

Solar Thermal Solutions for Food Processing Sector



1. Industry Overview

The food-processing sector has substantial thermal-energy requirements for processes such as washing, blanching, cooking, pasteurisation, sterilisation, drying, evaporation, concentration and hot-water generation. Thermal energy is commonly supplied by biomass, coal, natural gas, furnace oil, LPG or electricity, depending on the process and location. These energy costs can be significant, particularly for MSME food-processing units.

Solar Heat for Industrial Processes (SHIP) can provide a portion of this thermal demand using solar energy. Solar heat can be integrated directly into the process, through a hot-water circuit, as boiler-feedwater preheating, or through steam generation. IEA SHC identifies food and beverage processing as an important application area for industrial solar heat, particularly where heat demand is below approximately 250°C. In India, MNRE identifies food processing and dairy among industrial sectors with good potential for CST deployment. MNRE estimates the industrial CST market potential in India at approximately 6.45 GW_{th}.

2. Typical Thermal Applications

Table 1: Food processing applications, indicative temperature range and typical heat medium

Food-processing application	Indicative temperature	Typical heat medium
Washing / cleaning	40 – 80°C	Hot water
Blanching	70 – 100°C	Hot water / steam
Cooking	80 – 120°C	Hot water / steam
Pasteurisation	60 – 100°C	Hot water / steam
Sterilisation / retorting	100 – 140°C+	Steam / pressurised hot water
Drying	60 – 150°C	Hot air / hot water / steam
Evaporation / concentration	60 – 150°C+	Steam / hot water
Boiler feedwater preheating	60 – 120°C	Hot water

3. Solar Thermal Technology Options

The appropriate technology should be selected based on required process temperature, heat-load profile, available area, solar resource and integration point.

Table 2: Solar thermal technology options, indicative applications and temperature range

Solar thermal technology		Indicative application	Temperature Range
Non-concentrating solar thermal	Flat Plate Collector (FPC)	Washing, cleaning, low-temperature hot water	30–80°C
	Evacuated Tube Collector (ETC)	Hot water, washing, preheating	40–100°C
Non-imaging concentrating	CPC/evacuated-tube CPC/xCPC	Hot water, blanching, low/medium-temperature process heat	60–120°C
Concentrating Solar Thermal	Scheffler / parabolic dish	Hot water, steam and direct process heating	100–250°C
	Parabolic Trough Collector (PTC)	Medium-temperature process heat and steam	100–250°C
	Linear Fresnel Reflector (LFR)	Steam, thermal-oil heating and boiler integration	100–250°C
	Higher-temperature CST systems	Selected specialised processes	Up to 400°C

Thermal storage can improve the utilisation of solar heat where the solar resource and process demand do not coincide. For dairy industry applications below 120°C, hot-water storage can be a relatively simple option. Potential storage options include:

- Hot-water tank: Low-temperature processes
- Pressurised water: Processes above 100°C
- Thermal-oil storage: Medium-temperature applications
- Phase-change materials: Specific temperature ranges
- Molten salt: Higher-temperature applications

4. How Solar Heat Can Be Integrated

A key principle in industrial solar thermal design is to identify the most technically and economically suitable integration point rather than simply connecting the solar field to the main boiler. IEA SHC specifically highlights process integration and selection of the appropriate integration concept as a critical part of SHIP project design.

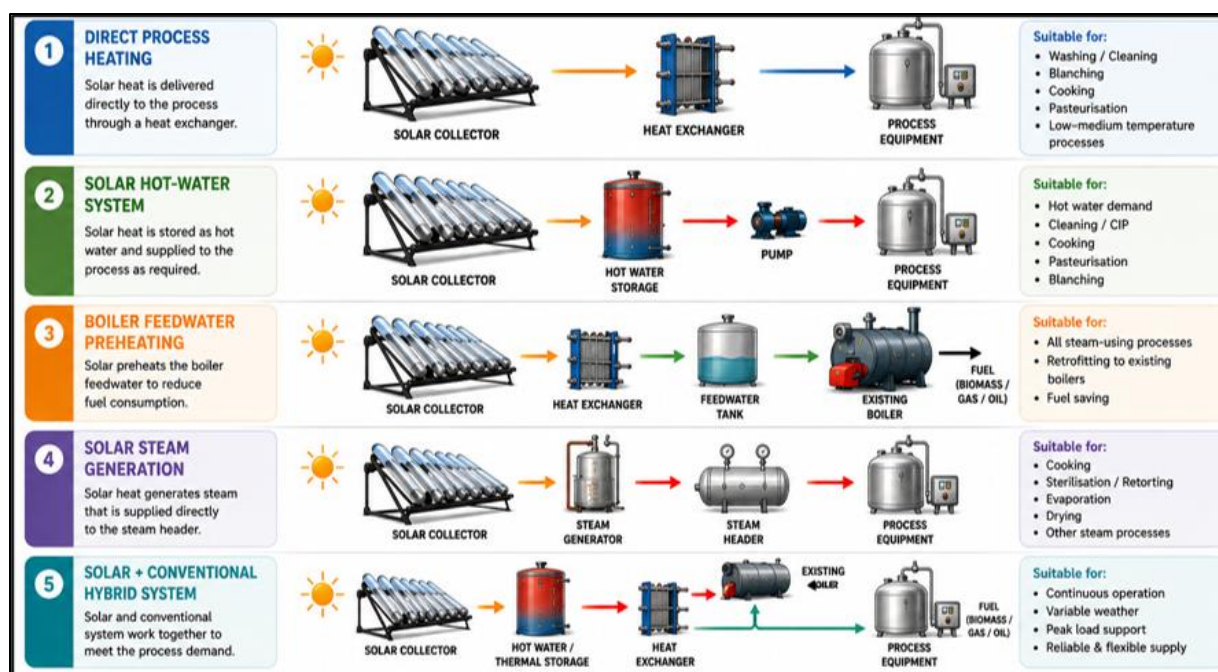


Figure 1: Illustration of solar heat integration to food processing industries

5. Key Benefits for Dairy Processing MSMEs

Solar thermal systems can potentially supply 20 - 50% of suitable process-heat demand in well-matched food-processing applications, depending on solar resource, process temperature, operating schedule, collector area, storage and system integration. The resulting fuel and cost savings are project-specific and should be assessed through an hourly heat-load and solar-yield analysis. Key economic indicators include annual solar heat delivered, fuel displaced, annual cost savings, O&M costs, LCOH, NPV, IRR and payback period. Thermal storage and integration with existing boilers can further improve solar utilisation and project economics. Table below presents key benefits for food processing MSMEs.

Table 3: Key benefits for food processing sector MSMEs

 ENERGY	- Reduces consumption of biomass, LPG, diesel, furnace oil or natural gas. - Reduces boiler fuel requirement. - Provides renewable thermal energy for daytime production.
 ECONOMIC	- Reduces exposure to fuel-price fluctuations. - Can reduce long-term thermal-energy costs. - Can extend the useful role of existing boiler infrastructure.
 ENVIRONMENTAL	- Reduces fossil-fuel consumption and associated GHG emissions. - Can reduce local air-pollutant emissions where fossil or poorly controlled biomass combustion is displaced.
 OPERATIONAL	- Can be integrated with existing boilers. - Thermal storage can improve solar utilisation. - Hybrid operation maintains process reliability.

6. Indian Case Example

Tapi Food Products, Mangarol, Surat, Gujarat has been using a CST system with 10 Scheffler parabolic-dish concentrators (10 m² each) for process steam generation. The system generated approximately 350 kg/day of steam at about 6 kg/cm² pressure, supplying steam to the food-processing operation and reducing conventional fuel consumption. The project was supported by government subsidies and is widely cited as one of India's earliest industrial solar process-heat applications..

Parameter	Reported project information
Project	Solar Thermal Boiler-Feedwater Preheating at Tapi Food Products
Location	Mangarol, Surat, Gujarat
Industry	Food processing
Product	Fruit-based products including papaya tutti-frutti
Year	2007
Technology	Scheffler concentrators
Collector area	10 x 9.3 m ² per collector = 93 m ²
Heat production	350 kg/day of steam at about 6 kg/cm ² pressure
Existing heat source	Wood-fired boiler
Solar application	Boiler-feedwater/process-heat preheating
Fuel saving	70 tonnes of firewood per year
CO₂ emission avoided	122 tCO ₂ /year (considering IPCC default emission factor of 112 kg CO ₂ /GJ and net calorific value 15.6 GJ/tonne for wood)

7. Sources and References

- 1) Ministry of New and Renewable Energy (MNRE) - Concentrated Solar Thermal – CST for Heat Generation.
- 2) IEA SHC Task 49 / Task 64 resources on Solar Heat for Industrial Processes (SHIP).