

Solar Thermal Solutions for Pharmaceutical Sector



1. Industry Overview

Pharmaceutical manufacturing has significant thermal-energy requirements across formulation, washing, cleaning-in-place (CIP), sterilisation, distillation, evaporation, drying, granulation, hot-water generation and utility systems. Thermal energy is commonly supplied by fossil-fuel-fired boilers, electric heaters, heat pumps or other conventional systems, depending on the process and plant configuration.

Solar Heat for Industrial Processes (SHIP) can supply part of this demand through hot-water generation, boiler-feedwater preheating, solar steam, hot-air generation or indirect process heating. Pharmaceutical plants are particularly attractive for solar integration because many heat requirements fall in the low- to medium-temperature range. Solar heat should normally be transferred through suitable heat exchangers or qualified steam/hot-water systems so that product quality, water quality, hygiene and GMP requirements are maintained.

2. Typical Thermal Applications

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

Pharmaceutical application	Indicative temperature	Typical heat medium
Process hot water / washing	50 - 80°C	Hot water
Cleaning-in-place (CIP)	60 - 90°C	Hot water / steam
Distillation / purified-water systems	55 - 100°C	Hot water / steam
Sterilisation / autoclaving	121 - 134°C	Saturated steam
Evaporation / concentration	100 - 150°C+	Steam
Drying	60 - 150°C+	Hot air / steam
Granulation	60 - 120°C	Hot air / steam
Boiler feedwater preheating	50 - 120°C	Hot water / suitable HTF
Low-pressure process steam	120 - 160°C	Steam

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)	Low-temperature hot water, washing and preheating	30 - 80°C
	Evacuated Tube Collector (ETC)	Hot water, washing and utility preheating	40 - 100°C
Non-imaging concentrating	CPC/evacuated-tube CPC/xCPC	Low/medium-temperature hot water and process heat	60 - 120°C
Concentrating Solar Thermal	Scheffler / parabolic dish	Solar steam, process heating and hot water	100 - 250°C
	Parabolic Trough Collector (PTC)	Medium-temperature process heat, thermal oil and steam	100 - 250°C
	Linear Fresnel Reflector (LFR)	Steam and medium-temperature process heat	100 - 250°C
	Higher-temperature CST systems	Selected drying/thermal 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 many pharmaceutical applications below 120°C, hot-water storage can be a relatively simple option. Potential storage options include hot-water tank, pressurised water, thermal-oil storage, phase-change materials and molten salt.

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.

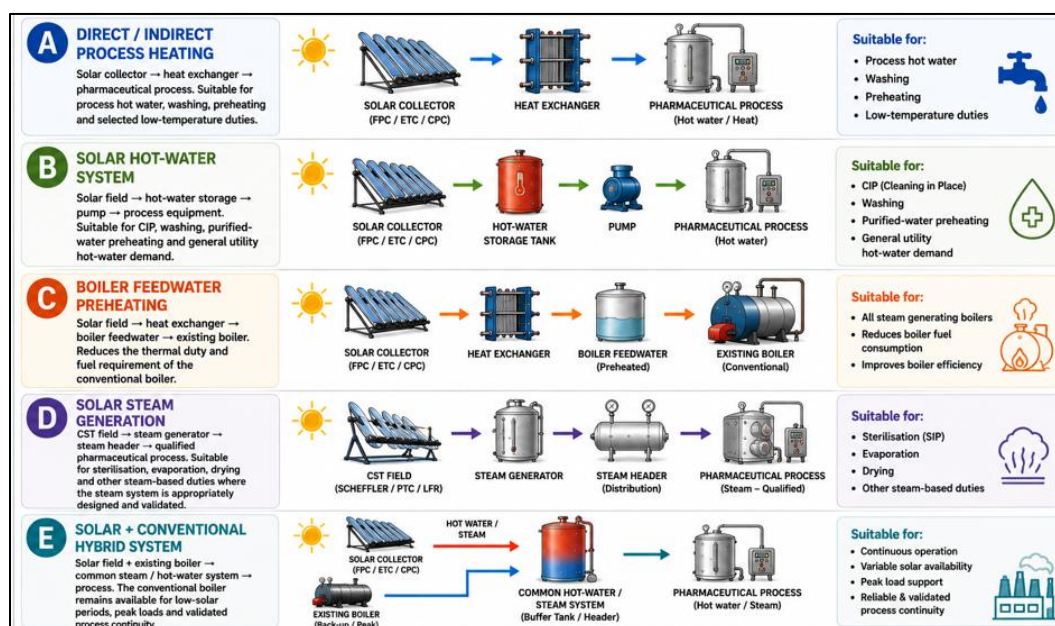


Figure 1: Illustration of solar heat integration to pharmaceutical manufacturing industries

5. Key Benefits for Dairy Processing MSMEs

Solar thermal can potentially supply a significant share of suitable pharmaceutical process heat where the solar resource, process temperature, operating schedule and collector area are well matched. As a preliminary screening range, a solar contribution of approximately 20–50% of suitable process heat may be considered; the actual solar fraction and fuel displacement should be established through project-specific hourly heat-load and solar-yield analysis. Economic assessment should include annual solar heat delivered, fuel displaced, annual cost savings, O&M costs, LCOH, NPV, IRR and payback.

Figure below presents key benefits for pharmaceutical MSMEs.

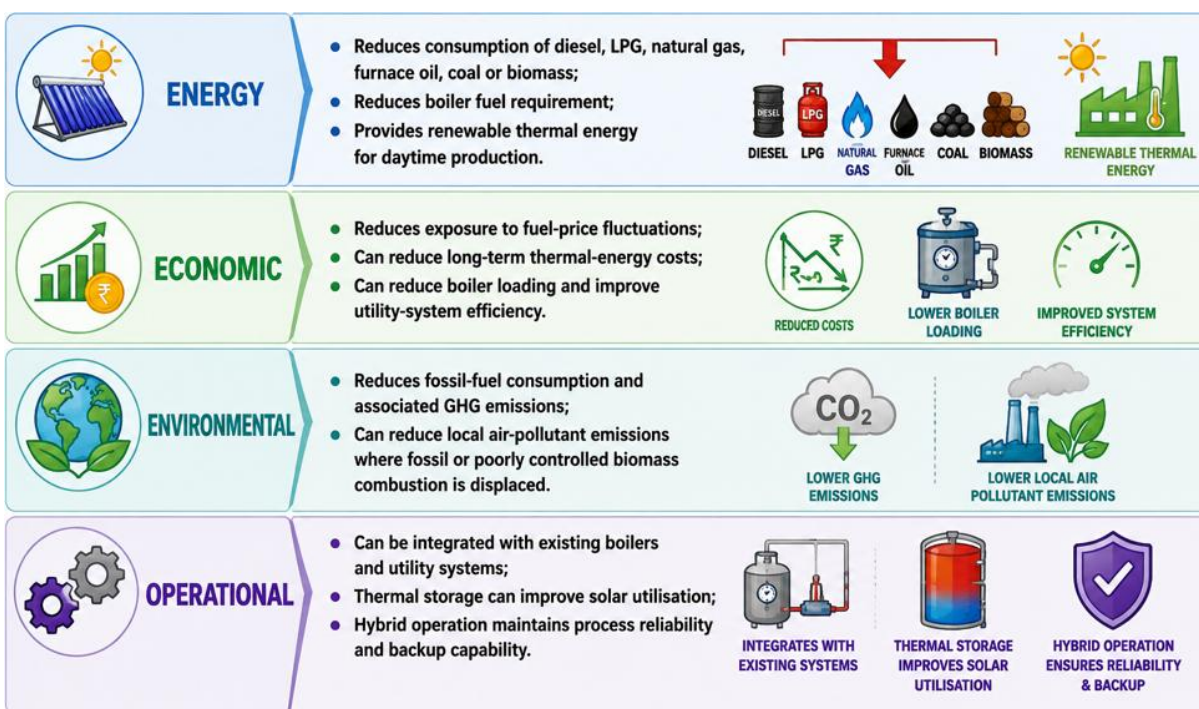


Figure 2: Key benefits for pharmaceutical sector MSMEs

6. Indian Case Example

Natural Capsules Limited (NCL), Puducherry, provides a strong pharmaceutical-sector example of CST integration. The system was implemented under the MNRE-GEF-UNIDO project to reduce dependence on fossil fuel used in the existing boiler. The project was inaugurated in March 2021 and is reported as a demonstration project for the pharmaceutical sector.

Parameter	Reported project information
Project	CST process-heat system at Natural Capsules Limited
Location	Pichaveerampet, Puducherry

Parameter	Reported project information
Industry	Pharmaceutical – capsule manufacturing
Year of installation	March 2021
Technology	Paraboloid dish CST with dual-axis tracking
Number of dishes	64
Total collector area	281.6 m ²
Thermal output	3.8 kW _{th} per dish at standard test condition; 243 kW _{th} nominal field capacity
Operating temperature / pressure	110 -120°C at 1.5 bar
Process application	Hot water for capsule manufacturing and washing and boiler-feedwater preheating
Daily thermal output	8 lakh kcal/day as reported
Existing fuel	Diesel-fired boiler
Reported diesel saving	150 - 200 litres/day
Reported solar contribution	70–80% of heat; SPV-powered heat pump 20–30%
Project cost – CST component	₹138 lakh
Reported payback	2.9 years with financial assistance 3.3 years without assistance
Annual fuel (diesel) saving	45,000 - 60,000 L/year (considering 300 working days)
CO₂ emission avoided	121 - 161 tCO ₂ e/year (considering diesel emission factor of 2.68 kg CO ₂ e/litre)

7. Sources and References

- 1) MNRE, Concentrated Solar Thermal – CST for Heat Generation.
- 2) Natural Capsules Limited, Puducherry – CST Case Study, MNRE-GEF-UNIDO project; updated 20 September 2022.
- 3) UNDP/MNRE Sun Focus case studies on CST process-heat applications in Indian industry.
- 4) Solar Heat for Industry: India — pharmaceutical-sector process mapping and solar-technology applications.
- 5) IEA SHC Task 49 / Task 64 resources on Solar Heat for Industrial Processes (SHIP).
- 6) GHG Protocol stationary-combustion guidance and Indian diesel emission-factor references for screening calculations.