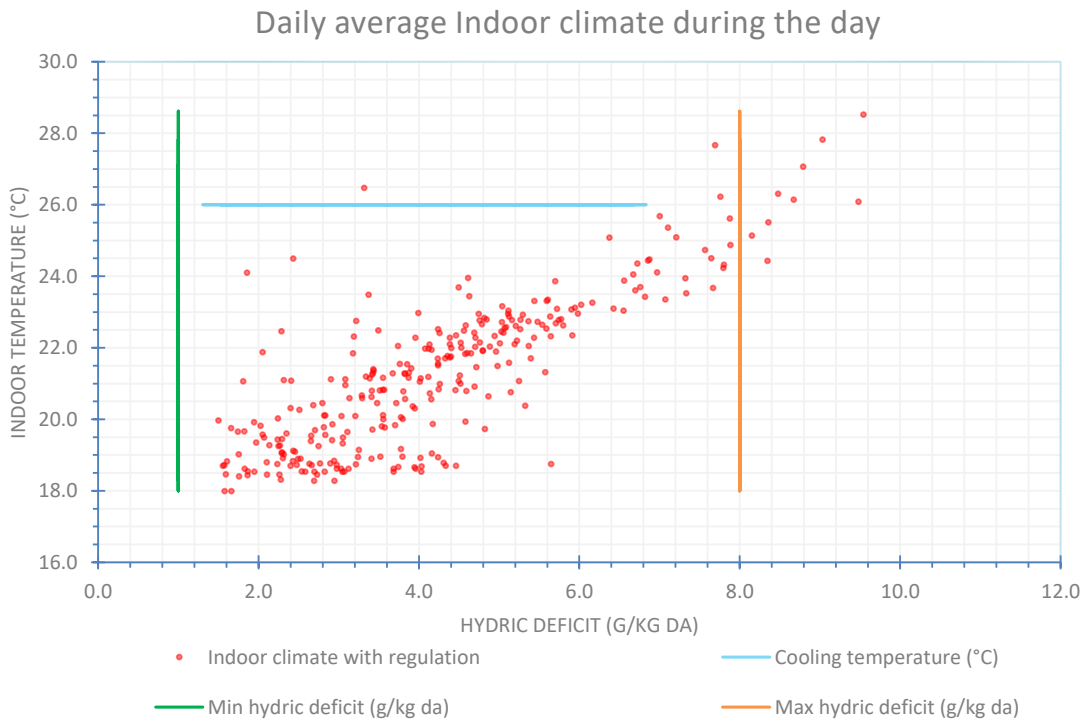


8. Climate control and risks management

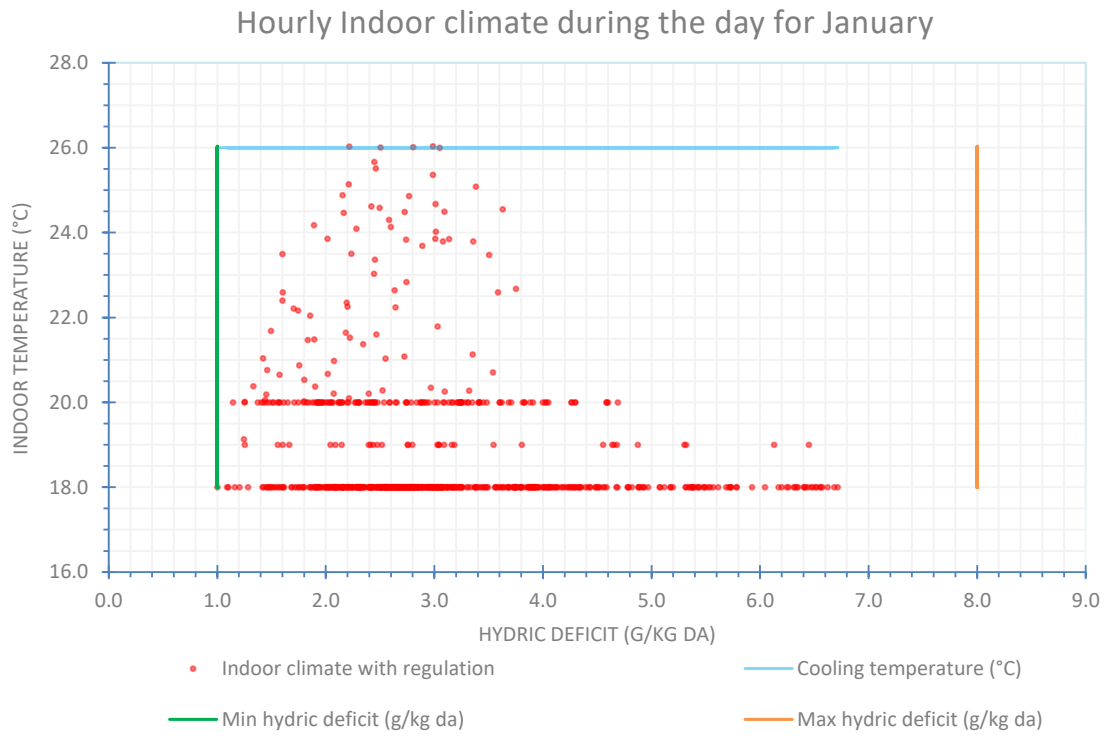
Daily correlation between internal solar radiation and average indoor temperature



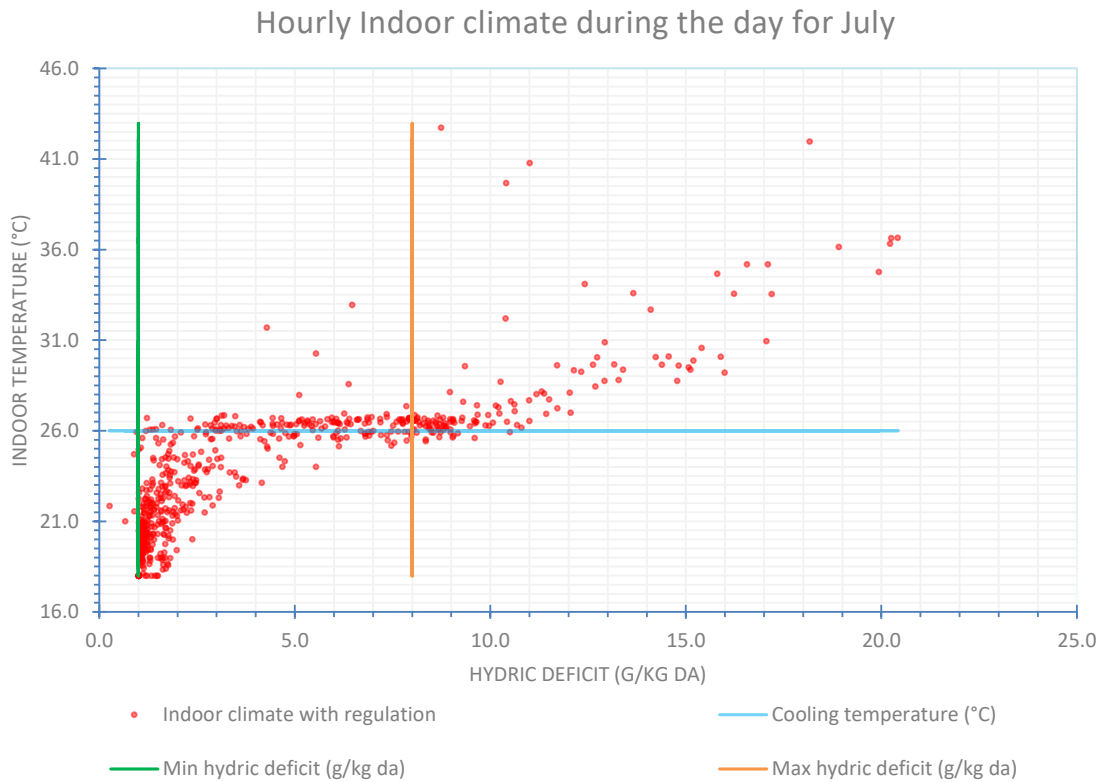
Daily average indoor climate during daytime



Hourly indoor climate during daytime in January

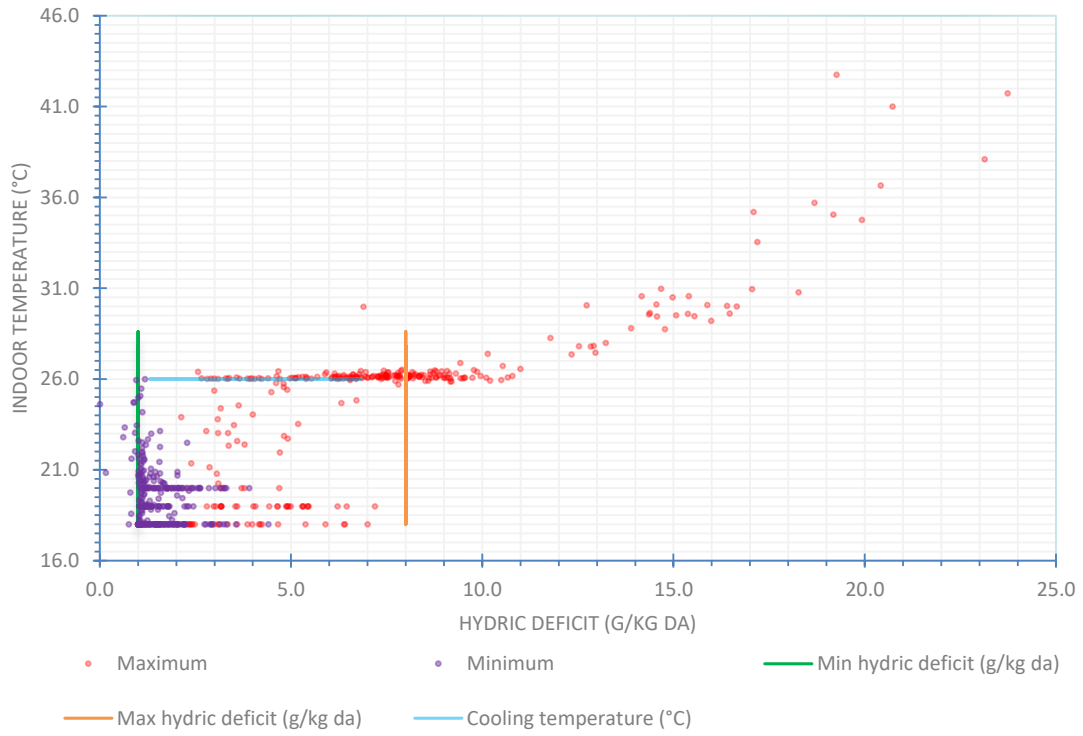


Hourly indoor climate during daytime in July

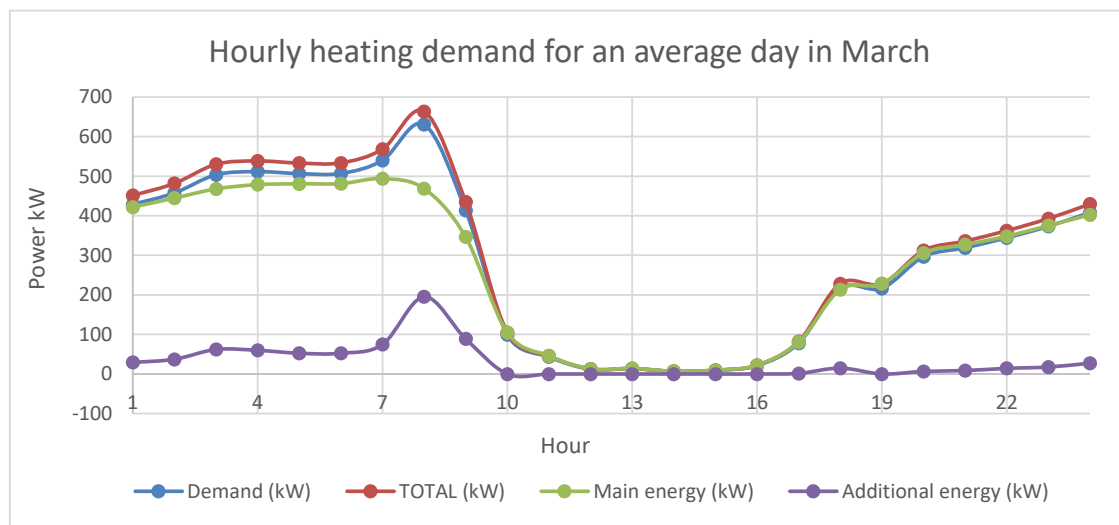
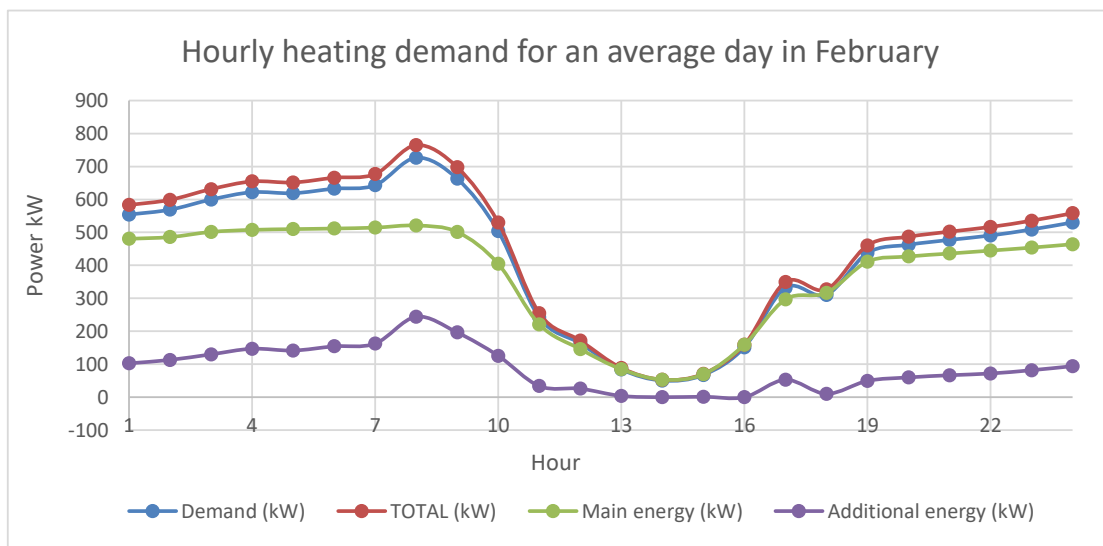
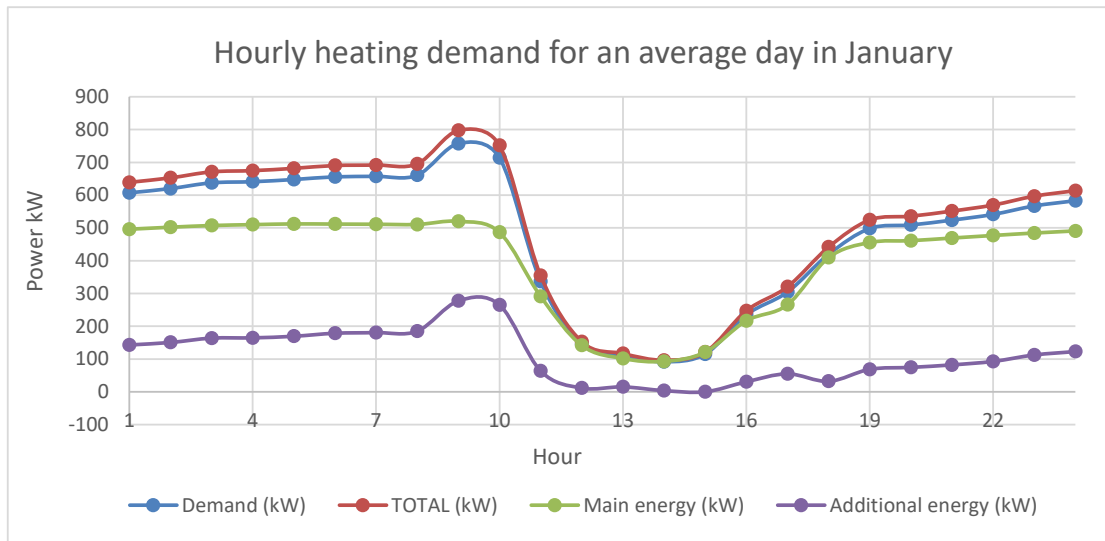


Daily extreme indoor climate during daytime

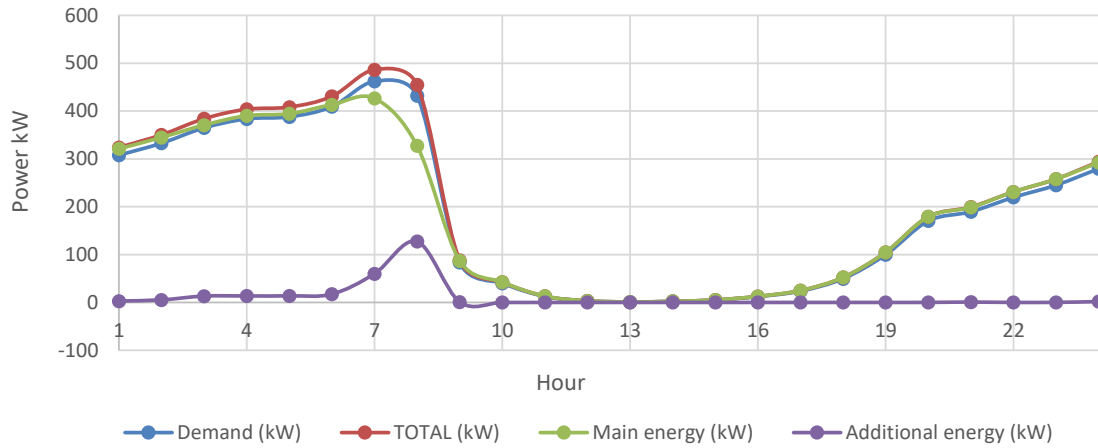
Daily Extreme indoor climate during the day



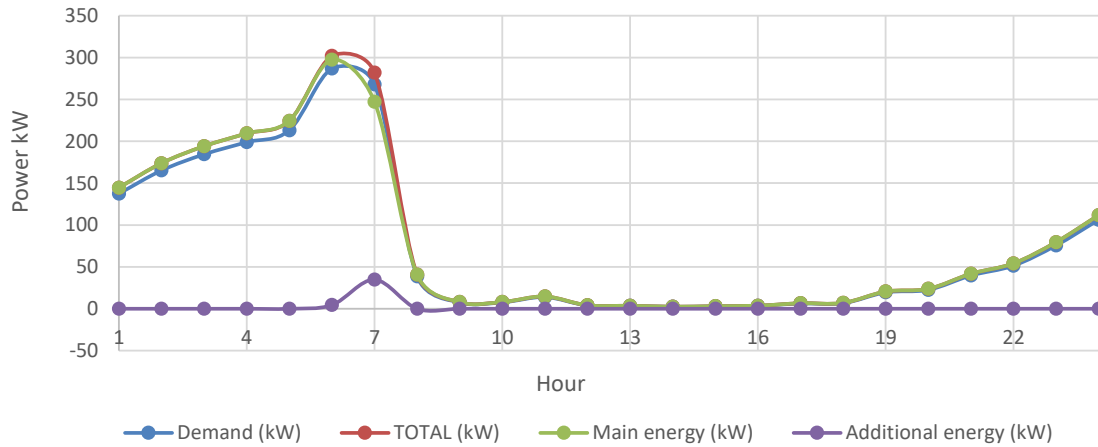
9. Daily energy consumption



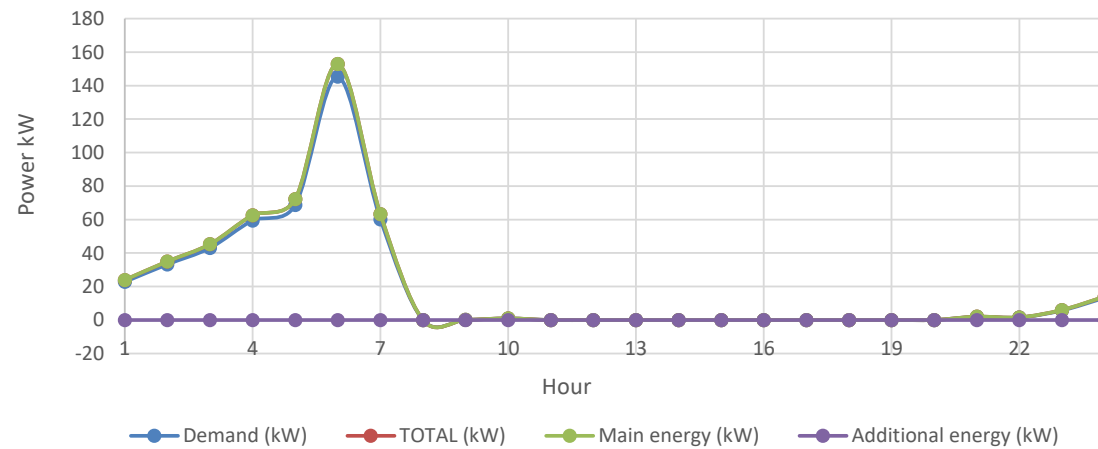
Hourly heating demand for an average day in April



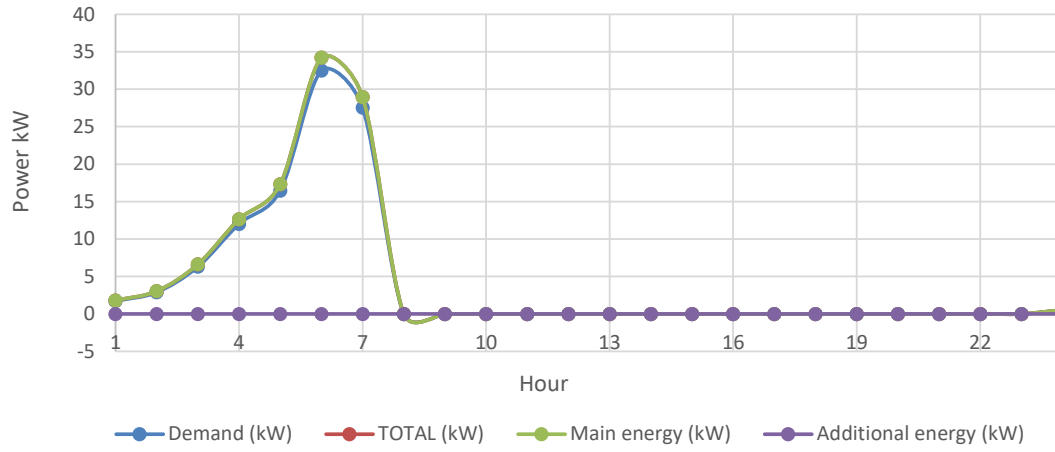
Hourly heating demand for an average day in May



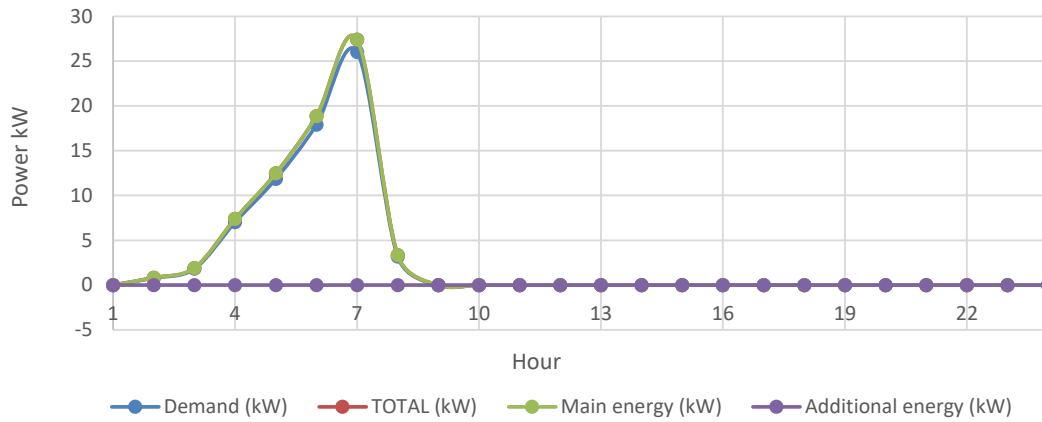
Hourly heating demand for an average day in June



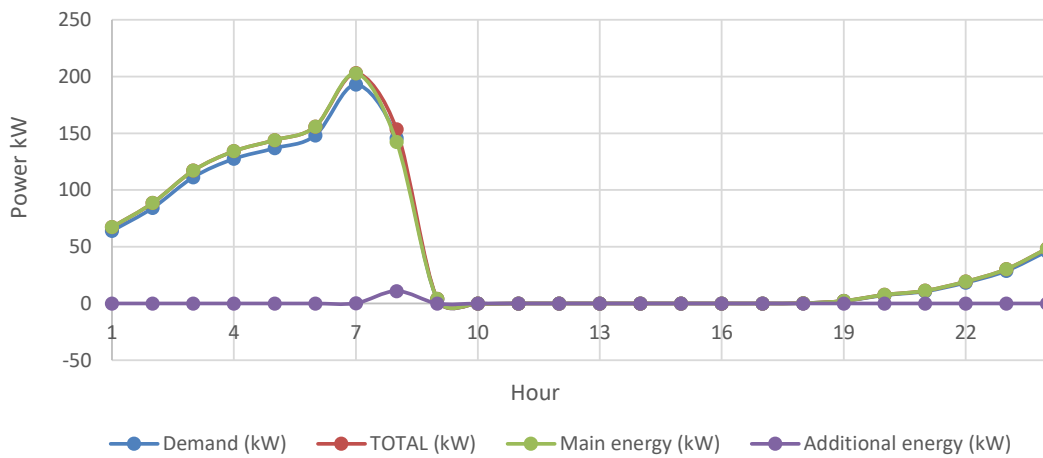
Hourly heating demand for an average day in July



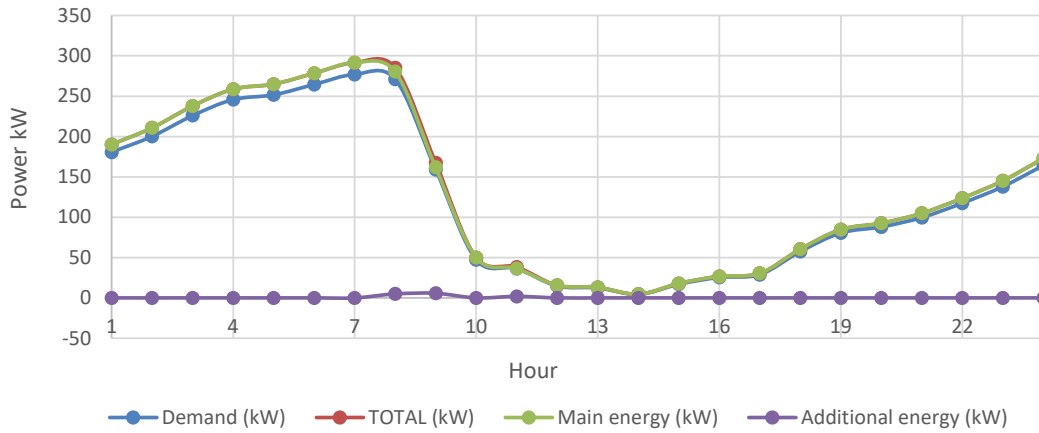
Hourly heating demand for an average day in August



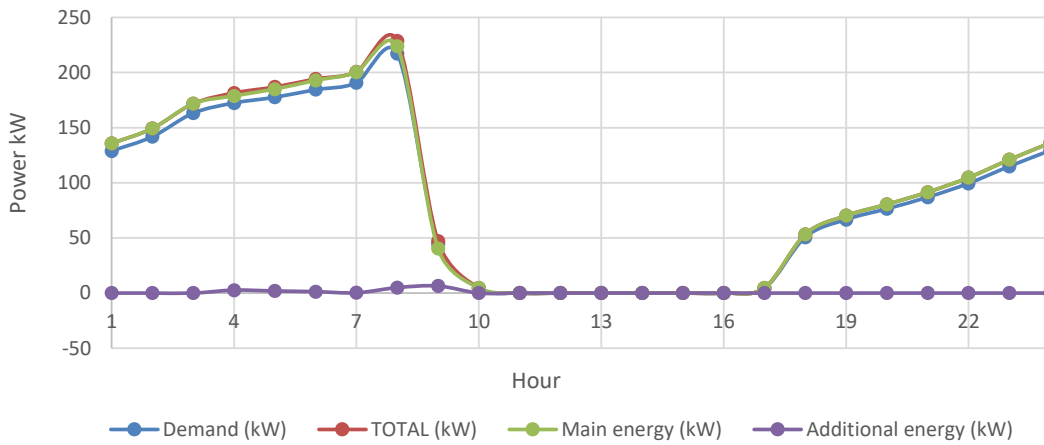
Hourly heating demand for an average day in September



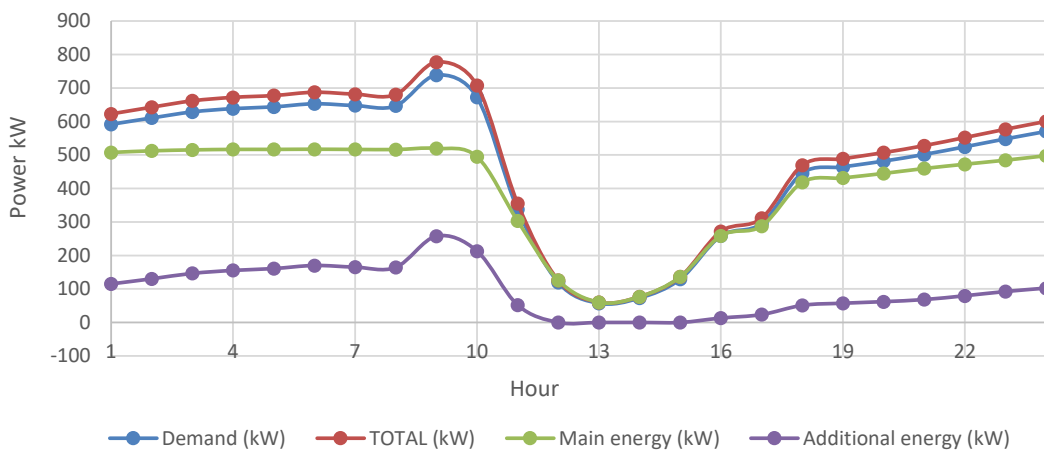
Hourly heating demand for an average day in October



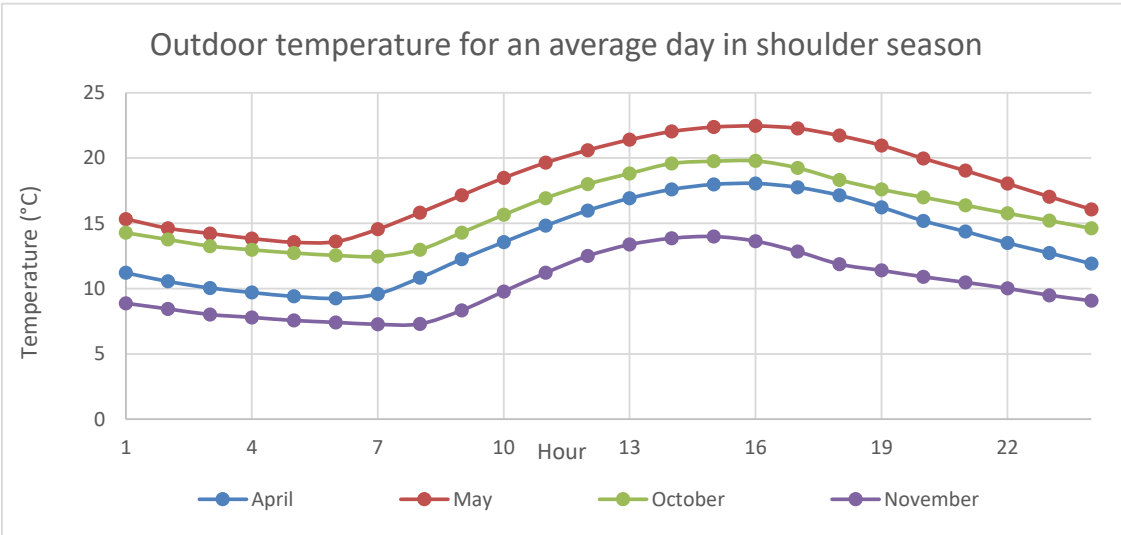
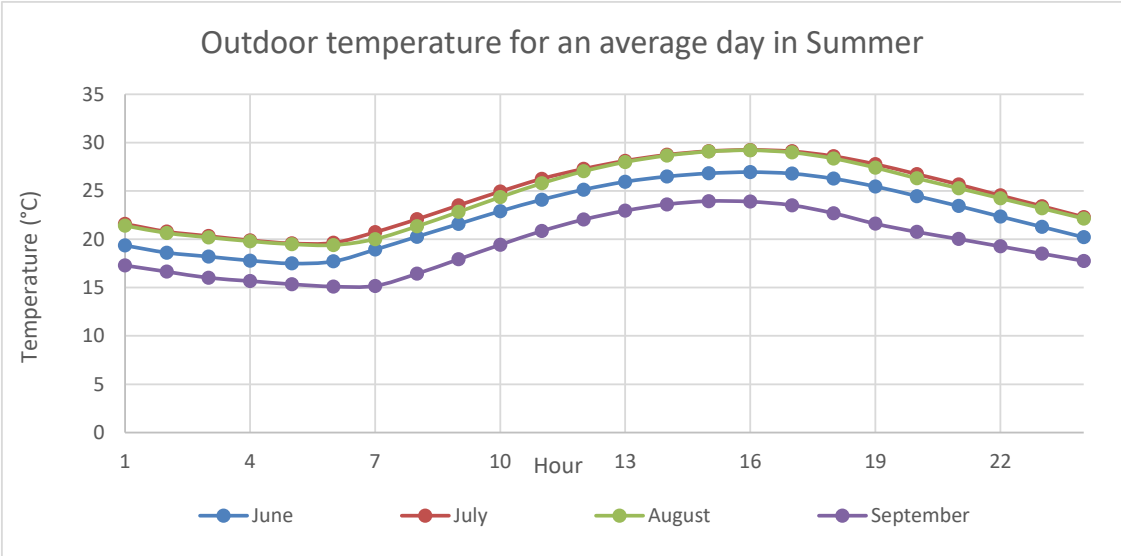
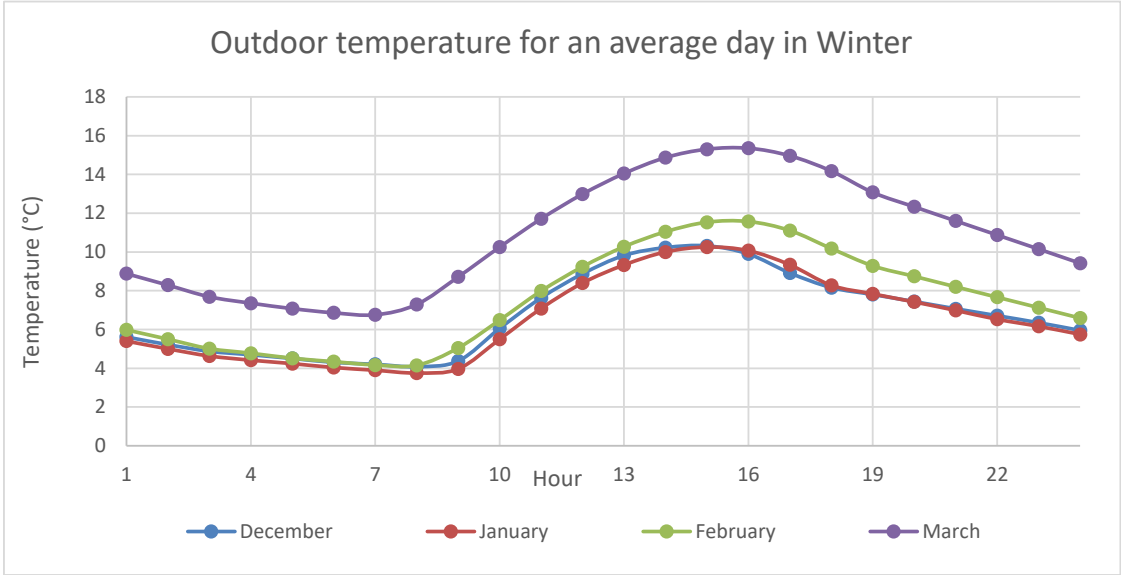
Hourly heating demand for an average day in November



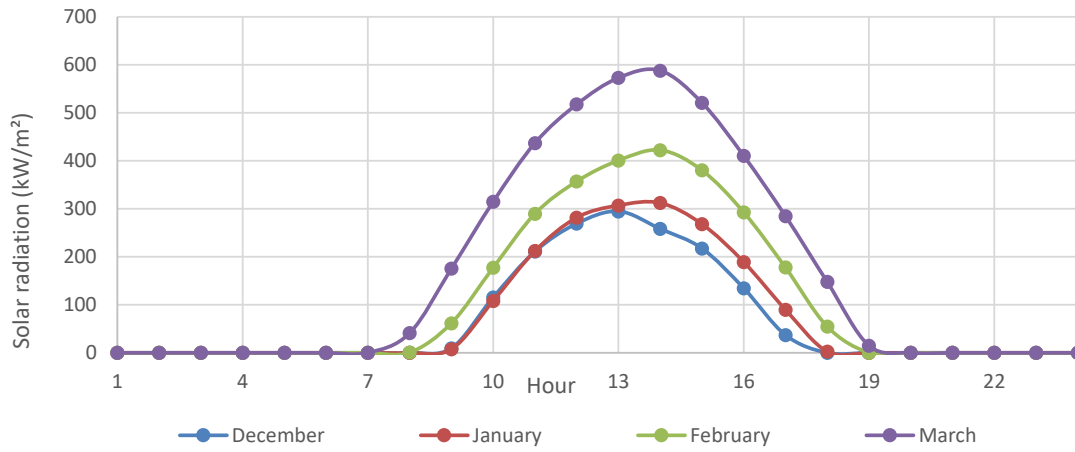
Hourly heating demand for an average day in December



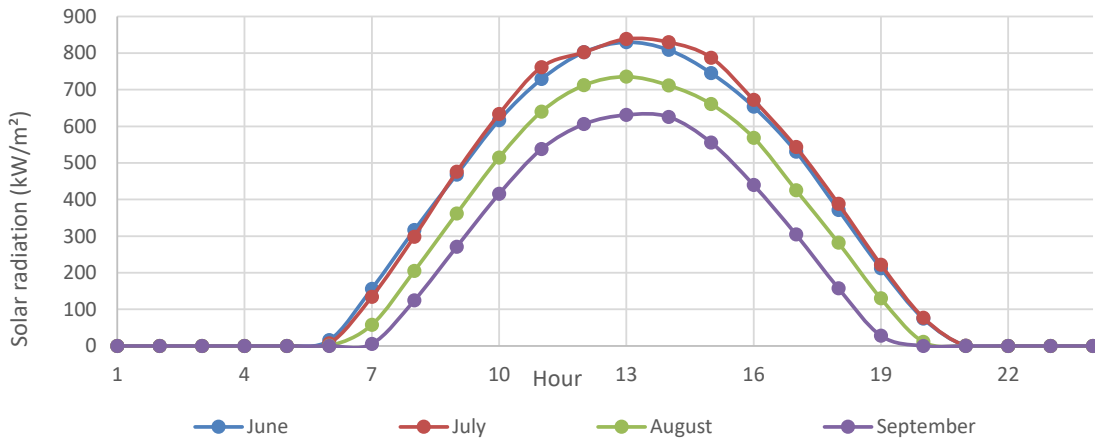
10. Outdoor climate



Solar radiation for an average day



Solar radiation for an average day in Summer



Solar radiation for an average day in shoulder season

