# Report energy requirements Ljusdal


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**Inhoudsopgave**

# 1. Introduction

Royal Pride Holland B.V. investigates the opportunity of producing tomatoes in Sweden. Within this context they asked us to estimate the energy requirements at given location (Ljusdal). The facility will comprise 7 hectares of greenhouses equipped with supplemental lighting (18.000 lux). They also asked to review available climatological data for this location. For this purpose we used the database of meteonorm.com. Their application is able to generate typical datasets for any given location on earth and is considered to be fairly accurate. Using this information we made an estimate of heat and electricity usage (kWh) and load (kW)

**Assumptions:**

- Glass greenhouse equipped with at least 1 screen resulting in a saving of at least 50%. In practise this will take two screens.
- Supplemental lighting 18.000 lux (HP-sodium), maximum 18 hours per day or a global radiation sum comparable to 1.200 J/cm$^2$.day (outside greenhouse)
- 65% of the energy of the lights is assumed to be available for heating
- Heat load is estimated on the basis of an evaporation model and conduction of heat through the cover of the greenhouse driven by temperature difference.
- Continuous growth, thus no periods without energy demand (as opposed to crop changing periods when the greenhouse is temporarily empty)
- 18.000 lux = app 138,5 W/m$^2$ installed power
- Not accounted for occasional snowload, might rise energy consumption at snow days

*Figure 1, Ljusdal Sweden*

## 2. Conclusions

Total heat demand is estimated to be about 383 kWh/m$^2$.year. Total electricity demand is estimated at 420 kWh/m$^2$. Please note that heat is given in kWh ( 1 kWh = 3,6 MJ). To generate this heat with a gasboiler you need more gas (often also quoted in kWh) than this reading due to conversion losses.

*Table 1 Estimated energy demand (power and heat)*

| | heat | electricity operations | electricity lighting | total electricity | |
|---|---|---|---|---|---|
| jan | 50 | 0,59 | 77 | 78 | kWh |
| feb | 45 | 0,54 | 67 | 67 | kWh |
| mrt | 43 | 0,59 | 47 | 47 | kWh |
| apr | 34 | 0,58 | - | 1 | kWh |
| mei | 23 | 0,59 | - | 1 | kWh |
| jun | 15 | 0,58 | - | 1 | kWh |
| jul | 14 | 0,59 | - | 1 | kWh |
| aug | 20 | 0,59 | - | 1 | kWh |
| sep | 30 | 0,58 | - | 1 | kWh |
| okt | 25 | 0,59 | 70 | 71 | kWh |
| nov | 35 | 0,58 | 75 | 75 | kWh |
| dec | 49 | 0,59 | 77 | 78 | kWh |
| **Totaal** | **383** | **7,00** | **413** | **420** | **kWh** |

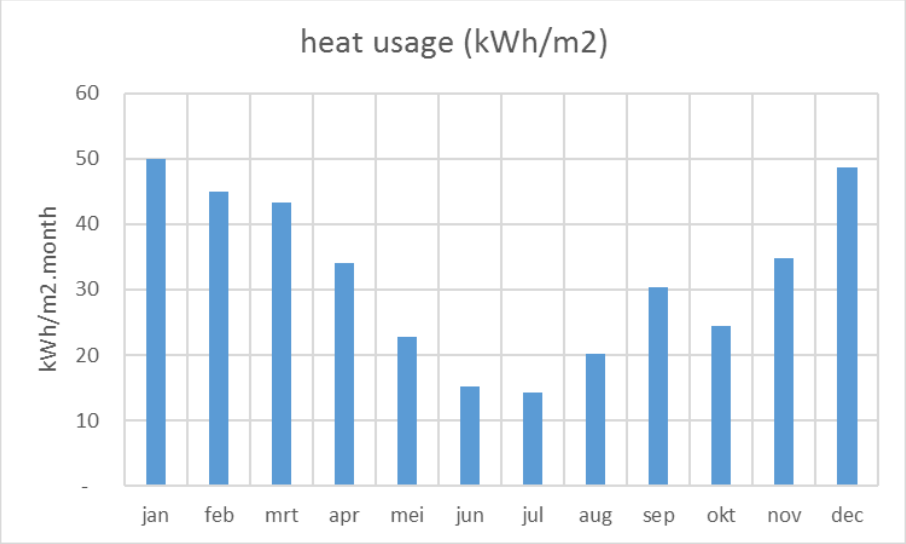


*Figure 2 Estimated heat usage*

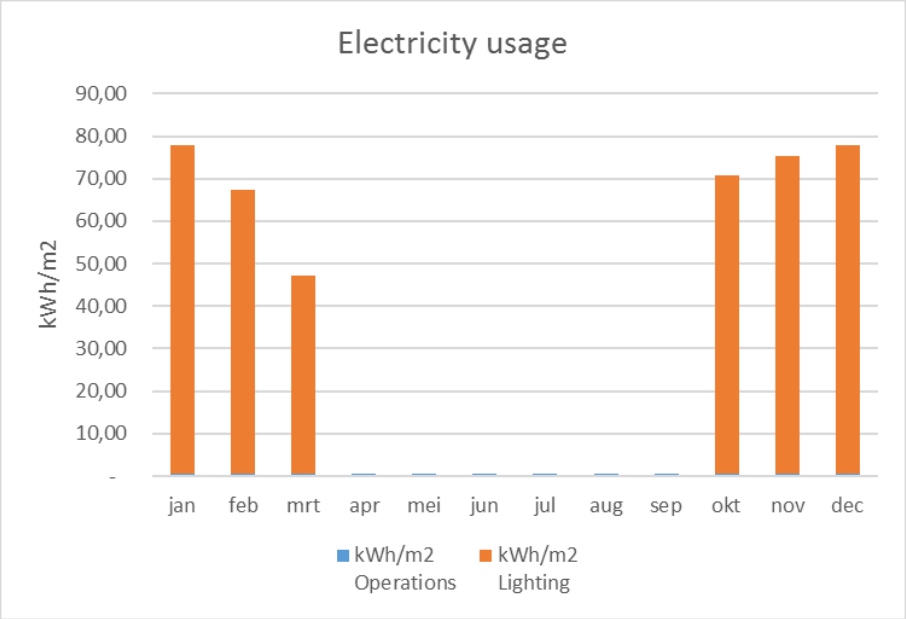


*Figure 3 electricity usage*

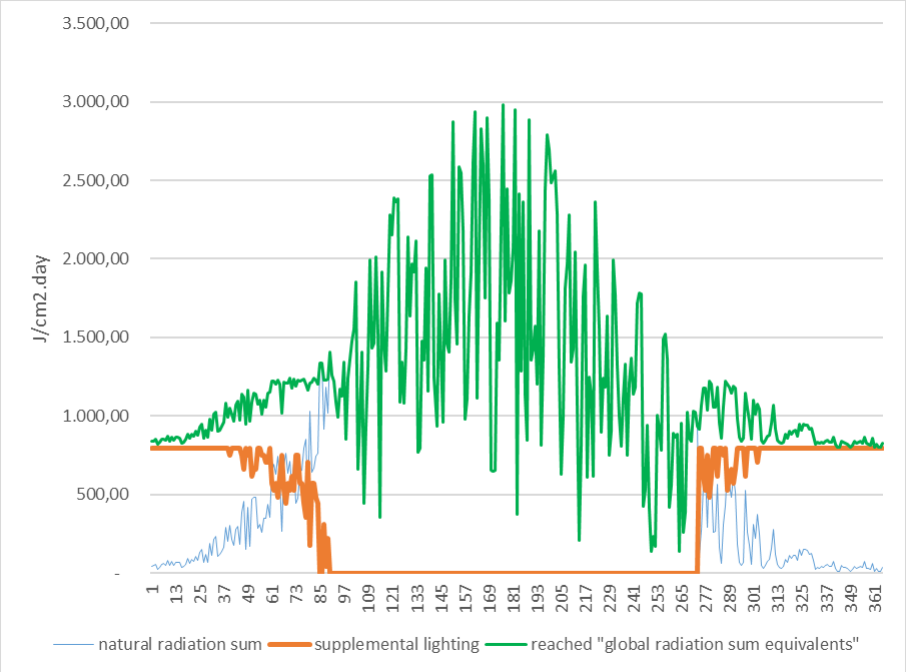


*Figure 4, Effect of supplemental lighting*

The effect of lighting is given in figure 4, expressed as a comparison to outside global horizontal radiation (global radiation equivalents).

| Uur | jan | feb | mrt | apr | mei | jun | jul | aug | sep | okt | nov | dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00 | 100% | 100% | 42% | 0% | 0% | 0% | 0% | 0% | 0% | 97% | 100% | 100% |
| 01 | 100% | 100% | 71% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 02 | 100% | 100% | 77% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 03 | 100% | 100% | 81% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 04 | 100% | 100% | 84% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 05 | 100% | 100% | 87% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 06 | 100% | 100% | 87% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 07 | 100% | 100% | 87% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 08 | 100% | 100% | 90% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 09 | 100% | 100% | 77% | 0% | 0% | 0% | 0% | 0% | 0% | 97% | 100% | 100% |
| 10 | 100% | 100% | 52% | 0% | 0% | 0% | 0% | 0% | 0% | 84% | 100% | 100% |
| 11 | 100% | 89% | 29% | 0% | 0% | 0% | 0% | 0% | 0% | 65% | 100% | 100% |
| 12 | 100% | 79% | 23% | 0% | 0% | 0% | 0% | 0% | 0% | 65% | 100% | 100% |
| 13 | 100% | 79% | 16% | 0% | 0% | 0% | 0% | 0% | 0% | 61% | 100% | 100% |
| 14 | 100% | 75% | 16% | 0% | 0% | 0% | 0% | 0% | 0% | 68% | 100% | 100% |
| 15 | 100% | 100% | 35% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 16 | 100% | 100% | 74% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 100% | 100% |
| 17 | 100% | 100% | 55% | 0% | 0% | 0% | 0% | 0% | 0% | 97% | 100% | 100% |
| 18 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 19 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 20 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 21 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 22 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 23 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

*Figure 5 Estimated lighting hours (with striped natural daylight at Ljusdal)*

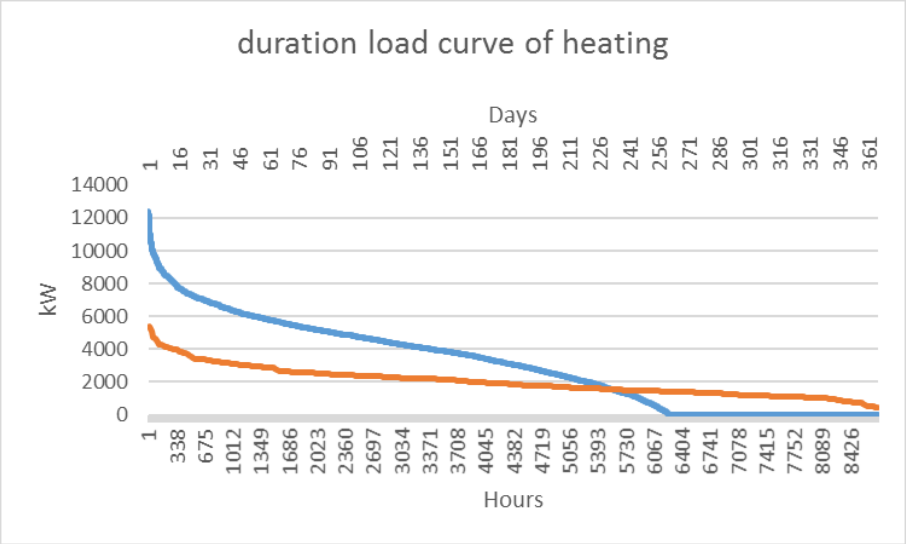


*Figure 6 Duration load curve (blue = hourly and orange = 24h average)*

The heat duration load curve of the facility is given in figure 6. The blue line is the curve of the actual hourly load in the greenhouse. The system in the greenhouse needs to be able to emit max 12 MW. This is higher than the estimated average daily load (orange). Assuming sufficient heat storage, a heat source of about 6 MW should be sufficient to heat the facility. Please note that this is only valid under the condition of lighting (18 hours/day), which provides a large part of the required energy to maintain greenhouse temperature. If lighting should fail, more capacity is needed. Back-up should be able to provide about 13 MW of heat in case lighting failures. Occasional snowload could also lead to additional heat demand.

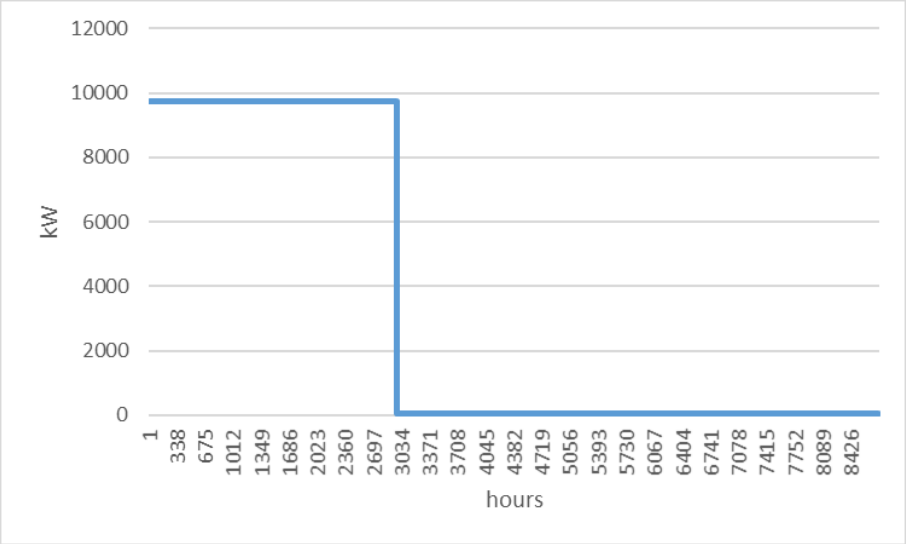


*Figure 7 year duration curve of electricity*

Total power demand for the facility is estimated at somewhat less than 10 MW. So a power connection of at least 10 MVA would be required. From figure 7 follows a total of about 3.000 lighting hours.

# 3. Climatological information

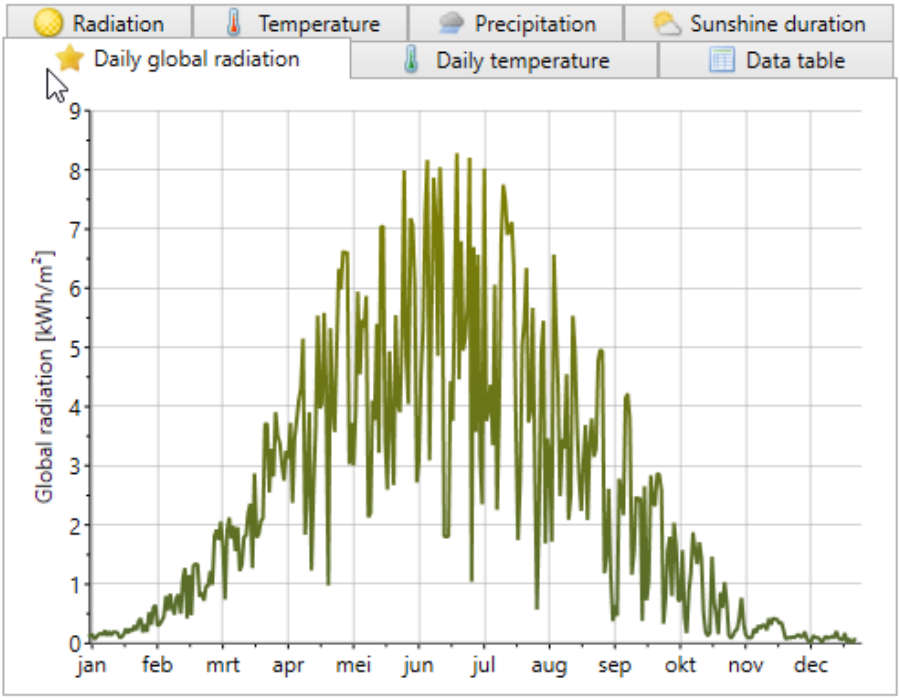


*Figure 8 global horizontal radiation*

Please note that a global horizontal radiation sum of 1 kWh/m$^2$ equals 360 J/cm$^2$.day.

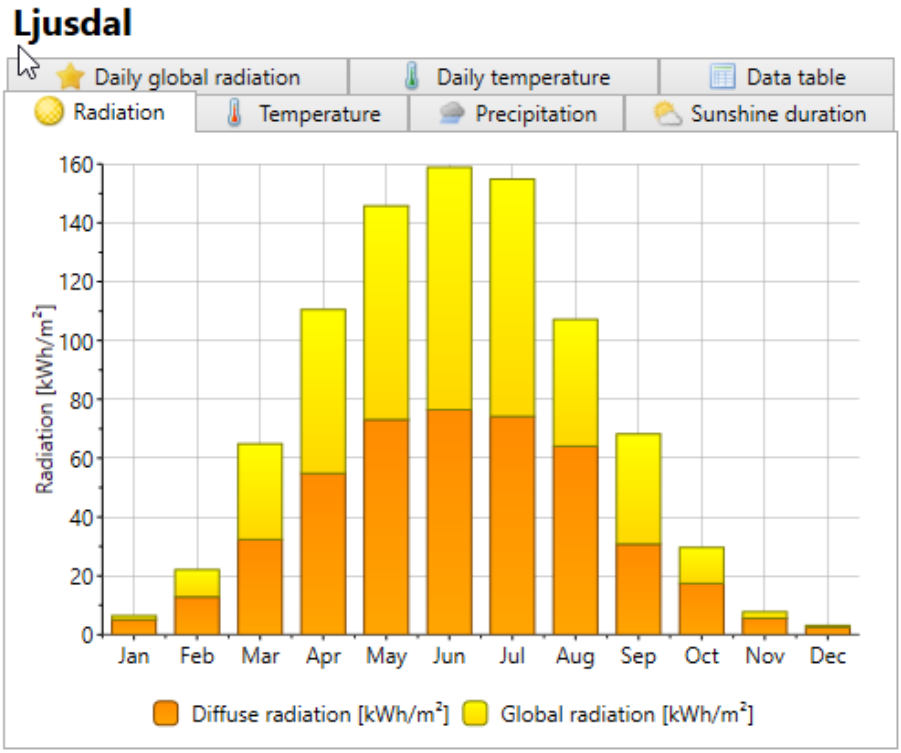


*Figure 9 global radiation, breaked down to diffuse and direct radiation*

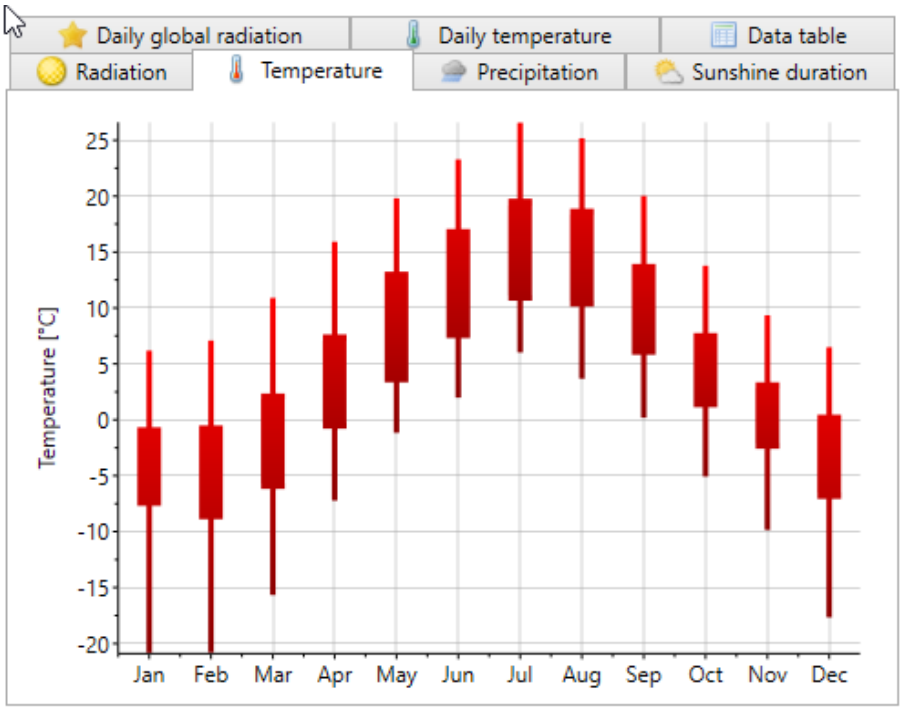


*Figure 10 Temperature*

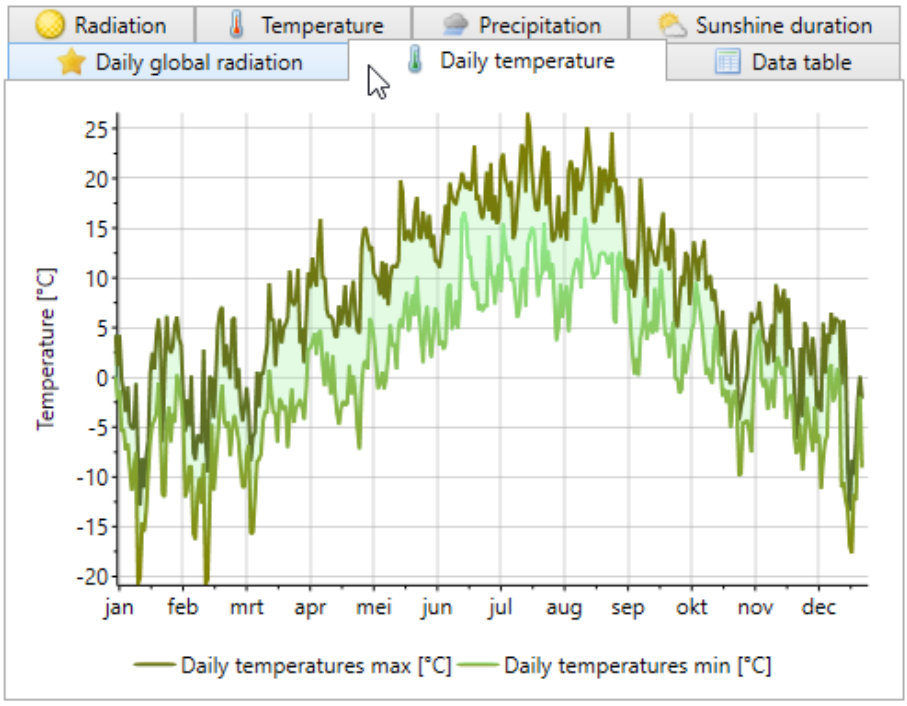


*Figure 11 Temperature*

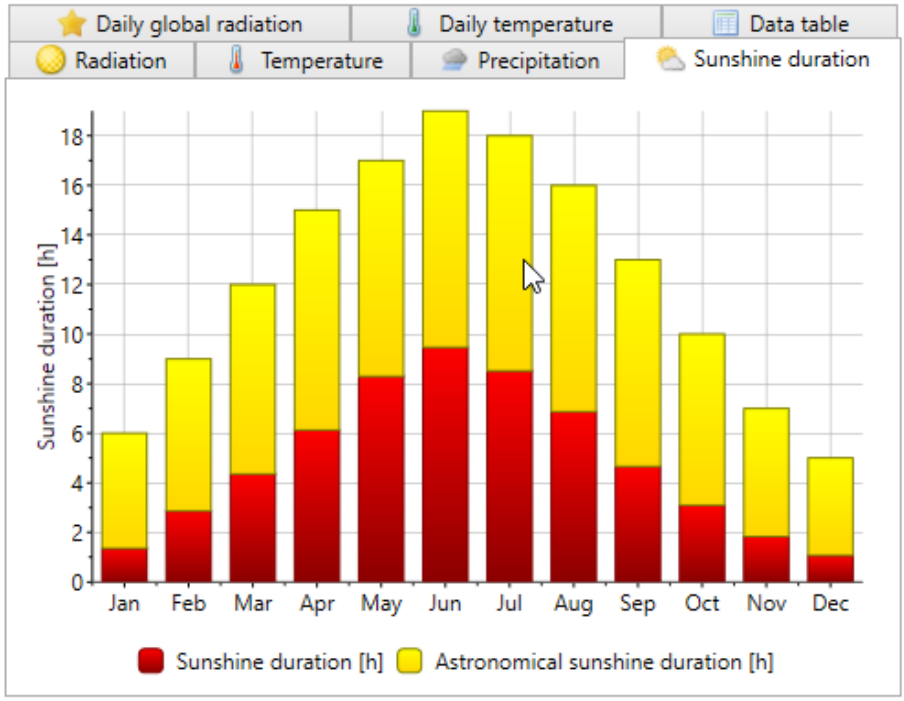


*Figure 12 Sunshine hours*

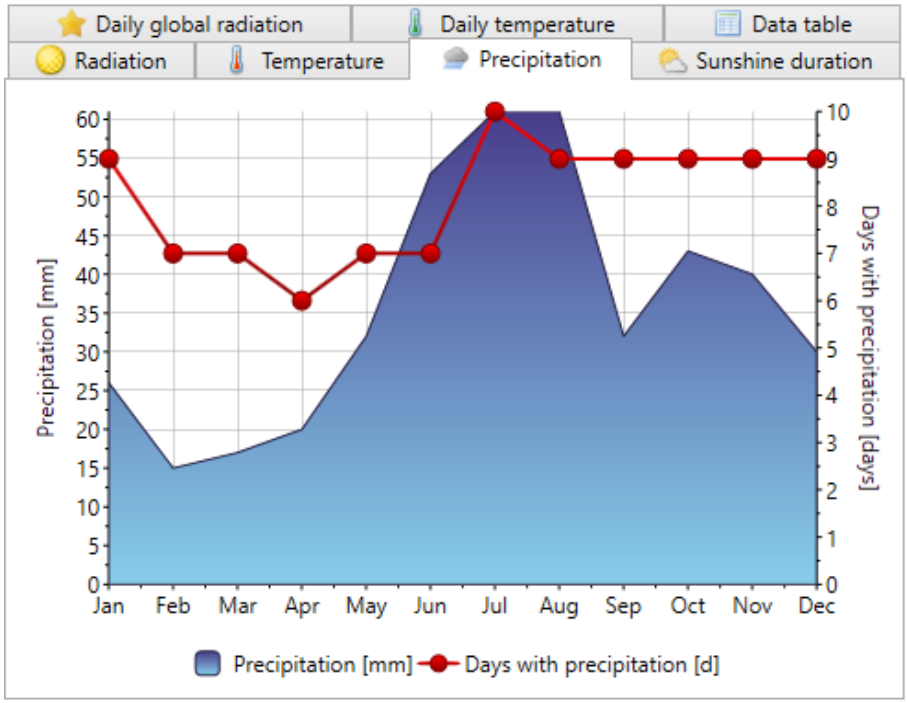


*Figure 13 Preciptation*