Solar Thermal Heating for Biogas Plant in Hooksiel, Germany

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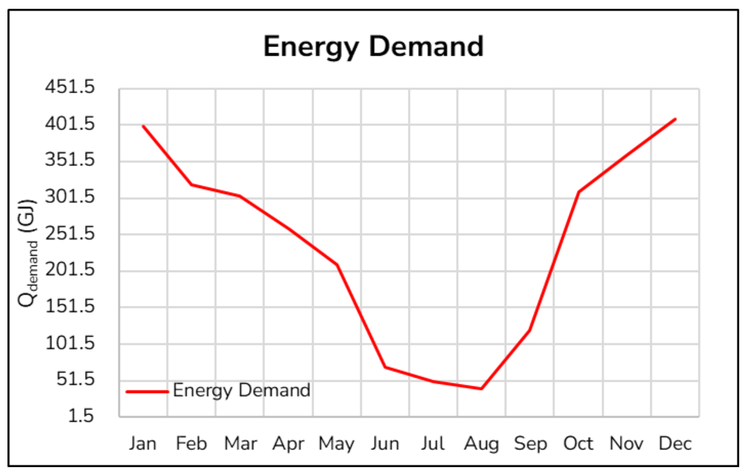
Location & Energy Demand

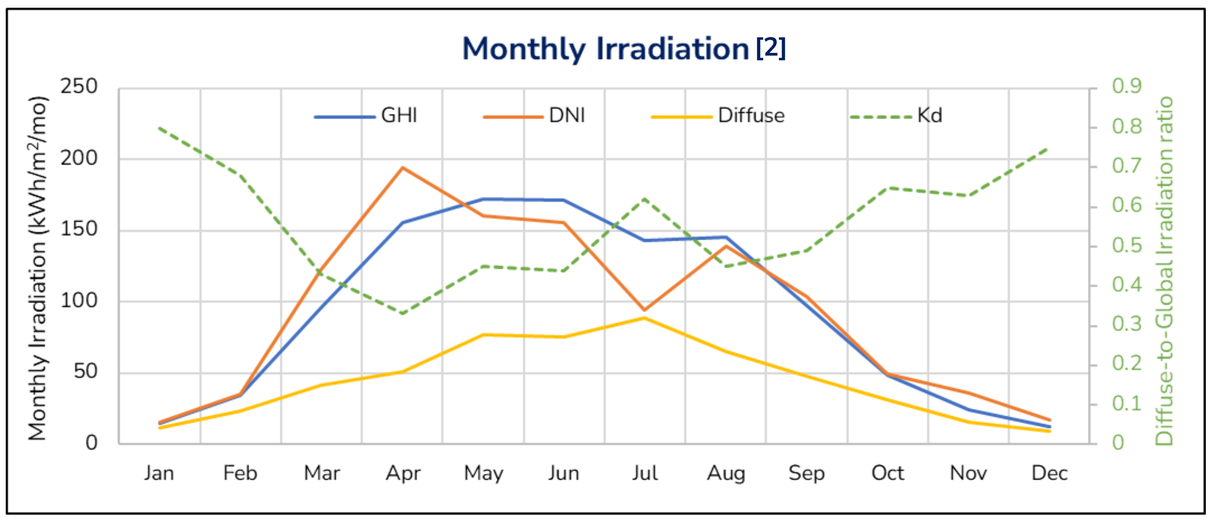
- The location is in Hooksiel, Germany
  Lat-Long coord. : 53°8'28.25"N, 8°12'52.81"E.
- The Biogas plant has 4241 m^3 of manure-slurry mixture.
- The manure needs a temperature of $T_{desired}$ = 34°C.
- The energy demand is higher in the winter and lower in the summer as shown in the plot[3].

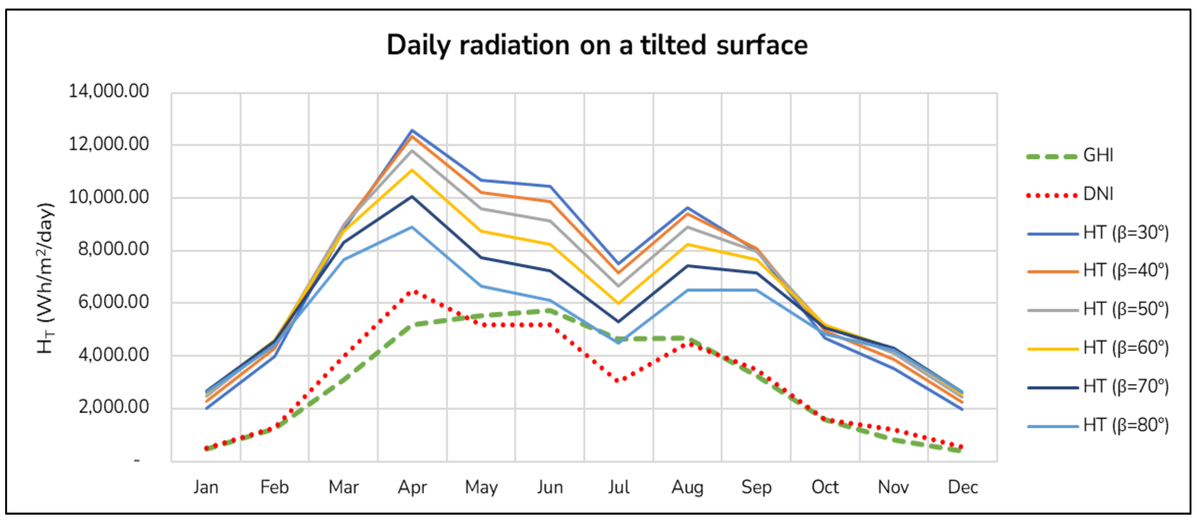


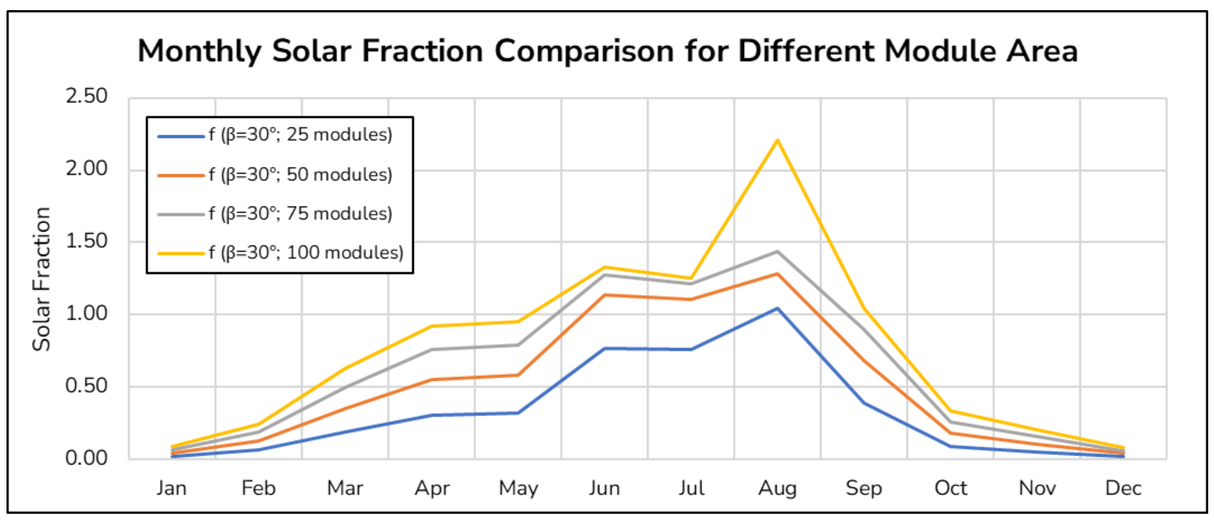
Solar collector

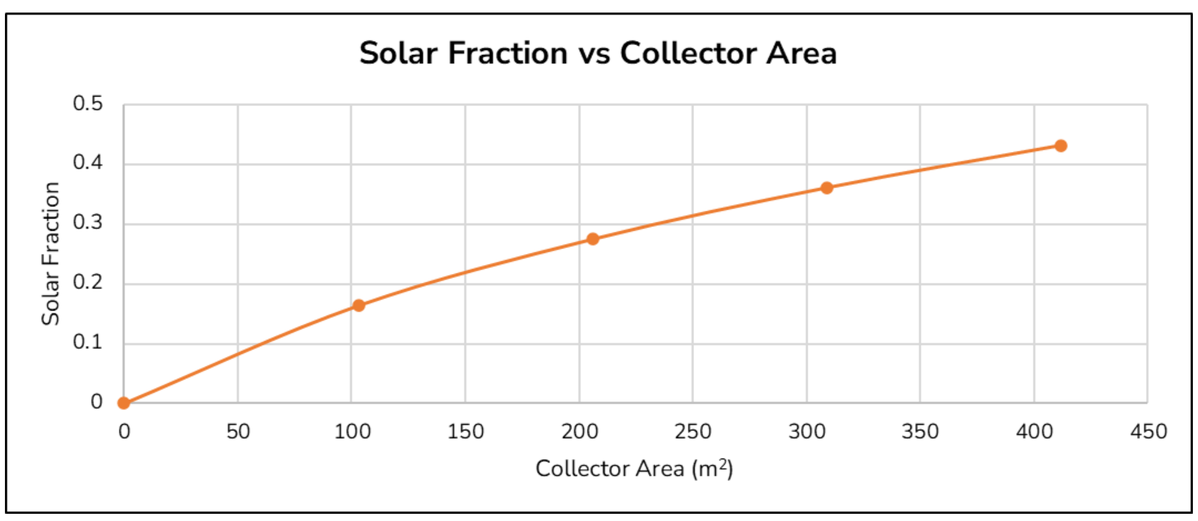
Manufacturer	BMI Braas
Collector Type	Flat plate
Collector Model	TK4 AlTi
$T_{reference}$ [°C]	100
η_0	0.723
a_1 [W/m²]	3.17
a_2 [W/m²]	0.018
G_T [W/m²]	850
Flowrate [(kg/s)/m²]	0,029
Ac [m²]	4.12

Result of F-chart method: Monthly solar fraction as a function of tilt angle and collector area





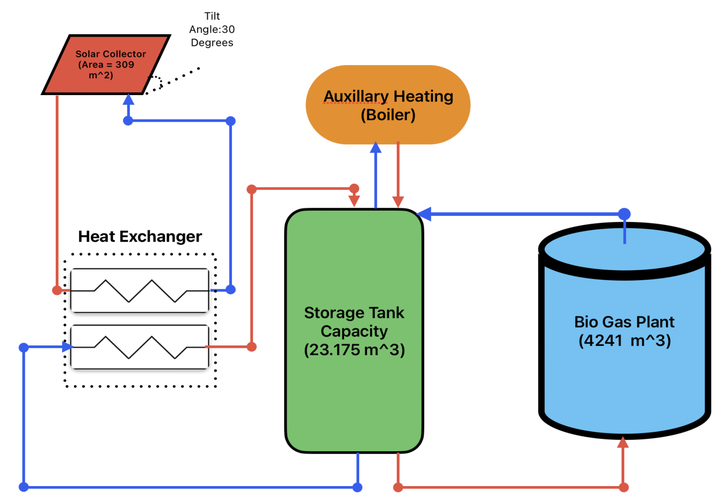




Solar Thermal Heating Systems

- High flow system, mass flow: 8.96 kg/s
- Parallel Connection
- Needed storage tank: 23.175 m^3 (comply to DIN 4753-1:2019-05 standard)
- Preferred tilt angle: 30°
- Preferred collector area: 309 m^2
- Annual performance/solar fraction: 36% with 75 modules.
- The values of Solar fraction was observed to decrease with increase in Tilt Angle (Beta)

System Layout



Conclusion and Inferences

- From the above calculations, we can infer that the modelled solar collector is sufficient to supply the energy demand for the bio gas plant entirely in summer and 7-19 % of the demand in winter.
- An additional boiler is required to compensate for this loss in energy in winter.
- The cost of the system was calculated to be 100,425 EUR which is very expensive for such a heating system.
- Assumption that f-chart method can be used here: We need $F'_R * A_c < 120 m^2$ and that it is comparable to DHW.
- One might need to consider a combination of parallel and series connections.
- Potentially more viable for supplying smaller biogas plants.

References

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[3] http://www.jeeng.net/pdf-89660-26831?filename=Analysis%20of%20Heat%20Loss%20of.pdf
[4] Duffie, John A.; Beckman, William A. (2013): Solar Engineering of Thermal Processes. Fourth Edition. Wiley Science