Solar Water Heating
and
Solar Thermal Energy Solutions

SOLAR THERMAL

IT'S HOT AGAIN!

GovEnergy
www.govenergy.gov

GSA

Phoenix, AZ
August 3-6, 2008

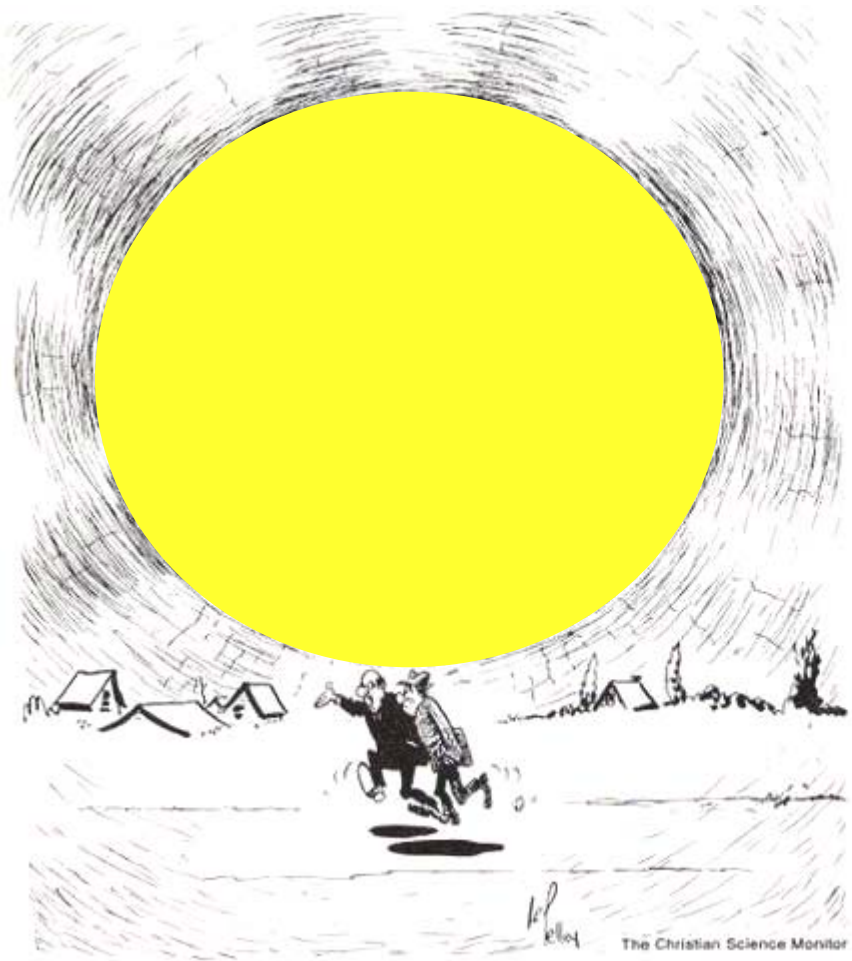
Solar Water Heating
and
Solar Thermal Energy Solutions

Great Lakes

Bill Guiney
Program Manager
Renewable Energy Solutions

Johnson Controls

Solar Thermal Technologies

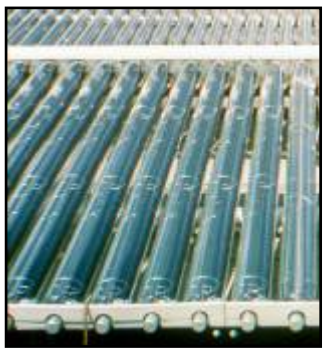


"We've got to look for a new source of energy!"

Solar Technologies:

- **Solar Thermal**
  - Water Heating
    - Service hot water
    - Boiler Make-up
    - HVAC supplemental system
  - Swimming Pool (most cost effective application)
  - Concentrating Solar Power (Solar Thermal Electric)

Solar Thermal Technologies



High Temperature

Electric Power Generation
Air-Conditioning
Industrial Process Heat

Mid Temperature

Hot Water
Air-Conditioning

Low Temperature

Pool & Spa

Solar Thermal Technologies:

Applications and Uses:

- Can be the most cost effective solar technology
- Easy to retrofit to most buildings
- Reliable and low maintenance
- Typically can fit into many 15 to 20-year PC projects without incentives
- Incentives are available in many States, (www.DSIREUSA.com) further improving project's cash flow

Solar Thermal Technologies: Applications

Water Heating

- Jails, Barracks, Administrative & Maintenance Facilities, Animal Care & Horse Stables (Mounted/Canine Military Police), Police & Fire Stations, Schools
- Hospitals, Health Clinics
- Kitchens, Dining Halls
- Laundry
- Hot Water & Steam Boiler Make-Up (very efficient and cost effective)

- **Space Conditioning - Heat/Cool**
  - Absorption- Desiccant Cooling- Hydronic (radiant or forced air) Heating
  - Make-up Outdoor Air
- **Swimming Pool Heating** (Low hanging fruit)
- **Power Generation-**
  - Concentrating Solar Power (CSP) 1MW or more in SW areas with high direct beam solar radiation

Hot Water Demand

SOLAR THERMAL is DESIGNED for 50-80% of the *ACTUAL LOAD*

- Swimming pool surface area and seasonal use
- Boiler make-up water
  - Determined load
- Administrative Buildings
  - 1-gallon per person per day
- Dining Halls-Restaurant- Kitchens
  - 2.4-gallons per meal served
- Dorms- Housings- Jail
  - 10 to 15-gallons per day per person

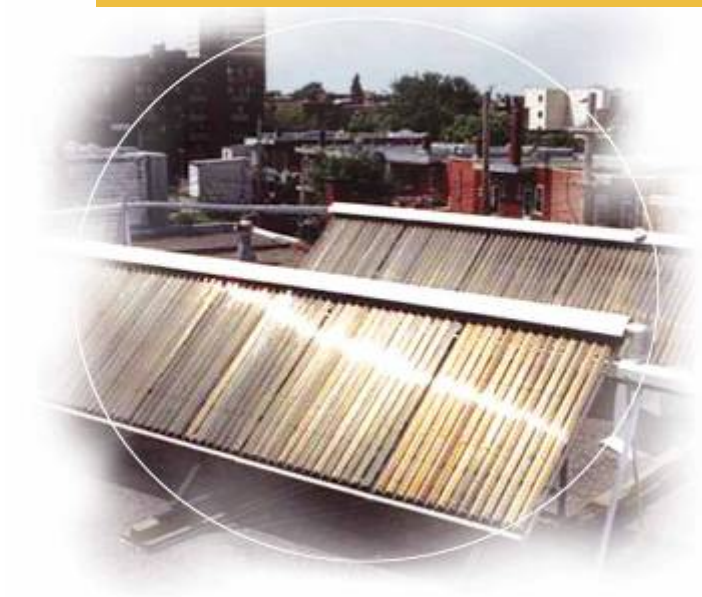
Solar Sizing and Performance Software

Natural Resources Canada | Ressources naturelles Canada

Canada

RETScreen® International

Solar Water Heating Project Model



http://www.retscreen.net

NASA UNEP GEF

GovEnergy www.govenergy.gov

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Performance Modeling

Project Information

10-year

Historical Weather Data

System Sizing

Annual Solar Production

Economic Analysis

Includes:

Estimated Savings

System Costs

O&M Costs

RETScreen® Energy Model - Solar Water Heating Project

Training & Support

Site Conditions		Estimate	Notes/Range
Project name		JCI Glendale SDHW	*See Online Manual*
Project location		Milwaukee	
Nearest location for weather data		Milwaukee, WI	*Complete SR&HL sheet*
Annual solar radiation (tilted surface)	MWh/m²	1.61	
Annual average temperature	°C	8.1	-20.0 to 30.0
Annual average wind speed	m/s	5.0	
Desired load temperature	°C	60	
Hot water use	L/d	11,400	
Number of months analysed	month	12.00	
Energy demand for months analysed	MWh	251.84	

System Characteristics		Estimate	Notes/Range
Application type		Service hot water (with storage)	
Base Case Water Heating System			
Heating fuel type	-	Natural gas - mmBtu	
Water heating system seasonal efficiency	%	65%	50% to 190%
Solar Collector			
Collector type	-	Glazed	*See Technical Note 1*
Solar water heating collector manufacturer		Solene	*See Product Database*
Solar water heating collector model		SLCO32	
Gross area of one collector	m²	2.95	1.00 to 5.00
Aperture area of one collector	m²	2.84	1.00 to 5.00
Fr (tau alpha) coefficient	-	0.79	0.50 to 0.90
Fr UL coefficient	(W/m²)/°C	4.60	1.50 to 8.00
Temperature coefficient for Fr UL	(W/(m?°C)²)	0.00	0.000 to 0.010
Suggested number of collectors		55	
Number of collectors		34	
Total gross collector area	m²	100.4	
Storage			
Ratio of storage capacity to coll. area	L/m²	157.0	37.5 to 100.0
Storage capacity	L	15,141	
Balance of System			
Heat exchanger/antifreeze protection	yes/no	Yes	
Heat exchanger effectiveness	%	90%	50% to 85%
Suggested pipe diameter	mm	N/A	8 to 25 or PVC 35 to 50
Pipe diameter	mm	38	8 to 25 or PVC 35 to 50
Pumping power per collector area	W/m²	0	3 to 22, or 0
Piping and solar tank losses	%	1%	1% to 10%
Losses due to snow and/or dirt	%	2%	2% to 10%
Horz. dist. from mech. room to collector	m	30	5 to 20
# of floors from mech. room to collector	-	2	0 to 20

Annual Energy Production (12.00 months analysed)		Estimate	Notes/Range
SWH system capacity	kW_{th}	67	
	MWth	0.067	
Pumping energy (electricity)	MWh	**0.00**	
Specific yield	kWh/m²	854	
System efficiency	%	53%	
Solar fraction	%	34%	
Renewable energy delivered	MWh	**85.74**	
	million Btu	292.57	

Complete Cost Analysis sheet

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www.govenergy.gov

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Allows The PDE To Determine The Financial Costs/Savings And Cash Flow

RETScreen® Financial Summary - Solar Water Heating Project

Annual Energy Balance

Project name		JCI Glendale SDHW	Electricity required	MWh	-
Project location		Milwaukee			
Renewable energy delivered	MWh	85.74			
Heating fuel displaced	-	ıtural gas - mmBtu			

Financial Parameters

Avoided cost of heating energy	$/mmBtu	13.000	Debt ratio	%	0.0%
			Income tax analysis?	yes/no	No
Retail price of electricity	$/kWh	-			
Energy cost escalation rate	%	6.0%			
Inflation	%	2.5%			
Discount rate	%	10.0%			
Project life	yr	30			

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**		
Feasibility study	0.0%	$	-	O&M	$	50
Development	0.0%	$	-	Electricity	$	-
Engineering	8.5%	$	12,000			
Energy equipment	29.6%	$	41,907	**Annual Costs and Debt - Total**	**$**	**50**
Balance of system	52.4%	$	74,062			
Miscellaneous	9.5%	$	13,457	**Annual Savings or Income**		
Initial Costs - Total	100.0%	**$**	**141,426**	Heating energy savings/income	$	5,851
Incentives/Grants		$				
				Annual Savings - Total	**$**	**5,851**
Periodic Costs (Credits)						
Valves and fittings		$	250	Schedule yr # 10,20,30		
Control/Pump		$	1,200	Schedule yr # 15,30		
		$	-			
End of project life -		$	-			

Financial Feasibility

Pre-tax IRR and ROI	%	7.4%			
After-tax IRR and ROI	%	7.4%			
Simple Payback	yr	24.4	Project equity	$	141,426
Year-to-positive cash flow	yr	15.0			
Net Present Value - NPV	$	(38,771)			
Annual Life Cycle Savings	$	(4,113)			
Benefit-Cost (B-C) ratio	-	0.73			

Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(141,426)	(141,426)	(141,426)
1	6,152	6,152	(135,274)
2	6,523	6,523	(128,751)
3	6,916	6,916	(121,835)
4	7,333	7,333	(114,503)
5	7,775	7,775	(106,728)
6	8,243	8,243	(98,485)
7	8,740	8,740	(89,745)
8	9,266	9,266	(80,479)
9	9,824	9,824	(70,655)
10	10,096	10,096	(60,560)
11	11,043	11,043	(49,517)
12	11,708	11,708	(37,809)
13	12,413	12,413	(25,396)
14	13,160	13,160	(12,237)
15	12,214	12,214	(23)
16	14,791	14,791	14,768
17	15,681	15,681	30,450
18	16,625	16,625	47,075
19	17,625	17,625	64,700
20	18,276	18,276	82,975
21	19,809	19,809	102,785
22	21,001	21,001	123,786
23	22,264	22,264	146,049
24	23,603	23,603	169,652
25	25,022	25,022	194,674
26	26,527	26,527	221,201
27	28,121	28,121	249,322
28	29,812	29,812	279,134
29	31,604	31,604	310,738
30	30,463	30,463	341,201

Energy Cost

Incentives

Years to Positive Cash flow

Annual savings

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www.govenergy.gov

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Annual Performance
Is The Important Element In The Design

Typically 50-80% of the Annual Hot Water Load

Depends On Climate. Southern Latitudes Typically Have Better Performance Because Of Warmer Ground Water

Performance

Sized For July- Not December

Typically Do Not Exceed 85-95% of July Load

Avoids Overheating Issues

December is 28% of Load

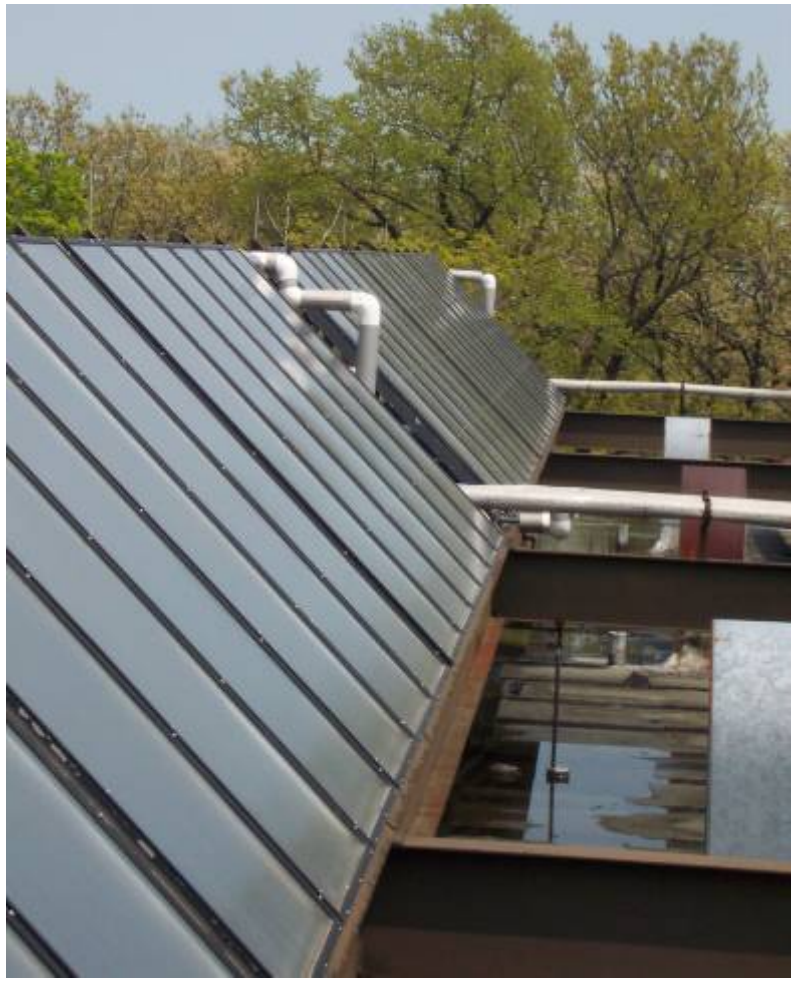
Annual is 67% of Load

	Solar Fraction	Delivered MMBtu
Jan	0.389	2.039
Feb	0.524	2.474
Mar	0.615	3.190
Apr	0.746	3.720
May	0.851	4.351
Jun	0.919	4.518
Jul	0.935	4.737
Aug	0.904	4.586
Sep	0.805	3.973
Oct	0.666	3.419
Nov	0.397	1.990
Dec	0.284	1.483
Year	**0.668**	**40.486**

Four Types of Solar Water Heating Thermal Collectors

Flat Plate
Mid-Temp
Solar Collector

Most Common Solar Water Heating Panel



Evacuated Tube Heat Pipe

Compound Parabolic Collector (CPC) Solar Collector Technology

Solargenix Energy, LLC
Chicago, IL

Johnson Controls

Integrated Collector Storage (ICS) Solar Collector Technology

TCT Solar
Jacksonville, FL

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ICS Solar Water Heating
Typically South of the Mason Dixon Line (Limited Freeze Protection)
No moving parts
Simple Pre-Heater for Existing Water Heating Systems

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Small 30-50-gallon systems
or
Large Commercial Applications

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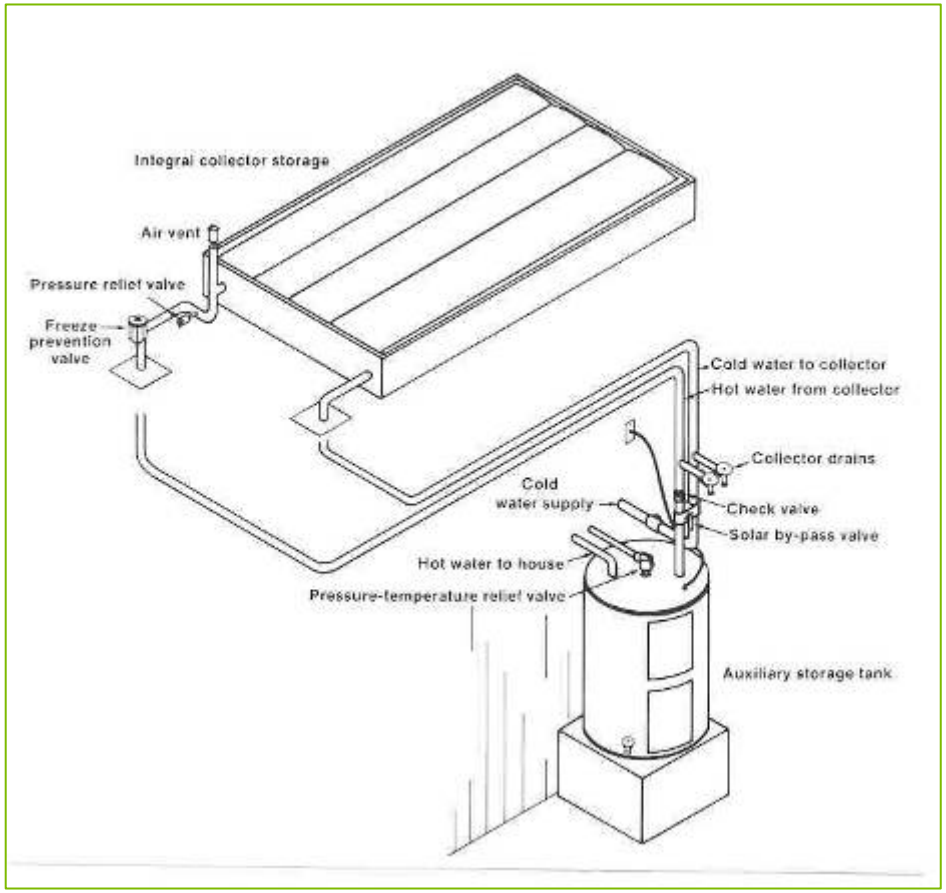
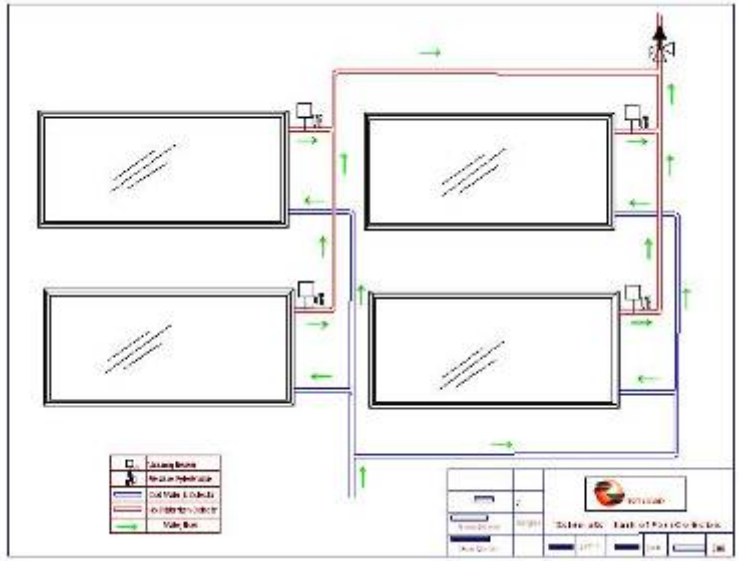
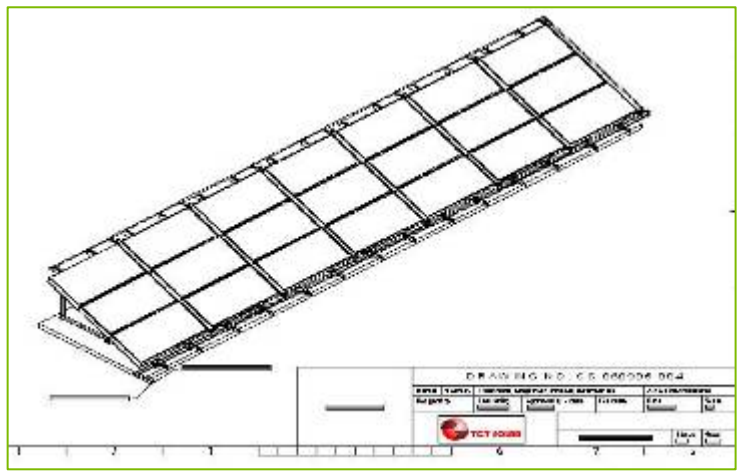
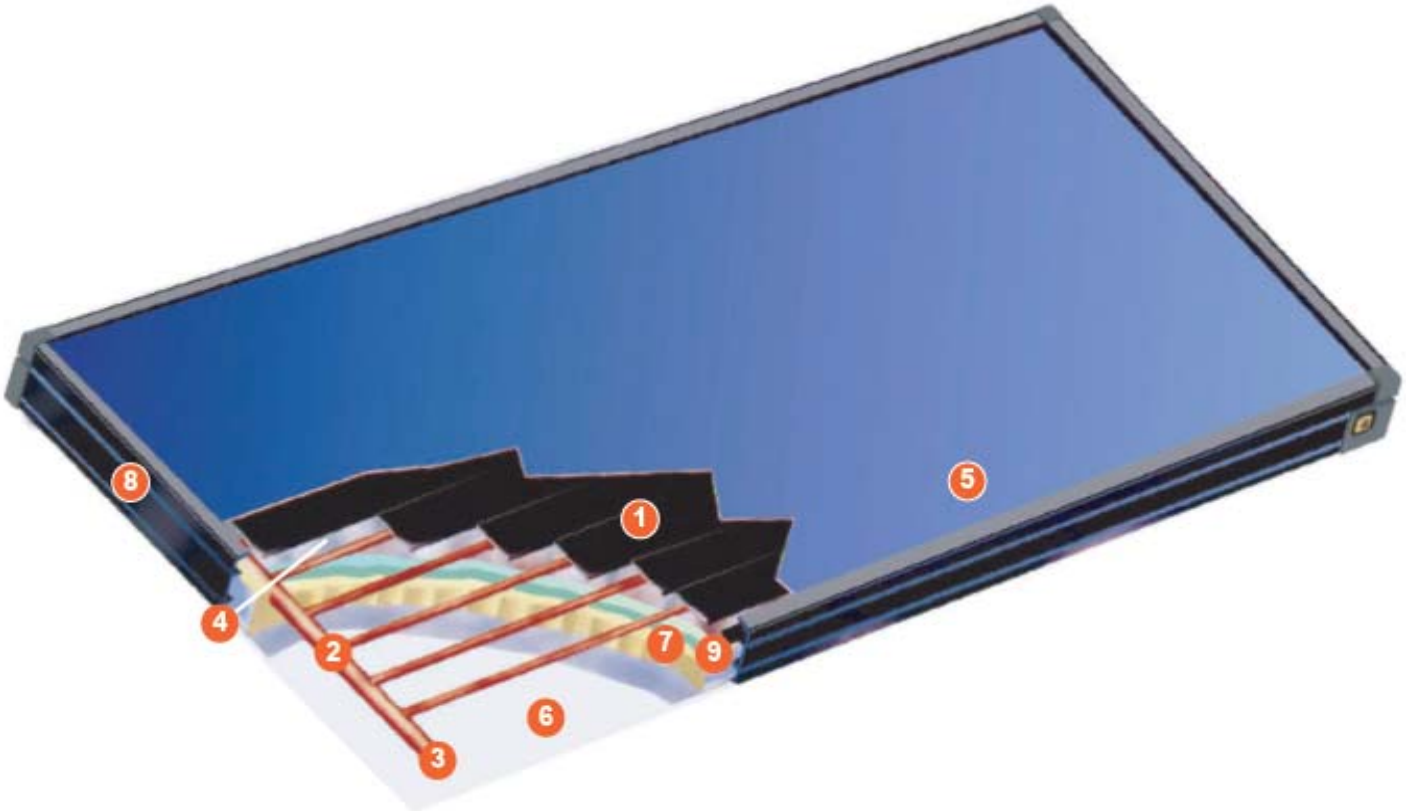


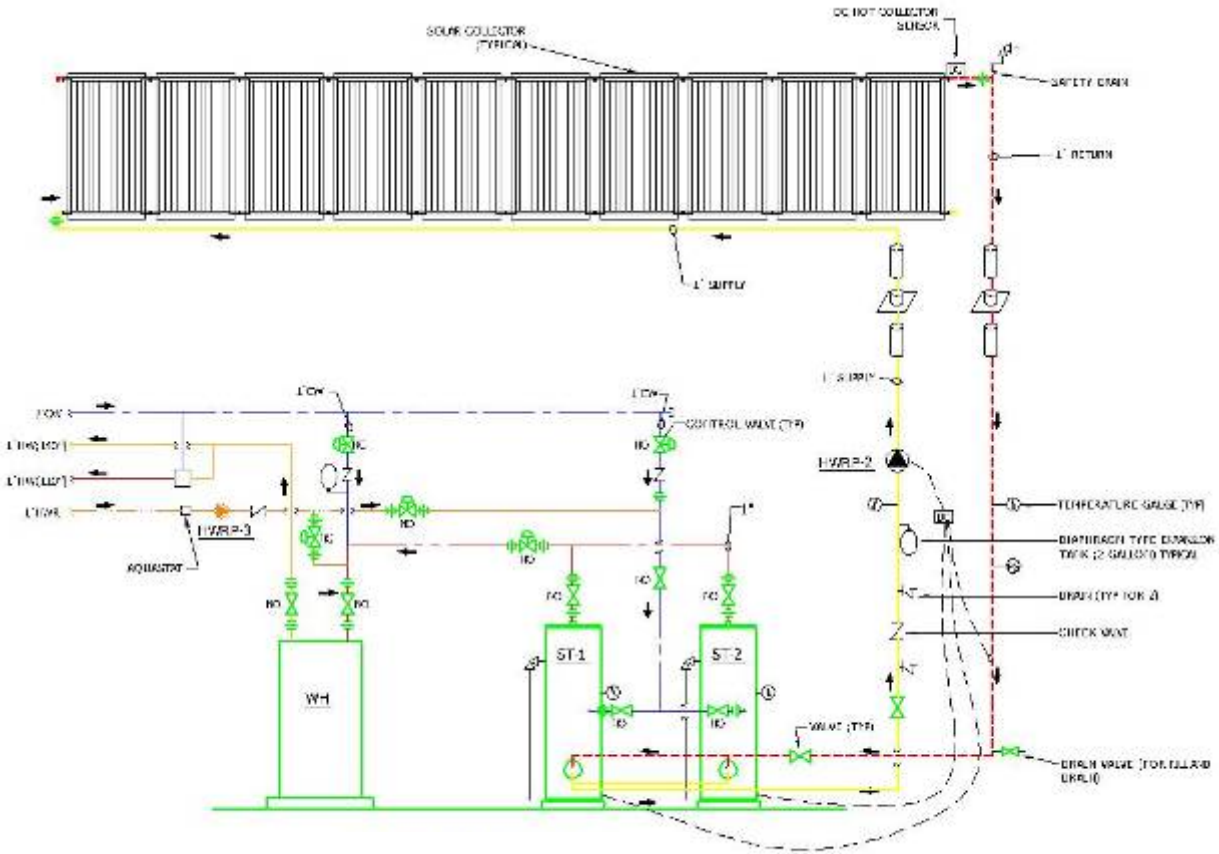




Copper Flat Plate Collector
Used for Active Solar Water Heating Systems



Proven Designs and Reliable Performance



Think About Packaged Systems

Solar Water Heating System

Small Systems
Pre-packaged
Pre-engineered
Specifications
Literature
O&M Manuals

Johnson Controls

SOLAR WATER HEATING SYSTEM
DRAIN BACK

Drainback Tank Specifications

Inner Tank (DBT & DBX models):
- **Stainless Steel** construction from type 304 alloy
- Seams and fittings are Inert Gas Arc welded
- Connection fittings are ¾" female, NPT
- Each tank is provisioned for a vertical sight gauge with ½" female, NPT fittings
- Recommended working pressure is 40psi, maximum is 50 psi

Outer Jacket & Insulation (DBT & DBX models):
- Rigid foam insulation poured and molded in place, 1" on sides and bottom, 1½" on top (R7.2 per inch)
- White ABS plastic outer shell with white ABS vacuum molded end caps
- White polyethylene moldings around all fittings

Heat Exchangers (DBX models):
- Standard internal heat exchanger coils are .662" smooth copper tube with .025" wall thickness
- Connections are ½" female NPT
- Available surface areas: 3.4ft², 6.2ft², 9.8ft²
- Type "L" copper water tube available upon request

Part Number	Description	Tank Capacity	Dry Weight	Max Sq Ft Collectors (HX Models)	Height/ Diameter
DBT 15 SS	15 Gallon Drainback Tank	9.9 USg	21 lbs	-	17.5" / 16"
DBT 15 SS	15 Gallon Drainback Tank	14.7 USg	25 lbs	-	24.5" / 16"
DBX 1534 SS	15 Gallon Drainback Tank w/ ½" heat exchanger, 3.4 ft²	9.5 USg	24 lbs	68	17.5" / 16"
DBX 1562 SS	15 Gallon Drainback Tank w/ ½" heat exchanger, 6.2 ft²	9.2 USg	27 lbs	126	17.5" / 16"
DBX 1562 SS	15 Gallon Drainback Tank w/ ½" heat exchanger, 6.2 ft²	14.1 USg	31 lbs	126	24.5" / 16"
DBX 1598 SS	15 Gallon Drainback Tank w/ ½" heat exchanger, 9.8 ft²	13.6 USg	35 lbs	192	24.5" / 16"

These incredible drainback tanks can be configured for use in a variety of ways ....
- As retrofit to an existing water heater
- As a reservoir for heat exchanger tanks
- As a complete new Solar DHW system

Solar Collector Array
Pump
Solar Storage
Cold water service
Pump

DBX Units can convert any standard tank to a solar water heater...

240-gallon Solar Water Heating System

Military Barracks -Dorm

6,000-Gallon – 100 Collector
Solar Water Heating Systems
USMC Camp Lejeune, NC

EPA Building - Washington DC

Parabolic Trough

5th Type --Typically used for Higher Temperature Applications

Solar Cooling

Solar Air Conditioning Project

Solar Air Conditioning Project

- **180 collector ground mounted array**
- **Low tilt in Texas for summer cooling**

Solar Air Conditioning Project

Liquid Desiccant Cooling System

Solar Electric Generation System (SEGS)

acciona Energy

GovEnergy
www.govenergy.gov

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Solar Electric Generation System (SEGS)

Nevada Solar One
March 2007

Dish Concentrator

Towers / Central Receiver

Build Customer Confidence and the JCI Brand
Solar Thermal Typical Component Life

Component	Years
Collector	29
Pump	12
Storage tank	9.4 (electric heater)
Controller	8.9
Heat Exchanger	10.8
Expansion tank	8.4
Vents & Valves	4.3 - 13.7

John Harrison- Senior Analyst- Florida Solar Energy Center

Reliability

It is not a technical issue.

Reliability is directly related to:

1. Design
2. Installation
3. Maintenance

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