SOLAR HOT WATER

FOR COLD CLIMATES

Economic and Design Considerations to Maximize Performance

ENTECH Engineering, Inc.
PO Box 871
Block Island, RI 02807
(401) 466-8978
www.entech-engineering.com

Have you heard

Solar Assisted Heating, and in particular, “Domestic” Water Heating is alive and well and being practiced in cold weather climes.

….. and it can be a very cost effective option for homeowners.

What can solar do for you?

Dispelling Myths

#1 There is not enough solar energy in cold weather climates to make solar energy technology cost effective.

#2 Conventional water heating isn't all that expensive.

#3 Solar water heating is expensive.

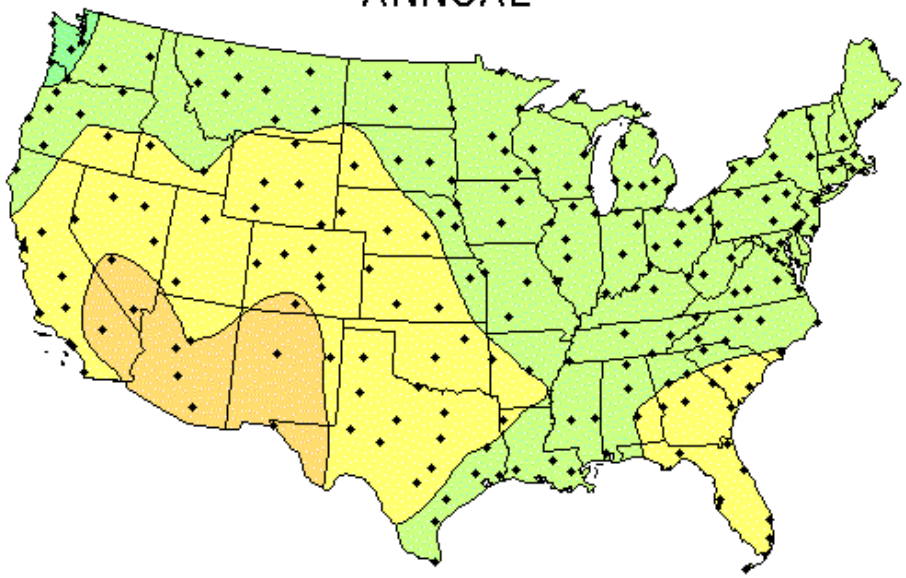
Myth#1

There is not enough solar energy in cold weather climates to make solar energy technology cost effective.

Truth is.....

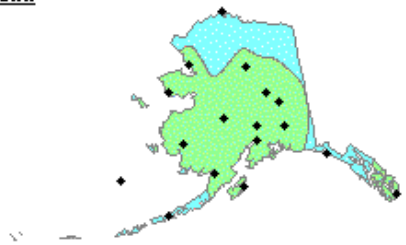
Average Daily Solar Radiation Per Month

ANNUAL

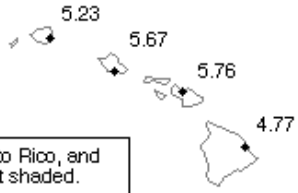


Flat Plate Tilted South at Latitude

Alaska

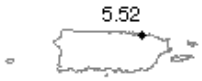


Hawaii



Hawaii, Puerto Rico, and Guam are not shaded.

San Juan, PR



Guam, PI

Collector Orientation

Flat-plate collector facing south at fixed tilt equal to the latitude of the site: Capturing the maximum amount of solar radiation throughout the year can be achieved using a tilt angle approximately equal to the site's latitude.

This map shows the general trends in the amount of solar radiation received in the United States and its territories. It is a spatial interpolation of solar radiation values derived from the 1961-1990 National Solar Radiation Data Base (NSRDB). The dots on the map represent the 239 sites of the NSRDB.

Maps of average values are produced by averaging all 30 years of data for each site. Maps of maximum and minimum values are composites of specific months and years for which each site achieved its maximum or minimum amounts of solar radiation.

Though useful for identifying general trends, this map should be used with caution for site-specific resource evaluations because variations in solar radiation not reflected in the maps can exist, introducing uncertainty into resource estimates.

Maps are not drawn to scale.

NREL

National Renewable Energy Laboratory
Resource Assessment Program

kWh/m²/day

- 10 to 14
- 8 to 10
- 7 to 8
- 6 to 7
- 5 to 6
- 4 to 5
- 3 to 4
- 2 to 3
- 0 to 2
- none

FLATA13-208

Myth #2

Conventional Water Heating Isn’t All That Expensive.

Truth is.....

How much does conventional water heating cost?

- Standard design practice is that approximately 100 gallons of water a day per person are consumed.
- Of this, 30 gallons is hot water.

What are the inefficiencies in getting hot water to your faucet?

- Combustion Efficiency 80% - 88%
- Heat Transfer Efficiency 93%
- Standby Losses Efficiency 75%
- Pipe Losses Efficiency 80%

Therefore, heating water requires:

1 unit of energy output/.85/.93/.75/80 = 2.1 units of energy of input.

The efficiency of heating water is:

$$\frac{\text{1 unit of energy output}}{\text{2.1 units of energy input}}$$

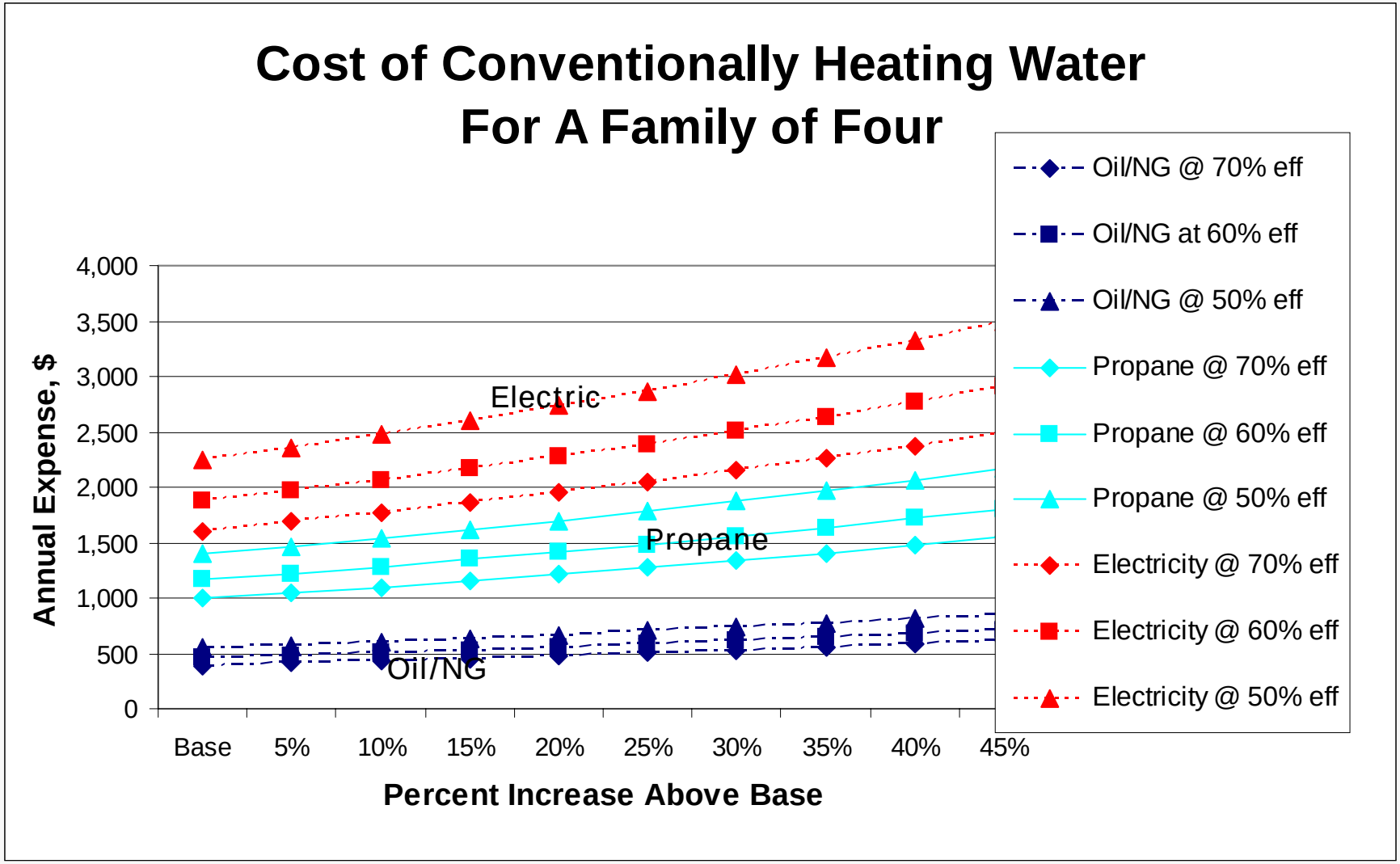
= 47%.

This doesn’t include the inefficiencies of:

- Fuel Extraction
- Fuel Processing
- Fuel Transportation
- Fuel Storage

Surprisingly, the efficiency and cost of the sun transporting its energy to earth has stayed relatively constant over the past 4 billion years.

How do these inefficiencies translate into cost?



Oil Base Price: $1.40/gallon

Propane Base Price: $2.50 gallon

Natural Gas Base Price: $1.20/therm

Electricity Base Price: $.15/kWh

Properly designed, a solar assisted domestic water heating system should displace between 2/3 and 3/4 of these costs.

Myth #3

Solar water heating is expensive.

Truth is.....

It is expensive not to incorporate solar water heating into your existing home, and it is especially expensive for the homeowner not to incorporate it into new construction.

Example for a Solar Water Heater

- a. 2 panel system $5,800
- b. Renewable Grant (state dependent), est. $0 to $1,650
- c. Federal Tax Credit (we can hope) $0
- d. State Tax Credit (state dependent) $1,450
- e. Actual Installed Cost $2,700 to $4,350
- f. Annual Savings $640
- g. Simple Payback: 2,700/640= 4.2 years, 4,350/640= 6.8 years
- h. Return on Investment: 1/4.2= 24% 1/6.8 = 15%

This adds between $16 and $30 per month to your 30 year mortgage.

This saves between $53 and $85 per month depending upon fuel displaced.

Cash flow is positive in all scenarios.

Over cumulative savings over fifteen years will be between $6,660 and $12,420.

Not bad for a cold weather climate.

Comparing Investment Alternatives

• Stock Market Since 1802	7.15%
• Small Stocks	12.5%
• Real Estate	11.1%
• DJI	10.0%
Bonds	5.2%
• T-Bills	3.7%
• Renewable Energy	15.0%

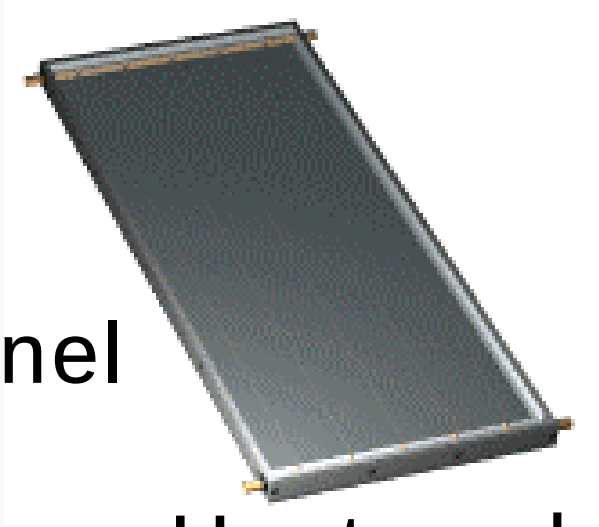
Cold Climate Design Considerations

- Freezing Temperatures

- Hot Temperatures

A cold climate solar-assisted domestic water heating system's design must be able to meet large temperature extremes, *or not operate* during times of those temperature extremes.

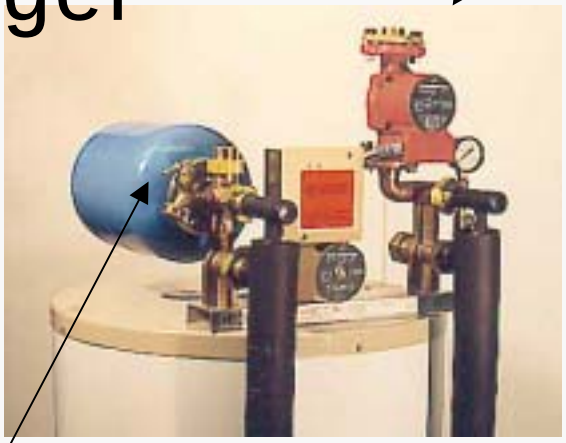
Why?



Solar panel

Solar fluid pump

Heat exchanger



Solar fluid expansion tank

Solar storage tank

Schematic of a Close Loop Solar Water Heating System

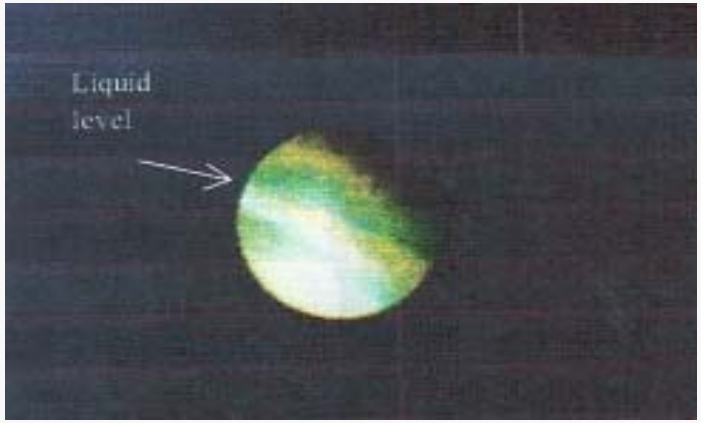
The weak point of closed loops systems is the glycol.

- Propylene glycol begins to break down at 170F
- Solar collectors can easily experience these temperatures on hot, sunny days or when the collector stagnates leaving fluid in the collector
- It may become black (carbon particles) and/or very acidic. The black particles can accumulate at a bend or crevice in the collector loop and cause blockage of flow.

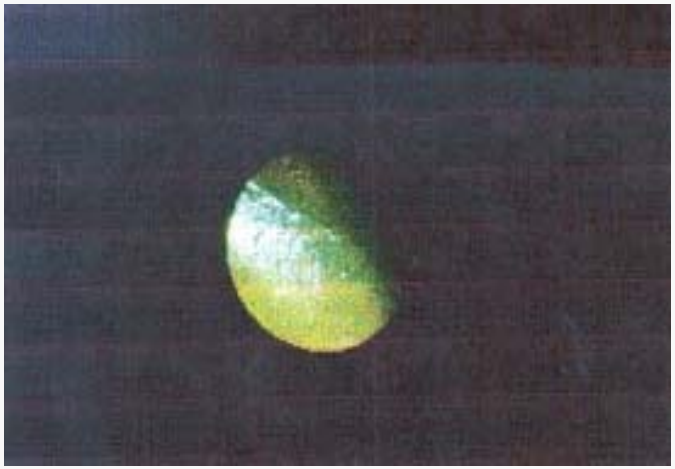
A blocked collector loop can cause the pump to overheat, which may destroy the seals, and glycol then leaks from the pump. Acidic glycol can erode the brass and copper components in the solar water heater.

Propylene Breakdown

48 hours



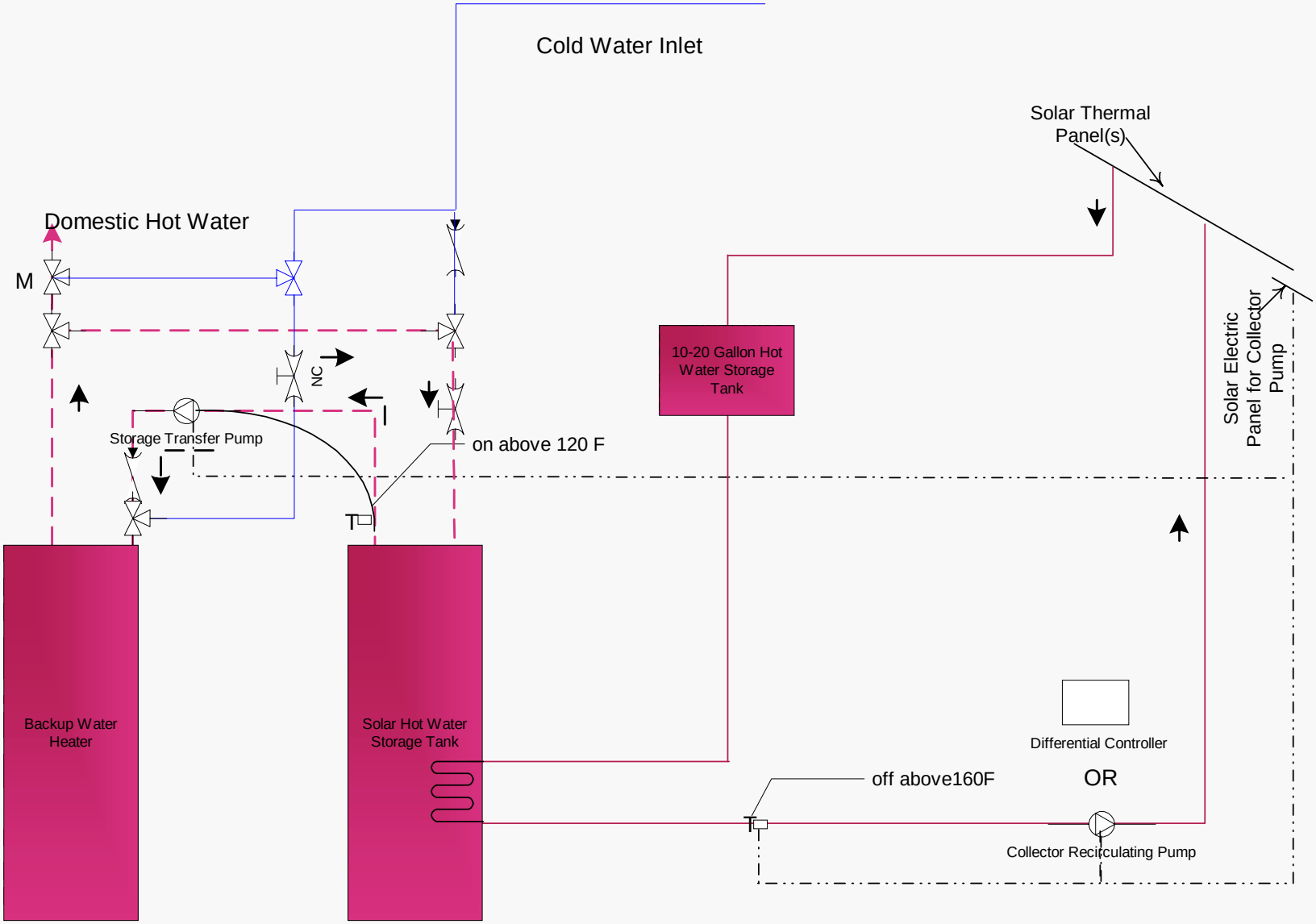
72 hours



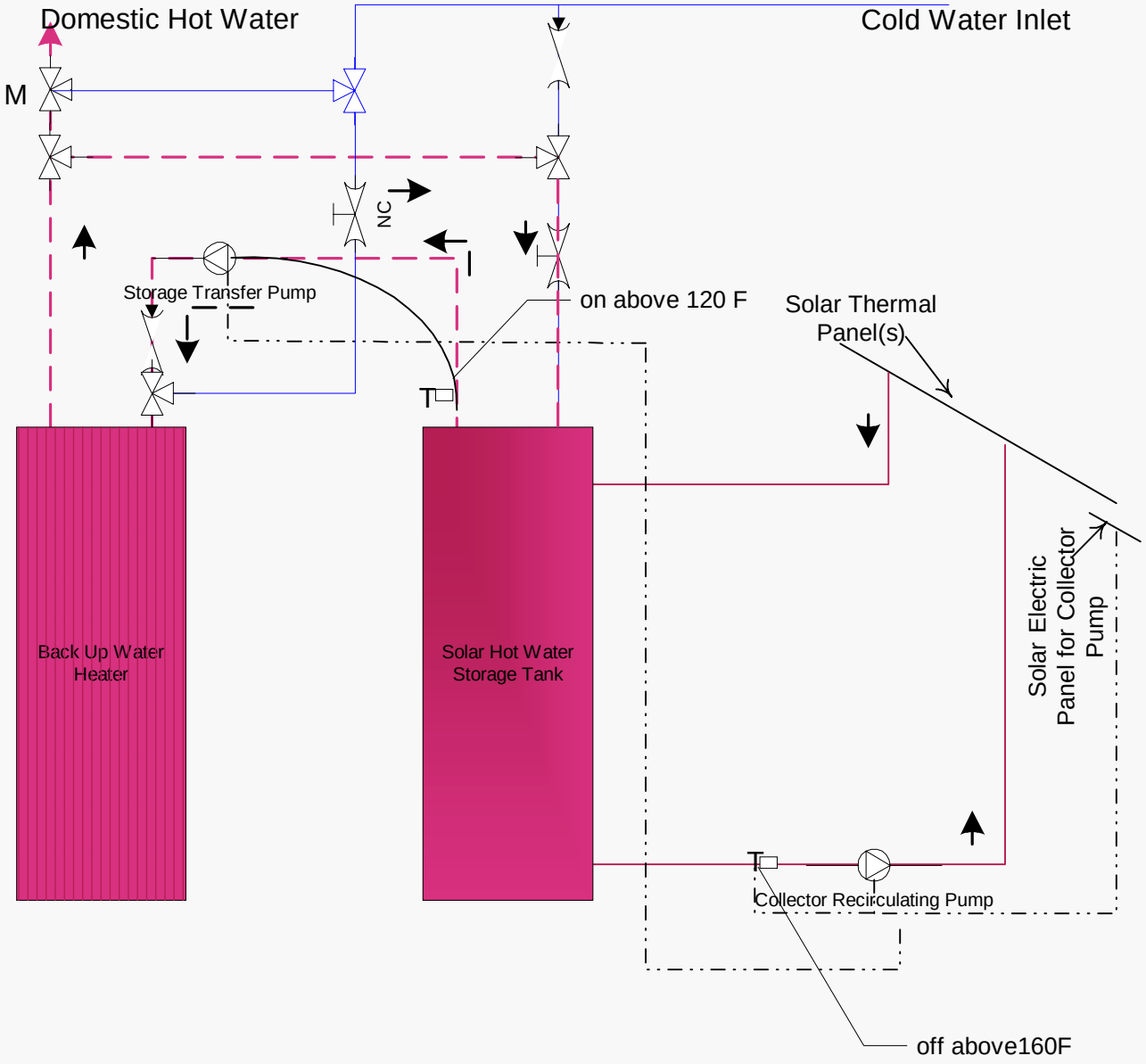
96 hours

120 hours

Schematic of an Drainback Solar Water Heating System



Schematic of an Open Loop Solar Water Heating System



What can’t solar do?

- Solar is not very good at adding heat to hydrondic (baseboard) systems.

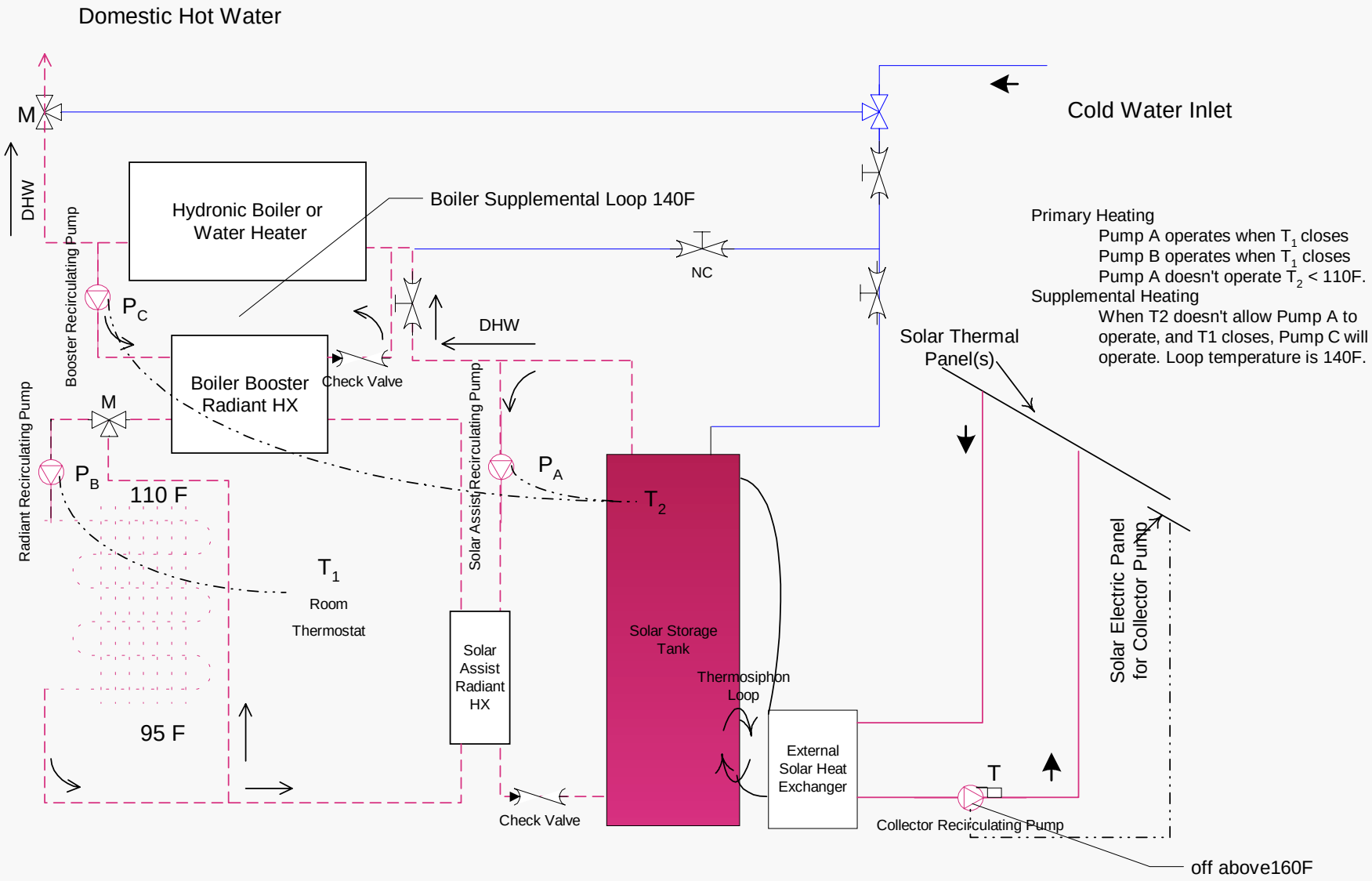
Heat Transfer is from High Temperature to Low Temperature, Thydronic >Tsolar

Typically, hydrondic systems operate between 165 and 185F, while solar fluid is between 120 and 140F in the winter.

Solar can help heat radiant floor systems under certain conditions.

- The radiant fluid setpoint temperature should be less than 100F (Tsolar>Tradiant)
- There must be a way of dissipating the energy gathered, or not gathering all the energy possible in the summer.

Schematic of an Radiant Floor and Domestic Water Heating Solar Water Heating System



Location Design Considerations

Our two choices are:

- Roof Mounted
- Ground Mounted

Roof Mounted

- Snow will accumulate on low angle collectors. The collectors need to be accessible for removing snow, or the pitch should be raised to 35F.

Ground Mounted

- The pipe from the collectors to the house must be at least 3’ deep (check local code for frost penetration depth), and very well insulated. The solar fluid pump needs to be sure that it can overcome the frictional losses in the pipe run between the panels and the pump. Shorter pipe runs mean lower frictional losses.

Here are some installations in New England

Residential Home
System Description: Grid Interconnected Solar Electric System, Wind Energy System and Solar Thermal System.
Output: Solar Electric 1,440 watts, Wind Electric 900 watts, Solar Thermal 80 square feet

Residential Home
System Description: Solar Thermal System.
Output: 64 square feet

Residential Home
System Description: Solar Thermal System.
Output: 64 square feet

Residential Home
System Description: Solar Thermal System.
Output: 64 square feet

Residential Home

System Description: Grid Interconnected Solar Electric and Solar Thermal Systems.

Output: Solar Electric 1,900 watts, Solar Thermal 32 square feet

Residential Home
System Description: Solar Thermal System.
Output: 64 square feet

Residential Home

System Description: Grid Interconnected Solar Electric and Solar Thermal Systems.

Output: Solar Electric 2,000 watts, Solar Thermal 64 square feet

Residential Home
System Description: Solar Thermal System.
Output: 96 square feet

Residential Home
System Description: Solar Thermal System.
Output: 64 square feet

Residential Home
System Description: Solar Thermal System.
Output: 64 square feet

Town of New Shoreham Town Beach:
System Description: Six solar collector, open loop seasonal domestic water heating system for heating shower water. Displaces #2 oil.
Output: 192 square feet

Town of New Shoreham Hospitality Center
System Description: Solar Thermal System.
Output: 64 square feet

Ocean View Foundation Cullinen House: Facility used for retreats and education

System Description: Grid Interconnected Solar Electric System with battery backup, and solar assisted radiant floor and domestic water heating system that displaces #2 oil.

Output: Solar Electric 2,000 watts, Solar Thermal 96 square feet

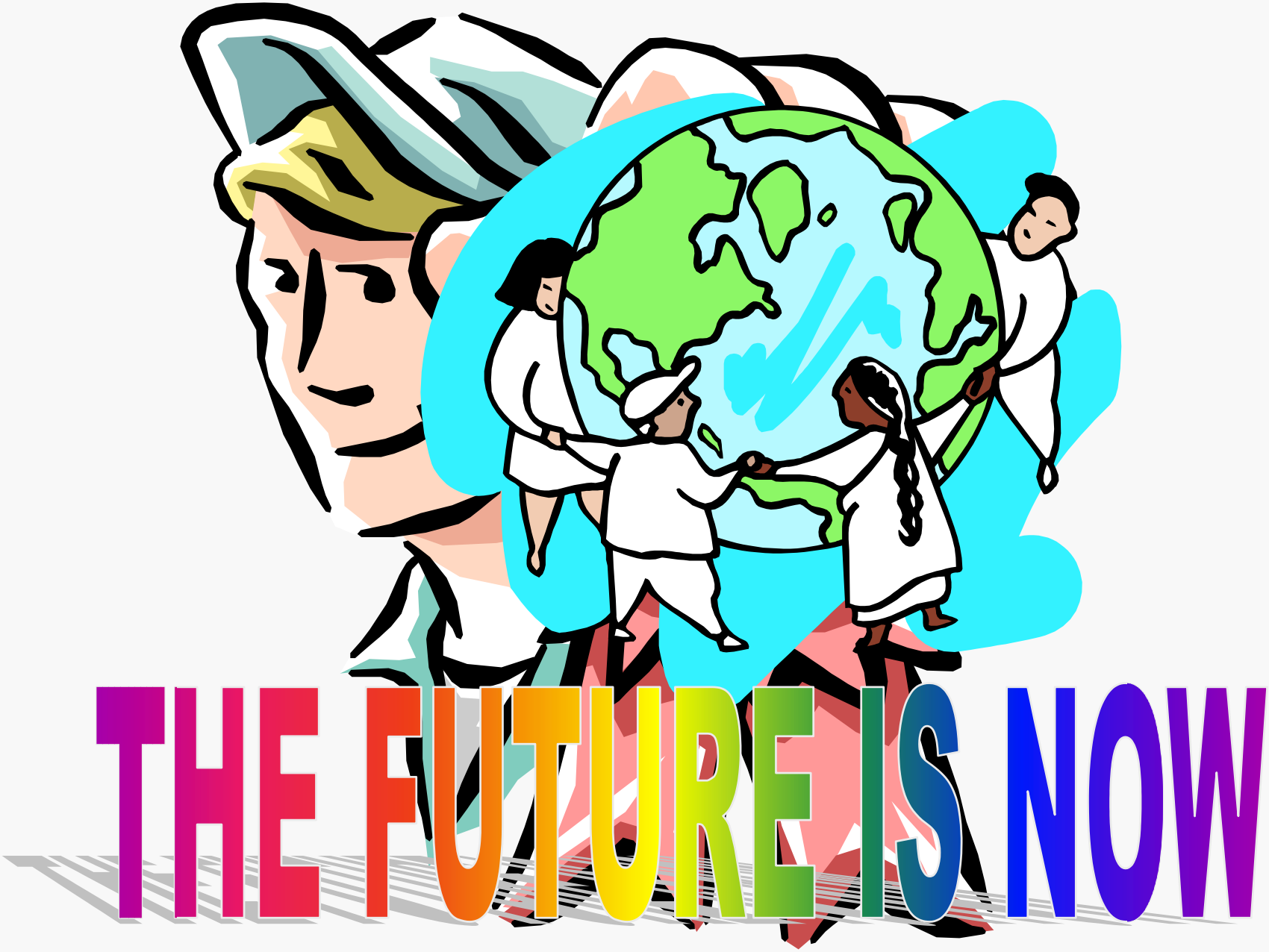
Residential Home
System Description: Solar Thermal System.
Output: 64 square feet

Residential Home
System Description: Solar Thermal System.
Output: 64 square feet

What Are The Next Steps?

If you are an existing home owner, contact a renewable energy professional to determine if renewable energy is feasible for your site and how to incorporate it into your home.

If you are building a new home, discuss renewable energy and how to incorporate it into your home with your builder and a renewable energy professional. Renewable energy systems are cheapest when installed during the construction of a home. Many builders do not want to “bother” with a renewable energy system. They very well may try to talk you out of it. Be persistent. Utilities are the largest ongoing cost of a home. Over the 40 year life of a home, utilities will cost well over $200,000.


THE FUTURE IS NOW