Feasibility Study

Solar Brewery

Met-Bräu Vertriebs GesmbH

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Feasibility for the implementation of solar cooling within a solar-brewery process

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The process

Since June 2006 the Austrian brewery „Neuwirth“, Met-Bräu Vertriebs GesmbH, offers solar brewed beer. The temperatures needed in the brewing processes are in the range between 50 and 95°C. This is a temperature range, which can be produced by advanced double glazed flat plate collectors. Whereas large-scale breweries have usually huge heat recovery potentials to provide heat for the low temperature processes due to several parallel production lines, this is not the case for small-scale breweries. They are operated usually in a batch process. Therefore small-scale breweries show a bigger potential for solar heat integration. AEE – Institute for Sustainable Technologies (AEE INTEC) in cooperation with the brew master developed an overall concept, which allows the integration of solar heat into the brewing process. Based on this, a brew kettle with special heat exchanges was designed and built.

The solar collectors of this demonstration plant have a capacity of 14 kW_{th} (20 m^2). The heat produced by special double-glazed, anti-reflective coated solar collectors is delivered to a hot water storage tank with a capacity of 0.85 m^3 where also a wood log fired heat backup with a capacity of 70 kW is implemented. The brew kettles have a volume of 400 and 200 litres respectively. With this system about 40,000 litres of beer are brewed annually. Fig. 1 shows the hydraulic concept of the brewery plant.

The beer mash is heated up to 95°C and after about 6 hours cooled down to about 75°C. This beer mash then is further cooled down to 10°C before entering the brew tank. This occures with fresh cold water to 18°C in the first step and with icewater in the second step. After the fermentation the beer is filled in pressure barrels which are stored in the refrigeration room at 4°C. The cold energy for the refrigeration room and the ice water production is done by two separate electrical driven compression chillers. The ice water tank has a volume of 200 l with a need of 1 kW cooling capacity. The cooling load of the refrigeration room is 5 kW during peak times when new beer bottles need to be cooled down to 4°C and 2.5 kW to keep the room constant at 4°C.

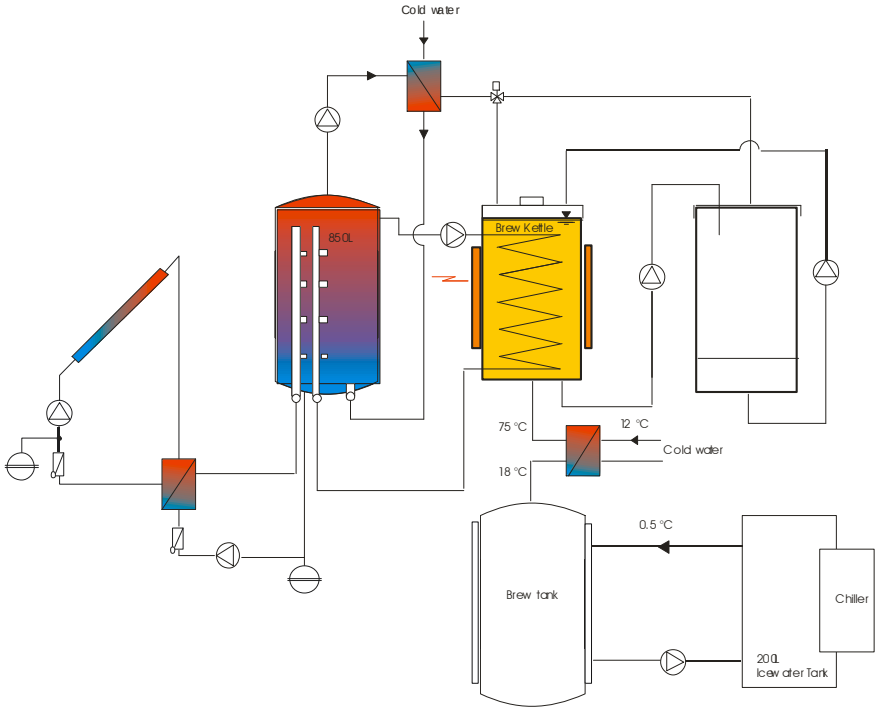

Fig. 1: Hydraulic concept of the SOLARBREWERY

A guest room with 200 m^2 space has no conditioning opportunity up to now. For this guest room cooling equipment shall be installed as well, the cooling load is approx. 9 kW when fully occupied.

Possible solar cooling concept

Because of the necessity of ice water production a PINK PSC12 absorption chiller with ammonia as coolant and water as solvent with a rated cooling capacity of 12 kW is proposed.
Under given conditions, like a generator flow of 85 °C and a return of 78°C, recooling temperature of 24 °C and cold water temperatures of -3/0 °C, a cooling capacity of around **6 kW** and a thermal coefficient of performance (COP_th) of 0.49 can be reached (icewater production). With the same conditions, but a cold water temperature of 6/12 °C (fan coils in the guest room) the cooling capacity is **11.5 kW** and the COP_th amounts 0.6. (6900 kg/h cold water flow, 4200 kg/h generator flow, 10000 kg/h recooling flow). Recooling can be done via a swimmingpool with a volume of 60 m^3 and the ground collectors of an existing ground coupled heat pump with a length of 1,000 m in total.

Two existing compression chiller will operate as back up; one for the ice water production (3.5 kW cold) and the other one for the refrigeration room (3.5 kW cold).
On Mondays and casually Tuesdays beer is brewed with the need of icewater and hot water for the brewery process, the unsteadily gastronomy business takes place from Thursday to Sunday and the refrigeration room has to be cooled continuously 7 days a week.

Table 1 shows the cooling power demand and the possible solar cooling power generation per weekday. As said before, ice water production with a cooling power demand of 1 kW is only needed Mondays and Tuesdays. The cooling demand of the refrigeration room is given every day. Whereas the demand during the brewery process with 5 kW is higher than the demand without internal loads (2.5 kW) the rest of the time. Thursday till Sunday there is gastronomy business where one 200 m^2 saloon needs 9 kW cooling power. In Table 1 the sum of the maximum cooling power demand is obvious for each weekday. Considering the different operating conditions, the possible cooling capacity of the thermal driven chiller is either 6 or 11.5 kW. So the comparison of cooling power demand and possible cooling power generation shows, that this absorption chiller can generate ice water, cool the refrigeration room and condition the saloon. A thermal back up with a heating capacity of 70 kW exists beside to two compression split units (two times 3.5 kW cold capacity).

Table 1: comparison between cold demand and possible cold production [kW]

	mo	tu	we	th	fr	sa	su
	cooling power demand						
icewater	1,0	1,0					
refrigeration room	5,0	5,0	2,5	2,5	2,5	2,5	2,5
gastronomy				9,0	9,0	9,0	9,0
sum	**6,0**	**6,0**	**2,5**	**11,5**	**11,5**	**11,5**	**11,5**
	possible cooling power						
absorption chiller	**6,0**	**6,0**	**11,5**	**11,5**	**11,5**	**11,5**	**11,5**
refrigeration room chiller	3,5	3,5	3,5	3,5	3,5	3,5	3,5
icewater chiller	3,5	3,5	3,5	3,5	3,5	3,5	3,5
	13	13	18,5	18,5	18,5	18,5	18,5

The double-glazed, anti-reflective coated solar collectors show an efficiency of 55 % at 90 °C collector temperature. With solar irradiation of 1000 W/m^2 it is possible to produce 11 kW_{th}.

In the following the required generator power is calculated for the different modes of operation:

Mo-Tu: COP_{th}=0.49 (-3/0°C), cooling power demand= 6 kW → Generator power=12.2 kW
We: COP_{th}=0.49 (-3/0°C), cooling power demand= 2.5 kW → Generator power=5.1 kW
Th-Su: COP_{th}=0.6 (6/12°C), cooling power demand= 9.0 kW → Generator power=15 kW

This shows that with 20m^2 collector area and a maximum of 11 kW_{th} heat production it is just possible to fulfil the heat requirements for cooling on Monday and Tuesday. But then there is a gap, if it is taken into account that also heat for the brewing process must be generated in parallel. Also from Thursday to Sunday the cooling demand of up to 9 kW demands heating power of 15 kW, which can just not be reached with the existing collector area.

Conclusion

Based on these facts, following proposal of implementing a solar cooling with a PSC12 absorption chiller is given:

1. Doubling of the collector area to about 40 m²
2. Active heat backup at each brewing day. This is actually done with a wood log fired boiler but in near future the installation of an automatic operating wood chip boiler is planned.
3. If thermal energy does not suffice for cooling, the two existing compression chiller will serve as cold backup.
4. FanCoils will be integrated in the saloon and the refrigeration room, the icewater tank will be adapted with a connection to the absorption chiller.
5. The absorption chiller will be supplied with energy from the existing 850 l stratifier storage and the 2000 l heat storage. A cold water storage will be installed additionally.
6. Recooling is done in series via the swimming pool and the existing ground collector of the ground coupled heat pump.
7. A special control strategy has to be developed. It should allow a smooth brewing process, handle the thermal and electric back up systems in a way, that the cooling energy demands can be covered every time.

If the collector area is not enlarged, no significant contribution of the solar collectors for cooling is possible during the brewing process because the heat is needed anyway for heating the beer mash. But actually there is surplus of solar energy from Wednesday to Sunday which could be used for cooling the refrigeration room and improving the climatic situation in the guest room. Cooling demand at low temperature level during the brewing process still must be covered by the existing compression chillers.

If solar cooling is not used for the brewing process and therefore no ice water production is needed, alternatively to the PSC12 ammonia chiller the adsorption chiller ACS15 (15 kW nominal cooling capacity) from the company SorTech could be used. Advantage of this chiller is the integrated heat pump mode which perfectly could be combined with the wood chip boiler and the already existing ground collector in winter time for a high efficient space heating concept.