SOLAR HEAT INTEGRATION

Solutions for the decarbonisation of the pulp and paper industry

Energy Efficiency Solutions Forum (EESF)

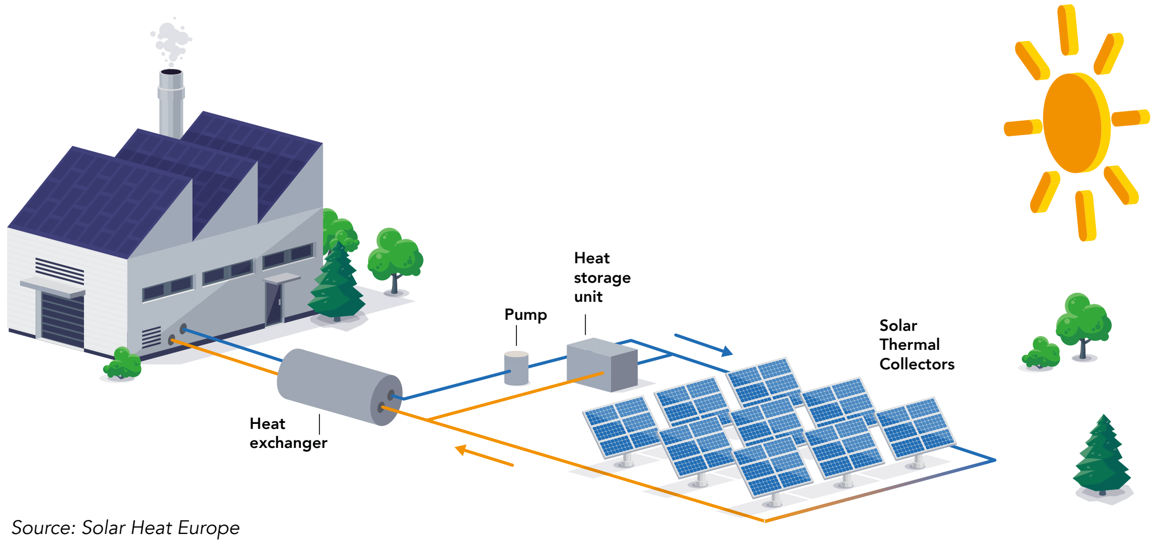
The pulp and paper sector is committed to achieving climate neutrality in Europe by 2050. This requires reducing emissions in our production processes by the implementation of energy-efficient technologies and the effective use of fossil-free energy sources.

Cepi's Energy Efficiency Solutions Forum (EESF) aims to accelerate the development and implementation of carbon-reducing technologies and solutions in our sector. We accomplish this by forging new partnerships and collaborating with developers and suppliers of energy efficiency technologies, as well as providers of fossil-free energy.

One of these fossil-free energy sources is Solar Heat for Industrial Processes (SHIP).

What is Solar Heat for Industrial Processes (SHIP)?

- Solar collectors are installed next to the production site and/or on extisting roofs and produce heat.
- Heat is then delivered as hot water, steam or thermal oil to the manufacturing site.
- Heat storage units ensure constant heat delivery, including on cloudy days, overnight or even multiple days.

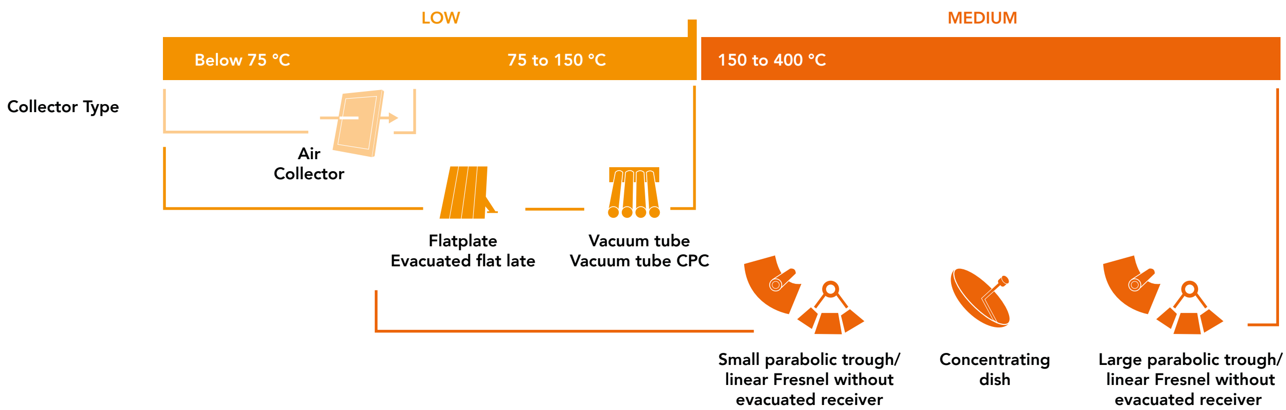


Source: Solar Heat Europe

Which solar thermal technologies exist and for which temperatures?

Various solar thermal technologies exist to produce pressurised hot water or steam:

- **Non-concentrating solar collectors**, for example, standard or evacuated flat plate and evacuated tube collectors. These generally yield three times more energy compared to solar photovoltaic modules (PV) for the same roof or land area. These collectors produce heat from direct and indirect irradiation and can reach temperatures of up to 150°C.
- **Concentrating solar collectors** use small or large parabolic mirrors/troughs, Fresnel mirrors/lenses or other means to achieve higher temperatures of up to 400°C. They are particularly efficient in sunny areas of Europe, as they work best on cloudless days, making use of direct irradiation.
- **Hybrid photovoltaic-thermal** (PVT) technology combines solar PV and solar thermal energy in one system. This type of collectors provides both electricity and heat at moderate temperature. Until now, this has mainly been used for commercial buildings' applications.



Source: Solar Heat Europe

What are the main parameters to consider when planning to use solar heat?

1. **Availability of land (or rooftop) area in the vicinity of the manufacturing processes**
   Solar thermal has the highest energy yield per m², but needs to be located close to its use for optimal efficiency.
2. **Solar irradiation**
   SHIP plants can be operational with good yields from North to South of Europe. Naturally, better performance is achieved in regions that have more sunny days.
3. **Type of technology and application needs**
   different solar technologies can address different temperature needs and heat needs from hot water to steam.
4. **Storage capacity**
   Non-pressurised storage up to 95 °C is state-of-the-art and can be installed in large capacities (ten thousands m³). High-temperature storages are also available.
5. **Integration with other technologies**
   Solar heat can be easily combined with other renewable energy sources.

Source: Greenone Tec

Solar Heat in practice - Case Studies

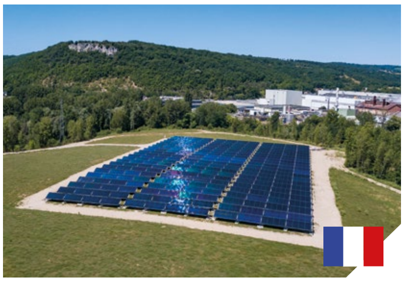
The examples below show that SHIP is already available for the paper industry, providing what is needed as a turnkey solution or a heat delivery contract.


Source: TVP

TVP Solar for Martini Rossi

600 m² collectors on 1000 m² roof top area produce steam at 155 °C (3.7 bar) = 390 MWh per year output.

⟶ 390 kWh useful energy per m² of roof area.


Source: New Heat

Savosolar/NewHeat for Condat

Tracker-mounted solar thermal plant, supplying heat for paper mill of the Lecta Group.

Used for make-up water.

Collector area: 4213 m²
Nominal solar capacity: 3.3 MW
Estimated annual heat production: 3.9 GWh
CO_2 avoided: 1078 TN / year
Commissioning year: 2018

⟶ 346 kWh useful energy per m² of land area.


Source: Absolicon

Absolicon for Birra Peroni

660 m² (462 kW) of Absolicon T160 solar collectors are used to generate both steam (at 155°C) and hot water (90°C) for the pasteurisation process.

A pressurised storage of 30 m³ can run the pasteuriser throughout the night.

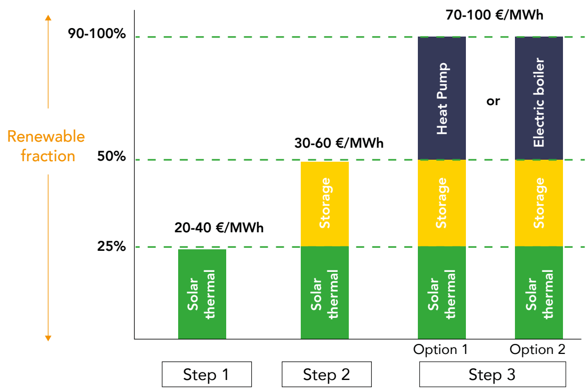
⟶ 400 kWh useful energy per m² of land area.

Competitive Levelised Cost of Heat

SHIP offers good cost stability compared to other solutions. Beside is a cost analysis that shows the financial benefits of using solar thermal technology, progressively integrating it with other solutions. Solar thermal energy can be stored in water storage (10% of the cost of comparable battery storage). It can also be combined with other technologies such as PV, resistance heaters and heat pump technology. Costs have significantly decreased with larger system sizes.

Large-scale SHIP plants benefit from economies-of-scale where larger projects tend to have lower costs.

The Levelised Cost of Heat (LCOH) is the average cost of energy supplied by a system over its lifetime. Calculation of LCOH takes into consideration the total capital expenditures (CAPEX) and operating expenditure (OPEX) of a system. CAPEX includes all turnkey costs, including short-term storage, and system integration.



Levelised Cost of Heat as a function of renewable fraction for different renewable sources in combination with storages (Source: Solar Heat Europe)

Case study for a virtual average pulp and paper plant:

A virtual average pulp or paper plant requiring 20 tonnes per hour of steam at 5 bar, 152°C which equates to approximately 95,000 MWh of yearly steam demand.

- The solar irradiation has been retrieved from the Meteonorm database for a typical meteorological year and ranges between 1800 kWh/m² in Spain to 1100 kWh/m² in Sweden.
- The system efficiency (ratio of useful energy to solar irradiation) is influenced by many factors (see textbox in page 2) and requires detailed individual calculations. In the case study it ranges from 60% for OptA/Spain to 30% OptB/Sweden.
- Location and storage capacity influence the possible renewable fraction (share of process heat demand covered by solar heat) and for the case study an average daily storage has been assumed.
- Specific CAPEX costs are defined as 500 to 643 €/kW for Option A and 643 to 857 €/kW for Option B.
- The examples of LCOH results are based on 25 years of lifetime, 5% discount and yearly OPEX of 1% of the initial CAPEX.
- Two potential scenarios for implementing SHIP in such a plant for three different geographical areas are proposed in the table below.
  - **Integration option A:** hot water system preheating at 95°C can cover 50% of the preheating demand, requiring between 0.8 ha (Spain) and 2 ha (Sweden) of land.
  - **Integration option B:** steam at 152°C can cover 25% of the total demand and requires between 6.8 ha (Spain) to 14.4 ha (Sweden) of available land.

Solar thermal is a well-subsidised technology in many European countries. Considering typical prices in 2024 and following internal consultations with members of Solar Heat Europe, heat delivery contracts could be provided in the indicative ranges shown below.

This is, of course, only indicative and highly depends on many factors to be assessed individually.

	Regions	Option A: Hot water at 95°C	Option B: Steam at 152°C
Required land area [ha]	Southern Europe (Madrid, Spain)	0.8	6.7
	Central Europe (Graz, Austria)	1.4	11.9
	Northern Europe (Stockholm, Sweden)	2.0	14.5
LCOH €/MWh incl. 0% subsidy	Southern Europe (Madrid, Spain)	25 - 32	52 - 69
	Central Europe (Graz, Austria)	39 - 51	87 - 116
	Northern Europe (Stockholm, Sweden)	56 - 73	104 - 139
LCOH €/MWh incl. 30% subsidy	Southern Europe (Madrid, Spain)	19 - 24	38 - 51
	Central Europe (Graz, Austria)	28 - 37	63 - 84
	Northern Europe (Stockholm, Sweden)	40 - 52	75 - 100

NB: Indicative ranges: Please consult potential providers for a specific analysis and tailored offer based on your needs and location.

More info about Solar Heat for Industrial Processes?