Design Project - SIE 2019

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Evaluation of heat sources for the production of microalgae


Current installation (Geneva), © H.Madi

Context

The company Enoil Bioenergies is a swiss biotechnology company. One of their activities is to study spirulina production in their research center in Geneva. The culture of this algae in a closed environment requires high heating needs. The willingness to upscale the production at a larger site in Charrat (VS) entails the need for suitable heat sources.

Project purposes

- → Determine the needs
- → Search for suitable heat sources for the site and find the appropriate devices
- → Evaluate these sources from an economic and environmental point of view
- → Set up preferential heating scenarios by contriving a scoring system

Methodology

- Visit of the research center in Geneva
- Literature review
- Practical calculations
- Discussions with experts in the field
- Contacts with technology sellers and Charrat municipality

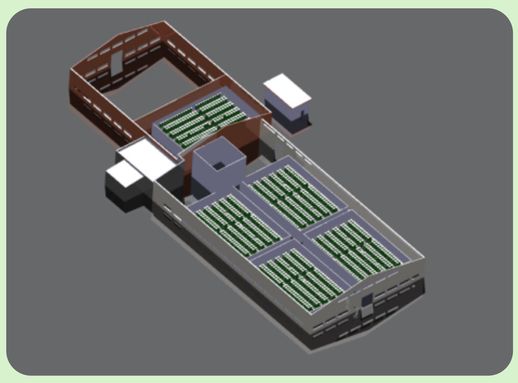
Building

Data

- 5 growth rooms of 3340 m^3
- Total Volume : 16'700 m^3
- 1500 batch reactors
- 1 drying room
- Assumed average temperature of 19°C in the rest of the building.
- Roof area : 5236 m^2

Needs

- Water temperature at 30 ° C → air temperature at 34°C in the growth rooms
- Air compressor for the injection of a CO_2-O_2 mixture in the reactors
- Air temperature at 35°C in the drying room
- Estimated annual heating needs: **~ 1'731'852 kWh**


Overview of the future site (Charrat)

Energy sources

Fuel oil
Condensation fuel oil boiler
Estimate: ~ 183'265 l/yr.
- big buried oil tank
- CO_2 and particle emissions

Gas
Condensation gas boiler
Estimate: ~ 168305 m^3/yr.
- CO_2 and particle emissions
- no gas network in Charrat

Wood
Shredded wood boiler
Estimate: ~ 1560 m^3/yr.
+ neutral CO_2 balance
- NOx, CO, VOCs emissions

Geothermal
Ground-to-water heat pump
+ efficient and constant all year long
- building in "Au" zone -> probes probably forbidden

Photovoltaic
Annual production : ~10^6 kWh
+ no need for fuel
+ no emissions
- high investment
- depending on the weather

Thermal solar
Annual production: ~716'000 kWh
+ no need for fuel
+ no emissions
- high investment
- depending on the weather

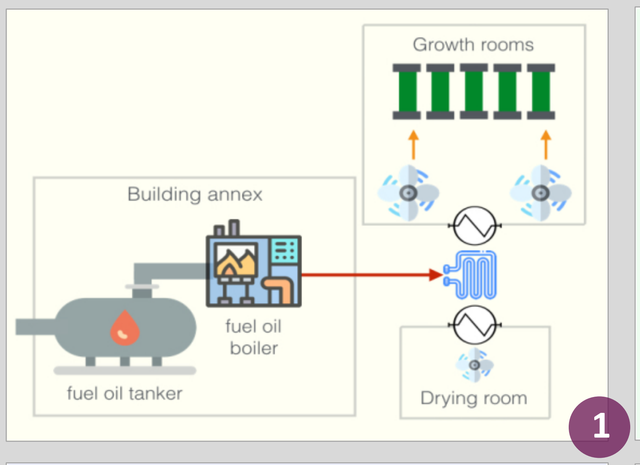
Air
Air-to-water heat pump
power uptake: ~ 494'815 kWh/yr.
+ no direct emission
- depending on the air temperature

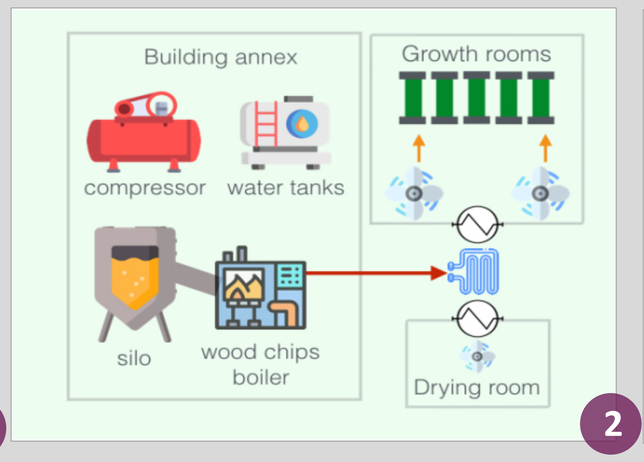
Compressor heat losses
Losses used to heat the air
heating capacity < 1 growth room
+ limitation of energy losses
+ free energy
- decisive choice of the compressor

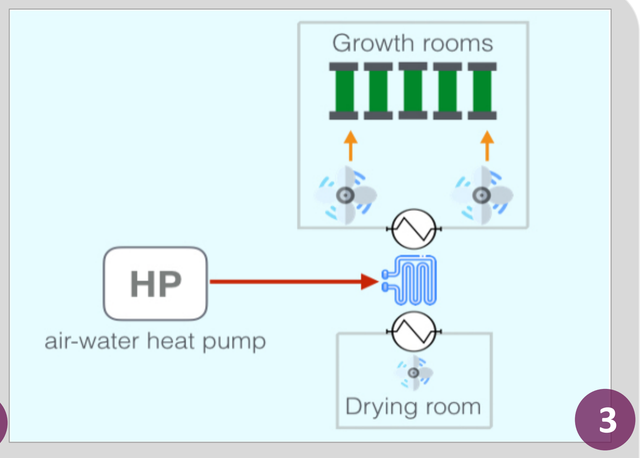
Scenarios

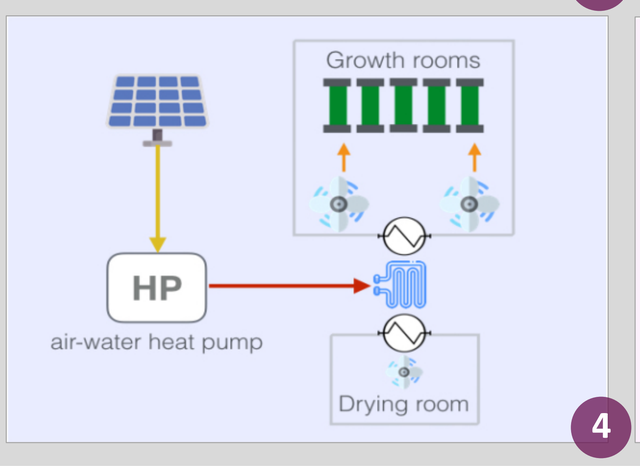
Caption :
hot water flow
hot air flow
electric current
heated water mass
fan
heat exchanger

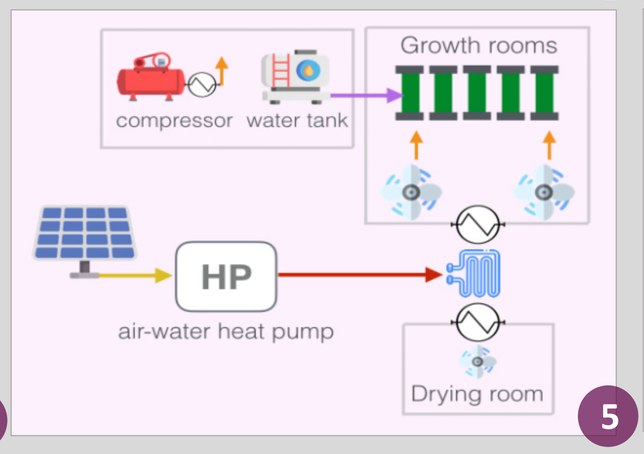
1. Fuel oil boiler
2. Shredded wood boiler
3. Air-to-water heat pump powered by electricity grid
4. Air-to-water heat pump powered by photovoltaic panels
5. Air-to-water heat pump powered by photovoltaic panels + recovery of compressor heat losses
6. Example of complex scenario using only indigenous energy sources (not properly assessed because too many unknowns)

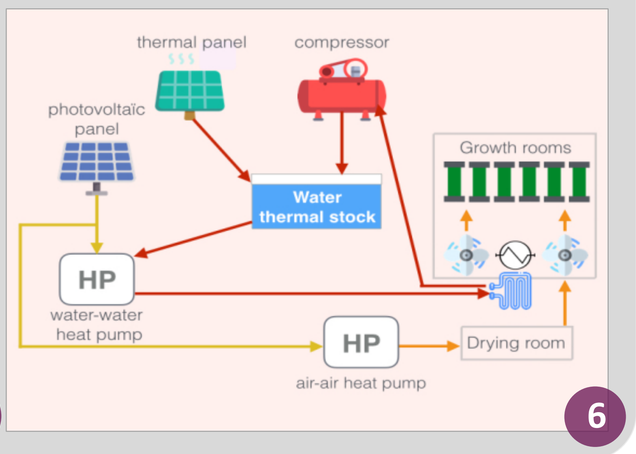












Assessment

	Storage ease	Origin	CO_2	Ressource depletion	Smoke emission quality	Global ecology	Price	Subsidies	Weighted average
Scenario 1	+	abroad (swiss finish) ++	+	+	++	+	+	-	+
Scenario 2	++	local (forests) +++	+++++	++	+	+++	+++	-	+++
Scenario 3	++++	local (electricity mix) +++	+++	++++	+++	+++	++	++	++
Scenario 4	++++	local (on the roof) ++++	++++	++++	++++	++++	++++	++++	++++
Scenario 5	++++	local (on the roof) ++++	+++++	++++	++++	+++++	+++++	++++	+++++

- The price includes the basic investment and functioning over 10 years.
- The given weights are : storage (5%), origin (5%), ecology (40%), price (45%) and subsidies (5%).

Discussion

- Scenario 5 seems to be the best scenario given the chosen criteria.
- Wood heating can also be adapted to the context if the life of the plant is less than 10 years.
- The choice of important criteria is subjective and this scenario is "the best" only among the selected ones.
- As the building is not yet transformed, the study is based on many assumptions.
- There is a legal aspect that one has to take into account (subsidies, prohibitions).
- The options (in particular those of scenario 6 could be deeper explored with the use of building 3D modelling, simulation software and precise professional price quotes.

Conclusions

→ The study shows that a heating design including an air-to-water heat pump, photovoltaic panels and recovery of compressor heat losses would be well suited to the context.

→ This work is a preliminary study that would be interesting to support later, including exploring the possibilities presented in scenario six.

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