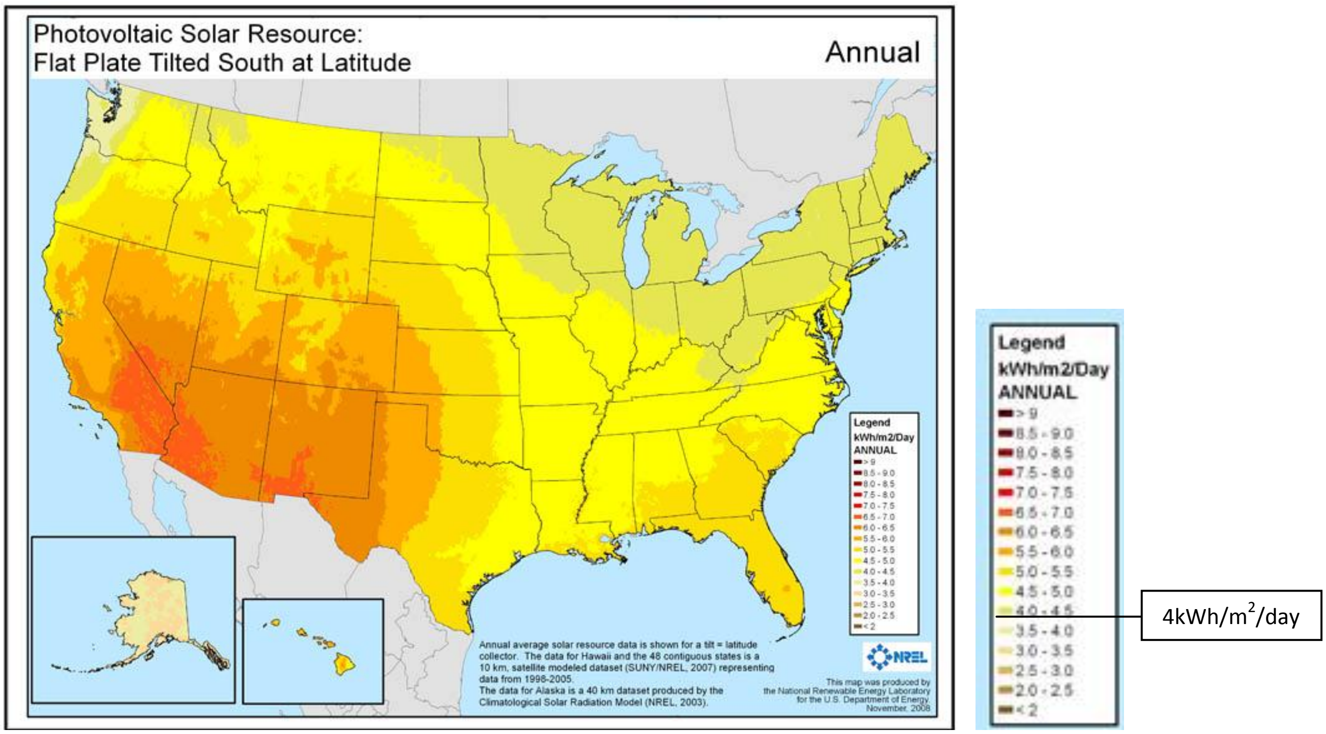
Solar Hot Water

[STRATEGY]

BRIEF DESCRIPTION

Solar hot water systems use a collector to absorb heat from the sun and transfer that heat to water, which is stored for use as needed. A conventional system providing any necessary additional heating is used for backup. Solar hot water systems are best for buildings with high, steady daily volume of hot water use that has greater demand during the summer and later in the day. Per the 2010 Sustainable Design and Development Policy Update, solar hot water heating will be provided for a minimum of 30 percent of a facility's hot water demand for all new construction projects with an average daily domestic hot water requirement of 50 gallons or more, located in areas receiving an annual average of 4kWh/m^2/day.



(http://www.nrel.gov/gis/solar.html)

Applications

Facility that pays high utility rates for its conventional water heating

- Mid-temperature solar water heating technologies can serve well in this situation.
- Systems that operate passively without pumps or electronic controls are often appropriate in warmer climates.

Large facilities such as prisons and hospitals

- Solar water heating is apt to be cost effective when there is consistent need for large volumes of hot water.
- Large mid- or high temperature systems can bring costs down to quite

competitive levels compared to conventional water heating.

Indoor swimming pool facilities

- Relatively inexpensive low-temperature systems can either greatly reduce conventional pool heating cost or extend the season where heating was considered too expensive.

Design Notes

Site Selection

- The required collector area is about 1 to 1.5 square feet for each gallon of water used per day on average.
- System is most effective when there is a minimal distance between the collector panels and water storage tanks.
- The roof can be flat or tilted south, and needs to be unshaded.

Freezing Protection

- Freeze protection should be considered.

Water Temperature Control

- In warm seasons, water temperatures may be above 140°F (60°C). Mixing valves should be installed to keep occupants from being scalded.

Maintenance

- It is important to train the facility managers and other personnel to properly maintain the solar hot water systems.
- On direct systems, collectors may require periodic treatment with a nontoxic solution.

References/Useful Resources:

[1] Solar Water Heating: Using the Sun to Heat Domestic Water Makes Sense in Almost Any Climate. http://www1.eere.energy.gov/femp/pdfs/26013.pdf

[2] Greening Federal Facilities: An Energy, Environmental, and Economic Resource Guide for Federal Facility Managers and Designers. http://www1.eere.energy.gov/femp/pdfs/29267.pdf

[3] Solar Hot Water Resources and Technologies. http://www1.eere.energy.gov/femp/technologies/renewable_shw.html

[4] Solar Water Heating: Well-Proven Technology Pays Off in Several Situations http://www1.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf

[5] Parabolic-Trough Solar Water Heating http://www1.eere.energy.gov/femp/pdfs/FTA_para_trough.pdf

[6] Solar Ready Buildings Planning Guide http://www1.eere.energy.gov/femp/pdfs/46078.pdf

[7] Department of the Army Memorandum: Sustainable Design and Development Policy Update (Environmental and Energy Performance) July 8 and 16, 2010

Solar Hot Water

[ENERGY AND ENVIRONMENT]

Energy Savings

Water Heating

- Solar hot water systems typically provide 40–80 percent of annual hot water needs. They can meet the total hot water demand in many regions of the U.S. during summer months.

Social Benefits

Greenhouse Gas (GHG) Reduction

- Reduce the environmental impacts associated with the use of electricity or fossil fuel.

Guiding Principles[1]

On-Site Renewable Energy

- Per the EISA Section 523, meet at least 30 percent of the hot water demand through the installation of solar hot water heaters, when life cycle effective.

Associated LEED Credits (NC 2009)[2]

EAc2 On-Site Renewable Energy (1-7 points)

- Use on-site renewable energy systems to offset building energy costs.

Percentage Renewable Energy	Points
1%	1
3%	2
5%	3
7%	4
9%	5
11%	6
13%	7

[1] Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings www.wbdg.org/pdfs/hpsb_guidance.pdf

[2] USGBC LEED Reference Guide for Green Building Design and Construction, 2009 Edition

Product Images

(Source: http://www.rheem.com/products/solar_water_heating/
http://solardirect.com/water-heaters/solar/active/trendsetter/main.htm)

Components **Solar Collector, storage tank, and possibly a drainback system**

Cost Range $10 to $150 per square foot; Recently six solar hot water heaters were recommended at Fort Bragg with first costs estimated at $2,250 - $4,200 depending on the size of equipment and building hot water needs.

- The cost depends on the size and type of system selected.
- New-construction systems typically cost less than retrofit projects.

		Suitable system size	Cost/ft^2 for 40 ft^2 unless noted	Freeze tolerance	Hard water tolerance	Maintenance need
Low-Temperature Systems						
Unglazed		for pools	\$10-\$25 (400 ft^2)	none	good	very low
Passive Mid-Temperature Systems						
Integrated collector		small	\$50-\$75	moderate	minimal	very low
Thermosiphon	direct	small	\$40-\$75	none	minimal	low
	indirect	small	\$50-\$80	moderate	good	low
Indirect, Active, Mid-Temperature Systems						
Flat-plate, antifreeze		small	\$50-\$90	excellent	good	high
		large	\$30-\$50 (30,000 ft^2)			
Flat-plate, drain back		small	\$50-\$90	good	good	high
Direct, Active, Mid-Temperature Systems						
Drain down		small		corrections being developed	minimal	high
Recirculating		small			minimal	high
High-Temperature Systems						
Evacuated tube	direct	small	\$75-\$150	good	minimal	high
	indirect	large	\$75-\$150	excellent	good	high
Parabolic trough		large	\$20-\$40 (30,000 ft^2)	excellent	good	high

(Source: http://www1.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf)

Product Types

Collector types include un-glazed solar collectors, glazed solar collectors, and evacuated tube solar collectors. The systems are either direct or indirect, which can use pure water or an ethylene glycol solution. Glazed solar collectors are the most common systems for small to medium sized water heating needs. These systems achieve water temperatures up to 160 degrees Fahrenheit and meet domestic hot water needs.

Building Type	Per Capita Hot Water Consumption (gallons/day)	Drainback Recommendation	Economies of Scale Potential
Administration	1	Yes	Low-Moderate for small buildings; Moderate-High for large buildings
Assembly or MWR	1	Yes	Low
Barracks	13.1	Yes	High
Dining	7.2	Generally Yes	High
Health	18.4	Generally Yes	High
Lodging	14	Generally Yes	Moderate-High depending on load profile
School	1.8	Yes	Low [3]

Active direct or "open-loop" systems

- 5-10 percent more efficient than indirect systems.
- Pump circulates water from the collectors to the storage tank.
- Suitable for mild and moderate climates with good water quality. These systems are not allowed where freezing occurs.
- Especially applicable to swimming pool heating.

Active indirect or "closed-loop" systems

- Pump circulates a fluid with a low freezing point (e.g. propylene glycol) in the collector loop.
- Suitable for all climates.

Passive integral collector-storage (ICS) systems

- A collector and storage tank are combined into one unit.
- Potable water (generally pressurized tap water) enters at the bottom of the ICS collector, and warm water is drawn from the top.
- Roof structures must be strong enough to support the storage tank.

[3] Adapted from the Draft PNNL Report: "Solar Domestic Hot Water Design Template for Fort Bragg, North Carolina"

- The systems do not need mechanical parts, so it is less expensive than an active solar heater and the maintenance requirements are minimal.

Passive thermosiphoning systems

- A separate storage tank is located above the collector. Warm water rises from the collector to the tank.

Basic types of solar collectors

- Unglazed swimming pool heaters (for low-temperature applications)
- Flat-plate collectors (for humid climates)
- Evacuated-tube collectors (operating at high temperatures with high efficiency)
- Parabolic-trough collectors. (highly efficient systems for nonresidential and institutional applications)

Drainback system

- Allows for the systems to be used in a variety of climates.
- Addresses the challenge of buildings potentially being unoccupied for prolonged periods, such as during deployments.
- Increases the complexity and cost of the solar hot water system, and result in higher maintenance.
- Drainback systems are slightly more efficient if water is used in the loop, due to its higher thermal capacity.

Vendors

Bosch Solar
http://www.boschsolar.com/StartPageBoschSolarcom/tabid/394/Default.aspx

Rheem Solar Water Heating Products
http://www.rheem.com/products/solar_water_heating/

Solar Direct
http://www.solardirect.com/swh/swh.htm

Warranty Info

10 years

Code Restrictions

The Unified Facilities Criteria does not allow for direct pure water solar hot water systems to be installed in locations where freezing occurs unless there is a drainback system.

SECTION 22 33 30. 00 10 – SOLAR WATER HEATING EQUIPMENT[4]

SYSTEM DESCRIPTION

Provide a solar energy system arranged for preheating of service (domestic and/or process) water using flat plate liquid solar collectors. Include in the system components a solar collector array, storage tank, pump[s], automatic controls, instrumentation, interconnecting piping and fittings, [uninhibited food-grade propylene-glycol and water heat transfer fluid in a closed loop], [potable water heat transfer fluid in an open loop], [heat exchanger], [expansion tank], and accessories required for the operation of the system.

COLLECTOR SUBSYSTEM

A. Solar Collector Construction

Collectors shall be of the flat plate, liquid, internally manifolded type. Each collector shall be provided with cover glazing, an absorber plate, heat transfer liquid flow tubes, internal headers, weep holes, insulation, and a casing. Collectors shall be of weather-tight construction. Solar collectors shall withstand a stagnation temperature of 177 °C (350 °F) and a working pressure of 862 kPa (125 pound per square inch) without degrading, out-gassing, or warping. Collector net aperture area shall be as shown and shall be a minimum of 2.6 square meters (28 square feet). Collector length, width, and volume shall be as shown.

B. Absorber Plate and Flow Tubes

Absorber sheet or plate shall be copper. Top of absorber plate shall be coated with selective surface of black chrome and shall have an emissivity less than 0.2 and absorptivity greater than 0.9. Flow tubes shall be Type L or Type M copper, and shall be soldered, brazed, or mechanically bonded to the absorber plate. Tubes shall be installed on the absorber plate so that they drain by gravity.

C. Cover Glazing

Each collector shall have a single layer of cover glazing made of clear float, water white or low iron type tempered glass. Glass shall meet ASTM C 1048. Cover glazing shall be completely replaceable from the front of the collector without disturbing the piping or adjacent collectors. Cover glazing shall be separated from the collector by a continuous gasket made of EPDM rubber.

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[4] Specification language modified from the Whole Building Design Guide's Unified Facility Guide Specifications, Section 22 33 30.00 10 – Solar Water Heating Equipment. Accessed August 2010 at *http://www.wbdg.org/ccb/DOD/UFGS/UFGS 22 33 30.00 10.pdf*.

D. Insulation

Back and sides of the absorber plate shall be insulated. Insulation shall fill space between absorber plate and casing and shall have an R value of 4 minimum. Insulation shall conform to EPA requirements in accordance with Section 01 62 35 RECYCLED / RECOVERED MATERIALS and shall be fibrous glass, polyisocyanurate, urethane foam, or other material suitable for the intended purpose, and shall withstand the moisture, sun exposure, and stagnation temperature limitations of the solar collector. Polyisocyanurate insulation shall not come in contact with the absorber plate.

E. Solar Collector Performance

Thermal performance shall be plotted on the thermal efficiency curve in accordance with ASHRAE 93. The y-intercept shall be equal to or greater than 0.68, and the numerical value of the slope of the curve (FRUL) shall be between 0 and minus 5.7 watts per square meter per degree K (0 and minus 1.0 Btu per hour per square foot per degree F) 0 and minus 1.0 Btu per hour per square foot per degree F. Manufacturer's recommended volumetric flow rate and the design pressure drop at the recommended flow rate shall be as shown. Manufacturer's recommendations shall allow at least seven collectors to be joined per bank while providing for balanced flow and for thermal expansion considerations.

SOLAR COLLECTOR ARRAY

A. Net Absorber Area and Array Layout

Array shall consist of an assembly of solar collectors as shown with a minimum total array aperture area of [_____] square meters (or square feet). Solar collectors shall be assembled as shown in banks of equal number of collectors. Banks shall consist of no less than 4 and no more than 7 collectors each. Collector array shall be oriented so that all collectors face the same direction and are oriented within 20 degrees of true south and with respect to true south as indicated. Collectors arranged in multiple rows shall be spaced so that no shading from other collectors is evident between 1000 hours and 1400 hours solar time on December 21. Minimum spacing between rows shall be as shown.

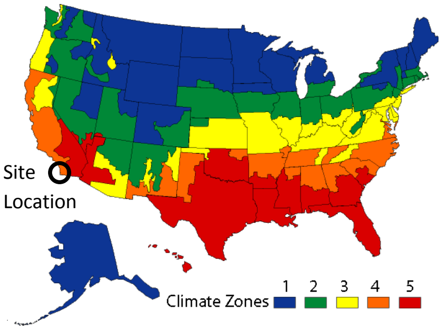
TRANSPORT SUBSYSTEM

A. Heat Exchanger

The heat exchanger construction and testing shall be in accordance with ASME BPVC SEC VIII D1. Minimum design pressure rating shall be 862 kPa (125 pounds per square inch). Heat exchanger shall be capable of returning a hot-side exit temperature of [49]°C ([120] °F) or less given a hot-side approach temperature of 60 °C (140 °F) and a cold-side approach temperature of 38 °C (100 °F). Heat exchanger shall be capable of withstanding temperatures of at least 116 °C (240 °F). Heat exchanger shall be capable of operation at the flow rates as shown.

Marine Corps Base Camp Pendleton

Southern California



(Source: http://www1.eere.energy.gov/femp/pdfs/46348.pdf)

Facility

- U.S. Marine Corps Base Camp Pendleton is the largest expeditionary training facility on the West Coast. It accommodates more than 41,500 marines and family members, with a daytime population of approximately 100,000.
- The Camp Pendleton training pools provide daily training for Marine Corps personnel year round. The pools have a capacity of 500,000 gallons each and typically use natural gas for water heating and electricity for pumps and other mechanical equipment.

Approach

- In the summer of 1995, a pilot study was completed. An inactive solar pool heating system for $10,000 was installed. The collector array has 2,560 square feet of unglazed collectors using copper pipes.
- In 2007, the base implemented two integrated solar thermal/PV systems at its 53 Area and 62 Area training pools.
- Each pool is equipped with 152 SHW collectors (covering 6,384 square feet) and 108 PV modules (covering 1,485 square feet).

Results

- The pool chosen as a pilot project is currently used only 3-4 months. If the pool was used year-round, it would save $8,000 per year in natural gas.
- At 53 Area and 62 Area training pools, each solar thermal collector produces 39,400 Btu of energy each day, resulting in combined annual energy production of 4,371 million Btu (MBtu) for both arrays. This eliminates the annual consumption of 54,726 Therms of natural gas for heating the two pools.
- The total cost of the integrated solar hot water/photovoltaic arrays was $1.1 million, with annual energy cost savings of $101,600. The project received a utility incentive of $90,285 and the payback period is 10 years.