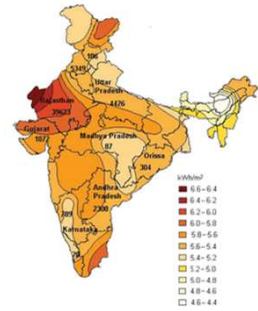


# Concentrated solar thermal for dairy

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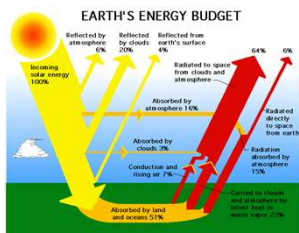
# Solar energy: India

- Solar radiation India
  - On a typical sunny day instantaneous radiation at noon on earth's surface is about 1000 W/m<sup>2</sup> varies over the day
  - Over 90% of India is > 5.0 kWh/m<sup>2</sup>/day
  - Significant regions are > 5.6 kWh/m<sup>2</sup>/day



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# Solar radiation

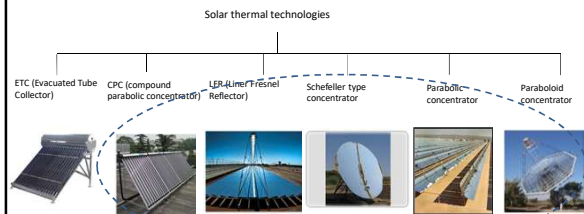


- Extra terrestrial radiation 1367 W/m<sup>2</sup>
- On earth solar radiation has two components
  - Beam radiation is vector quantity
  - Diffuse radiation is scalar quantity
- Total radiation on earth is Global radiation

Global radiation = Beam radiation + Diffuse radiation

Source: [http://ess.geology.ufl.edu/HTMLpages/ESS/GV/033/Notes/Radiation\\_Budget.gif](http://ess.geology.ufl.edu/HTMLpages/ESS/GV/033/Notes/Radiation_Budget.gif)

# Solar technologies under consideration



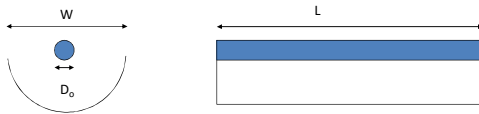
CST technologies

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## Definitions

**Aperture (W)** Plane opening through which solar radiation passes

**Concentration ratio (C)** ratio of the effective area of aperture to the surface area of absorber (not related to actual size of focus)

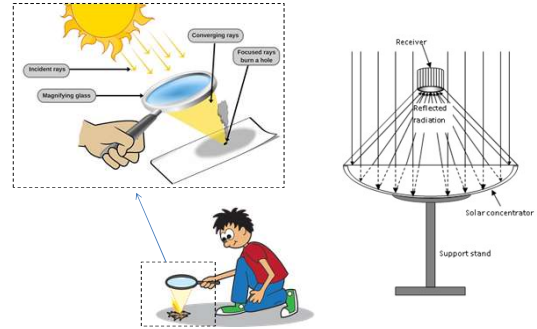


$$C = \frac{(W - D_o) \times L}{\pi \times D_o \times L}$$

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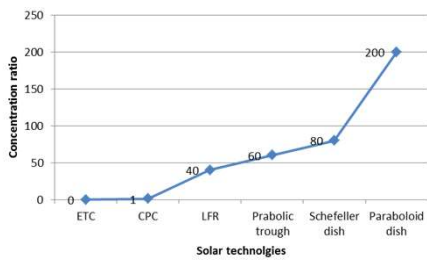
## What is concentrator technology ?



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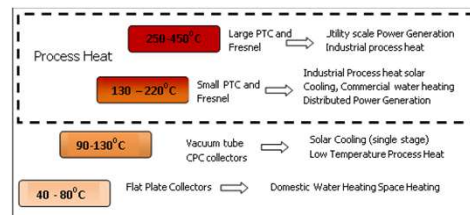
## Solar technologies and typical concentration ratio



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## Temperature levels for solar technologies



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## Industrial heating applications



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## Approach for CST adoption in dairy

- To qualify various filters, an approach of walk through study is adopted
- This includes
  - a) Observation of present processes
  - b) Discussion with operating team and management
  - c) Key service level requirement of a process
  - d) Overall energy balance and sample measurements
  - e) Study of operation schedule and logbook
  - f) Study of shadow free area available
  - g) Evaluate a suitable CST integration mode

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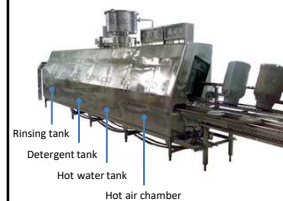
## Dairy facilities of Gokul

- Milk collection centers : 4 nos.
  - Milk collection 0.5-1.5 Lakh l /day
  - Major thermal process: Can washing and CIP
- Satellite dairy : 2 nos.
  - Milk collection 1.5-3 Lakh l /day
  - Major thermal process: Can washing, CIP and Pasteurization
- Main dairy : 1 no.
  - Milk collection more than 6-8 Lakh l /day
  - Major thermal process: Can washing, CIP, Pasteurization, Ghee making, Powder making etc.

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## Can washing station



- The operating temperature for rinsing tank is about 60-65 °C, detergent tank 80-85 °C, hot water tank 80-85 °C and hot air 110 °C
- The operation of system starts typically at 8.30 am to 1 pm in 1<sup>st</sup> shift and 6.30 pm to 9.30 pm in 2<sup>nd</sup> shift

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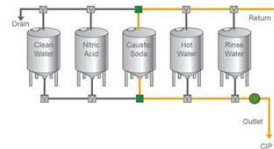
## CIP arrangement



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## CIP (Cleaning in place) process



- The cleaning solution is at 80-85 °C in close loop
- The hot cleaning solution is drained based on the strength (measured online with conductivity)
- The tank solution is heated with low pressure steam (1 bar (g)) using PHE (Plate heat exchanger)
- CIP is used for chemical cleaning and rinsing of milk contact surfaces (equipment, tanks and pipes)

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## Pasteurization process

- In pasteurization milk is taken at 4 °C, heated to 72 °C and stored back at 4 °C
- The process has inbuilt heat recovery of more than 90%, typical external heating or cooling requirement is of the order of 10 °C (i.e. heating or cooling load = 10 °C x mass flow rate of milk)
- Steam is used to heat close loop hot water maintained at 80-85 °C for heating milk
- The steam used is at low pressure at about 1 bar (g)

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## Ghee making and powder making

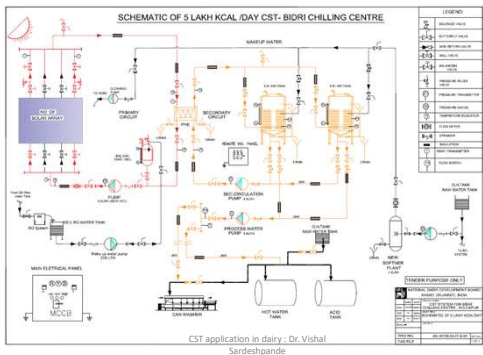
- Ghee making
  - Open pan melting of butter at 45-80 °C
  - Open pan cooking of ghee at 114 °C
- Powder plant
  - Multiple effect evaporator
  - Steam requirement at 17 bar (g)
  - Peak season operation
  - Generate condensate at 60-70 °C

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## Case study: Bidari



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## Operating data : Bidari

संगणक द्वारा निर्धारित (कंप्यूटर द्वारा)		बिदर - बिदर										
दिनांक	संगणक द्वारा निर्धारित	संगणक द्वारा निर्धारित	संगणक द्वारा निर्धारित	संगणक द्वारा निर्धारित	संगणक द्वारा निर्धारित	संगणक द्वारा निर्धारित		संगणक द्वारा निर्धारित	संगणक द्वारा निर्धारित			
						संगणक द्वारा निर्धारित	संगणक द्वारा निर्धारित					
11/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
12/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
13/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
14/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
15/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
16/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
17/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
18/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
19/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
20/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
21/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
22/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
23/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
24/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
25/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
26/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
27/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
28/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
29/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
30/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
31/11/2015	100000.0	15.00	2.5%	-	31/11/2015	100000.0	15.00	15.00	-	15.00	-	15.00
औसत	333333.3	15.00	2.5%	-		333333.3	15.00	15.00	-	15.00	-	15.00

बिदर - बिदर

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## Key leanings

- Understanding of heating application is important
- Choice of CST technology selection criteria is discussed
- Integration and application engineering is key for maximizing use of CST heat

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