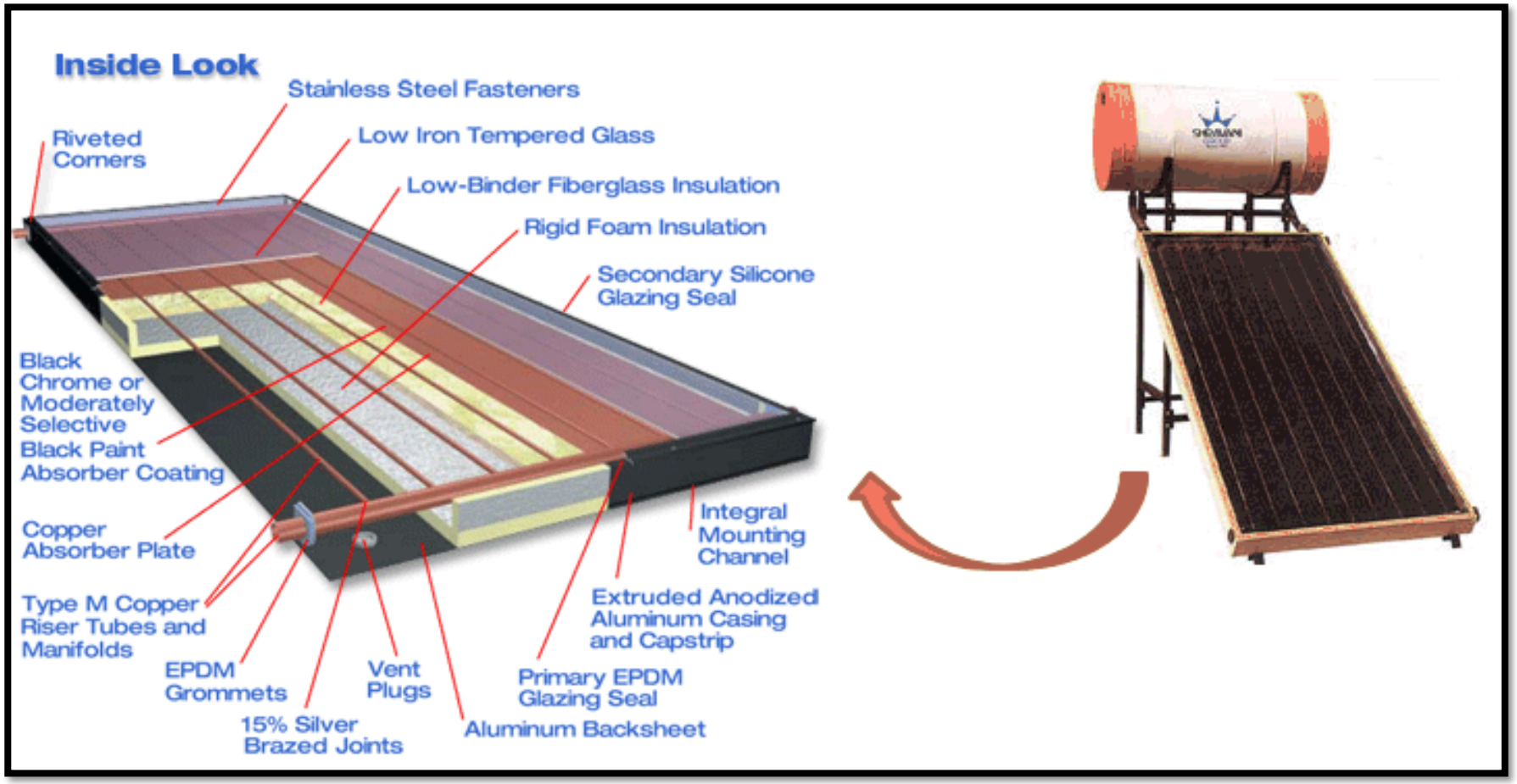
Industry 4.0 LAB

Design and Analysis of Solar Water Heating System

Department Of Chemical Engineering
School of Technology
Pandit Deendayal Energy University, Gandhinagar

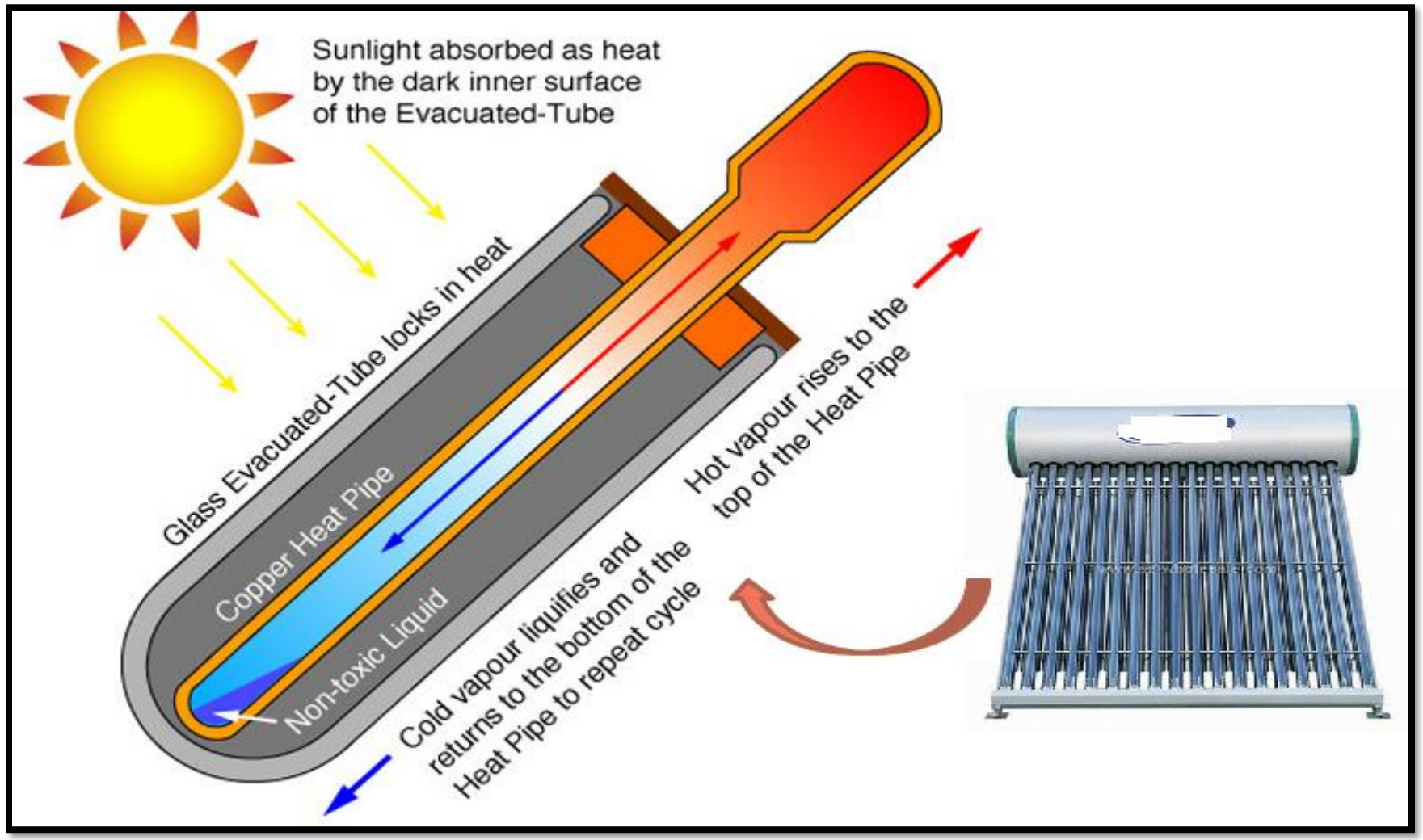
Solar thermal technology

Flat Plate solar collector:



Solar thermal technology

Evacuated Tube solar collector:



Industrial Applications of Thermal Energy

Industry	Process
✓ Food processing & Dairy	Chilling/cold storage, cooking, extraction, baking, pasteurization, sterilization, bleaching, drying etc.
✓ Breweries	Boiling, mashing, cold conditioning, fermentation etc
✓ Rubber	Heating, digestion, vulcanizing
✓ Pulp & paper	Pulping, digestion & washing, bleaching, evaporation & drying,
✓ Tobacco	Steam conditioning, drying & softening
✓ Electroplating	Post plating treatment, water heating, drying etc
✓ Pharmaceutical	Distillation, drying, evaporation, fermentation, injection & molding
✓ Textiles(Spinning & weaving, Finishing)	Preparing warps, sizing, de-sizing, scouring, bleaching, mercerizing, dyeing, drying & finishing
✓ Chemicals & Fertilizers	Distillation, effluent treatment, primary reforming, ammonia synthesis, CO_2 removal, methanation, steam stripping
✓ Refining	Desalting, cooking, thermal cracking, cleaning, wastewater treatment
✓ Ceramic tile & pottery	Beneficiation, drying, presenter thermal processing, glazing
✓ Desalination	Multiple effect distillation, multi stage flash distillation
✓ Plaster of Paris, Steel re-rolling, Cement, Mining	Augmenting steam to boilers, boiler feed water heating

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System Advisor Model 2020

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Start a new project >

Open a project file

New script | Open script

Quick start for new users >

Help contents

Check for updates...

Registration | About | Quit

Welcome

Do you have a question or feedback about SAM? Would you like to meet the SAM team? Join us for a SAM Round Table! Registration is free. These 30-minute online sessions are held the last Tuesday of each month at 2:30 pm Mountain time (GMT-6) -- all you need to participate is a computer with an internet connection.

Links to recordings of the 2020 SAM Webinars, including three on the latest battery model features, are available on the SAM website video pages, and on the Events page at https://sam.nrel.gov/events. We will post a new 2021 webinar schedule as soon as it is available.

You are using SAM 2020.11.29. The latest version is SAM 2020.11.29 (SSC 250).
To see complete version information for your SAM installation, click **About** in the lower left corner of this window.

SAM 2020.11.29

Choose a performance model, and then choose from the available financial models.

- Photovoltaic
- Battery Storage
- Concentrating Solar Power
- Marine Energy
- Wind
- Fuel Cell-PV-Battery
- Geothermal
- Solar Water Heating
- Biomass Combustion
- Generic System

- Distributed
- LCOE Calculator (FCR Method)
- No Financial Model

Help OK Cancel

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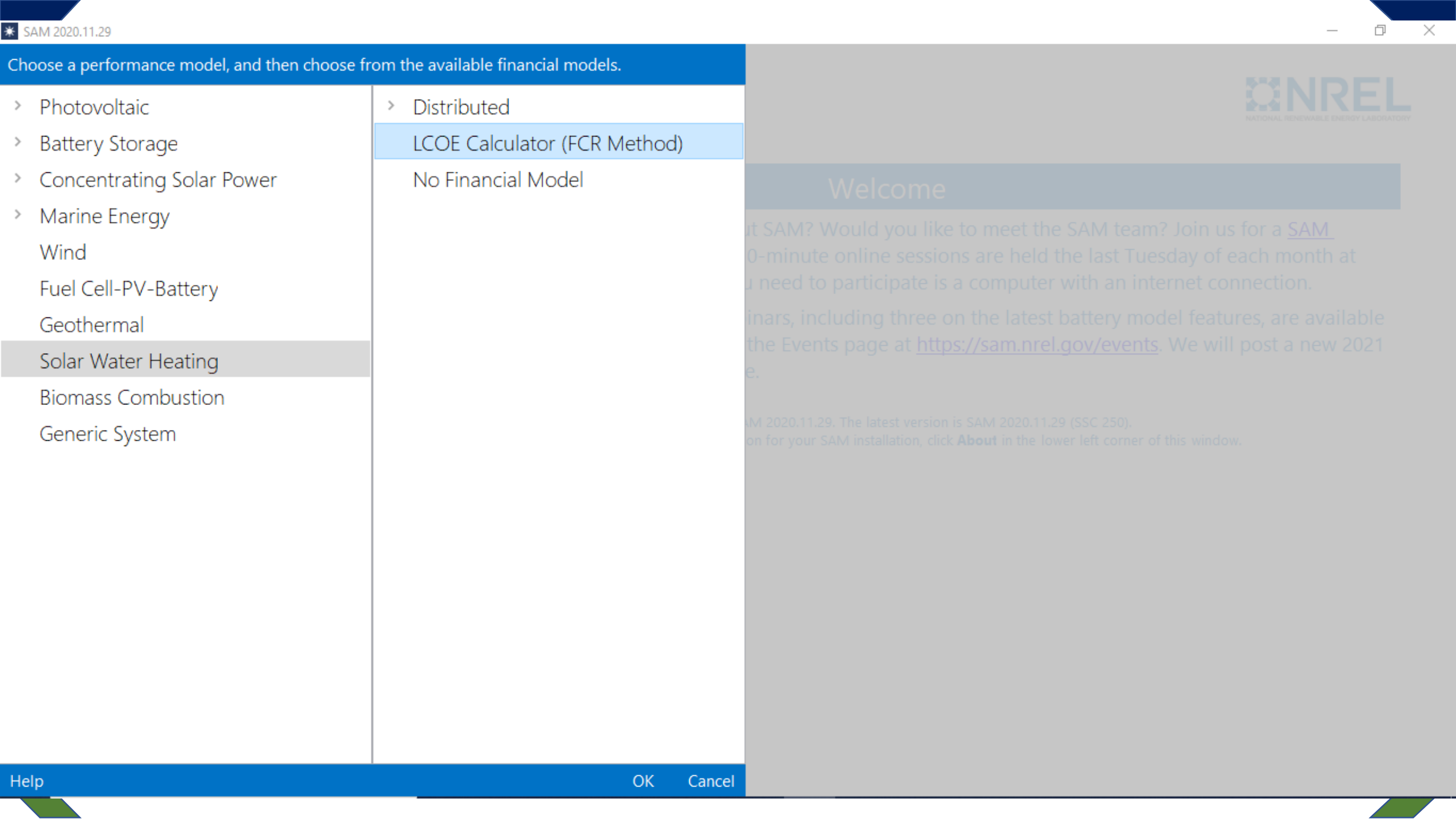
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File | Add | untitled | Help

Solar water, LCOE Calculator

- Location and Resource
- Solar Water Heating
- Financial Parameters

Simulate >

Parametrics | Stochastic | P50 / P90 | Macros

tucson_az_32.116521_-110.933042_psmv3_60_tmy	32.13	-110.94	-7	773	67345	NSRDB
ahmedabad_23.021624_72.579707_psm3_60_tmy	23.05	72.55	5.5	0	18330	NSRDB
new_delhi_28.613897_77.215956_psm3_60_tmy	28.65	77.25	5.5	0	33896	NSRDB

SAM scans the following folders on your computer for valid weather files and adds them to your Solar Resource library. To use weather files stored on your computer, click Add/remove Weather File Folders and add folders containing valid weather files.

C:\Users\Rajat/SAM Downloaded Weather Files

Add/remove weather file folders...

Refresh library

Download Weather Files

The NSRDB is a database of thousands of weather files that you can download and add to your to your solar resource library: Download a default typical-year (TMY) file for most long-term cash flow analyses, or choose files to download for single-year or P50/P90 analyses. See Help for details.

(•) One location ( ) Multiple locations [ ] Advanced download

Type a location name, street address, or lat,lon in decimal degrees | Default TMY file | Download and add to library...

For locations not covered by the NSRDB, click here to go to the SAM website Weather Page for links to other data sources.

Weather Data Information

The following information describes the data in the highlighted weather file from the Solar Resource library above. This is the file SAM will use when you click Simulate.

Weather file: C:\Users\Rajat\SAM Downloaded Weather Files\ahmedabad_23.021624_72.579707_psm3_60_tmy.csv | View data...

Header Data from Weather File

Latitude	23.05 DD	Station ID	18330
Longitude	72.55 DD	Data Source	NSRDB
Time zone	GMT 5.5		
Elevation	0 m		
Time step	60 minutes		

For NSRDB data, the latitude and longitude shown here from the weather file header are the coordinates of the NSRDB grid cell and may be different from the values in the file name, which are the coordinates of the requested location.

Annual Averages Calculated from Weather File Data

Global horizontal: 5.57 kWh/m²/day

Optional Data

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File | Add | untitled | Help

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Hot Water Draw

Hourly hot water draw profile: Edit array... kg/hr

Scale draw profile to average daily usage: ☑

Total annual hot water draw: 73000 kg/year

Average daily hot water usage: 200 kg/day

System

Tilt: 30 deg

Azimuth: 180 deg

Total system flow rate: 0.091056 kg/s

Working fluid: Water

Number of collectors: 2

Diffuse sky model: Isotropic

Irradiance inputs: Beam and Diffuse

Albedo: 0.2 0..1

Total system collector area: 5.96 m2

Rated system size: 3.41806 kW

Shading

Shading losses: Edit shading... | Open 3D shade calculator...

System Availabilty

Edit losses...

Constant loss: 0.0 %

Hourly losses: None

Custom periods: None

Collector

◉ Enter user-defined parameters

○ Choose from library

User-defined collector

Collector area: 2.98 m2

FRta: 0.689

FRUL: 3.85 W/m2.C

Incidence angle modifier: 0.2

Test fluid: Glycol

Test flow: 0.045528 kg/s

Filter: | Name

Name	SRCC Number	Type	Area	IAM	FRta	FRUL	Test Fluid
Heliodyne Inc. Gobi 406 001	2007027B	Glazed Flat-Plate	2.5	-0...	0.726	3.4	0
Heliodyne Inc. Gobi 336 001	2007027A	Glazed Flat-Plate	2.49	-0...	0.725	3.24	0
Heliodyne Inc. Gobi 406 002	1981085G	Glazed Flat-Plate	2.5	0.09	0.719	5.31	0

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Average daily hot water usage: 200 kg/day

System

Tilt: 30 deg

Azimuth: 180 deg

Total system flow rate: 0.091056 kg/s

Working fluid: Water

Number of collectors: 1

Diffuse sky model: Isotropic

Irradiance inputs: Beam and Diffuse

Albedo: 0.2 0..1

Total system collector area: 2.98 m2

Rated system size: 1.70903 kW

Shading

Shading losses: Edit shading... | Open 3D shade calculator...

System Availabilty

Edit losses...

Constant loss: 0.0 %

Hourly losses: None

Custom periods: None

Collector

◉ Enter user-defined parameters

○ Choose from library

User-defined collector

Collector area: 2.98 m2

FRta: 0.689

FRUL: 3.85 W/m2.C

Incidence angle modifier: 0.2

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LCOE Calculator

The fixed-charge rate method of calculating the levelized cost of energy simplifies time-dependent calculations and is appropriate for market-level analysis such as for the NREL Annual Technology Baseline, or for very preliminary project analysis. The cash flow method of SAM's other financial models is more suitable for more detailed project analysis. See Help for details.

Capital and Operating Costs

System capacity	1.71	kW	
	○ Enter costs in $	◉ Enter costs in $/kW	
Capital cost	1.00	2,000.00	
Fixed operating cost (annual)	0.00	50.00	
Variable operating cost	0.0000	$/kWh	

Financial Assumptions

◉ Enter fixed charge rate ○ Calculate fixed charge rate

Fixed charge rate (real)	0.098	Analysis period	20	years	Fixed charge rate (FCR) 0.098
		Inflation rate	2.5	%/year	FCR = CRF · PFF · CFF (see below)
		Internal rate of return (nominal)	13	%/year	
		Project term debt	60	% of capital cost	
		Nominal debt interest rate	8	%/year	
		Effective tax rate	40	%/year	
		Depreciation schedule	Value Solved Edit...	% of capital cost	
		Annual cost during construction	Value Solved 100	% of capital cost	
		Nominal construction interest rate	8	%/year	

Reference Values

Capital recovery factor (CRF)	0.083	Capital cost (CC)	3,418.06	$
Project financing factor (PFF)	1.127	Fixed operating cost (FOC)	85.45	$
Construction financing factor (CFF)	1.024	Variable operating cost (VOC)	0.00	$/kWh

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System

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Azimuth: 180 deg

Total system flow rate: 0.091056 kg/s

Working fluid: Water

Number of collectors: 1

Diffuse sky model: Isotropic

Irradiance inputs: Beam and Diffuse

Albedo: 0.2 0..1

Total system collector area: 2.98 m2

Rated system size: 1.70903 kW

Shading

Shading losses: Edit shading... | Open 3D shade calculator...

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Constant loss: 0.0 %

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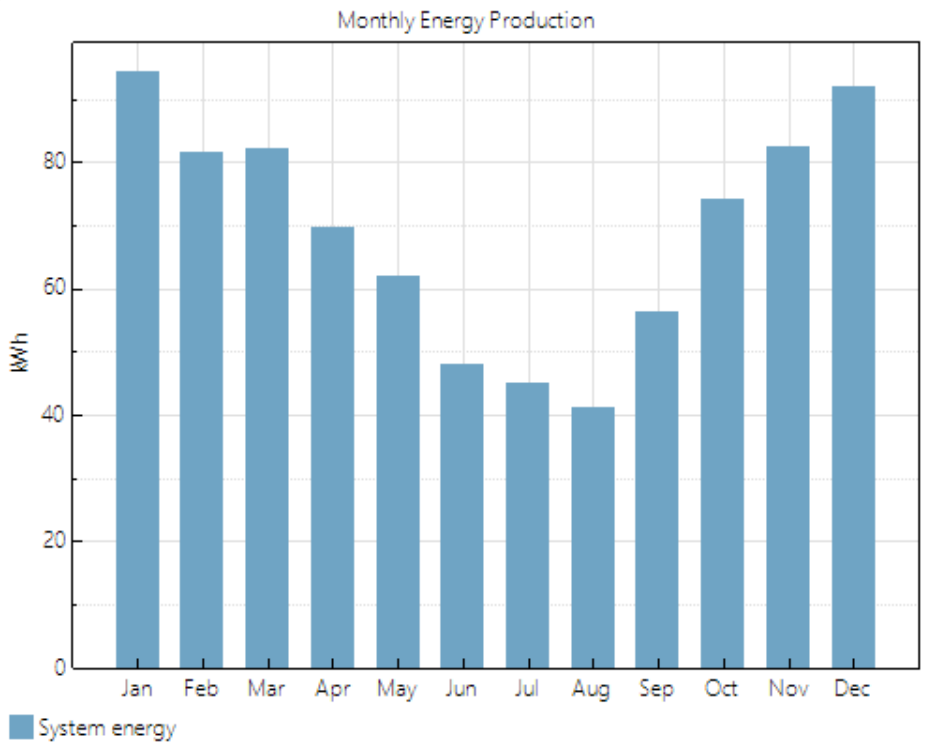
Summary | Data tables | Graphs | Time series | Profiles | Statistics | Heat map | PDF / CDF | Notices

Metric	Value
Annual energy saved (year 1)	829 kWh
Solar fraction (year 1)	0.83
Aux with solar (year 1)	33.6 kWh
Aux without solar (year 1)	1,002.6 kWh
Capacity factor (year 1)	5.5%
Levelized cost of energy	50.72¢/kWh



Problem Statement

Aim: Design a SWH system and assess the annual energy saved for a varying water demand of 50 l/day to 300 l/day (interval of 50 l) for a single collector costing Rs. 150000 (2000$) for your native location. Calculate the LCOE and Capacity factor for varying water demand and plot the results (w.r.t. varying water demand).

Submission must have following points:

Aim

Software details

Steps:

Location/ Weather file

and so on… (include screen shots for explanation)

Results and Discussion

Conclusion


Thank You!