SHIP Egypt

Solar Process Heat

Wolfgang Glatzl & Josef Buchinger

AEE INTEC & ConPlusUltra

Outline

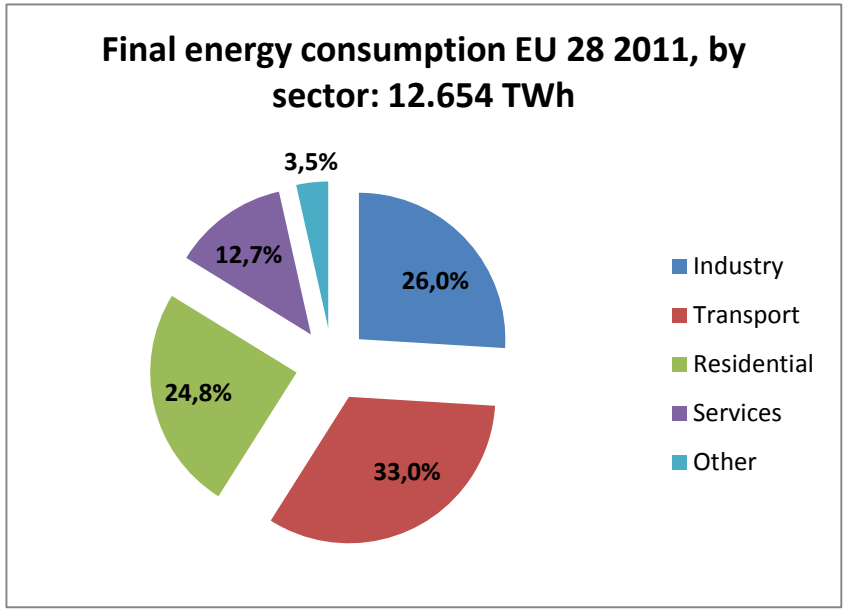
- Introduction „Solar thermal heat for industrial processes“
  - Motivation and potentials
  - Assessment methodology for solar thermal integration
  - Classification of integration concepts
  - Process heat collectors

- **Concepts and experiences with installed systems**
  - **Introduction to the project „SolarBrew“**
  - **State of the project and introduction to the three demonstration sites**
    - **Brewery Goess, Austria (Mashing)**
    - **Brewery Valencia, Spain (Pasteurizing)**
    - **Malting Plant Vialonga, Portugal (Drying)**

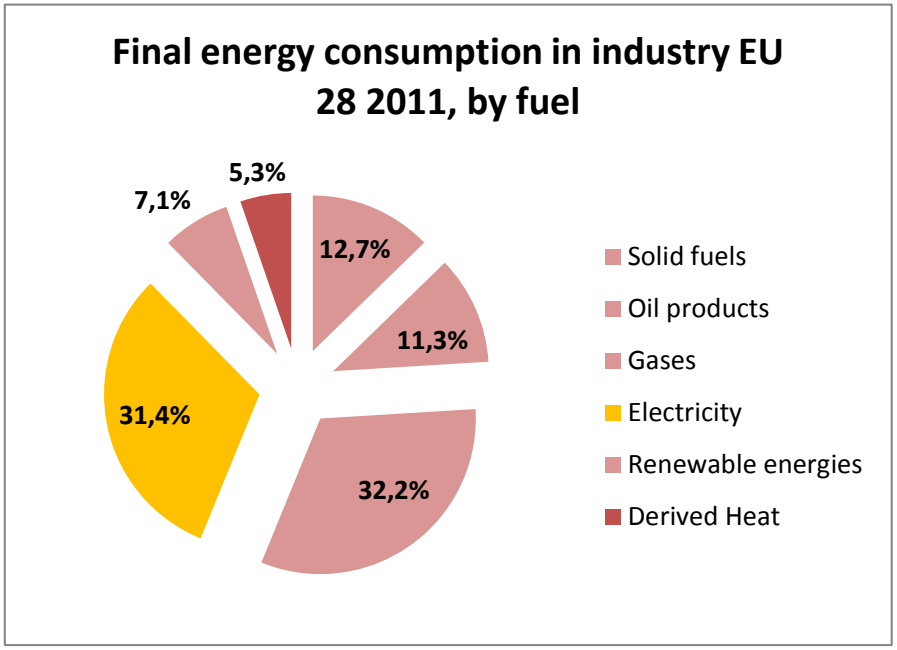
Motivation and potentials

Why solar thermal heat in industry?

- Industry sector is second largest energy consumer
- Predominant share of industrial energy demand is heat (57% in 2010) @ different temperature levels



data source: Eurostat 2013 (online data code: nrg_100a)

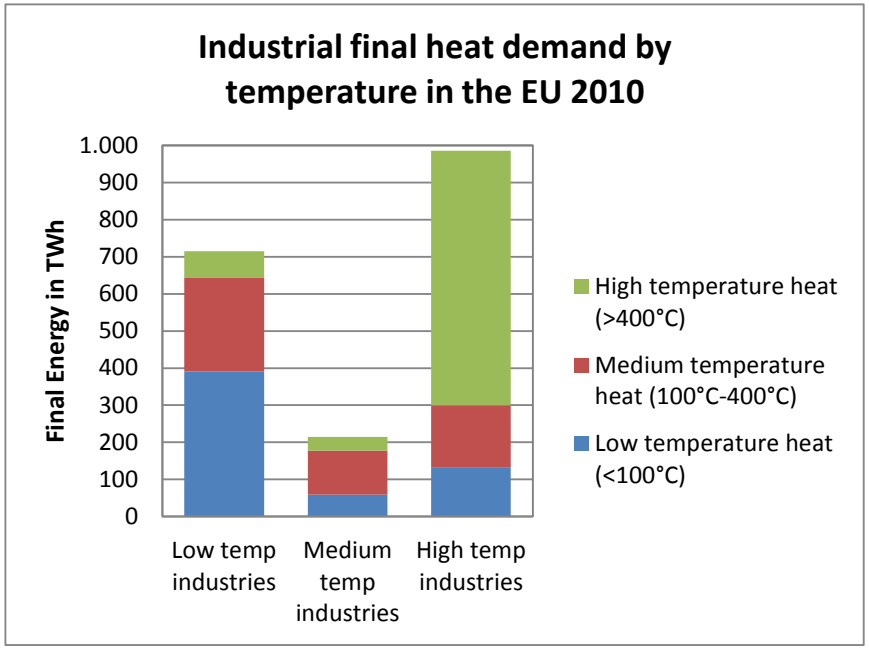


data source: Eurostat 2013

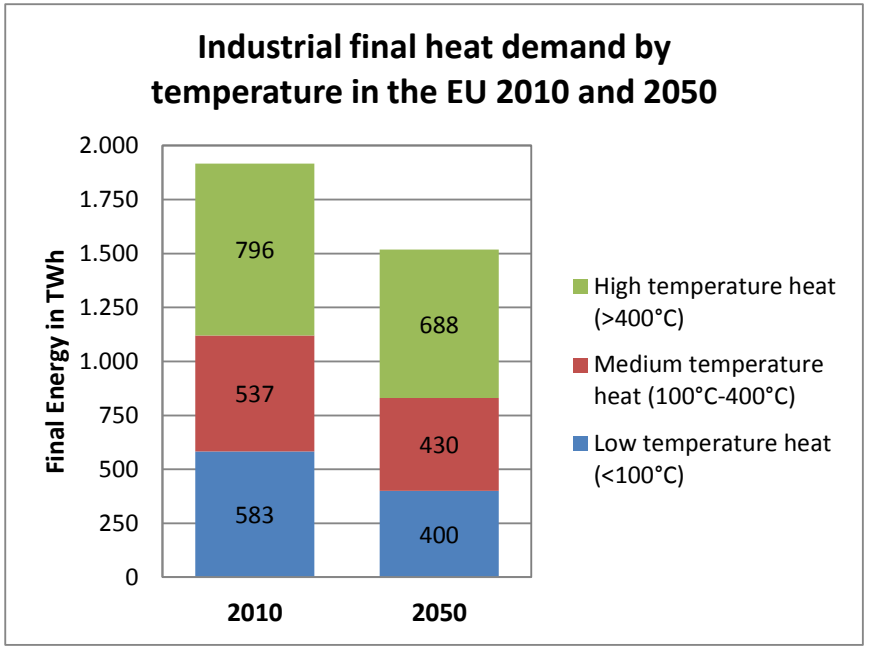
Motivation and potentials

Why solar thermal heat in industry?

- 30% of heat needed @ temperatures <100°C → suitable for non-concentrating solar thermal technology
- 28% of heat needed @ temperatures between 100 and 400°C → suitable for concentrating solar thermal technology



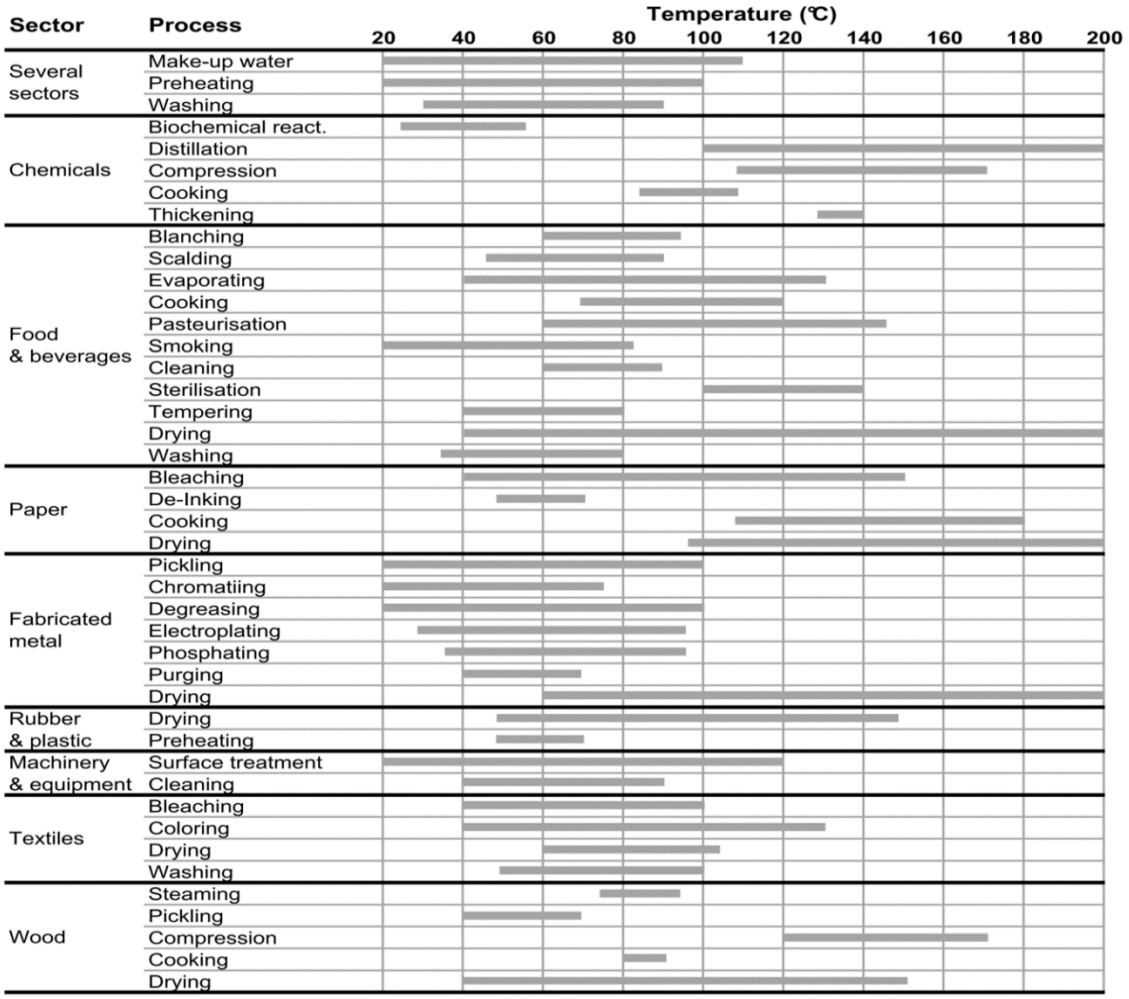
data source: IEA ETP 2012



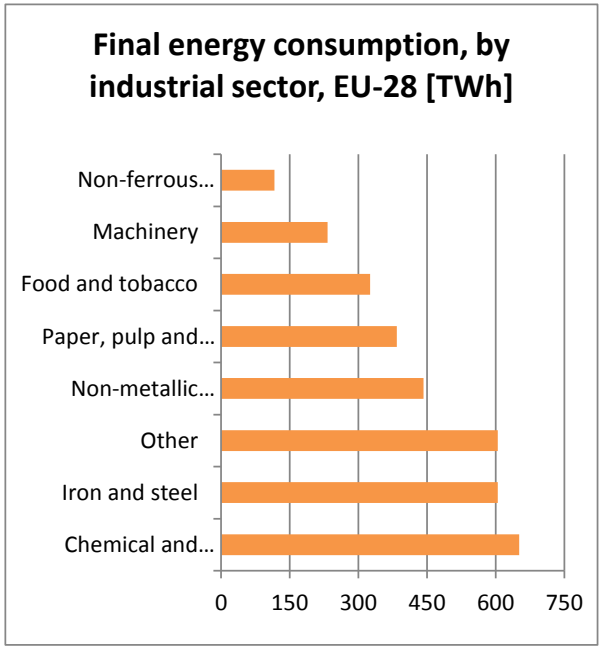
data source: IEA ETP 2012

Motivation and potentials

Process temperature levels of various industrial processes



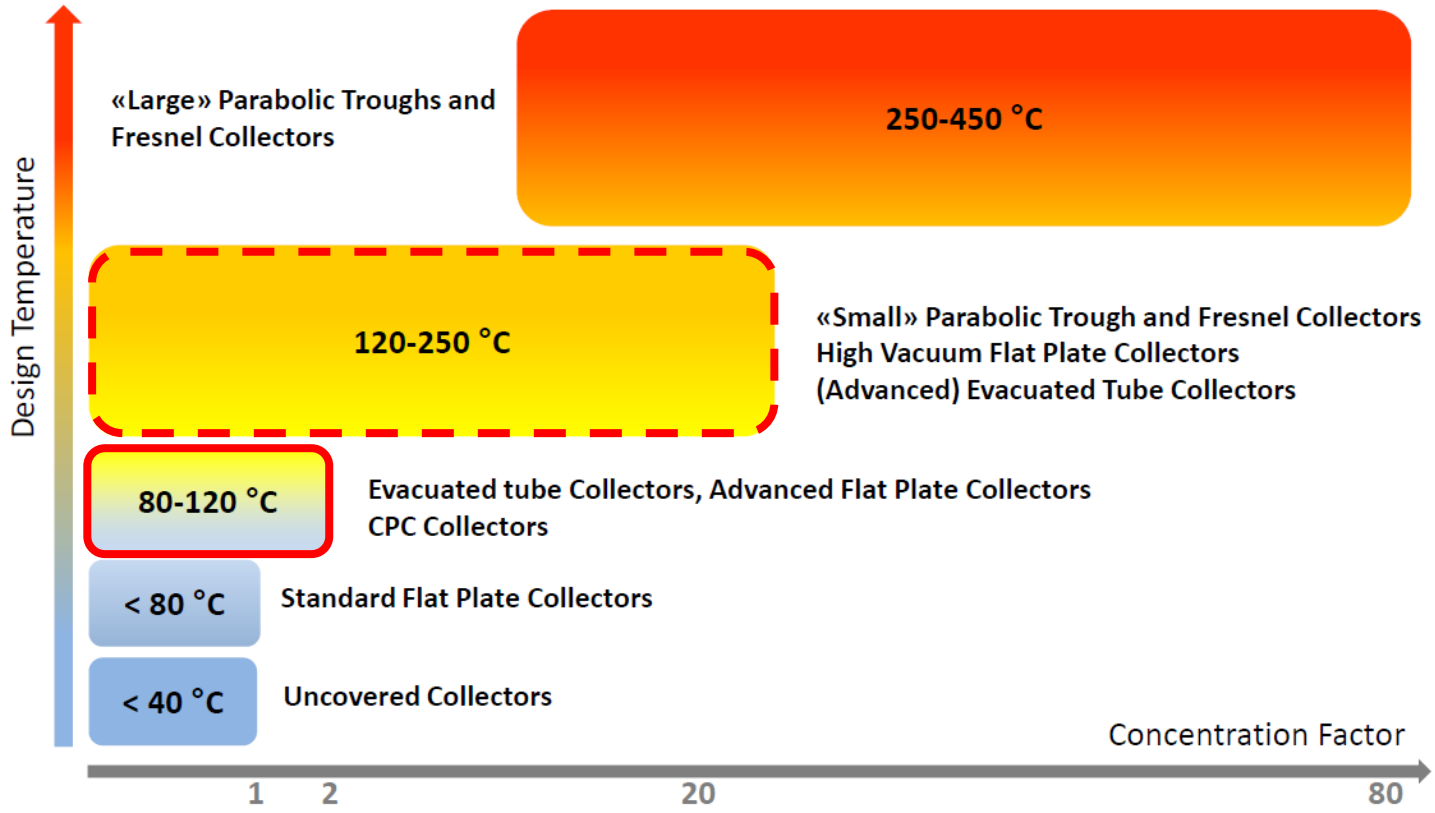
Source: IEA SHC Task 49/IV 2013



data source: Eurostat 2013 (online data code: nrg_100a)

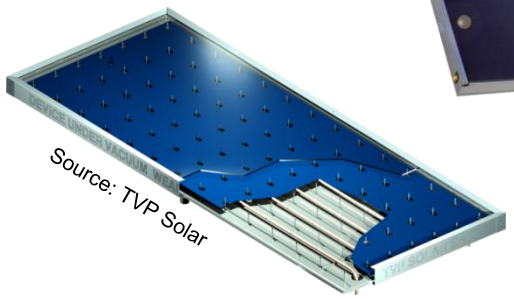
Motivation and potentials

Solar thermal collectors and design temperatures

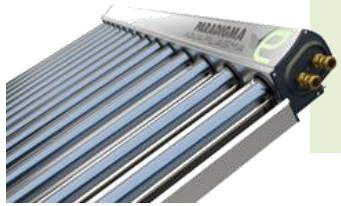


Process heat collectors

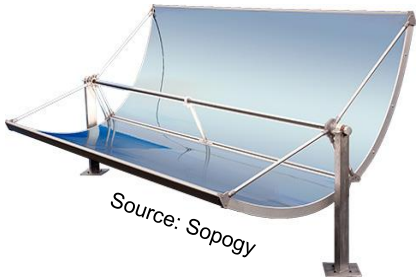
Source: GREENoneTEC



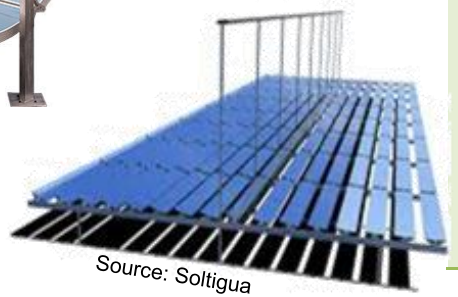
Source: TVP Solar



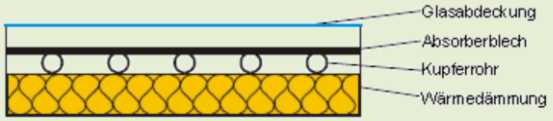
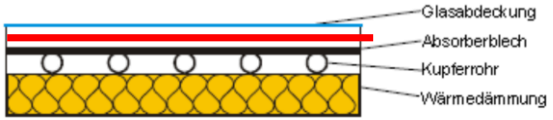
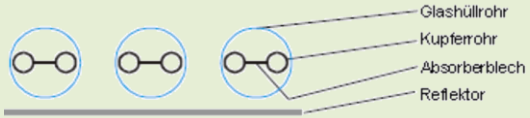
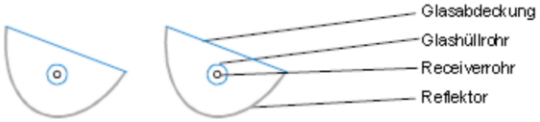
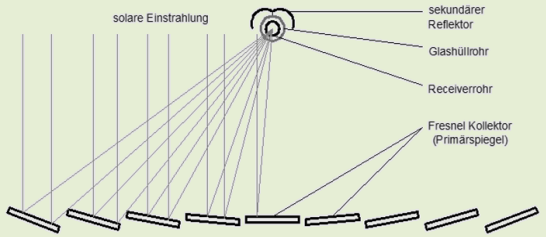
Source: Ritter Solar XL



Source: Sopogy

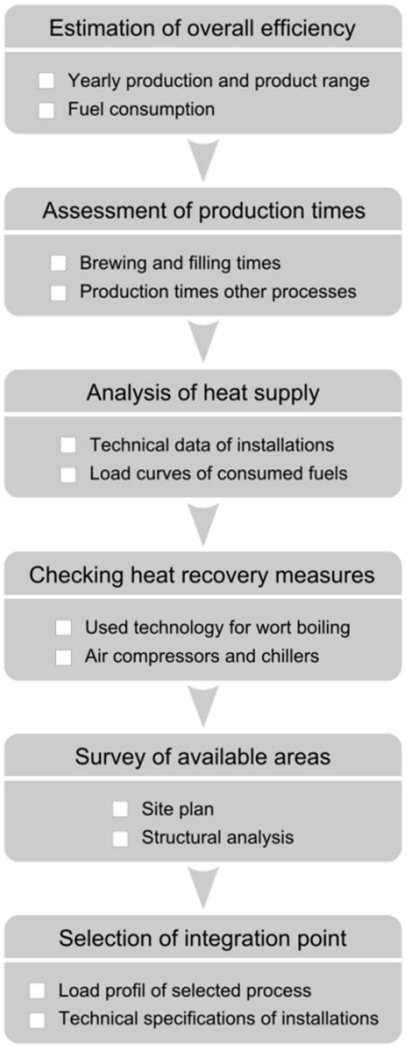


Source: Soltigua

TYPE	SKETCH (cross-section)	Design temperature
Standard flat plate collectors		**20 – 80 °C**
Advanced flat plate collector (vacuum filled, multiple covers, etc.)		**60 – 120 °C** up to 160 °C
Evacuated tubular collector		**60 – 120 °C** up to 160 °C
Parabolic trough collectors		**120 – 250 °C** up to 400 °C
Fresnel collectors		**120 – 250 °C** up to 400 °C

Assessment methodology

- **Energy audit on-site (basic data acquisition, company visit)**
- **Assessment of production times and still-stands (daily, weekly, annually)**
- **Analysis of heat supply and evaluation of representative load profiles**
- **Identifying process optimization and energy efficiency measures**
- **Survey of available areas (ground or roof) for solar thermal system installation**
- **Selection of solar thermal integration point and hydraulic integration concept**
- **Detail engineering of the solar thermal system**

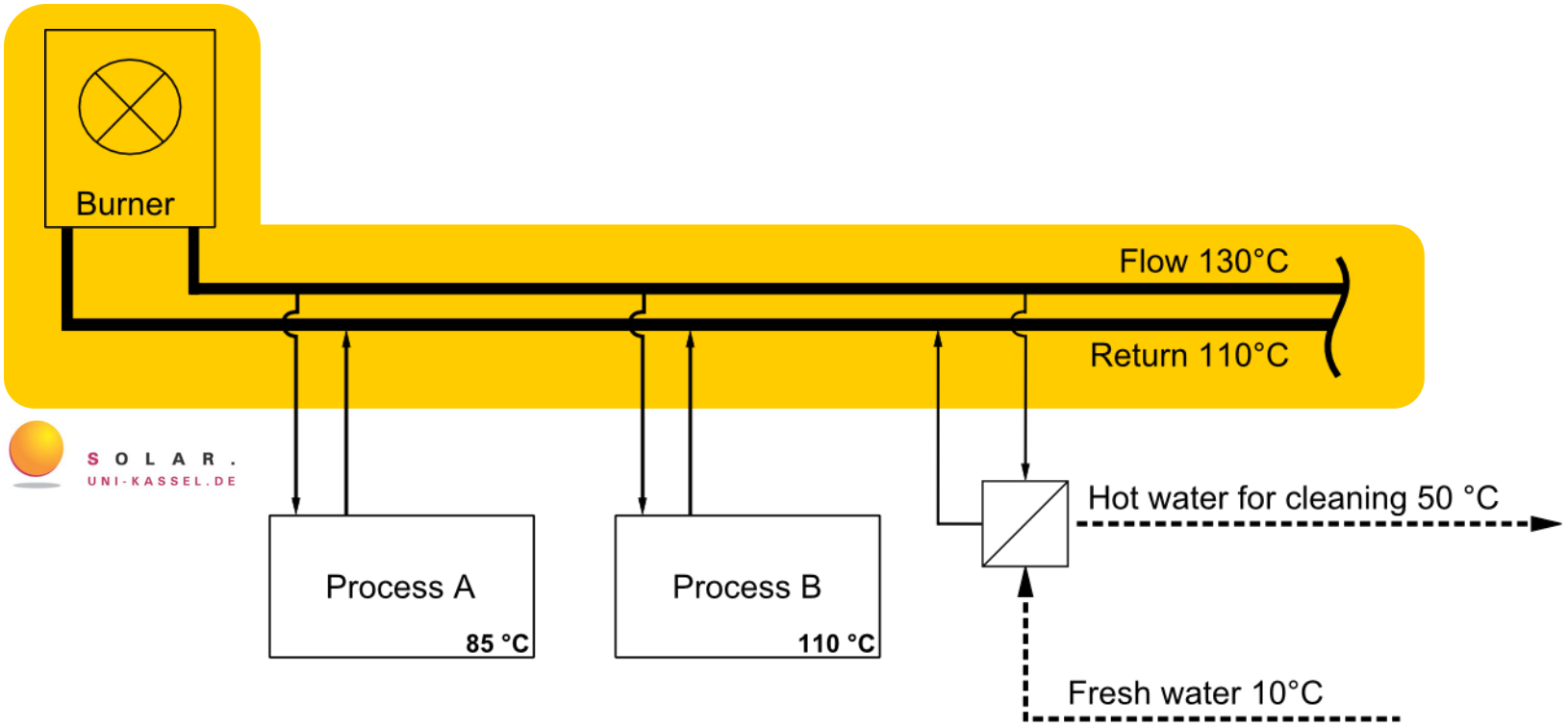


Source: IEA SHC Task 49 / IV 2013 / B. Schmitt

Integration concepts

Classification of integration concepts

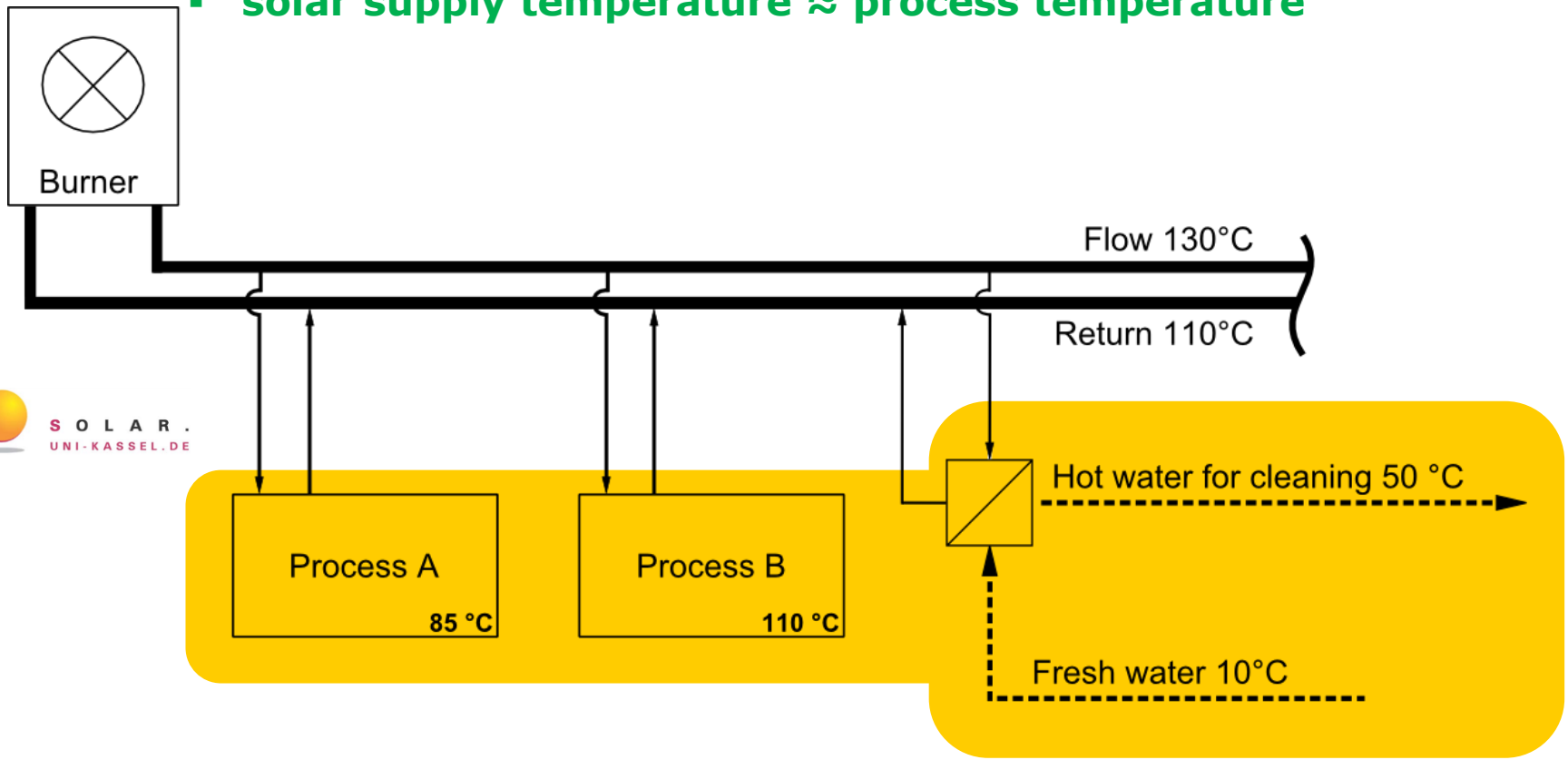
- Option 1: Integration on **supply** level
  - **"easy" hydraulic system integration**
  - **solar supply temperature > process temperature**



Integration concepts

Classification of integration concepts

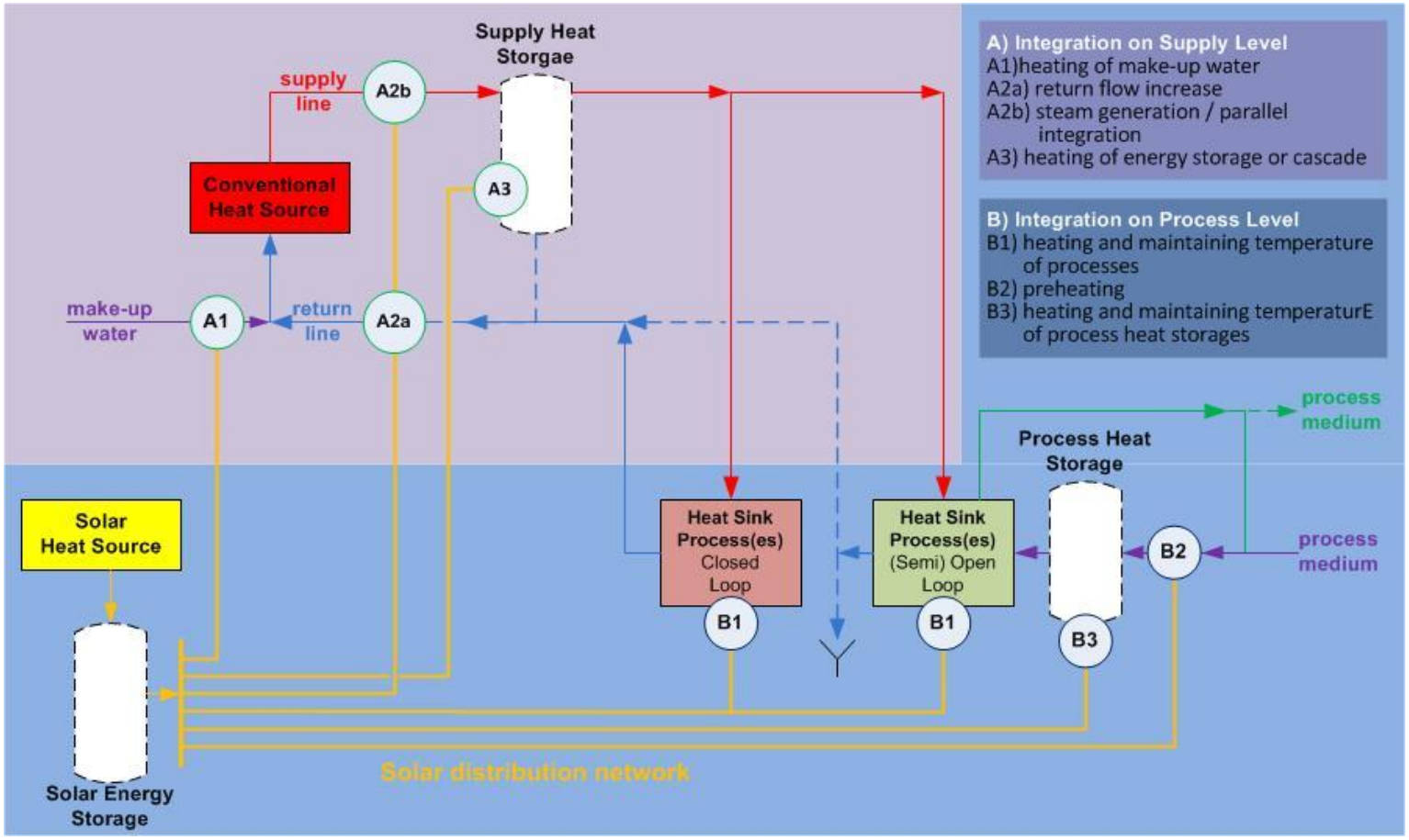
- Option 2: Integration on **process** level
  - **"complex" hydraulic system integration**
  - **solar supply temperature ≈ process temperature**



Integration concepts

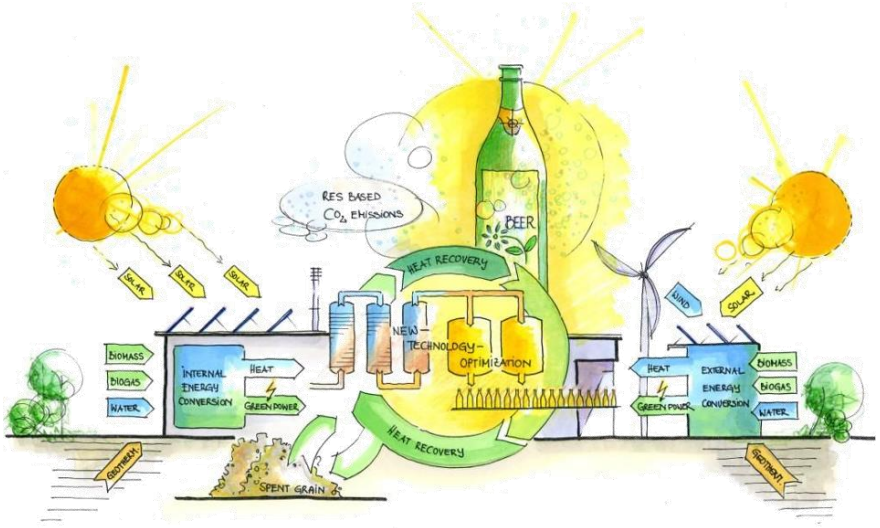
Classification of integration concepts

- Possible integration points for solar process heat applications



Source: IEA SHC Task 39 / IV 2013

SolarBrew



Solar Brew: Solar Brewing the Future

EU FP7 (2012 – 2015)

Projekt Nr. 295660

- **PROJECT CONSORTIUM**
- **AEE INTEC (coordinator)**
- **HEINEKEN Supply Chain B.V.**
- **GEA Brewery Systems GmbH**
  - process engineering
- **Sunmark A/S**
  - solar engineering

SolarBrew

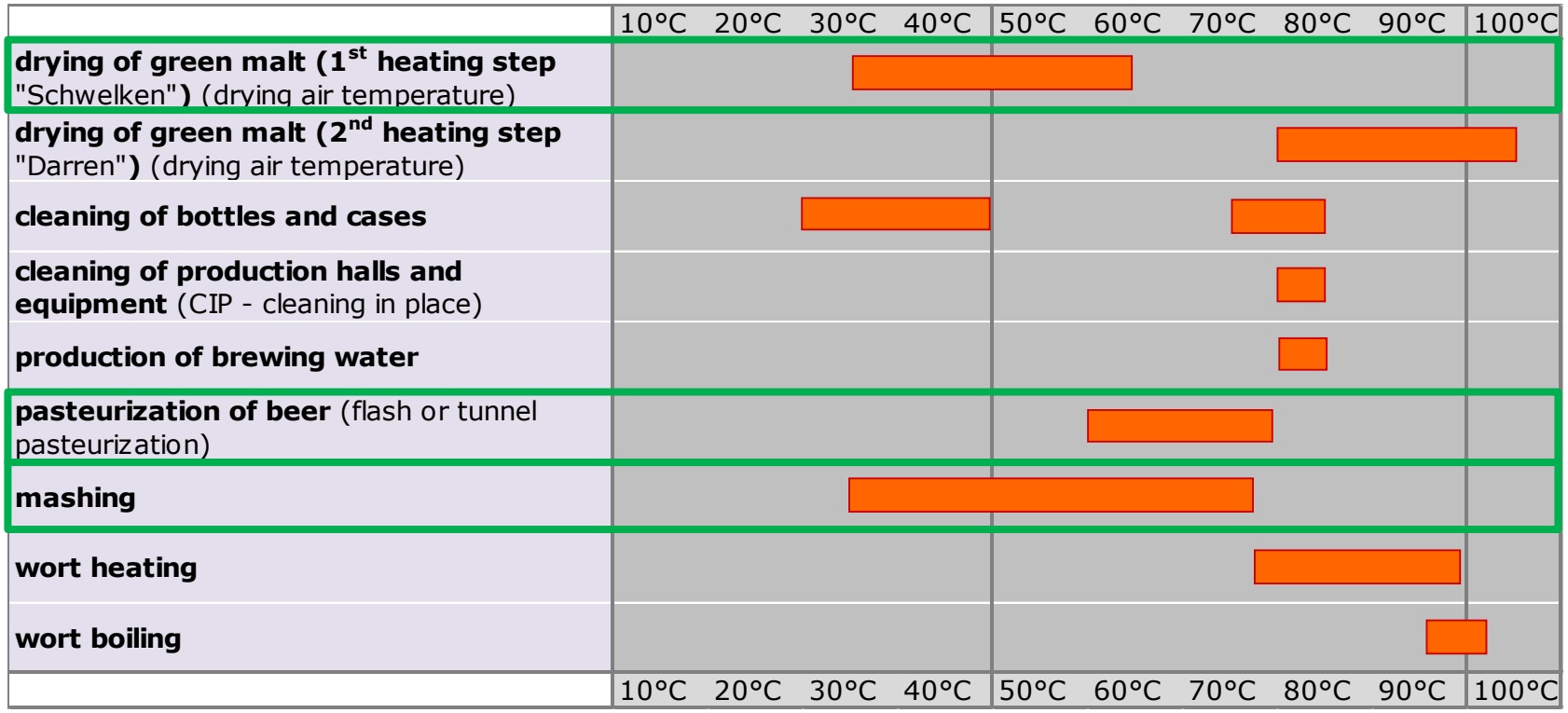
Introduction to the project SolarBrew

- Demonstration of the technical and economical feasibility of large scale solar process heat applications ≥ 1 MWth,p in the brewing industry
  - Development of concepts for a solar heat integration on process level at temperatures ≤ 80°C
  - Design and construction of three demonstrators with a total capacity of 5.0 MWth,p
  - Development of a holistic "Green Brewery Sector Concept" combining energy efficiency and renewable heat integration

SolarBrew

Potential for solar heat in the brewing industry

- All thermally driven processes in breweries and malting plants require heat at a temperature on process level of between 25 and 105°C

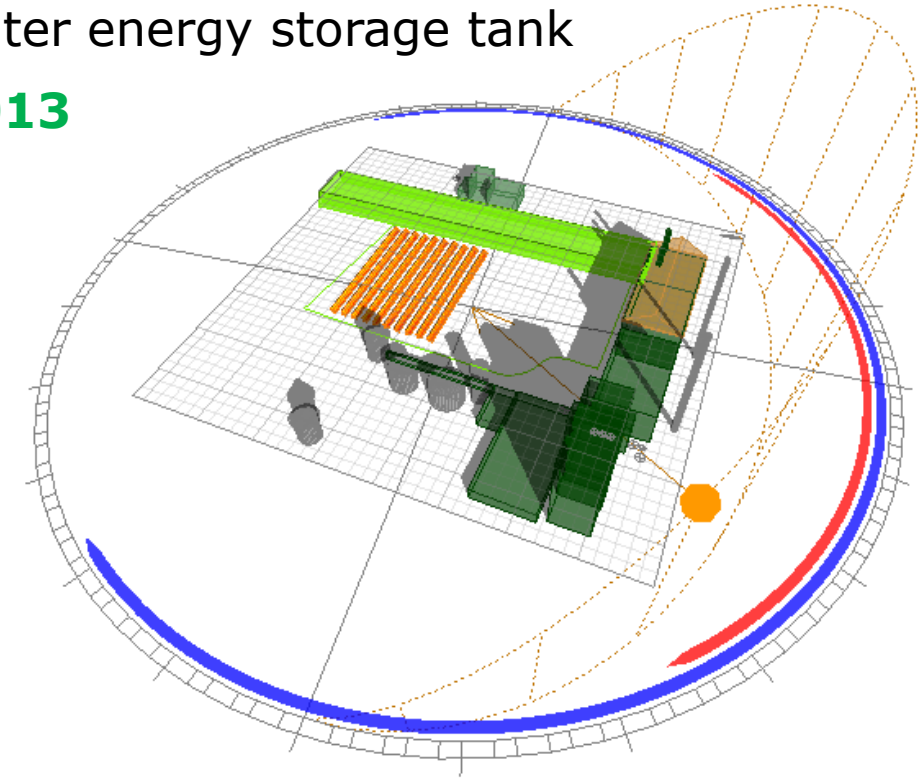


State of the project

BREWERY GOESS

- Solar assisted mashing process
- 1.500m² ground mounted flat plate collector field
- 200m³ pressurized hot water energy storage tank
- **Commissioned: June 2013**

4.6 million pints of beer
per year brewed with the power from the sun*

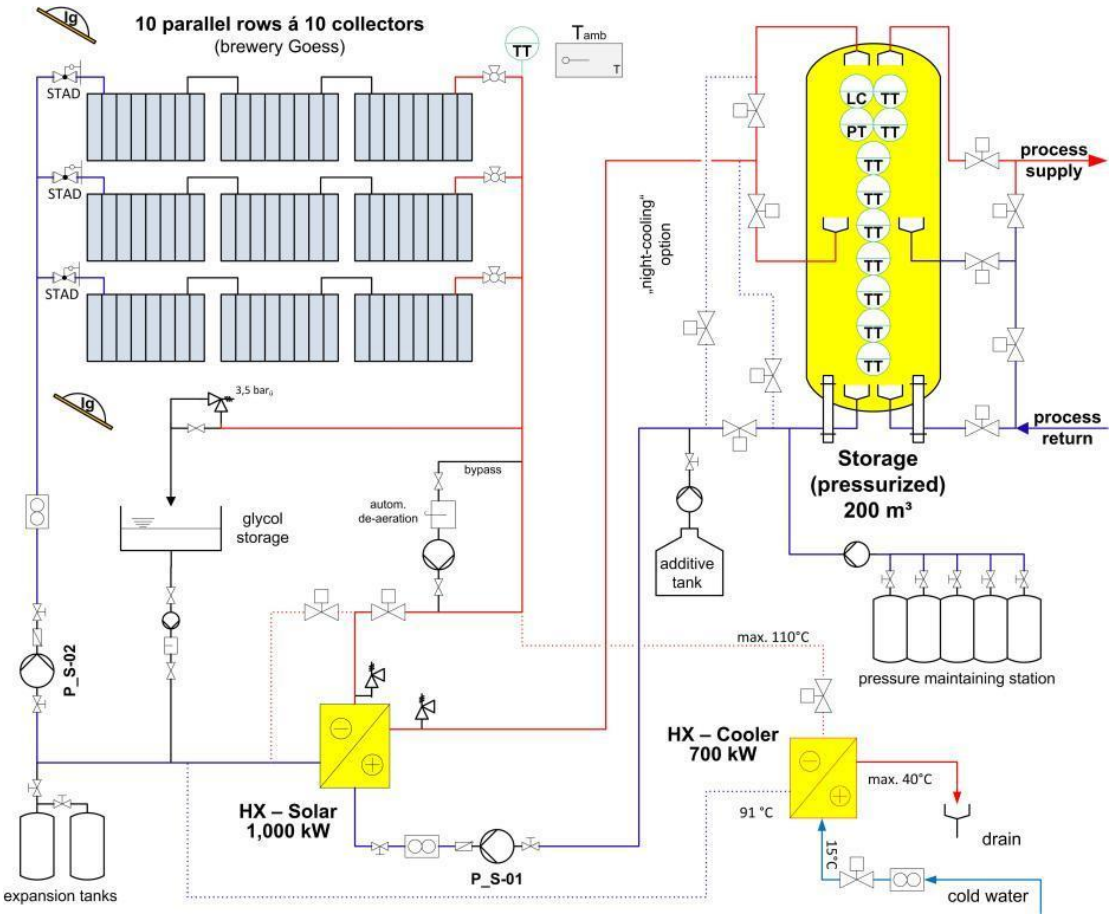


* assuming 60 MJ thermal energy consumption per hl of beer in the brewery Goess

State of the project

BREWERY GOESS

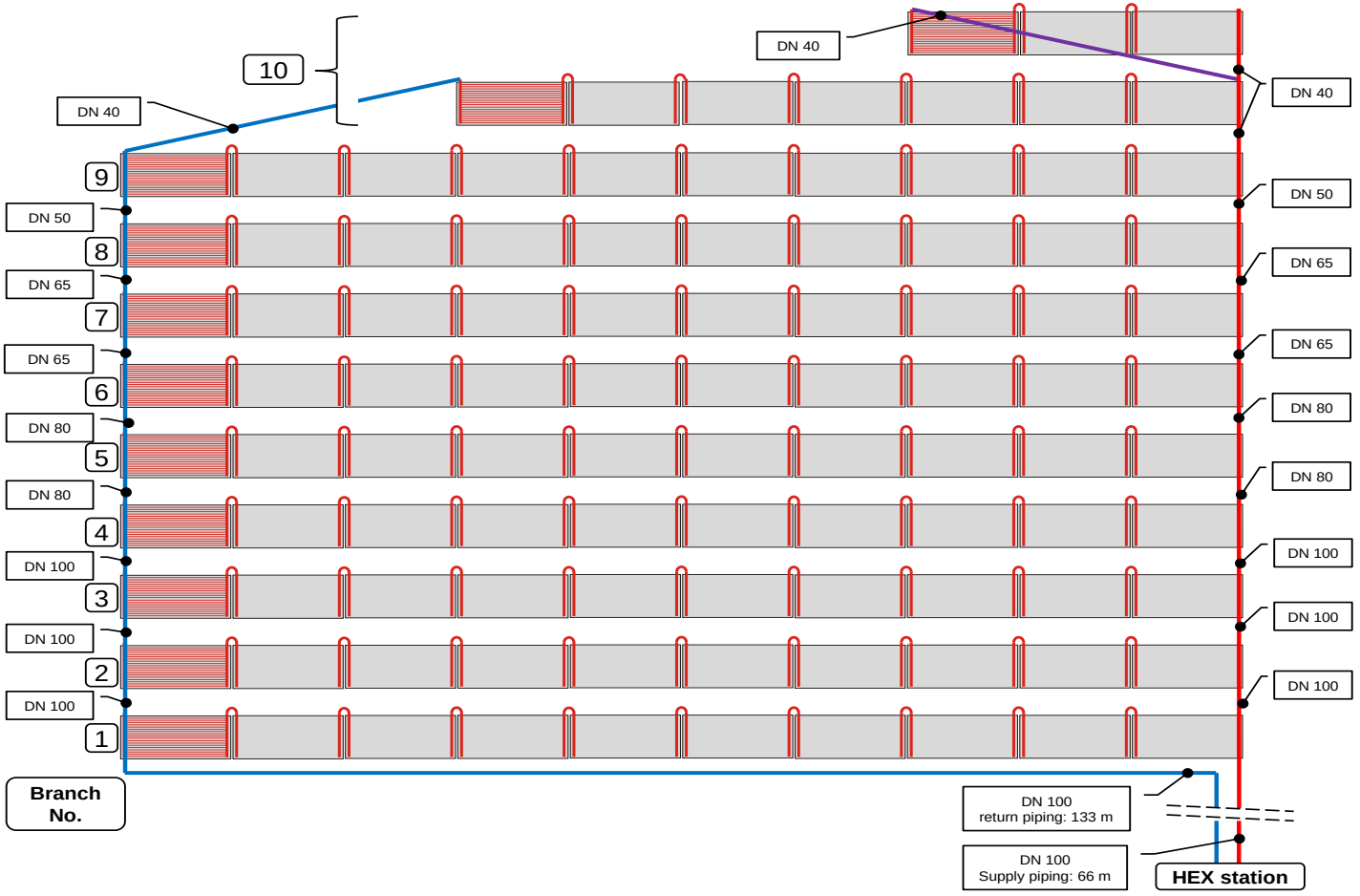
- Schematic diagram of the solar primary and secondary loop



State of the project

BREWERY GOESS

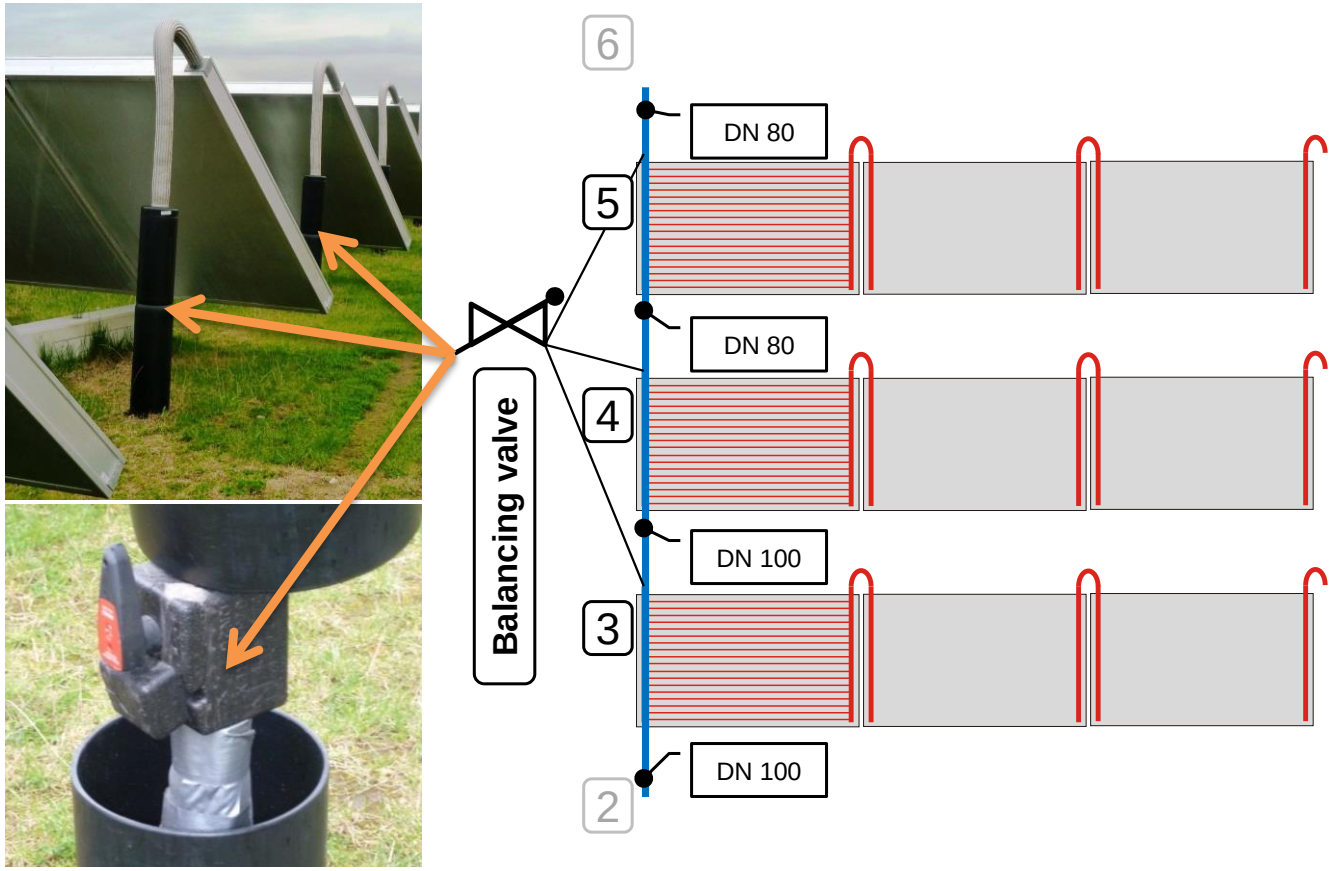
- Collector field hydraulics



State of the project

BREWERY GOESS

- Collector field hydraulics – hydraulic balancing

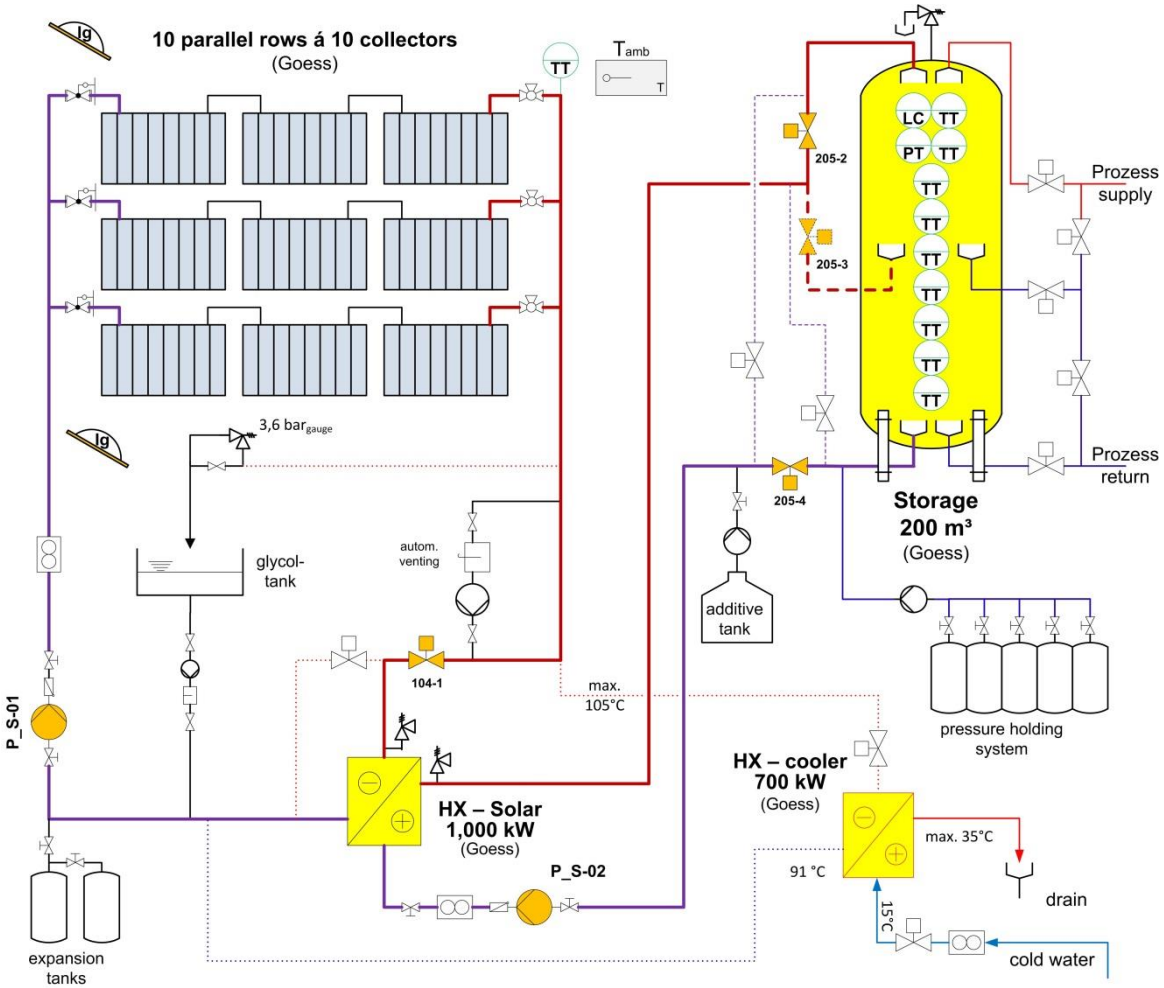


State of the project

BREWERY GOESS

- Stagnation prevention

- Stagnation prevention is done by means of 1) night cooling and 2) active water/water HX
- A pressure controlled safety valve opens if all other proceeding measures fail (due to malfunction, power outages, etc...).



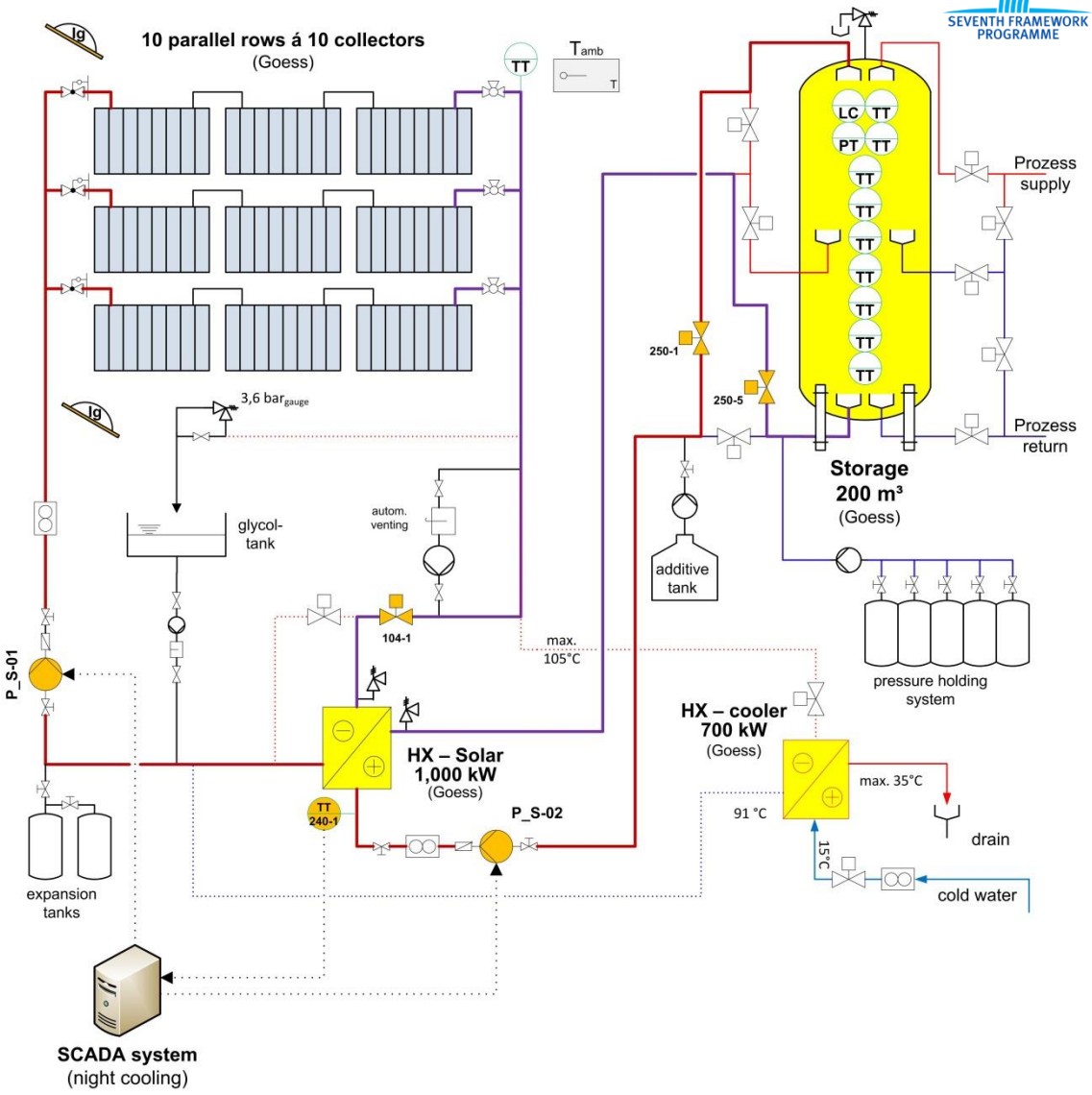
State of the project

BREWERY GOESS

- Stagnation prevention

1) night cooling

- Manual or automatic start via SCADA system
- valves 250-1, 250-5 and 104-1 open and the pumps in secondary (P_S-02) and primary (P_S-01) loop start
- Night cooling function is switched off either after a pre-defined time (e.g. 240 minutes) or automatically as soon as the temperature TT_240-1 falls below a certain value (e.g. 60°C).



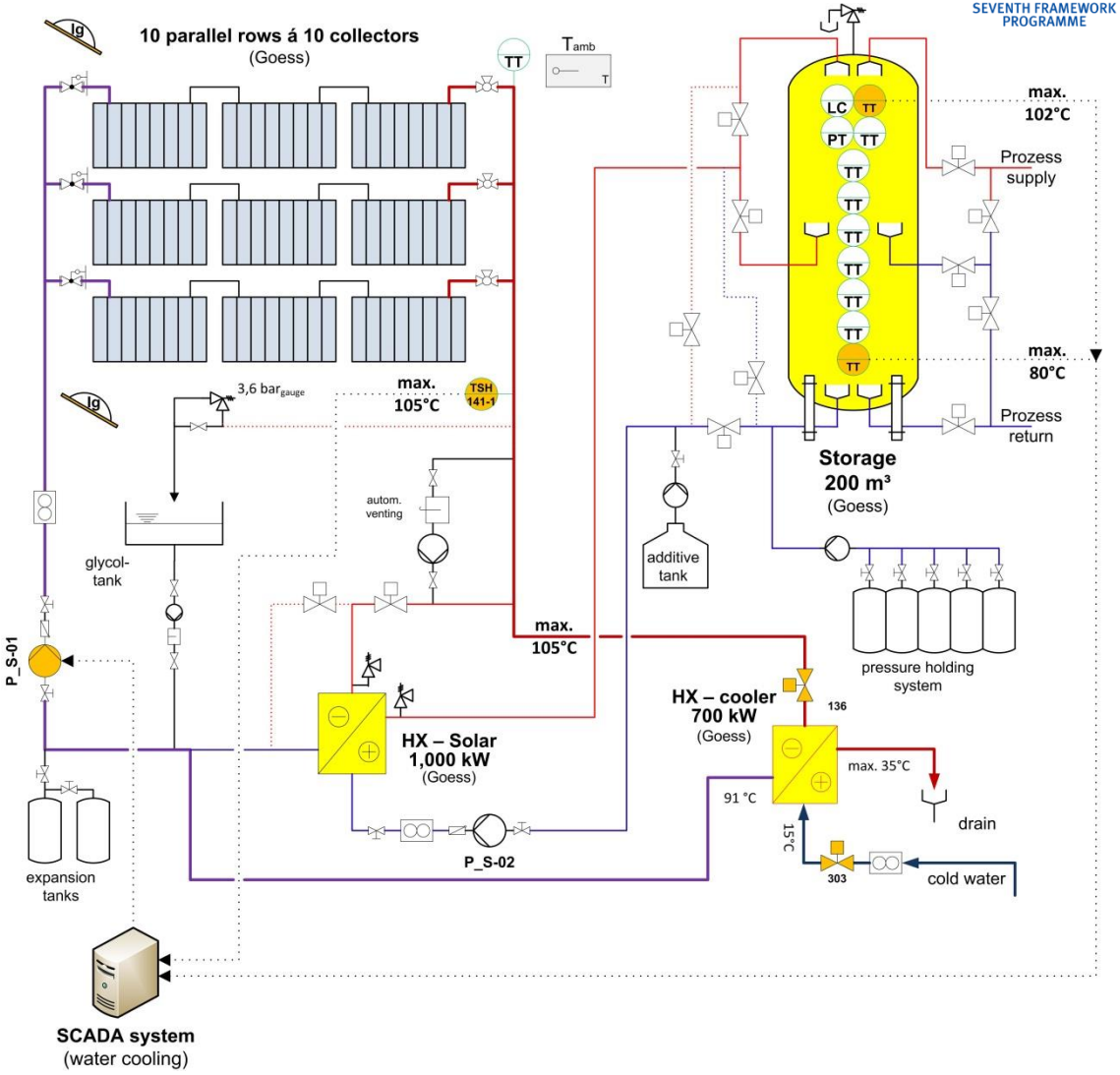
State of the project

BREWERY GOESS

- Stagnation prevention

2) Water cooler

- Cheapest option
- Cooling mode temperature-controlled by SCADA system
- As soon as one of the three following criteria is fulfilled (adaptable) the motor-operated valves 136 and 303 are automatically opened and solar secondary pump (P_S-02) is switched off:
  - TSH 141-1 >105°
  - T storage top > 102°C
  - T storage bottom >80°C



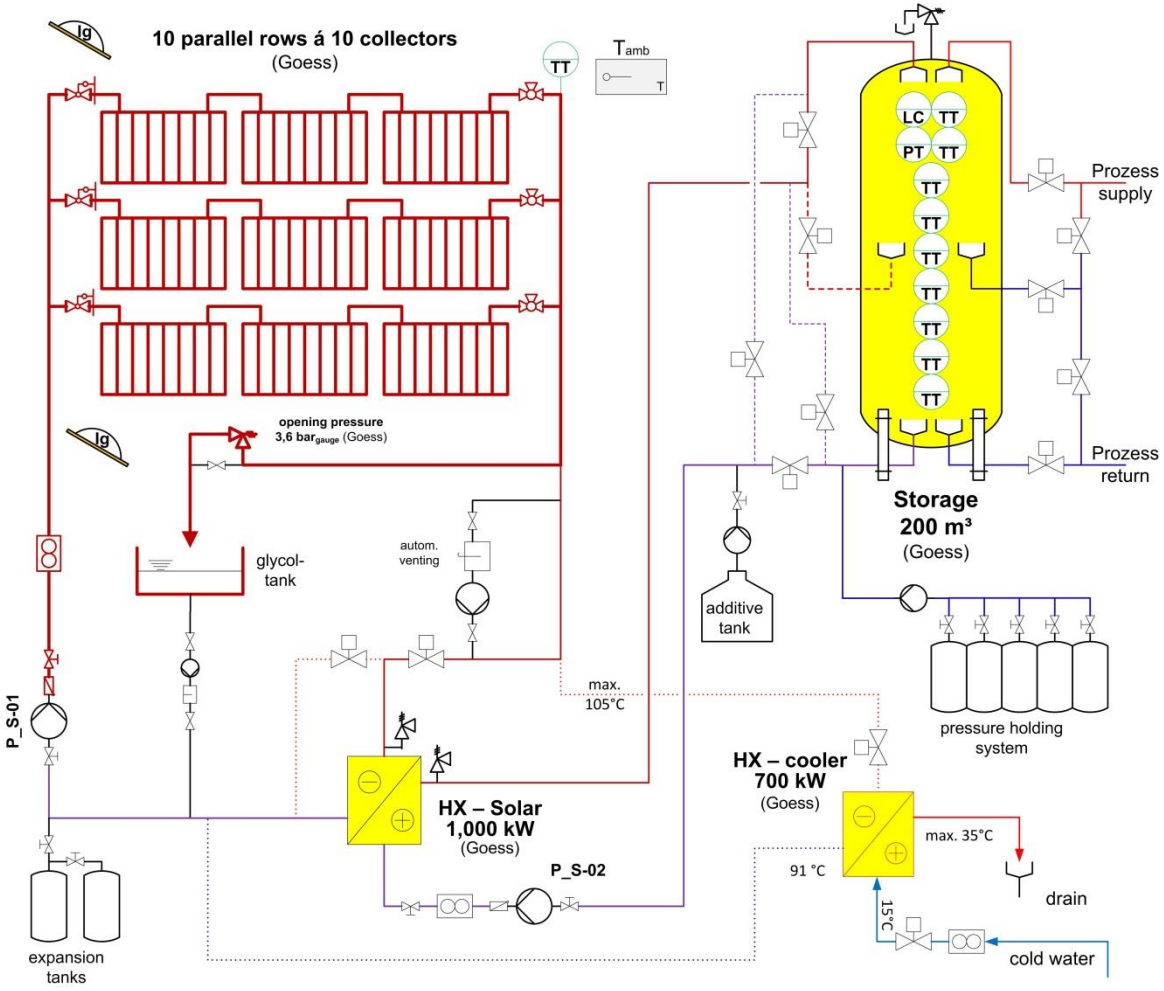
State of the project

BREWERY GOESS

- Stagnation prevention

3) pressure controlled safety valve

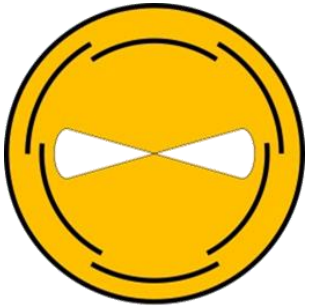
- The relief valve in the solar primary supply loop opens at relatively low pressure (3.6 bar_{gauge}) and medium is directly released into a glycol tank
- The low opening pressure limits the maximum stagnation temperature
- After stagnation the system has to be refilled with a manually operated pump and lost collector fluid has to be re-added.

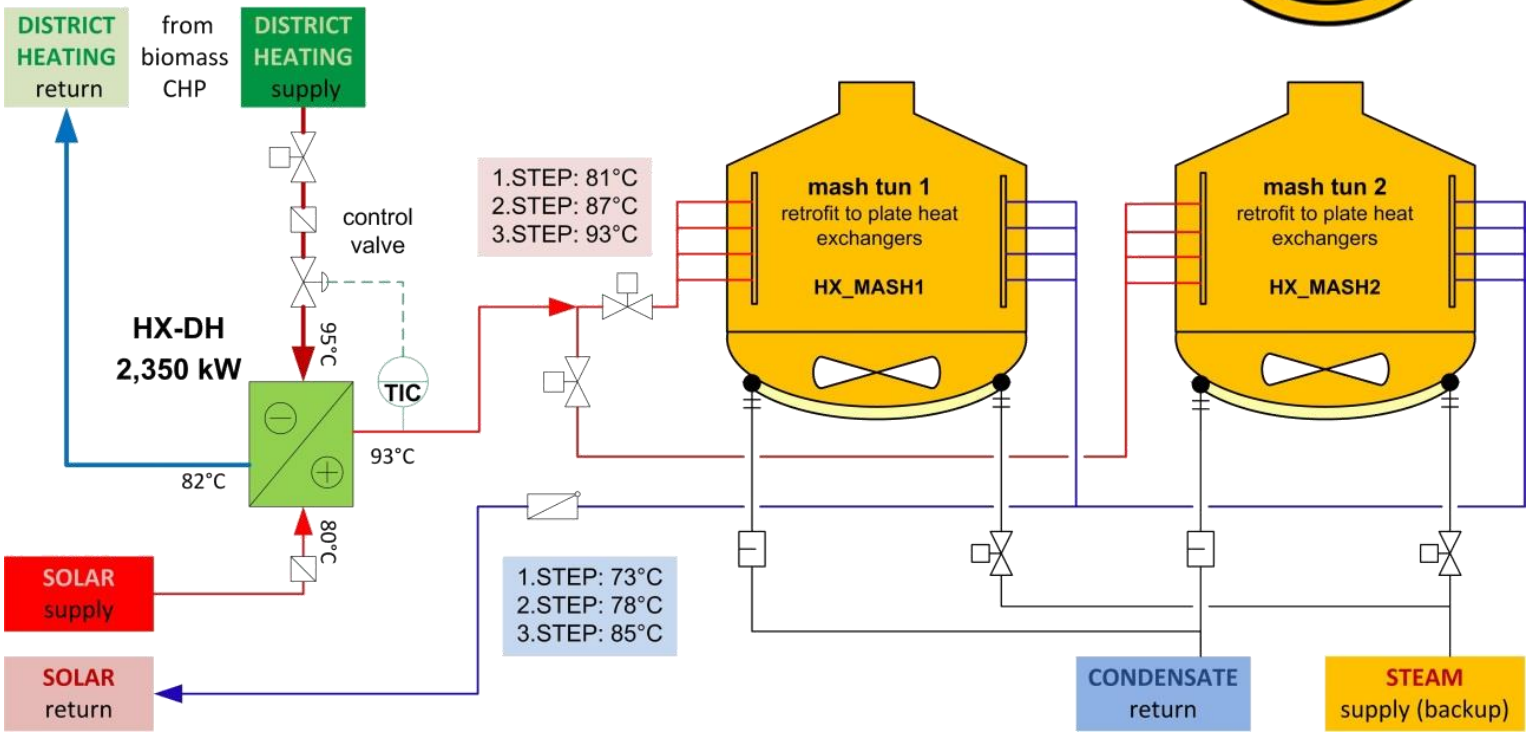


State of the project

BREWERY GOESS

- <u>Solar heat integration to mash tuns</u>
- Retrofit of two existing mash tuns with heat exchanger templates





State of the project

BREWERY GOESS

- Construction of the heat exchanger templates

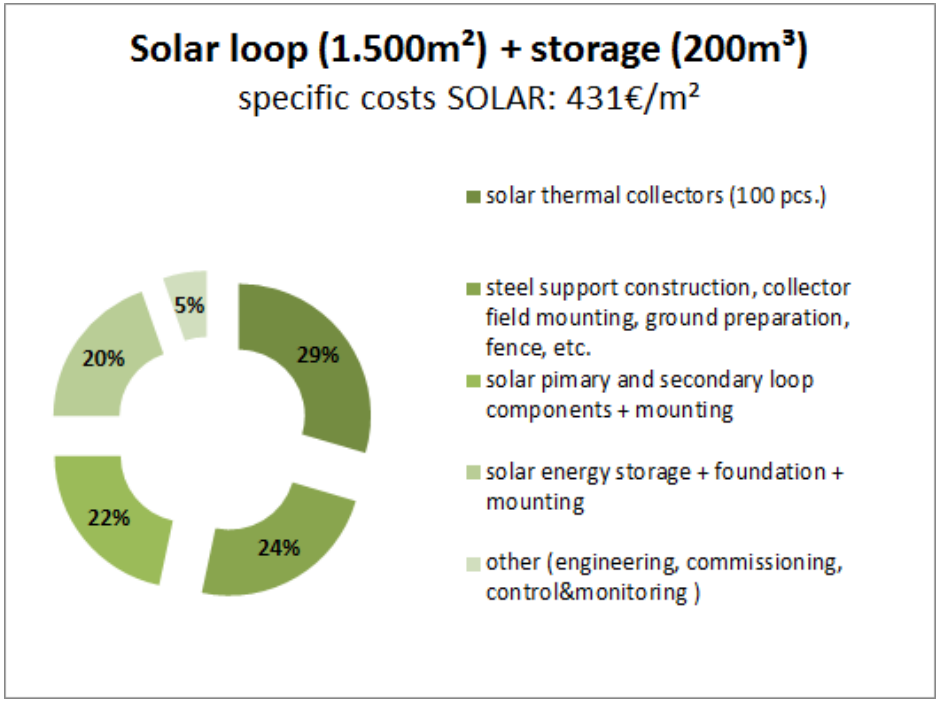


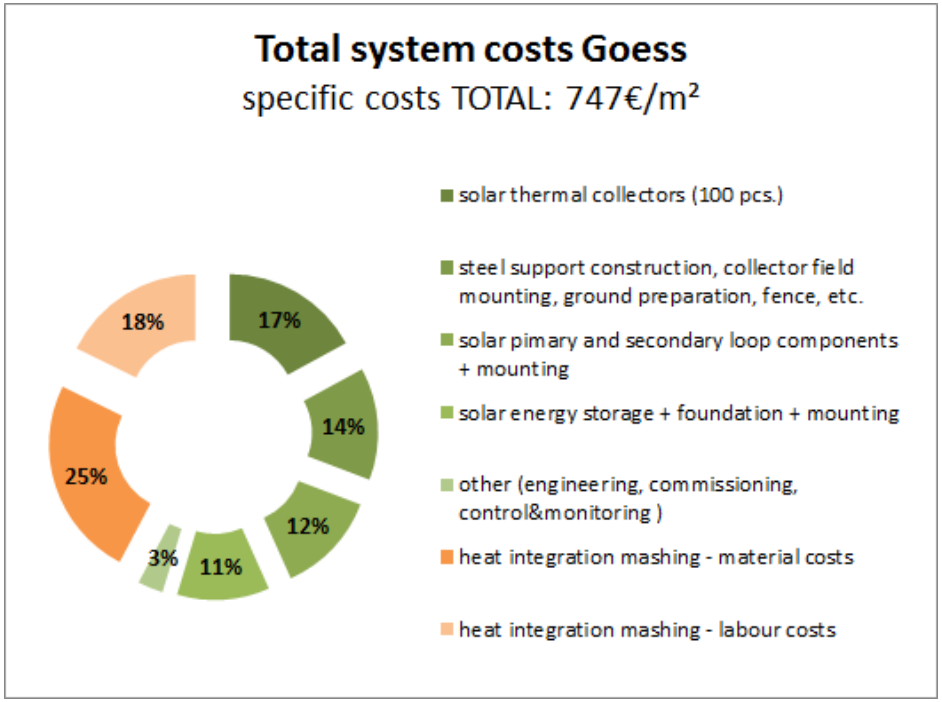



State of the project

BREWERY GOESS

- Costs solar loop + storage (without subsidies): **431 €/m² gross**
- Total system costs (without subsidies): 747 €/m² gross





State of the project

BREWERY GOESS

- Construction of the 200m³ solar energy storage

State of the project

BREWERY GOESS

- Construction of the 1,500m² solar thermal collector field

State of the project

BREWERY GOESS

- Construction of the 1,500m² solar thermal collector field

State of the project

BREWERY VALENCIA

- Solar assisted pasteurization of beer
- 1.620m² ground mounted flat plate collector field
- 350m³ atmospheric hot water energy storage tank
- **Construction end: Spring 2014**

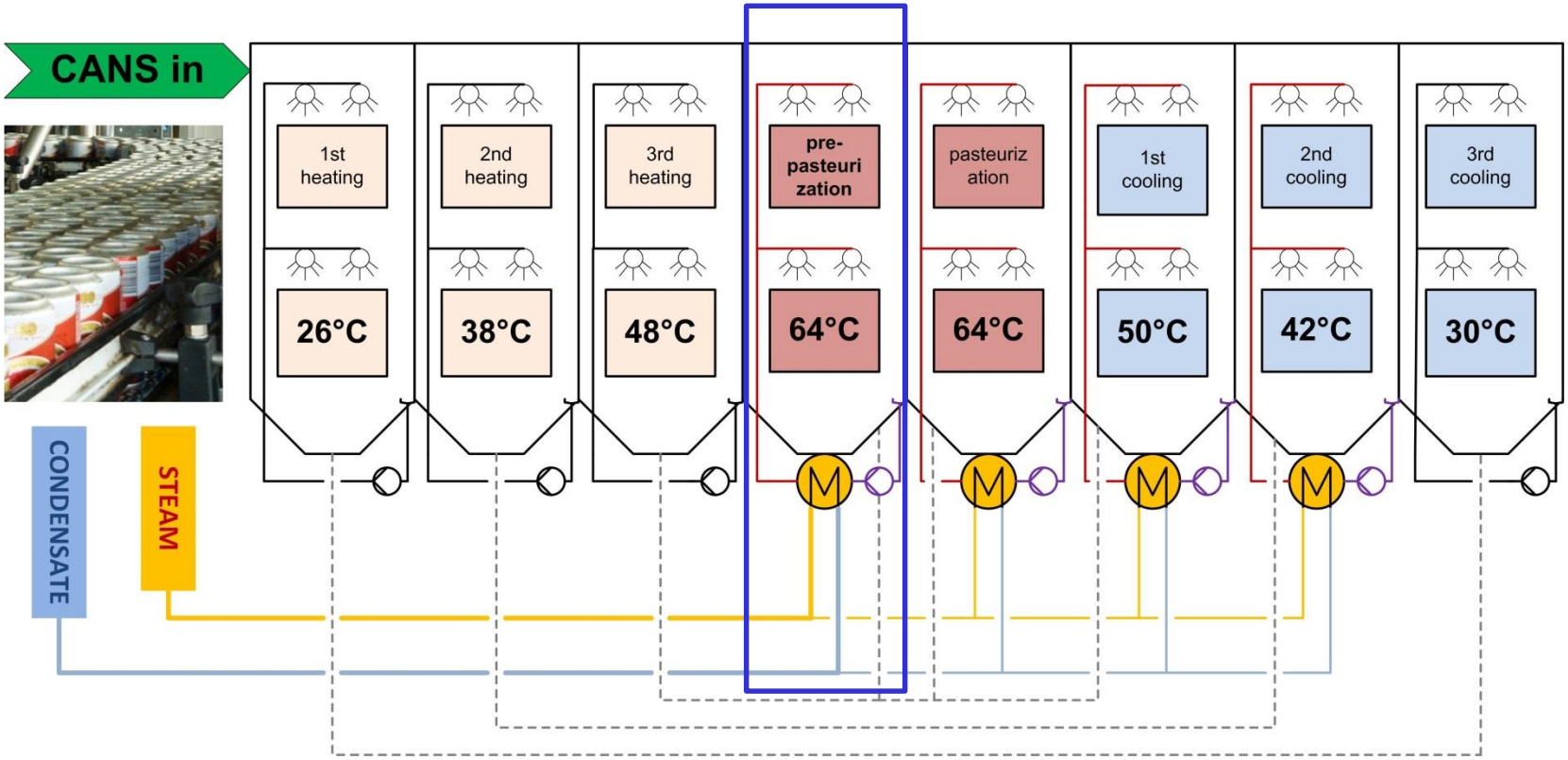
9.6 million pints of beer
per year brewed with the power from the sun*

* assuming 70 MJ thermal energy consumption per hl of beer in the brewery Valencia

State of the project

BREWERY VALENCIA

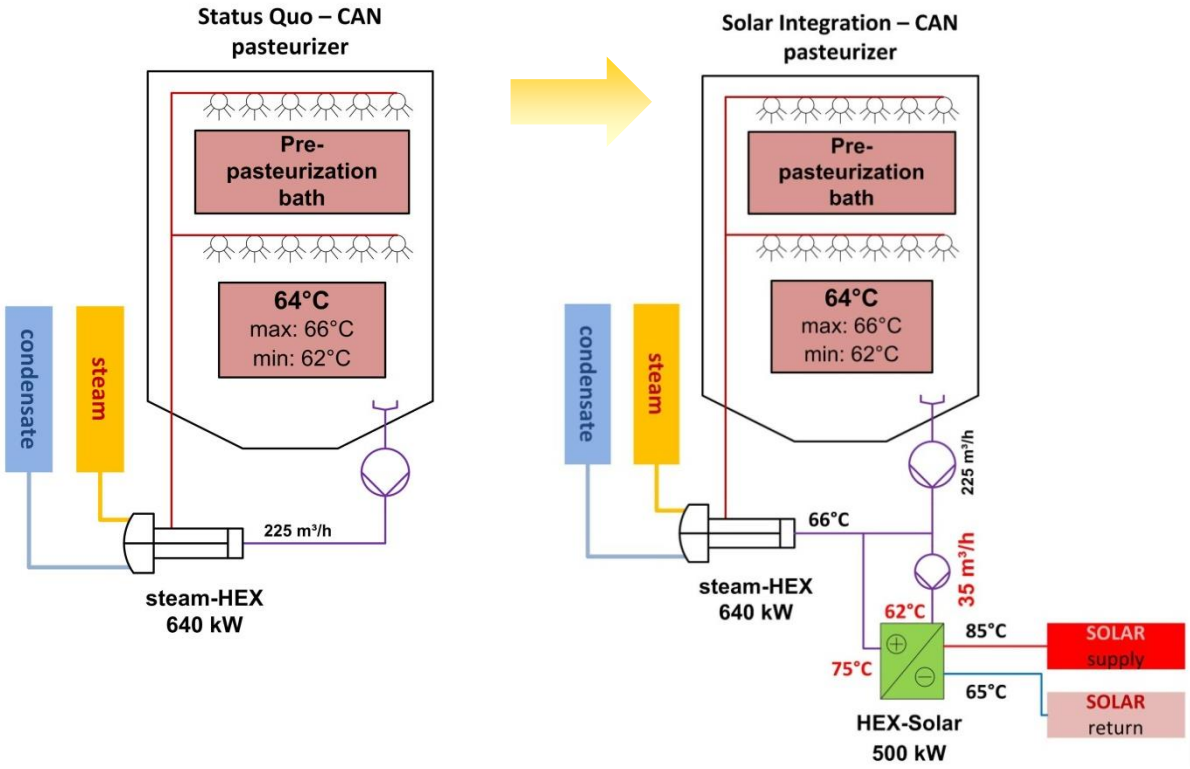
- Solar heat integration to a tunnel pasteurizer



State of the project

BREWERY VALENCIA

- Retrofit of a steam based supply system with a serial connected hot water plate heat exchanger



tunnel pasteurizer

existing steam bundle HX

State of the project

MALTING PLANT VIALONGA

- Solar assisted drying of green malt
- 4.725m² ground mounted flat plate collector field
- 400m³ atmospheric hot water energy storage tank
- **Construction end: Spring 2014**

3.6 million tons malt per year dried with the power from the sun* → basis for **40 million pints of beer****

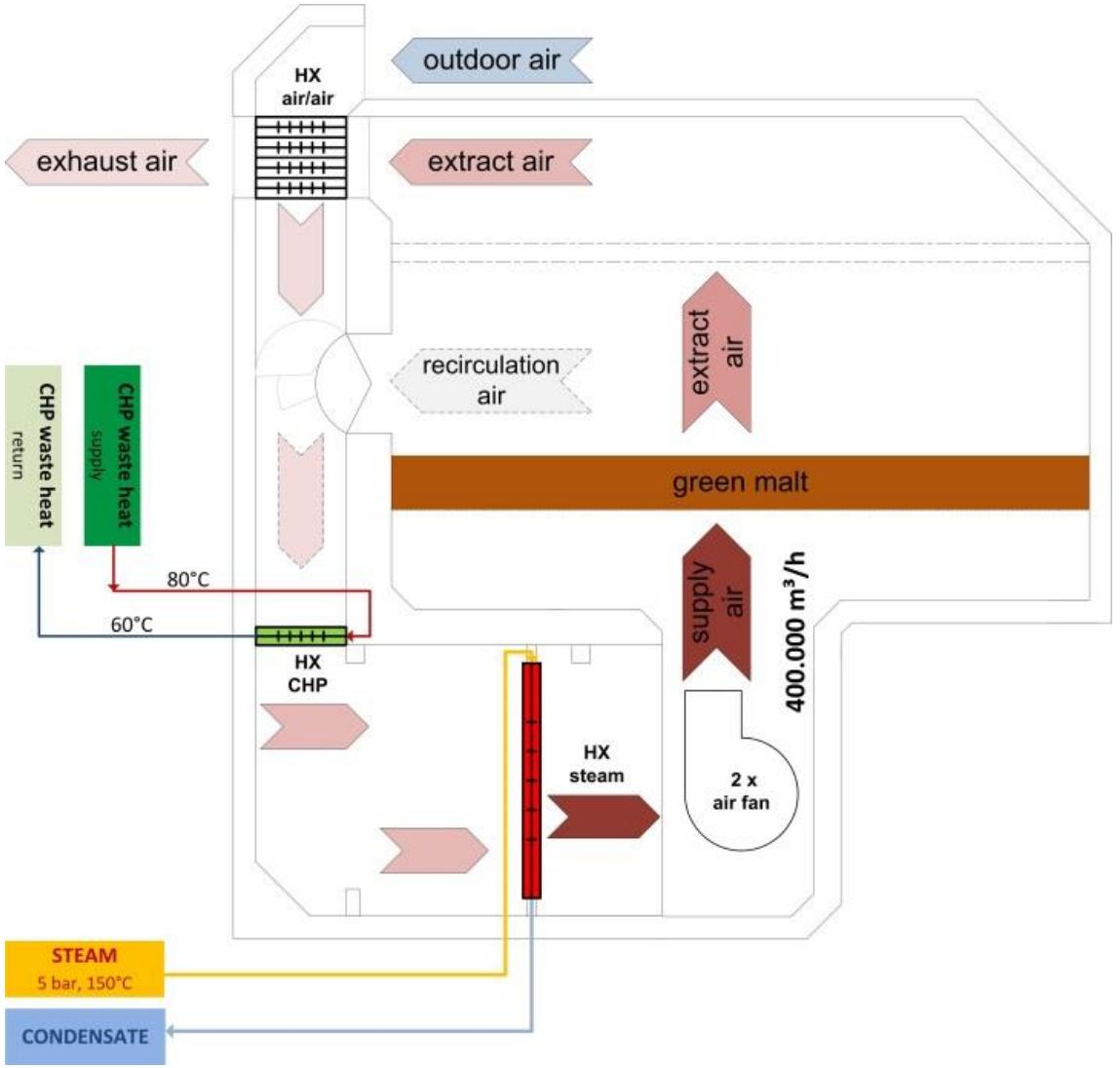
* assuming 3.1 MJ thermal energy consumption per ton of malt in Vialonga

** assuming 18 kg malt per hl of beer

State of the project

MALTING PLANT
VIALONGA

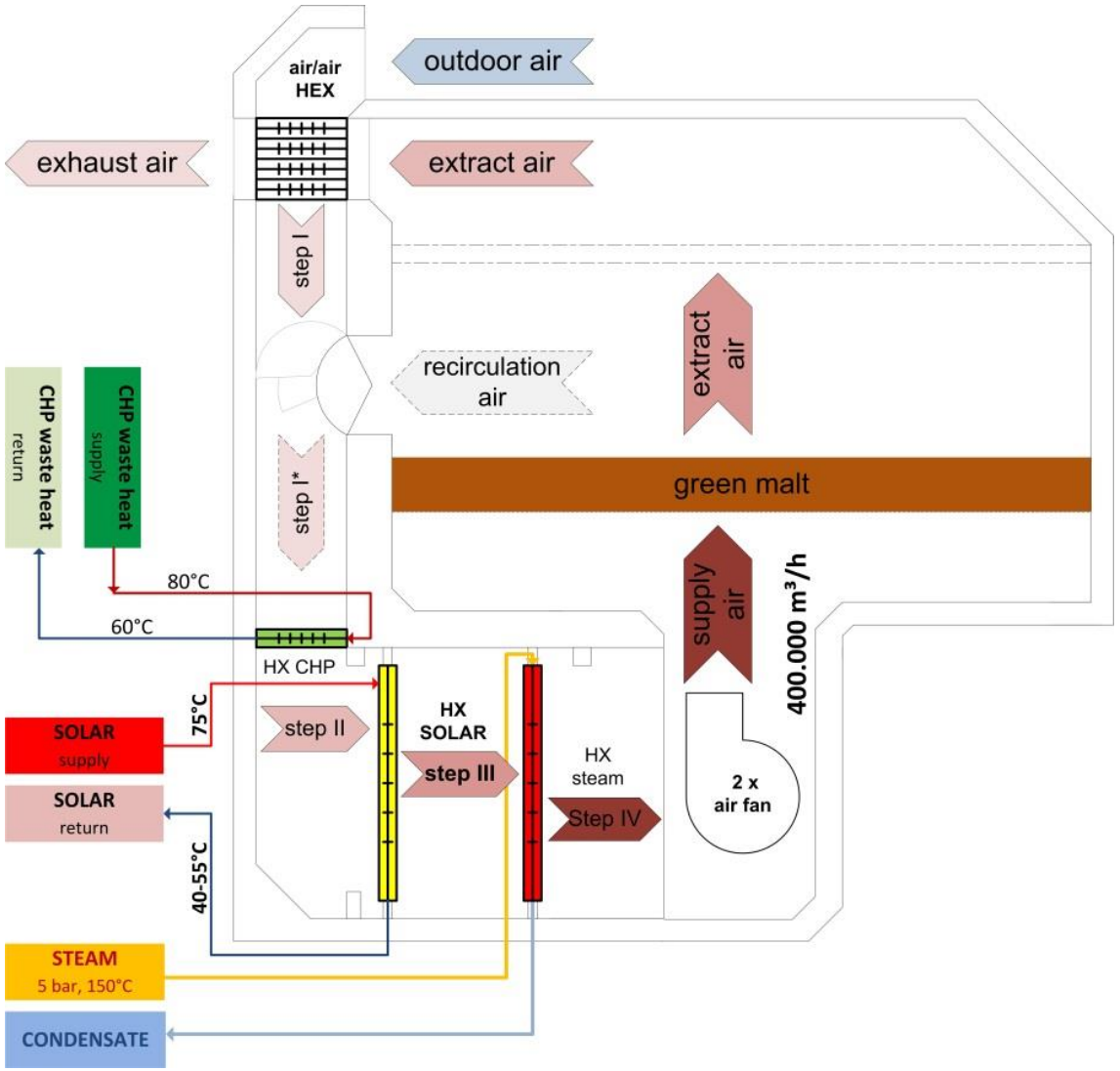
- <u>Solar heat integration to drying kiln</u>



State of the project

MALTING PLANT VIALONGA

- <u>Solar heat integration to drying kiln</u>
- Installation of a new water/air heat exchanger for the exergetically optimized cascade supply of heat
- Heating-up drying air from 35–55°C



State of the project

MALTING PLANT
VIALONGA


(GEA Brewery Systems)

step I

HX CHP

step II

step IV

step III

step II

HX STEAM

400.000 m³/h

Summary "SolarBrew"

Overview over the three demonstrators

SITE & LOCATION	Collector field size[1] [m²]	Thermal peak capacity [$MW_{p,th}$]	Solar energy storage volume [m³]	Process supplied process temperature [°C]	Expected solar yield[2] [kWh/(m²·a)]	Solar fraction[2,3] [%]	Irradiation onto horizontal plane [kWh/(m²·a)]
Brewery Goess, AT	1,375	1.0	200 (pressurized tank)	mashing **58-78°C**	**280**	**~ 30%**	**1.070**
Brewery Valencia, ES	1,485	1.0	350 (atmospheric tank)	pasteurization of beer **63-65°C**	**630**	**~ 45%**	**1.610**
Malting plant Vialonga, PT	4,331	3.0	400 (atmospheric tank)	drying of green malt **35-55°C**	**720**	**~ 20%**	**1.690**
Total	**7,191**	**5.0**					

[1] Reference: aperture area

[2] Simulation results based on representative (measured) load profiles

[3] Solar fraction with regard to the respective process supplied with solar thermal heat

Conclusions

There is huge (technical) potential for solar process heat applications in Europe

To obtain (exergetically) best results measures to increase energy efficiency have to be investigated prior to the integration of renewable energy supply technologies

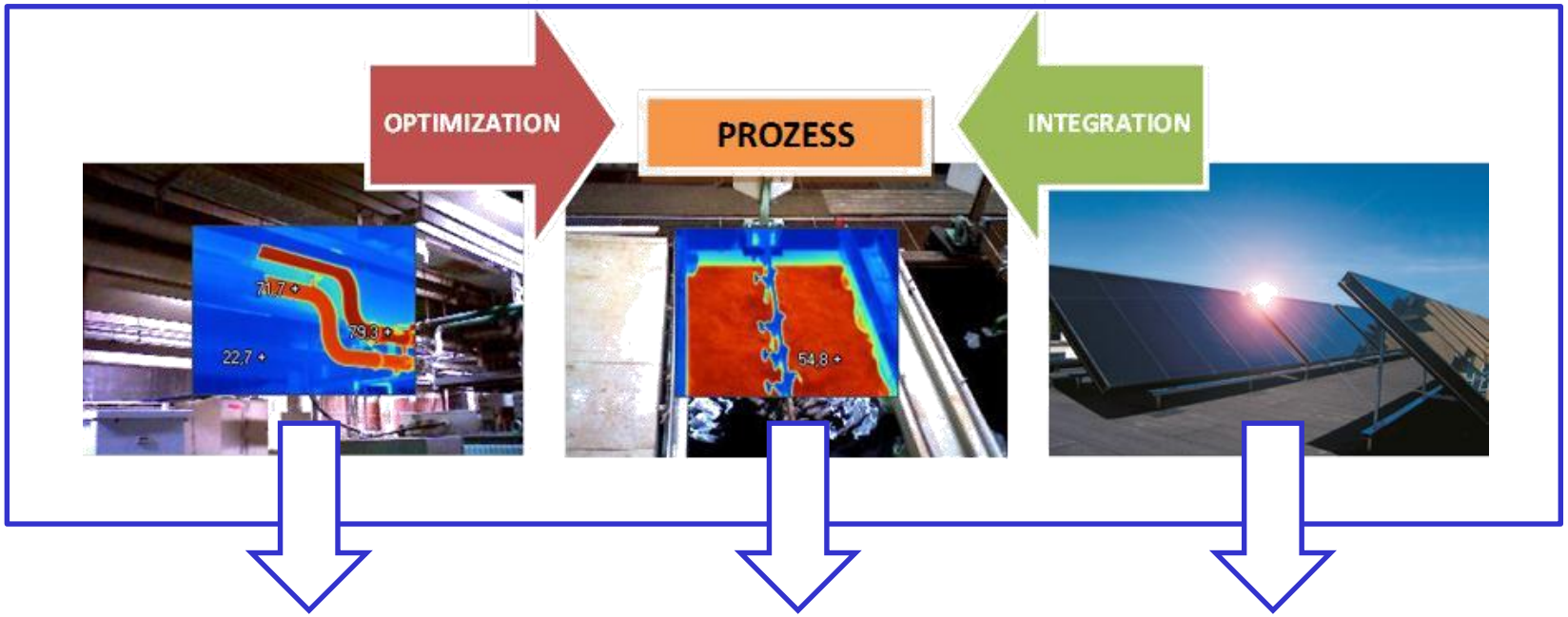
Detail engineering and construction of solar process heat applications demand both process engineering and solar engineering expertise – **a holistic methodological approach is needed**

This course aims to follow such an approach

IEA-SHC Task 49 / IV

Content: Solar Heat Integration in Industrial Processes

- further information: http://task49.iea-shc.org/



Subtask B

Process optimization
Process integration
Process intensification

Subtask C

Design guidelines
Case studies
Dissemination

Subtask A

Process heat
collectors

SHIP Egypt

Solar Process Heat

Wolfgang Glatzl & Josef Buchinger

AEE INTEC & ConPlusUltra