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Ministry of MSME, Govt. of India

CONCENTRATED SOLAR THERMAL

(CST)

Technology Selection & Project Development Package



Under
UNIDO-GEF-MoMSME Project:
Promoting Business Models for Increasing
Penetration and Scaling Up of Solar Energy



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Introduction

Industrial solar heat projects should be developed as energy-efficiency and process-integration projects, not simply as collector installations. The first question is not “Which CST technology should I buy?” but “Where can renewable heat displace a real and measurable thermal load at an acceptable temperature, with acceptable reliability and economics?”

Solar Heat for Industrial Processes (SHIP) can cover a wide range of industrial heat requirements. IEA SHC Task 49 and Task 64 emphasise process integration, heat-load profiles, yield assessment, storage management and suitable integration concepts as central elements of successful industrial solar-heat projects.

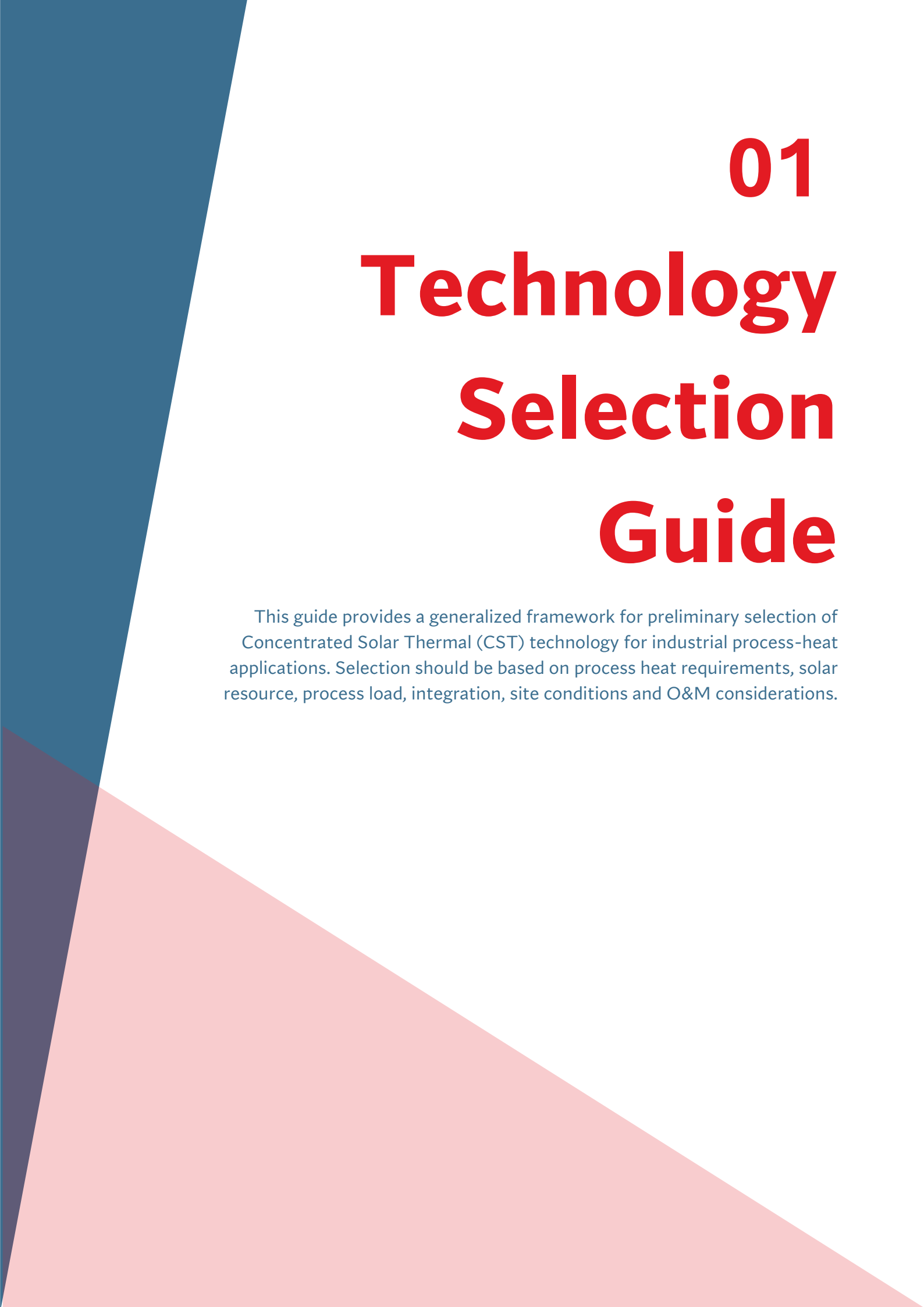
The following five principles are followed for an investable industrial solar-heat project:

- 1) Measure the heat load;
- 2) Improve efficiency and recover waste heat first;
- 3) Select the integration point before the collector;
- 4) Compare suppliers on useful heat and life-cycle cost; and
- 5) Contract, commission and verify performance at the process interface.

This technology selection and project development package provides a practical pathway from initial screening to procurement and performance verification of solar thermal systems for industrial process heat. It covers both conventional solar thermal systems and concentrating solar thermal (CST) systems. The broader term SHIP is used because many industrial loads below roughly 150°C can be served economically by non-concentrating technologies as well as low-concentration systems.

Recommended use of this package by project stage:

STAGE	USE THIS PACKAGE TO	
 1 Screening	Determine whether the industrial heat load is a plausible solar candidate.	
 2 Pre-feasibility	Estimate solar fraction, collector area, useful heat, fuel savings and indicative economics.	
 3 Feasibility	Collect measured data, assess integration points, simulate hourly performance and develop a business case.	
 4 DPR / tender	Prepare technical specifications, scope, guarantees, testing and commercial evaluation criteria.	
 5 Construction	Check engineering, safety, quality, integration and commissioning readiness.	
 6 Operation	Measure useful heat, fuel displacement, availability and system performance.	



01

Technology Selection Guide

This guide provides a generalized framework for preliminary selection of Concentrated Solar Thermal (CST) technology for industrial process-heat applications. Selection should be based on process heat requirements, solar resource, process load, integration, site conditions and O&M considerations.

1. Is Solar Heat Suitable for My Industry?

A solar thermal project is generally more attractive where a significant and repeatable thermal load occurs during periods of solar availability, the required temperature is compatible with available solar technologies, fuel costs are material, and there is sufficient roof or land area.

If the industry cannot establish a real heat load, has no suitable integration point, has inadequate solar/available area, or requires continuous high-temperature heat with no practical hybrid or storage solution, it may not be a right candidate for solar heat.

The following are a few screening indicators, but not mandatory thresholds.

SCREENING FACTOR		MORE FAVOURABLE CONDITION	WHY IT MATTERS
	1. Thermal demand	✓ Material, recurring thermal load	→ Larger and more stable loads generally improve utilisation
	2. Temperature	✓ Low/medium temperature; or higher temperature with suitable CST	→ Collector choice and efficiency depend strongly on temperature
	3. Daytime operation	✓ Good overlap with solar hours	→ Reduces curtailment and storage requirement
	4. Operating schedule	✓ High annual operating hours	→ Improves annual solar utilisation
	5. Fuel cost	✓ High or volatile fuel cost	→ Increases value of displaced fuel
	6. Solar resource	✓ Good solar availability; strong DNI for imaging CST	→ Determines annual useful heat
	7. Available area	✓ Adequate roof/land area with low shading	→ Limits collector field size
	8. Process flexibility	✓ Can accept preheated water/air/HTF or variable solar contribution	→ Makes integration easier
	9. Existing backup	✓ Boiler/furnace remains available	→ Maintains reliability during low-solar periods
	10. Water availability	✓ Adequate and quality controlled where required	→ Important for steam, cleaning and some cooling/heat-transfer systems

2. Understand Process Heat Requirement

Before selecting technology, define the heat sink. The same factory may have several heat sinks at different temperatures, such as hot-water washing at 70°C, drying at 120°C, boiler feedwater at 90°C and steam at 160–200°C. A solar system should normally be matched to the most suitable heat sink rather than being forced into the highest-temperature duty.

A reliable project should use measured data wherever practicable. At minimum, collect representative hourly thermal/fuel data for 7–14 days. For large or variable industrial systems, a month or more of representative data is preferable. Production-linked data should be collected so that thermal demand can be normalised to output.

The following information to be collected for the proposed industry/process as presented in the table below for first level assessment.

Data item	Minimum information to collect
Process / unit operation	Name, process description and production stage
Temperature	Supply, return, minimum, normal and maximum
Pressure	Operating and design pressure where relevant
Heat-transfer medium	Water, steam, air, thermal oil/HTF or direct process fluid
Thermal load	Peak, average and minimum kW _{th} /MW _{th}
Flow rate	kg/h, m ³ /h, Nm ³ /h as applicable
Operating hours	Hours/day, shifts/day, days/year
Production	Tonnes/day, batches/day or other relevant production metric
Fuel	Type, annual quantity, NCV and cost
Existing heater/boiler	Rated capacity, actual loading and efficiency if available
Heat recovery	Existing exhaust/waste-heat recovery and remaining opportunity
Process constraints	Quality, hygiene, pressure, contamination, response time and continuity requirements

3. Technology and Resource Assessment

3.1. Solar Thermal / CST Technology Landscape

Industrial solar heat should be viewed as a technology family rather than a single collector type. MNRE describes CST applications in India across industrial heat generation and identifies sectors such as dairy, food processing, paper and pulp, chemicals, textiles, fertilizer, breweries, pharmaceuticals, rubber and electroplating as having reported potential. MNRE cites an industrial CST market potential of about 6.45 GW_{th}.

The table below presents different solar thermal technologies, typical use in industry, indicative temperature range and solar source dependence.

Technology	Typical use in industry	Indicative temperature range	Solar resource dependence
Flat Plate Collector (FPC)	Hot water, washing, cleaning, low-temperature preheating	30–80°C	Low; uses direct + diffuse
Evacuated Tube Collector (ETC)	Hot water and utility/process preheating	40–100°C	Low–moderate
CPC / low concentration	Hot water and low/medium-temperature process heat	60–120°C	Moderate
Scheffler / parabolic dish	Steam and direct process heat	100–250°C+	High DNI

Technology	Typical use in industry	Indicative temperature range	Solar resource dependence
Parabolic Trough (PTC)	HTF/thermal-oil heating and steam	100–250°C+	High DNI
Linear Fresnel (LFR)	Steam and medium-temperature process heat	100–250°C+	High DNI
Higher-temperature CST	Specialised process heat	250–400°C+	High DNI and suitable process

Temperature ranges given in the table are indicative. Actual delivery temperature depends on collector design, flow, operating conditions, ambient temperature, solar resource and required efficiency. IEA SHC Task 49 describes industrial solar process-heat applications across low (<100°C), medium (100–250°C) and high (250–400°C) temperature ranges, while Task 64 addresses industrial heat sinks up to about 400°C.

3.2. Solar Resource Assessment

Solar resource assessment must be matched to the technology. Imaging concentrators depend primarily on direct normal irradiance (DNI), whereas non-concentrating systems can make better use of diffuse radiation. Use site-specific hourly or sub-hourly resource data for final design.

Resource item	Screening / feasibility requirement
DNI	Hourly/monthly data for imaging CST; include seasonal variation
GHI	Useful for broader solar assessment and non-concentrating systems
Ambient temperature	Hourly/monthly data for collector and storage performance
Wind speed	Design, stow and structural assessment
Rainfall / soiling	Cleaning frequency and O&M assessment
Shading / horizon	3-D or site-specific shading analysis where relevant
Solar yield	Annual and monthly useful thermal energy
P50/P90	Recommended for investment/financing decisions on larger projects

Important to be considered during solar resource assessment:

- Do not use annual average irradiation alone to estimate annual useful heat.
- State the data source, period, time resolution and uncertainty.
- For PTC/LFR/dish systems, verify that DNI is adequate during the factory's operating season and hours.
- Include collector orientation, row spacing, optical losses, thermal losses, soiling and downtime in the yield model.

3.3. Site and Land/ Roof Assessment

The following site parameters to be assessed to ensure its suitability for installation of CST system.

Assessment	Key checks
Land/roof	Area, ownership, structural capacity, access, drainage and future expansion
Solar geometry	Orientation, tilt/tracking envelope, shading and row spacing
Weather	Wind, rain, corrosion, flooding and extreme events
Utilities	Water, electricity, fuel, steam/hot-water/HTF connections
Process interface	Distance to heat sink, pipe/duct routing and pressure drop
Construction	Foundation, lifting, crane access and construction disruption
O&M	Cleaning access, safe walkways, spare-parts access and emergency access
Permits	Building, electrical, pressure, fire, environmental and other applicable approvals

3.4. Technology Selection Matrix

The rule for selection of technology presented in the table below. Select the heat sink first, then the integration concept, then the solar technology. Do not select a collector solely because it has the highest peak efficiency or the lowest ₹/m².

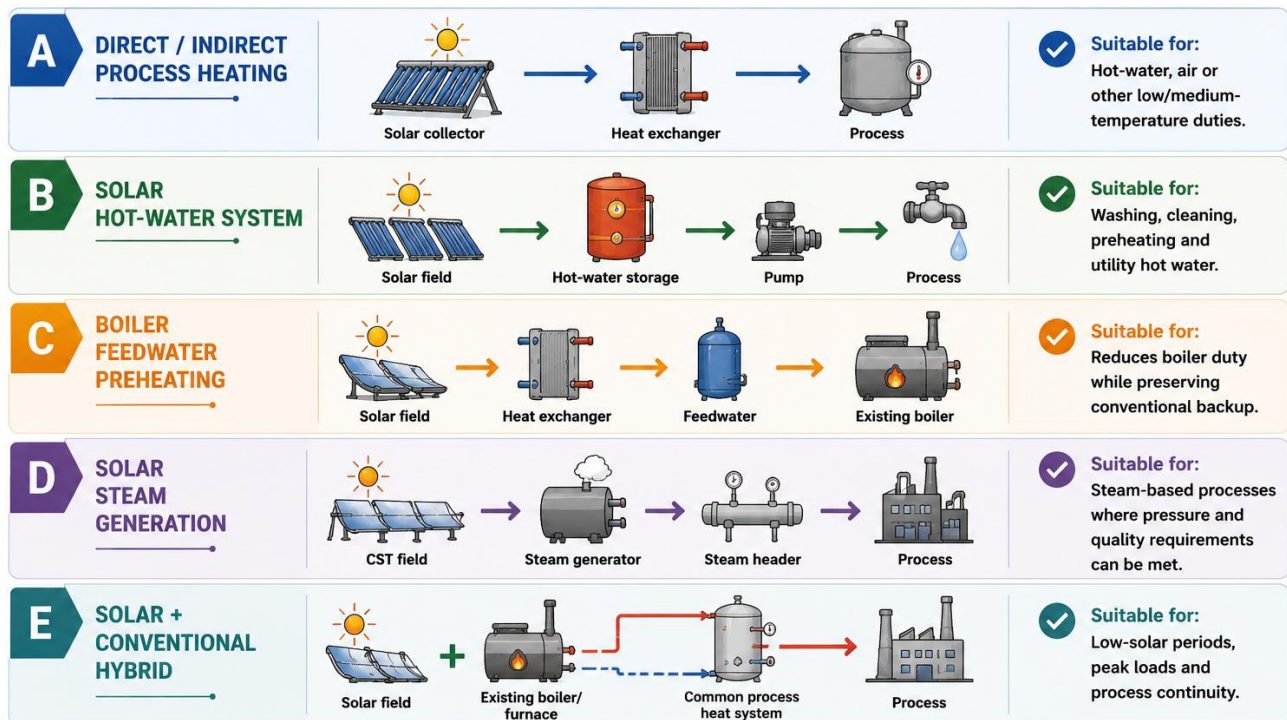
Criterion	FPC/ETC	CPC	Scheffler/Dish	PTC/LFR
Low-temperature hot water	Excellent	Excellent	Good	Limited/Good
Medium-temperature heat	Limited/Good	Good	Excellent	Excellent
Steam generation	Limited	Good	Excellent	Excellent
High DNI requirement	Low	Moderate	High	High
Tracking complexity	None/low	Low	Medium/high	Medium
Land requirement	Moderate	Moderate	Moderate	High
Typical integration complexity	Low	Low/medium	Medium	Medium/high
Best fit	<~100°C loads	~60–120°C loads	Steam/direct heat	~100–250°C+ heat

4. System Integration and Configuration

4.1. Selecting the Solar Heat Integration Point

The most important design decision is where solar heat enters the industrial energy system. IEA SHC Task 49 developed a methodology to identify and rank integration points and solar thermal system concepts. The methodology emphasises energy efficiency, heat recovery, integration-point identification and analysis before finalising the solar system.

The following illustration demonstrates typical ways to integrate solar thermal systems with industrial process-heat applications:



The following factors are to be considered for integration of CST to an industrial heating process.

- Temperature match between solar supply and process requirement.
- Annual operating hours and solar coincidence.
- Required process response time.
- Ease of hydraulic/duct connection.
- Potential for heat recovery and cascading.
- Need for thermal storage.
- Safety and hygiene constraints.
- Process downtime required for installation.
- Expected fuel displacement and economics.

4.2. Thermal Energy Storage

Thermal storage can improve the utilisation of solar heat where the solar resource and process demand do not coincide. Thermal storage should be added when there is a defined mismatch between solar availability and heat demand for the chosen industry. The storage size should be determined from the hourly load and solar-yield model.

Potential storage options are presented in the table below:

Storage type	Typical application	Key design checks
Hot-water tank	Low-temperature process heat	Temperature range, stratification, insulation, pressure
Pressurised water	Above 100°C applications	Pressure, safety, water quality, vessel compliance
Thermal oil	Medium-temperature HTF systems	Fluid stability, fire risk, degradation and expansion
Solid/sensible heat	Air/HTF buffering	Heat transfer rate, containment, cycling
PCM	Specific temperature window	Phase-change temperature, cycling and encapsulation
Molten salt	Selected higher-temperature CST	Freeze protection, corrosion, pumping and cost

4.3. Hybrid Operation and Backup

Industrial solar heat should normally be integrated so that the existing boiler/furnace remains available for low-solar periods, peak loads, process start-up and contingency operation. The control philosophy should define priority, set points, ramping, bypass arrangements and safe failure modes.

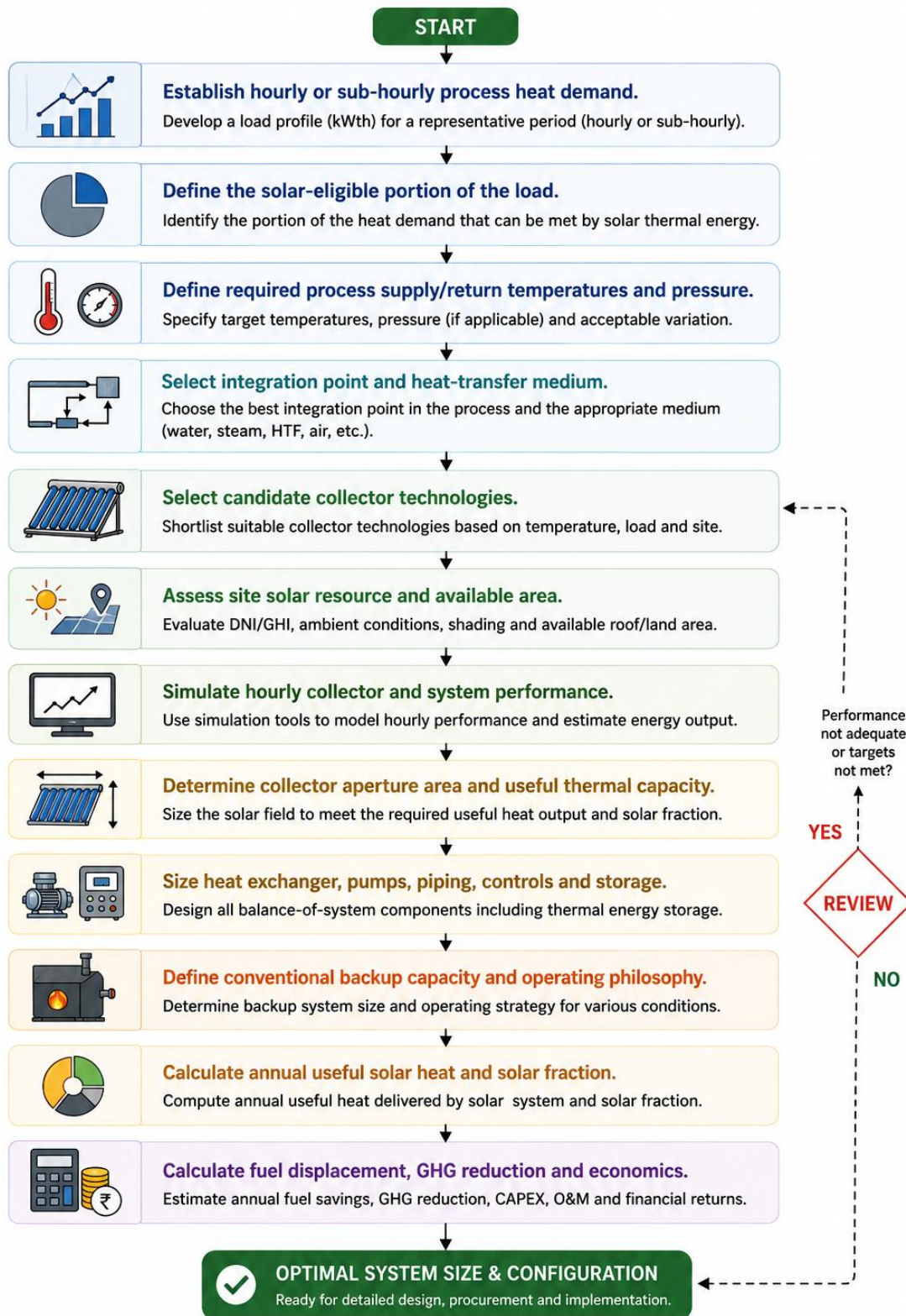
Operating condition	Recommended control response
Solar heat exceeds process demand	• Modulate solar field; • Charge storage if provided; • Avoid uncontrolled overheating
Solar heat partially meets demand	• Solar supplies base/preheat duty; • Conventional system supplies balance
Cloud transient	• Smooth through storage/control where practical; • Conventional system responds to deficit
No solar	• Conventional boiler/furnace supplies process
High wind / unsafe collector condition	• Automatic safe/stow mode and isolation as required
Process trip	• Solar field goes to defined safe state; prevent pressure/temperature excursions

02

System Sizing & Specification Framework

1. System Sizing Methodology

The primary objective to size or determine capacity of a solar thermal/ CST system is to meet the process heat demand. The flowchart below presents step-by-step methodology for system sizing.



A solar thermal system (collectors) should not be designed /sized to meet peak thermal load alone. The field must be sized against the hourly solar resource, process heat-load profile, operating temperature, allowable solar fraction, available area and backup/storage strategy.

2. Specification Framework

The specifications should translate the sizing results into clear, measurable and procurement-ready technical requirements. Specifications should be performance-based wherever practical and should avoid unnecessarily restricting the choice of proven CST technologies.

2.1. Design Basis

The project specification should clearly establish the following:

Parameter	Specification / Requirement
Process heat application	Process, hot water, steam, air heating, feedwater preheating, etc.
Required useful heat	kW _{th} / MW _{th}
Annual useful solar heat	MWh _{th} /year
Solar fraction	% of solar-eligible heat demand
Operating temperature	Supply and return temperature, °C
Operating pressure	bar(g), where applicable
Operating hours	hours/day and days/year
Solar resource	DNI/GHI and design meteorological year
Design life	Typically, 20–25 years
Availability target	Project-specific, e.g. ≥95%
Conventional backup	Existing boiler/furnace or dedicated backup
Storage requirement	None / buffer / thermal storage
Site constraints	Roof/ground area, shading, access and structural limitations

2.2. Solar Collector Field Specifications

In addition to particulars of collector technology and technical parameters the procurement document should clearly specify the required thermal performance as well.

The specification should include:

- Collector technology/type and operating principle.
- Gross and aperture area.

- Optical efficiency and thermal-loss characteristics.
- Design operating temperature range.
- Maximum operating temperature and pressure.
- Design wind speed and applicable structural loads.
- Collector tracking requirements, where applicable.
- Solar field orientation and allowable deviation.
- Shading and row-spacing requirements.
- Receiver/absorber specifications.
- Reflector/absorber durability and degradation requirements.
- Corrosion protection and material compatibility.
- Cleaning requirements and cleaning method.
- Expected annual performance and degradation.
- Collector manufacturer's warranty.

2.3. Solar Field Thermal Performance

The supplier should guarantee measurable performance at defined reference conditions. This is important because collector nameplate capacity alone should not be used to guarantee annual energy production.

The tender should define the following in regard to thermal performance:

- Reference solar irradiance/DNI;
- Ambient temperature;
- Inlet and outlet temperatures;
- Flow rate;
- Design operating pressure;
- Heat-transfer-fluid properties;
- Measurement locations;
- Allowable measurement uncertainty.

2.4. Heat Exchanger Specifications

Heat exchanger can be designed for direct heat transfer or indirect heat transfer.

Where indirect integration is used, specify:

- Heat-transfer duty, kW_{th} ;
- Primary and secondary fluid;
- Design inlet/outlet temperatures;
- Design pressure and temperature;
- Heat-transfer coefficient/design approach;
- Maximum allowable pressure drops;
- Materials of construction;
- Fouling allowance;
- Cleaning/maintenance provisions;

- Insulation;
- Safety relief arrangements;
- Isolation and bypass arrangements.

For industries like pharmaceutical, food and dairy applications, material compatibility and hygiene requirements should also be specified where the solar loop interfaces with process fluids.

2.5. Thermal Storage Specifications

Storage should be sized based on the actual mismatch between solar availability and process heat demand, rather than using an arbitrary number of hours.

Thermal storage should be specified as below:

- Usable thermal storage capacity ($\text{kWh}_{\text{th}}/\text{MWh}_{\text{th}}$);
- Nominal and minimum operating temperature;
- Charging and discharging temperature;
- Storage medium;
- Maximum allowable heat loss;
- Design pressure;
- Number of equivalent cycles;
- Insulation performance;
- Expansion provisions;
- Instrumentation;
- Temperature stratification requirements, where relevant;
- Safety and pressure-relief systems.

2.6. Pumps, Piping and Valves

Specifications should cover:

Pumps

- Flow rate;
- Head;
- Fluid temperature;
- Efficiency;
- Motor rating;
- Variable-speed operation;
- Duty/standby arrangement;
- Minimum flow protection.

Piping

- Design pressure and temperature;
- Pipe material;
- Corrosion allowance;
- Insulation thickness;

- Thermal expansion;
- Supports and anchors;
- Drain and vent arrangements.

Valves

- Isolation;
- Control;
- Check/non-return;
- Pressure-relief;
- Bypass;
- Emergency shutdown.

2.7. Instrumentation and Control

The CST system should include adequate instrumentation for both operation and performance verification. The control system should be designed to set priority of using heat from solar, storage and conventional backup subject to process temperature, pressure and safety constraints.

Minimum measurements should normally include:

- Solar irradiance/DNI;
- Ambient temperature;
- Collector inlet/outlet temperature;
- Heat-transfer-fluid flow;
- Process-side inlet/outlet temperature;
- Process heat flow;
- Storage temperature;
- Pump status and power;
- Boiler/furnace fuel consumption;
- System operating status;
- Alarm and fault conditions.

2.8. Performance Monitoring and Metering

A dedicated thermal energy meter should be provided at the agreed solar-energy delivery point. This is particularly important for ESCO/RESCO or performance-based contracts.

The monitoring system should report at least:

- Daily useful solar heat;
- Monthly useful solar heat;
- Annual useful solar heat;
- Solar fraction;
- Solar field availability;
- Collector efficiency;
- Storage performance;
- Conventional fuel consumption;

- Avoided fuel consumption;
- GHG emission reduction.

2.9. Conventional Backup and Hybrid Integration

The specification should explicitly define the role of the existing boiler/furnace. The solar system should not compromise process reliability. The conventional system should remain capable of meeting the process requirement when solar heat is unavailable, unless the project specifically provides an alternative backup arrangement.

The design should normally include:

- Automatic solar/backup changeover;
- Boiler/furnace minimum-load constraints;
- Peak-load operation;
- Cloud-transient response;
- Low-solar-period operation;
- Emergency bypass;
- Manual override;
- Fail-safe operation.

2.10. Electrical and Auxiliary Systems

Auxiliary electricity supply is an integral part of CST system.

Specifications should include:

- AC voltage and frequency;
- Connected load;
- Maximum auxiliary power;
- Pump motor efficiency;
- Control-panel requirements;
- Earthing and lightning protection;
- Cable and cable-tray requirements;
- Emergency power requirements;
- PLC/SCADA interface;
- Communication protocols;
- Remote monitoring requirements.

2.11. Civil and Structural Specifications

For rooftop CST, structural assessment should be completed before finalising collector area.

For roof or ground-mounted systems, the following parameters to be specified:

- Foundation design;
- Structural loading;
- Wind loading;

- Seismic requirements;
- Roof loading limits;
- Drainage;
- Equipment access;
- Maintenance access;
- Collector cleaning access;
- Fire access;
- Underground utilities;
- Site fencing where required.

2.12. Safety Specifications

The specification should address:

- High-temperature surfaces;
- Pressurised circuits;
- Steam hazards;
- Thermal-fluid leakage;
- Over-temperature protection;
- Over-pressure protection;
- Emergency shutdown;
- Fire safety;
- Worker access;
- Lock-out/tag-out;
- Chemical handling, where applicable;
- Hot-fluid exposure;
- Lightning protection;
- Safe maintenance access.

03

Procurement Checklist & Supplier Evaluation Criteria

Purpose: This checklist helps an MSME assess whether a proposed CST system is technically suitable, reliable, economical and appropriate for its industrial process.

How to use: Complete the basic requirement section first. Ask each supplier to provide the requested information and supporting documents. Wherever possible, compare suppliers on useful heat delivered, reliability and life-cycle cost, rather than only on the initial purchase price.

1. Procurement Checklist

The following checklist may be used to prepare the RFQ/RFP and evaluate technical bids.

Item	Procurement requirement
Process heat requirement	Define heat load, operating hours, temperature/pressure and annual demand.
Solar resource & site	Provide design solar resource, available area, shading and site constraints.
Collector system	Specify technology, aperture area, operating range, thermal performance and design life.
Solar field	Define layout, foundations, tracking, piping, insulation and cleaning arrangements.
Heat integration	Clearly specify the connection point, heat exchanger/steam generator and process interface.
Thermal storage	Specify required usable capacity, temperature range and performance, where applicable.
Balance of system	Include pumps, valves, piping, controls, instrumentation, electrical and safety systems.
Backup system	Define integration with existing boiler/furnace and required automatic backup operation.
Performance guarantee	Specify guaranteed useful solar heat, solar fraction and system availability.
Monitoring & M&V	Require calibrated heat metering, solar-resource measurement and fuel-consumption monitoring.
Testing & commissioning	Define FAT/SAT, commissioning and performance acceptance testing.
Warranty & O&M	Specify equipment warranty, performance warranty, O&M period, spares and response time.
Documentation & training	Require drawings, manuals, calculations, test certificates, training and as-built documentation.

1.1. Supplier Technical Bid Checklist

Once bid is received, the following checklist can be used to assess completeness of the offer.

- ☐ Process heat requirement independently reviewed
- ☐ Hourly/typical load profile provided
- ☐ Solar resource and data source stated
- ☐ Site/shading/land or roof assessment completed
- ☐ Technology selection justified
- ☐ Collector aperture area and layout provided
- ☐ Annual useful heat provided
- ☐ Monthly yield provided
- ☐ Solar fraction stated

- ☐ Auxiliary electricity stated
- ☐ Integration PFD/P&ID provided
- ☐ Heat exchanger / steam generator sized
- ☐ TES justified and sized, if applicable
- ☐ Backup/control philosophy defined
- ☐ Safety and emergency shutdown defined
- ☐ Applicable standards identified
- ☐ Reference industrial projects provided
- ☐ Detailed CAPEX and exclusions provided
- ☐ O&M and major replacement costs provided
- ☐ Performance guarantee included
- ☐ Commissioning/acceptance test defined
- ☐ M&V plan defined

2. Supplier Evaluation Criteria

Minimum technical qualification of supplier to be set before floating the bid document. The supplier should assess the site before finalising the system design.

A supplier should normally be considered technically responsive only if it:

- Has demonstrated industrial solar-thermal experience relevant to the proposed application;
- Provides a complete system design and performance calculation;
- Accepts clearly defined performance guarantees and M&V requirements;
- Provides verifiable reference projects;
- Demonstrates adequate O&M and after-sales support; and
- Meets the specified safety, quality and statutory requirements.

A 100-point technical evaluation is recommended before commercial evaluation.

Sl. No.	Evaluation criterion	Weight
1.	Relevant CST experience – industrial installations of comparable temperature and capacity	15
2.	Technical solution – suitability of collector, integration concept and system design	20
3.	Guaranteed performance – useful heat output, solar fraction and availability	20
4.	System engineering – heat exchanger, storage, hydraulics, controls and backup integration	15
5.	Reference projects – verified operating installations and performance data	10

Sl. No.	Evaluation criterion	Weight
6.	O&M capability – service network, response time, spares and maintenance plan	10
7.	Quality, safety & standards – QA/QC, testing, certifications and HSE provisions	5
8.	Project execution capability – engineering, construction and commissioning resources	5
	Total	100



04

Reference Technical Standards & Quality Benchmarks

This chapter provides a list of Indian and international standards related to CST systems and components.

1. International Standards

The following is the list of international standards as established by International Organization for Standardization (ISO) applicable for solar thermal systems.

Standard Code	Title	Description	Component/System
ISO 9806:2017	Solar energy - Solar thermal collectors - Test methods	Specifies test methods for durability, reliability, and performance of solar thermal collectors.	Solar Collectors
ISO 9459-1 to 5:2015	Solar heating - Domestic water heating systems	Testing and performance characterization for solar water heating systems.	Solar Water Heating
ISO 22975-1 to ISO 22975-5	Collector components (Tubes, insulation, glazing, absorber coating and heat pipes)	Component specific test methods.	Collector Components
ISO/TR 10217:2014	Solar energy - Water heating systems	Testing and performance criteria for natural circulation water heating systems.	Solar Water Heating
ISO 12241:2008	Thermal insulation for building equipment	Guidelines for insulating piping and equipment in solar thermal systems.	Insulation & Piping
ISO 10245:1999	Solar heating systems - Performance Testing	General performance testing for solar heating systems.	Solar Heating Systems
ISO 50001	Energy Management Systems	Guidelines for energy management systems in solar thermal installations.	Energy Management
ISO 13612-1:2014	Heating and cooling systems in buildings	Guidelines for solar-assisted heating and cooling systems.	Solar Cooling & Heating

2. Indian Standards

The following is the list of Indian standards as established by Bureau of Indian Standards (BIS) applicable for solar thermal systems.

Standard Code	Title	Description	Component/System
IS 16648 (Part 1):2017	Concentrated Solar Thermal – Specification – Part 1: Paraboloid Dish Concentrator	Specifies requirements for paraboloid dish concentrators used for CST applications, including system components and performance requirements.	Paraboloid Dish

Standard Code	Title	Description	Component/ System
IS 16648 (Part 2):2017	Concentrated Solar Thermal – Specification – Part 2: Scheffler Concentrator	Specifies requirements for Scheffler concentrators and their components for process heating and steam generation.	Scheffler Concentrator
IS 16648 (Part 3):2017	Concentrated Solar Thermal – Specification – Part 3: Parabolic Trough Concentrator	Specifies requirements for parabolic trough concentrators, including collector components, performance and operating provisions.	Parabolic Trough
IS 16648 (Part 4):2018	Concentrated Solar Thermal – Specification – Part 4: Non-Imaging Concentrator	Specifies requirements for non-imaging concentrators used for solar thermal applications.	Non-Imaging / CPC
IS 16648 (Part 5):2017	Concentrated Solar Thermal – Specification – Part 5: Test Methods	Provides methods for determining the thermal performance of CST collectors and systems.	CST Performance Testing



05

Appendixes

Appendix A. Industrial Data Collection Form

Field	Client response
Company / plant	_____
Industry / product	_____
Production quantity	_____
Process requiring heat	_____
Process temperature	_____ °C
Process pressure	_____ bar
Heat-transfer medium	_____
Peak thermal load	_____ kW _{th}
Average thermal load	_____ kW _{th}
Operating hours/day	_____
Operating days/year	_____
Fuel type	_____
Annual fuel consumption	_____
Fuel NCV	_____
Fuel price	₹ _____
Existing boiler/furnace capacity	_____
Existing efficiency	_____ %
Available roof/land	_____ m ²
Daytime heat demand	_____ %
Storage available/proposed	Yes / No
Backup heating	Yes / No
Production constraints	_____

Appendix B. Key Equations

Calculation	Equation / approach
Sensible heat	$Q = \dot{m} \times C_p \times (T_{out} - T_{in})$
Steam heat	$Q = \dot{m}_{steam} \times (h_{steam} - h_{condensate})$
Annual solar fraction	SF = Annual useful solar heat / Annual eligible process heat
Fuel displaced	Fuel = Useful solar heat / ($\eta_{conventional} \times \text{Fuel NCV}$)
GHG reduction	GHG = Fuel displaced $\times$ applicable emission factor
Simple payback	Payback = Net project investment / Annual net cash saving
LCOH	Discounted lifetime cost / Discounted lifetime useful thermal energy
NPV	Present value of project cash flows less initial investment

Appendix C. Glossary

Term	Meaning
CST	Concentrating Solar Thermal
SHIP	Solar Heat for Industrial Processes
DNI	Direct Normal Irradiance
GHI	Global Horizontal Irradiance
HTF	Heat Transfer Fluid
TES	Thermal Energy Storage
MWh_{th}	Megawatt-hour of thermal energy
kW_{th}	Kilowatt of thermal capacity
LCOH	Levelised Cost of Heat
M&V	Measurement and Verification
P50/P90	Energy-yield exceedance probabilities commonly used for risk assessment
Solar fraction	Share of eligible process heat supplied by useful solar heat
Useful heat	Thermal energy delivered at the defined process measurement boundary

