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Comparison of U.S., Chinese, and Israeli Solar Hot Water System Cost and Performance

ACEEE Hot Water Forum Session 6C:

Characterizing the Solar Water Heating Market Internationally

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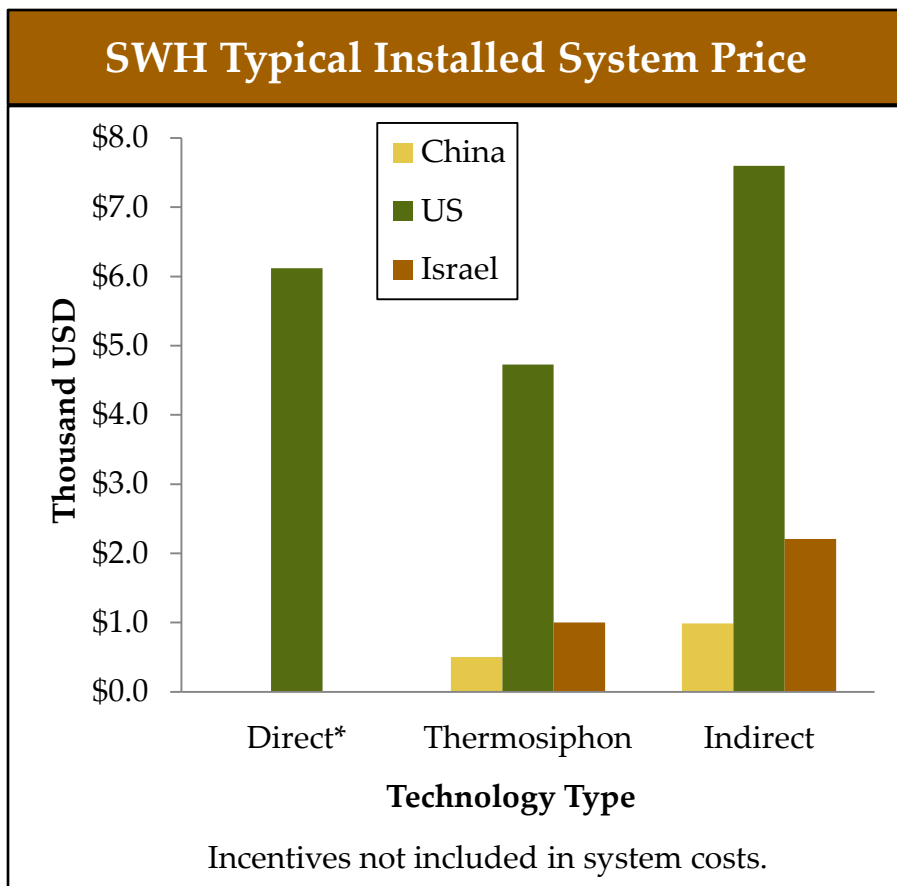
ENERGY

U.S. SWH systems are much more expensive than Israeli or Chinese systems, driven by different system types, specifications, quality, installation factors, and market volume.

| Characteristics | United States | Israel | China |
|--|---|---|--|
| Typical Installed Cost (domestic, 2-4 people) | \$6,000-10,000 | \$1,000-1,800 | \$300-1,000 |
| Most Common Technology | Indirect (with pump) | Thermosiphon (no pump) | Thermosiphon (no pump) |
| Tank Capacity | 80 gal | ~30 gal | 30-50 gal |
| Collector Sizes | ~50 sqft total | ~20 sqft total | ~20 sqft total |
| Backup System | Conventional electric/gas | Electric heating element | Electric heating element |
| Quality | Highest . SRCC certified | High. SRCC certified | Low. Many not certified Shorter system life. |
| Typical Installation | Collectors on pitched roof. Indoor tank. Complex design. Building not designed for SWH. Limited SWH experience. High labor costs. | Collectors and tank on flat roof. Simple system. Building designed for SWH. Experienced installers. Medium labor costs. | Collectors and tank on the roof (some flat, some pitched). Simple system. Experienced installers. Low labor costs. |
| Market Volume | 30,000 installs/year | 70,000 installs/year | 6,000,000 installs/year |

Sources: Israel: Amcor, Pro, Tovtoda. China: Changzhou Erjin Solar Energy Equipment Co., Zhejiang Shentai Solar Energy Co., Changzhou He Jia Solar Energy Co., China Verysolar Technology Co., Haining Oupairineng Solar Water Heater Co., Beijing Sunpu Solar, Linuo Ritter International (China-Germany JV), Tecco Group. U.S.: Butler Sun Solutions, A.O. Smith, Caleffi, Solahart, Solene/ Chromagen, Alternate Energy Technologies, Fafco, Silicon Solar, SunEarth, Inc., TCT Solar. U.S. costs confirmed against California Solar Initiative. All: IEA Solar Heat Worldwide 2010. CSI-Thermal Program reported costs and HECO: 2007, Ron Richmond.

Across all technology types, U.S. SWH systems are significantly more expensive than similar systems in China and Israel.

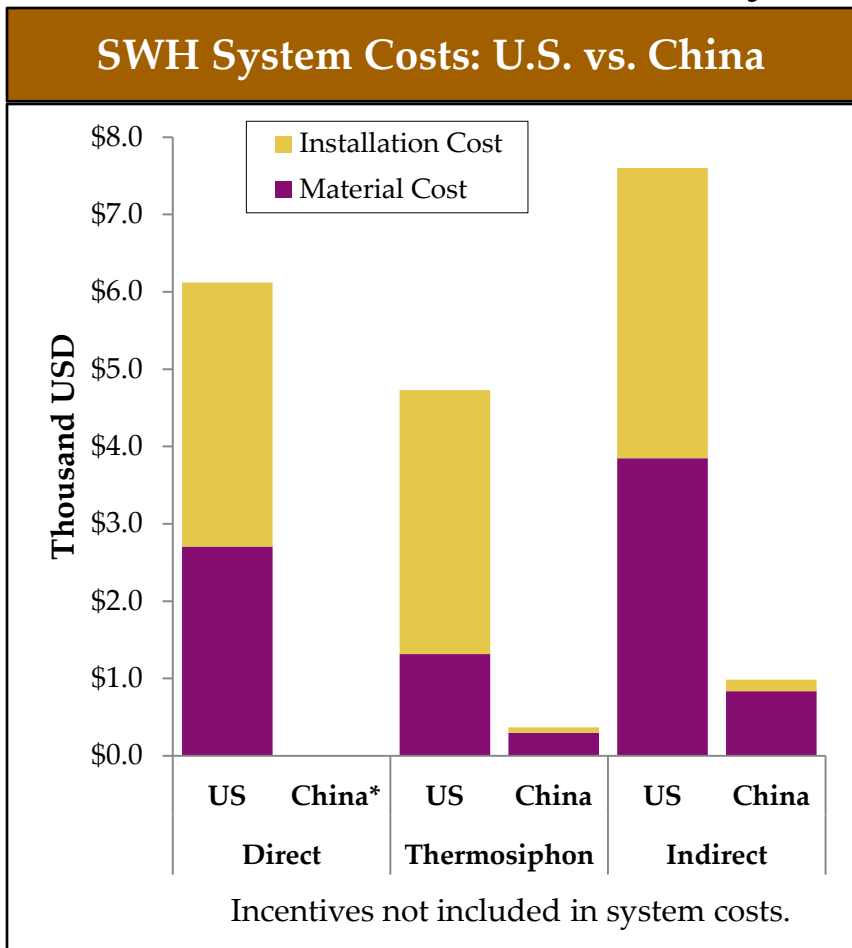


- Thermosiphon is the most common configuration in Israel and China.
- Continental U.S. typically uses indirect and direct systems.
- Thermosiphon system is used in Hawaii, where freezing is not a concern.
- Thermosiphon is the least expensive SWH system configuration, but even U.S. thermosiphon systems are far more expensive than Chinese or Israeli units.

Sources: Israel: Amcor, Pro, Tovtoda. China: Changzhou Erjin Solar Energy Equipment Co., Zhejiang Shentai Solar Energy Co., Changzhou He Jia Solar Energy Co., China Verysolar Technology Co., Haining Oupairineng Solar Water Heater Co., Beijing Sunpu Solar, Linuo Ritter International (China-Germany JV), Tecco Group. U.S.: Butler Sun Solutions, A.O. Smith, Caleffi, Solahart, Solene/ Chromagen, Alternate Energy Technologies, Fafco, Silicon Solar, SunEarth, Inc., TCT Solar, Solar Water Heating Supply Chain Market Analysis for the City of Milwaukee, Navigant Consulting 2010. U.S. costs confirmed against California Solar Initiative CSI-Thermal Program reported costs and HECO: 2007, Ron Richmond.

*Direct systems are uncommon in China and Israel.

Dramatically lower Chinese costs are driven simpler system designs, lower installation costs and system quality.



| | U.S. | China | Savings |
|--------------------|---|--|--|
| Capac. | 80 gal | 30-50 gal | ~\$150 |
| Backup | Electric/gas | Electric element | ~\$250 |
| Tank | Pressurized | Non-Pressurized | ~\$150 |
| Quality | Highest (more features). SRCC certified | Low; Many not certified. Shorter system lifetimes. | Varies |
| Installation Costs | Complex system. Collector on pitched roof. Tank in building. Inexperienced installers. High labor cost. | Simpler system. Collector and tank on roof. Mix of flat/pitched roofs. Experienced installer. Low labor costs. | Tank on roof: ~\$400. Other: varies, but >~\$800 |
| Market Volume* | 30,000 installs/year | 6,000,000 installs/year | Up to ~\$300. |

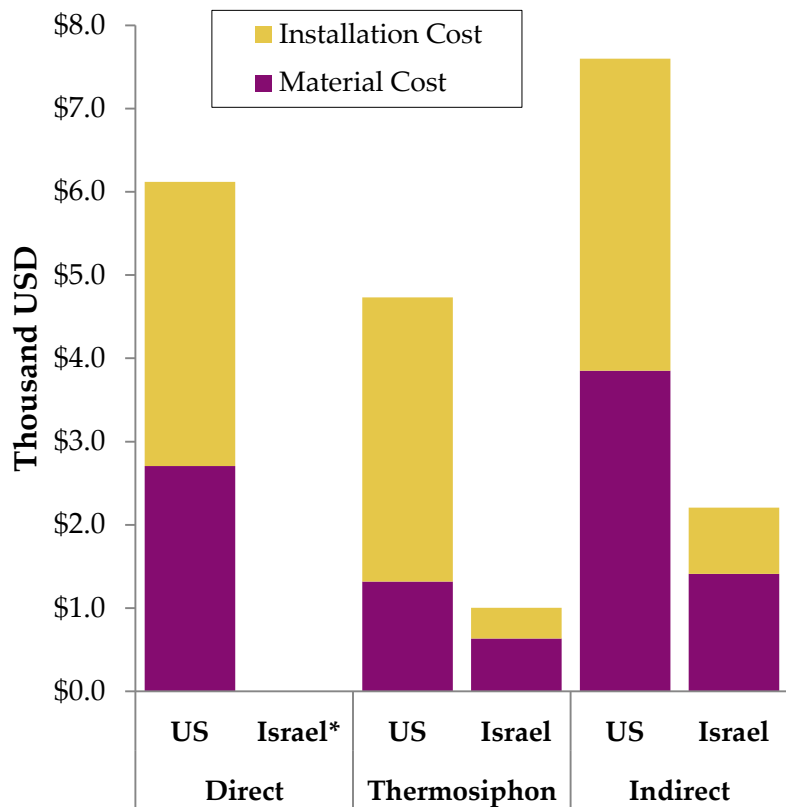
*Manufacturing volume impacts apply primarily to collectors, as other parts are common and already manufactured at scale.

Sources: China: Changzhou Erjin Solar Energy Equipment Co., Zhejiang Shentai Solar Energy Co., Changzhou He Jia Solar Energy Co., China Verysolar Technology Co., Haining Oupairineng Solar Water Heater Co., Beijing Sunpu Solar, Linuo Ritter International (China-Germany JV), Tecco Group. U.S.: Butler Sun Solutions, A.O. Smith, Caleffi, Solahart, Solene/ Chromagen, Alternate Energy Technologies, Fafco, Silicon Solar, SunEarth, Inc., TCT Solar, Solar Water Heating Supply Chain Market Analysis for the City of Milwaukee, Navigant Consulting 2010. U.S. costs confirmed against California Solar Initiative CSI-Thermal Program reported costs and HECO: 2007, Ron Richmond. Both: IEA Solar Heat Worldwide 2010.

*Direct systems are uncommon in China.

Israel typically uses thermosiphon systems, but costs are lower than comparable U.S. products, due to design differences and lower installation costs.

SWH System Costs: U.S. vs. Israel



Incentives not included in system costs.

*Direct systems are not typical in Israel. Quotes could not be obtained.

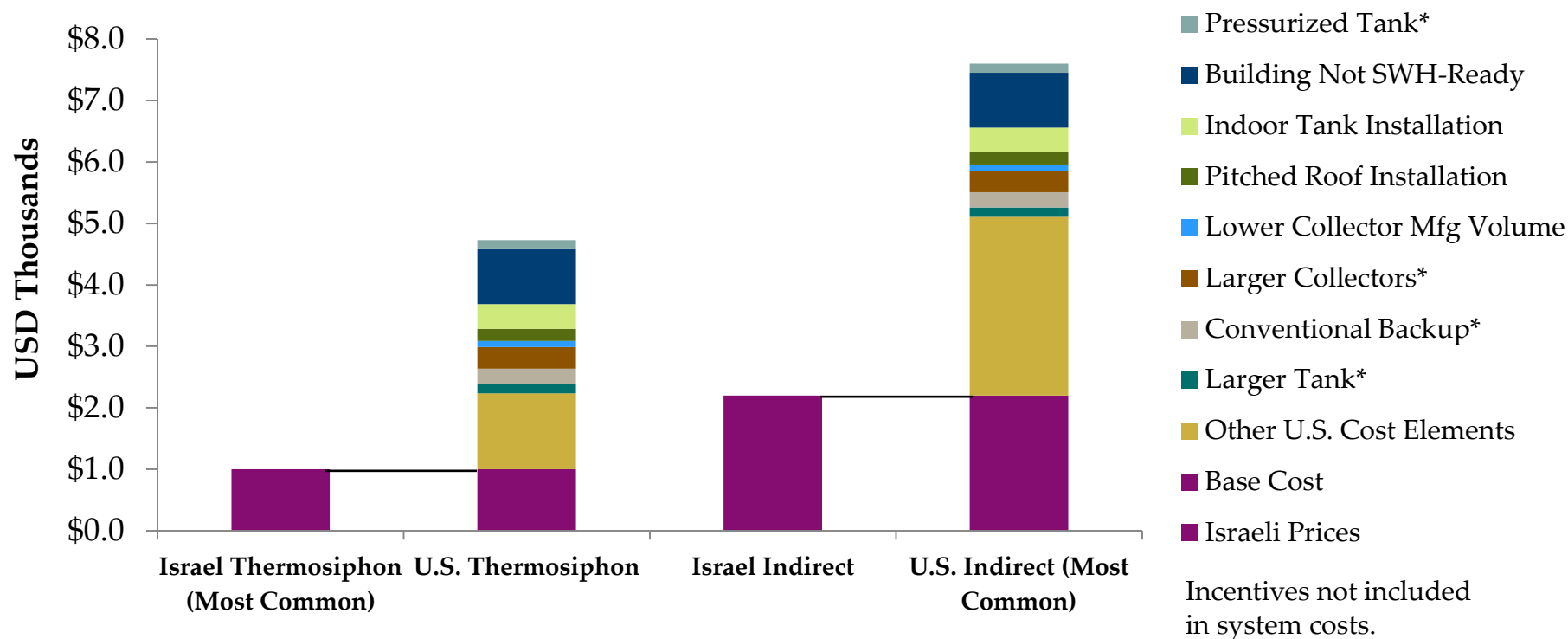
| | U.S. | Israel | Savings |
|----------------|---|---|--|
| Cap. | 80 gal | 30 gal | ~\$150 |
| Collect. | 50 sqft total | 20 sqft total | ~\$350 |
| Backup | Electric/gas | Electric element | ~\$250 |
| Tank | Pressurized | Non-Pressurized | ~\$150 |
| Quality | Highest (more features); SRCC certified | High; SRCC certified | Unknown |
| Install. Costs | Complex system. Collector on pitched roof. Tank in building. Inexperienced installer. Building not designed for SHW. High labor cost. | Simpler system. Collector and tank on flat roof. Experienced installer. Building designed for SHW. Lower labor costs. | Flat roof: ~\$200. Tank on roof: ~\$400. Building design for SHW: ~\$900. Other: Variable |
| Market Volume* | 30,000 installs/year | 70,000 installs/year | Manufact. more: up to ~\$100. |

*Manufacturing volume impacts apply primarily to collectors, as other parts are common and already manufactured at scale.

Source: Israel: Amcor, Pro, Tovtoda. U.S.: Butler Sun Solutions, A.O. Smith, Caleffi, Solahart, Solene/ Chromagen, Alternate Energy Technologies, Fafco, Silicon Solar, SunEarth, Inc., TCT Solar, Solar Water Heating Supply Chain Market Analysis for the City of Milwaukee, Navigant Consulting 2010. U.S. costs confirmed against California Solar Initiative CSI-Thermal Program reported costs and HECO: 2007, Ron Richmond. Both: IEA Solar Heat Worldwide 2010

A detailed cost comparison of U.S. and Israeli systems reveals many design differences, which impact both material and installation costs.

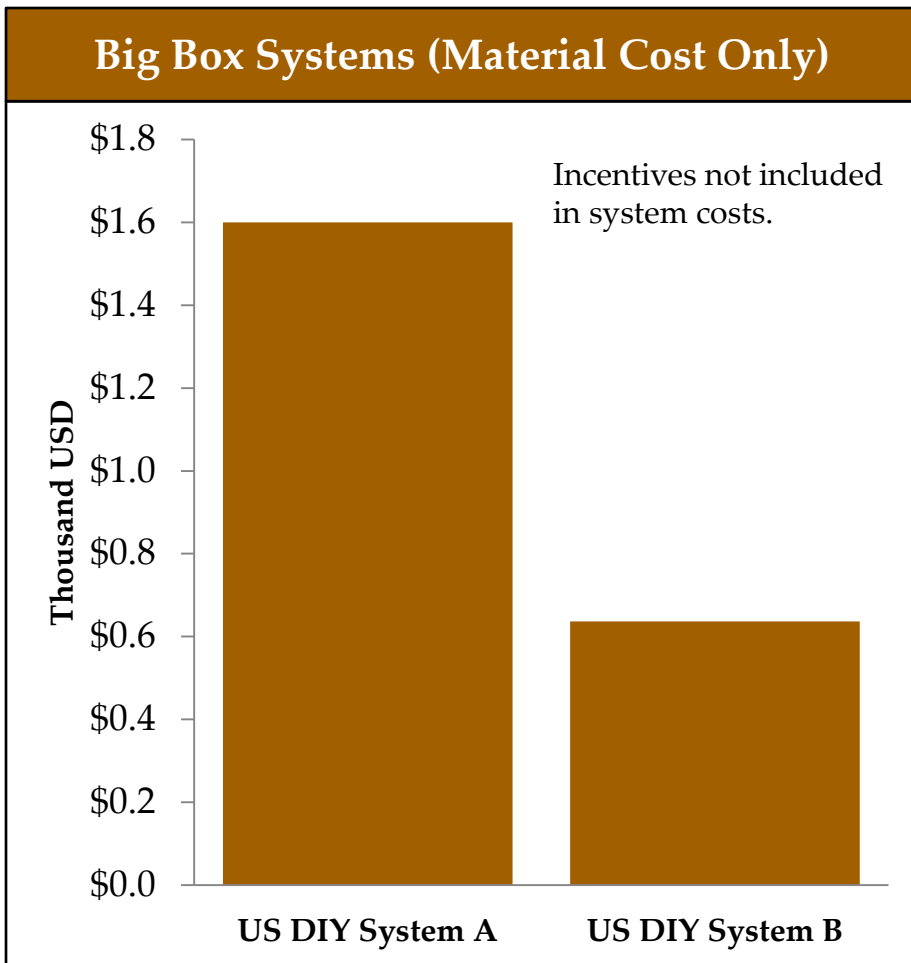
Elements of Total Installed Cost of Typical U.S. and Israeli Systems



➤ **Other U.S. Cost Elements: Higher quality/more features, less installation experience, higher labor rates, less installer competition, higher installer overhead/marketing costs, and higher installation costs associated with the asterisked material costs in the bar chart.**

Sources: Israel: Amcor, Pro, Tovtoda. China: Changzhou Erjin Solar Energy Equipment Co., Zhejiang Shentai Solar Energy Co., Changzhou He Jia Solar Energy Co., China Verysolar Technology Co., Haining Oupairineng Solar Water Heater Co., Beijing Sunpu Solar, Linuo Ritter International (China-Germany JV), Tecco Group. U.S.: Butler Sun Solutions, A.O. Smith, Caleffi, Solahart, Solene/ Chromagen, Alternate Energy Technologies, Fafco, Silicon Solar, SunEarth, Inc., TCT Solar, Solar Water Heating Supply Chain Market Analysis for the City of Milwaukee, Navigant Consulting 2010. U.S. costs confirmed against California Solar Initiative. CSI-Thermal Program reported costs and HECO: 2007, Ron Richmond. All: IEA Solar Heat Worldwide 2010.

Do-it-yourself systems are available through some major U.S. retailers, but are not common in China or Israel.



Source: NCI Analysis, Sears, Amazon.com.

- Since the systems are D-I-Y, there are no installation costs, greatly reducing the overall cost.
- These systems are available for purchase through major retailers such as Sears and Amazon.
- Israel expects to see D-I-Y systems in the market in the near future.
- No D-I-Y systems were found in China even though some systems are bought at retailers and shopping malls.

System A Specs

- Direct
- Evacuated Tube
- Connects to existing HW tank
- Includes back up heater and tank, circulating pump, control panel

System B Specs

- Direct
- Flat Plate
- Connects to existing HW tank
- Includes fittings, pump, valves, 4 solar panels

SWH policies vary across countries and greatly impact actual installed system prices, but US direct financial incentives are the most generous.

U.S.

- The federal government offers a 30% investment tax credit on SWH systems.
- State and utility rebates vary from \$500/system (Snohomish County PUD No 1 - Solar Express Rebate Program) to a maximum of \$5,000/system (Pennsylvania Sunshine Solar Rebate Program).
- Additionally, the state of Hawaii benefits from state, local, and utility rebates that can reduce the average installed cost by over 2/3.
- The State of Hawaii also mandates that all new homes are built with SWH systems.

Israel

- SWH systems were mandated in new construction of residential buildings after 1980. A number of pre-1980's buildings also have SWH installations.

China

- Under the national "Getting Household Appliances into the Countryside" initiative, up to 13% of system costs can be subsidized for rural customers (up to ~\$80 USD).
- Local programs, such as the one in Beijing, have invested up to \$30M for SWH subsidies (~\$10/system).
- Golden Sun Certification is not mandatory to manufacture or sell SWH in China, leading to variance in product quality. As of March 2011, only 30 of ~40,000 SWH manufacturers have earned this certification.

Source: HECO, U.S. Department of Energy, Israeli Department of Science and Technology, China Golden Sun Program, DSIRE Solar Incentive Database

Many factors contribute to the higher cost of U.S. SHW systems relative to Israel and China, but there are many misperceptions about their impact.

| Cost Factor | Impact | Explanation for Higher U.S. Costs |
|---------------------------------|------------------------|---|
| Technology Choice | High | The indirect system, which is the most common U.S. system type, is more expensive than the thermosiphon system, which is the dominant configuration in China and Israel. |
| Design | High | More complex systems with higher quality materials and additional features drive higher material and installation costs. |
| Building SWH Preparation | High | Buildings in Israel are designed to be SWH-ready, significantly reducing labor and material installation costs. |
| Installer Costs | High | Inexperience, higher overhead/marketing, less standardization, and less competition contribute to higher installation cost. |
| System Capacity | Medium | U.S. systems use double the collector area and storage tank capacity to meet U.S. hot water capacity expectations |
| Labor Rates | Medium/ Low | Higher labor rates increase installation costs, but they have a relatively small impact on total costs relative to Israel. |
| Quality | Medium/ Low | Chinese system quality is inferior but Israeli systems are certified to US and European standards. |
| Pressure Requirements | Low | U.S. end-users expect hot water at a high and steady pressure, necessitating pressurized systems, but expectations are less stringent in China and Israel. |
| Manufacturing Volume | Low | Lower U.S. manufacturing volumes relative to both countries has a modest impact on total cost, as it impacts primarily collector costs, and Israeli market is not so large. |
| Incentives/Rebates | N/A | U.S. incentives are far more generous than those in China and Israel. |

Two typical kinds of solar collectors and three typical solar water heater designs were considered.

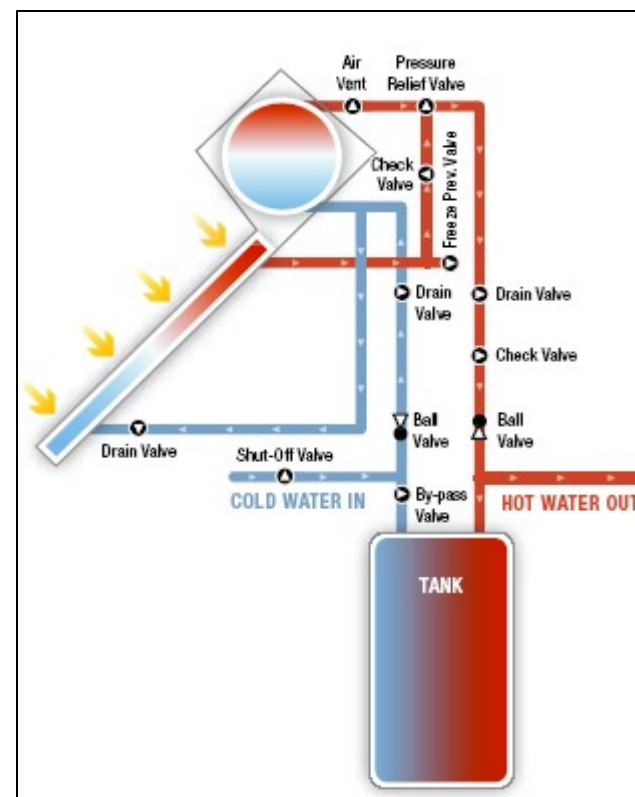
| | | Definitions |
|------------------------------|----------------|---|
| Types of Solar Collectors | Flat Plate | <ul style="list-style-type: none"> Water travels up pipes called “heat risers” inside the flat plate collectors and collect heat from solar absorbers. A glass plate is placed over the risers to reduce heat loss and protect the risers. |
| | Evacuated Tube | <ul style="list-style-type: none"> The air between concentric glass tubes are vacuumed to further reduce heat loss. Evacuated tube collectors are prone to breaking, particularly during hailstorms. |
| Types of Solar Water Heaters | Direct | <ul style="list-style-type: none"> In direct SWH systems, solar energy heats water. Direct systems use a forced circulation system (i.e., pumps). |
| | Indirect | <ul style="list-style-type: none"> In indirect SWH systems, a heat transfer liquid is heated and circulated through a heat exchanger to warm water. Indirect systems use a forced circulation system (i.e., pumps). |
| | Thermosiphon | <ul style="list-style-type: none"> In thermosiphon systems, the storage tank is elevated above the collectors. Water or heat transfer fluid warms and rises into the storage tank via natural convection. Cold water falls into the tubes. |

Solar Hot Water

Thermosiphon

Thermosiphon

- Water (or heat transfer fluid) is heated by solar power.
- Natural convection transports the hot water from the collector to storage.
- No pumps are required.
- Does not work well in areas with hard or acidic water.
- Can be used with flat plate collectors or evacuated tubes.



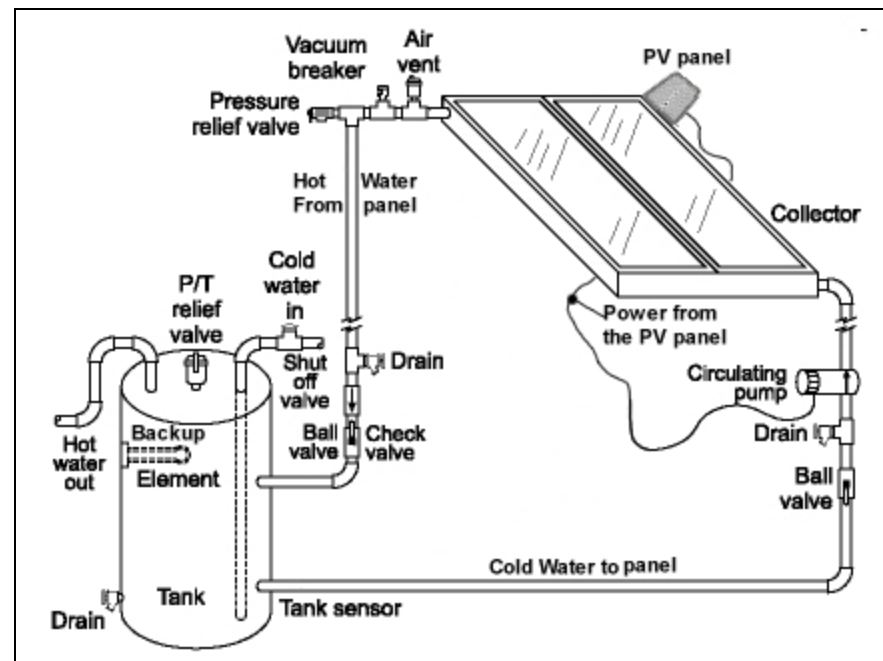
Source: http://www.solar-heating-today.com/image-files/thermosiphon_passive_direct_doe.jpg&imgrefurl=http://www.solar-heating-today.com/passive-solar-heating.html

Solar Hot Water

Direct Circulation

Direct Circulation

- When sufficient solar energy is available, the system pumps water from storage to the collectors to be warmed.
- Cannot be used in hard-water areas or areas that freeze frequently.
- Must withstand pressures.



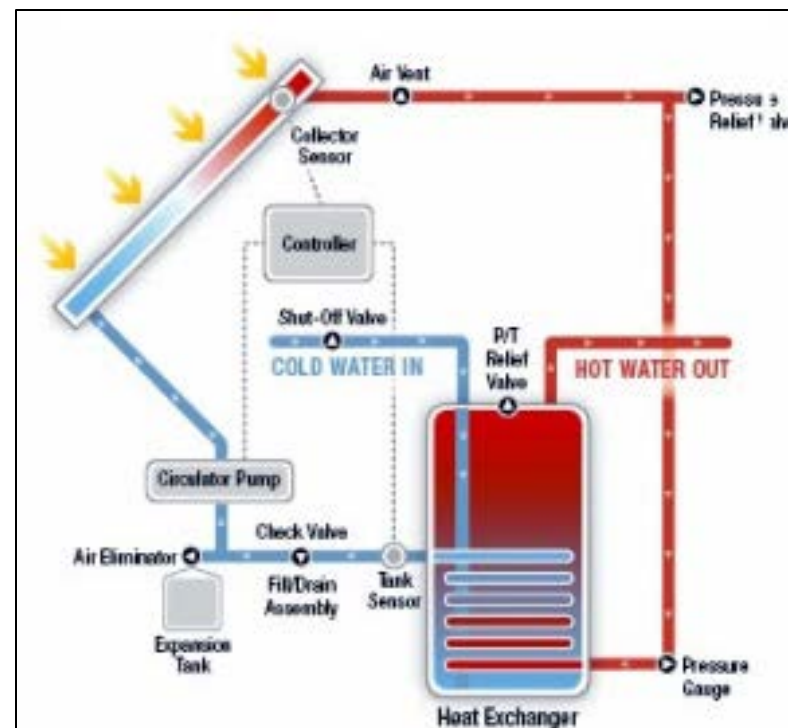
Source: http://www.solartechenergysystems.com/pics/solar_hot_water_Open_schematic_1.jpg

Solar Hot Water

Indirect Heating

Indirect Heating

- Solar energy heats a transfer fluid through a closed loop. A heat exchanger transfers the heat to potable water.
- Heat transfer fluids commonly include water/ethylene glycol and water/propylene glycol.



Source: http://www.solar-heating-today.com/image-files/active_indirect_propylene_glycol.jpg