Solar Water Heating Project Analysis

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Clean Energy Project Analysis Course

Glazed Flat Plate Collectors, Ontario, Canada

Photo Credit: NRCan

Natural Resources Canada Ressources naturelles Canada

Canada

Objectives

- Review basics of
  Solar Water Heating (SWH) systems

- Illustrate technical characteristics that are used to describe solar collectors

- Examples of solar thermal systems

The Sun's Available Energy

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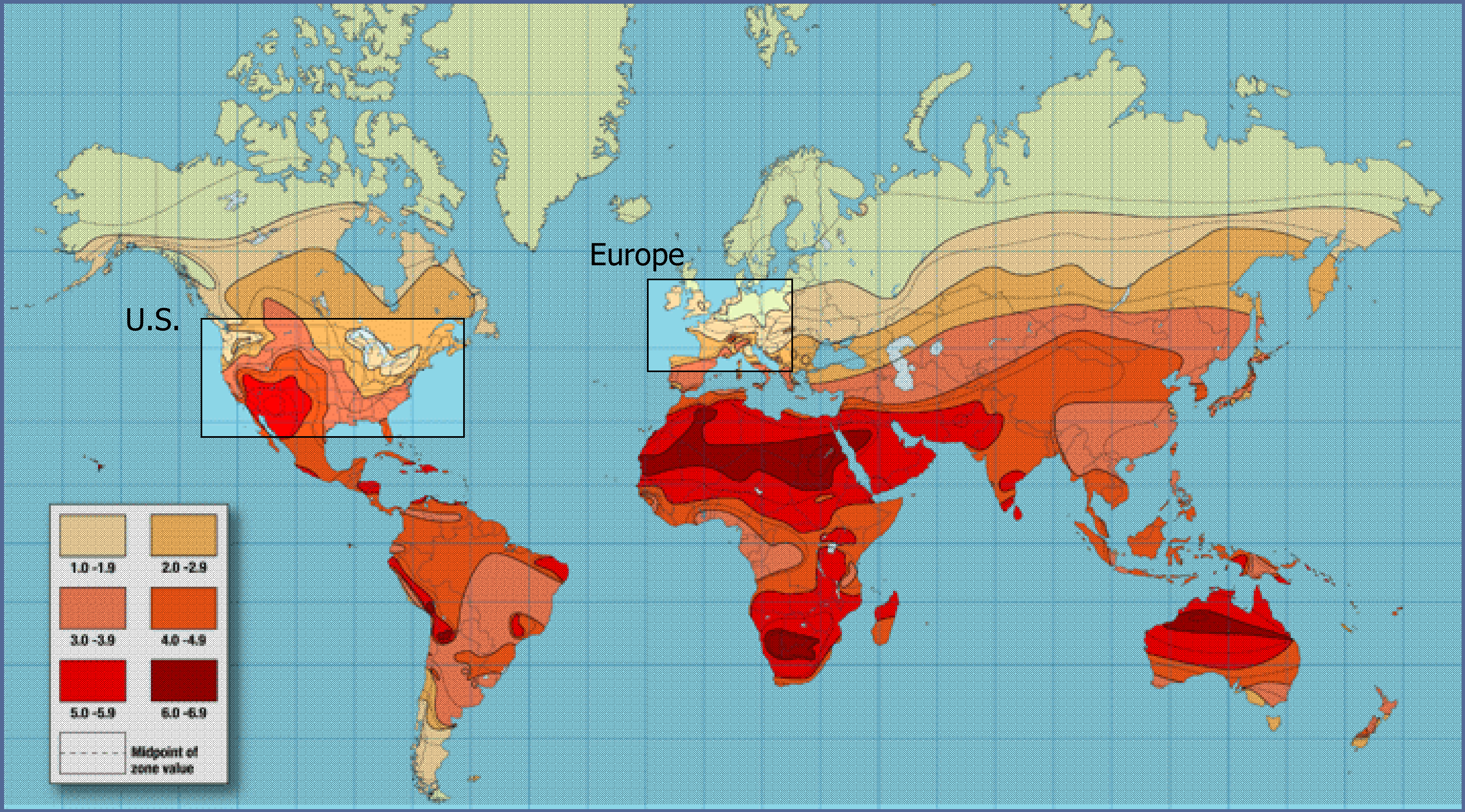

Photo Credit: ASE

Solar Water Heating in Various Climates

- For a domestic solar water heating system with 65 ft² of glazed collector, a demand of 80 gal/day of hot water at 140 °F and 80 gal of storage, the solar fraction is:

21% in Tromsø, Norway (70ºN)	81% in Matam, Senegal (16ºN)
40% in Yellowknife, Canada (62ºN)	59% in Puerto Limón, Costa Rica (10ºN)
32% in Warsaw, Poland (52ºN)	59% in Jakarta, Indonesia (6ºS)
51% in Harbin, China (46ºN)	86% in Huancayo, Peru (12ºS)
67% in Sacramento, USA (39ºN)	69% in Harare, Zimbabwe (18ºS)
39% in Tokyo, Japan (36ºN)	65% in Sydney, Australia (34ºS)
78% in Marrakech, Morocco (32ºN)	39% in Punta Arenas, Chile (53ºS)
75% in Be’er-Sheva, Israel (31ºN)	

What do SWH systems provide?

- Domestic Hot Water
- Process Heat
- Swimming Pool Heating

...but also...

- Increased hot water storage
- Extended swimming season (pool heating)

Conference Centre, Bethel, Lesotho

Photo Credit: Vadim Belotserkovsky

Housing Development, Kungsbacka, Sweden

Photo Credit: Alpo Winberg/ Solar Energy Association of Sweden

Basic Schematic of SWH Systems

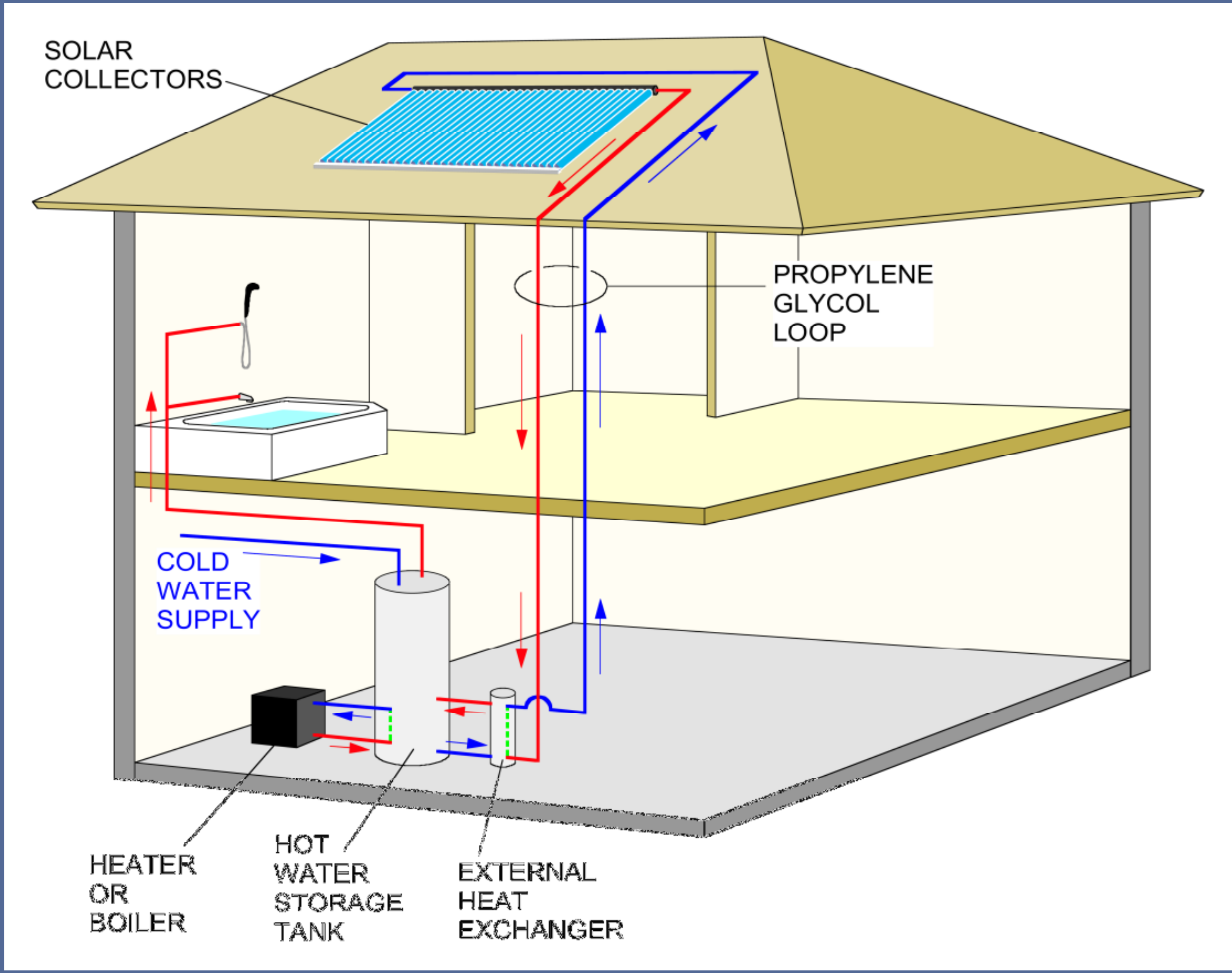

Photo Credit: Quixotic Systems Inc.

Components of SWH Systems

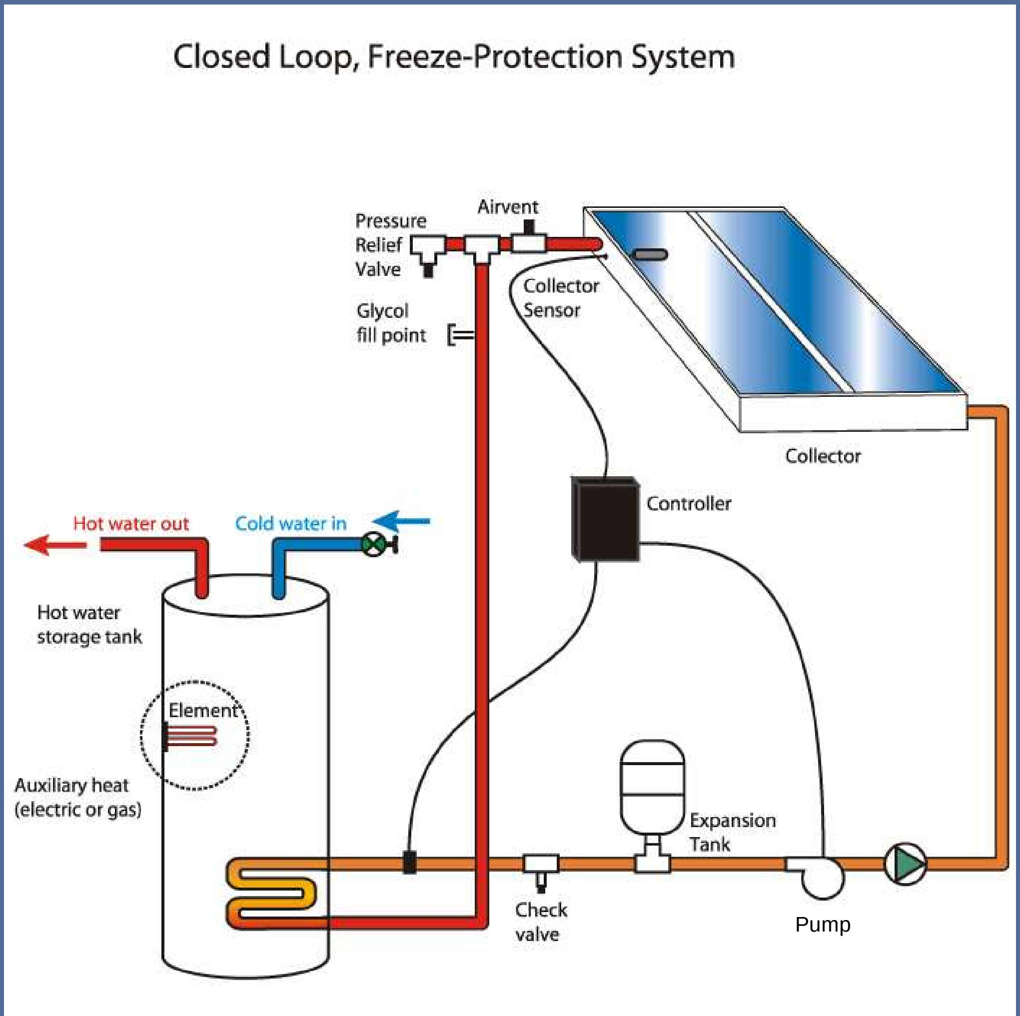

Photo Credit: Southface

Main Components:

- solar collector
- solar storage tank
- heat exchanger
- auxiliary heat source
- controller
- pump
- copper piping + insulation
- valves, fittings, gauges…

Unglazed Solar Collectors

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- Low cost
- Low temperature
- Rugged
- Lightweight
- Seasonal pool heating
- Low pressure
- Poor performance in cold or windy weather

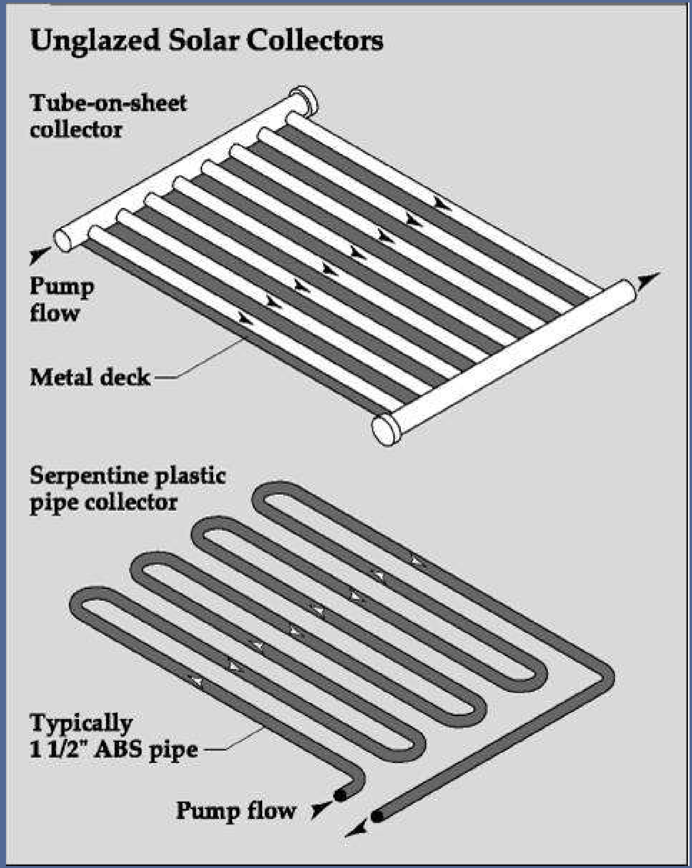


Photo Credit: EERE

Glazed Flat Plate Solar Collectors

- Moderate cost
- Higher temperature operation
- Can operate at mains water pressure
- Heavier and more fragile

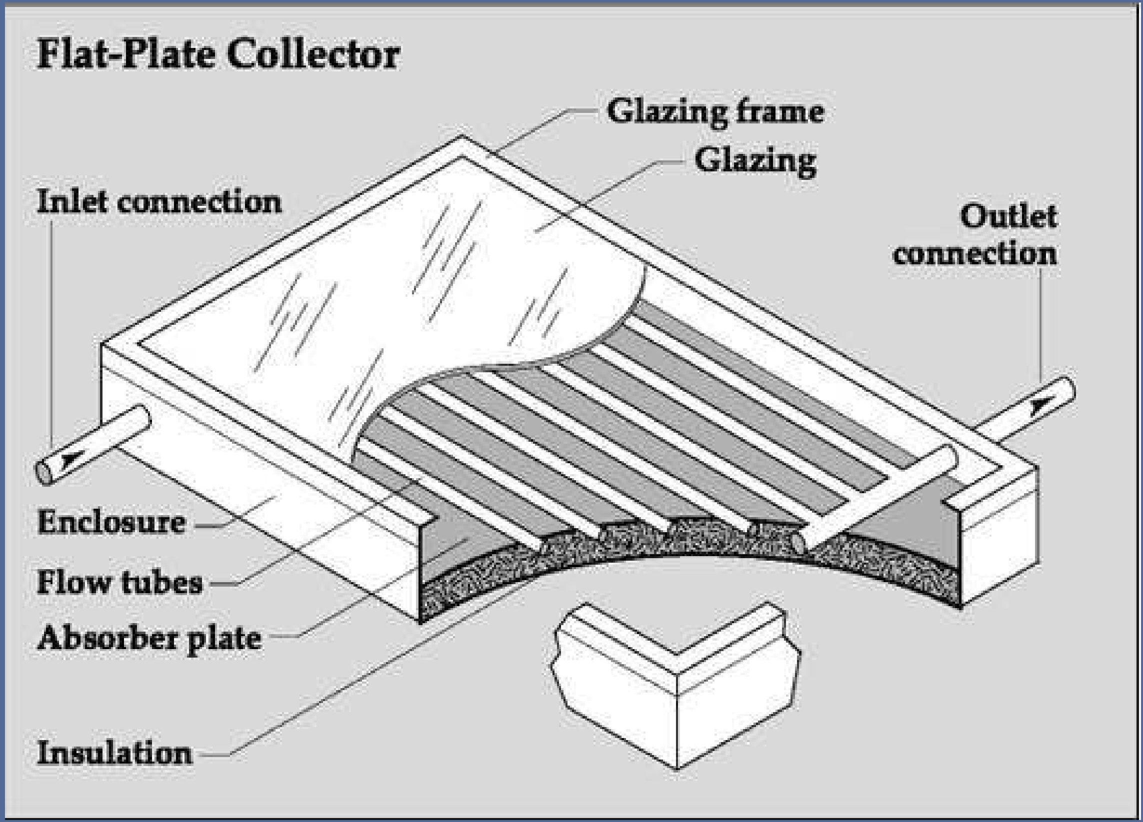


Photo Credit: EERE

Evacuated Tube Collectors

- Higher cost
- Little convection losses
- High temperature
- Cold climates
- Fragile
- Installation can be more complicated
- Snow is less of a problem

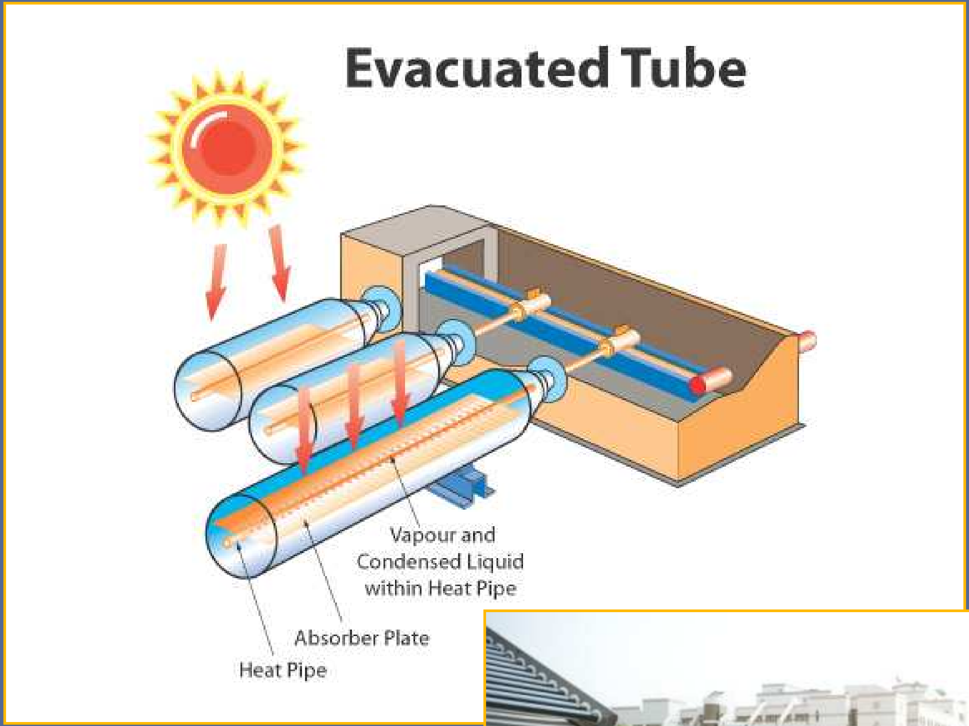


Photo Credit: NRCan

Tube Developed and Manufactured in China

Photo Credit: Nautilus

Solar Collector Parameters

Collector's Efficiency Equation (how efficient is the collector in capturing the sun's energy):

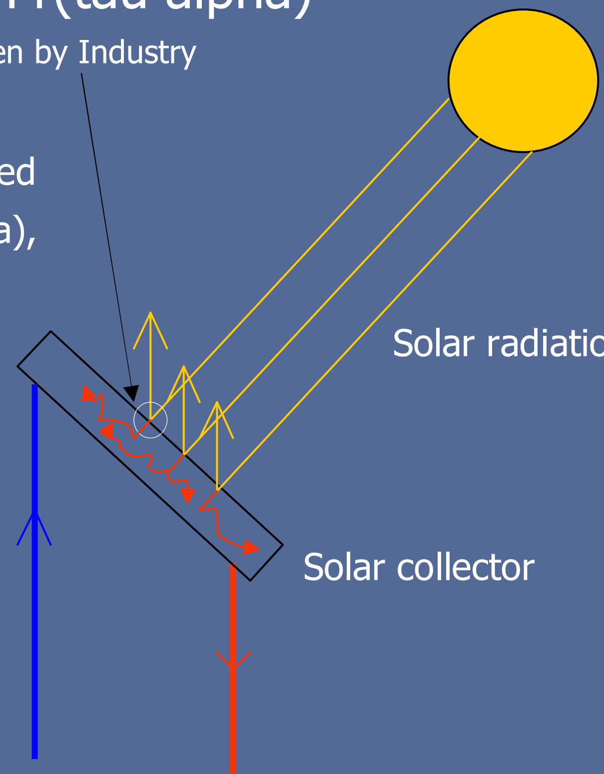
Collector efficiency = heat capturing capability - heat loss

η, Greek for eta

Fr($\tau\alpha$), Fr(tau alpha)

Given by Industry

The amount of solar energy that can be absorbed by the collector is characterized by Fr (tau alpha), its optical efficiency. The higher, the better.



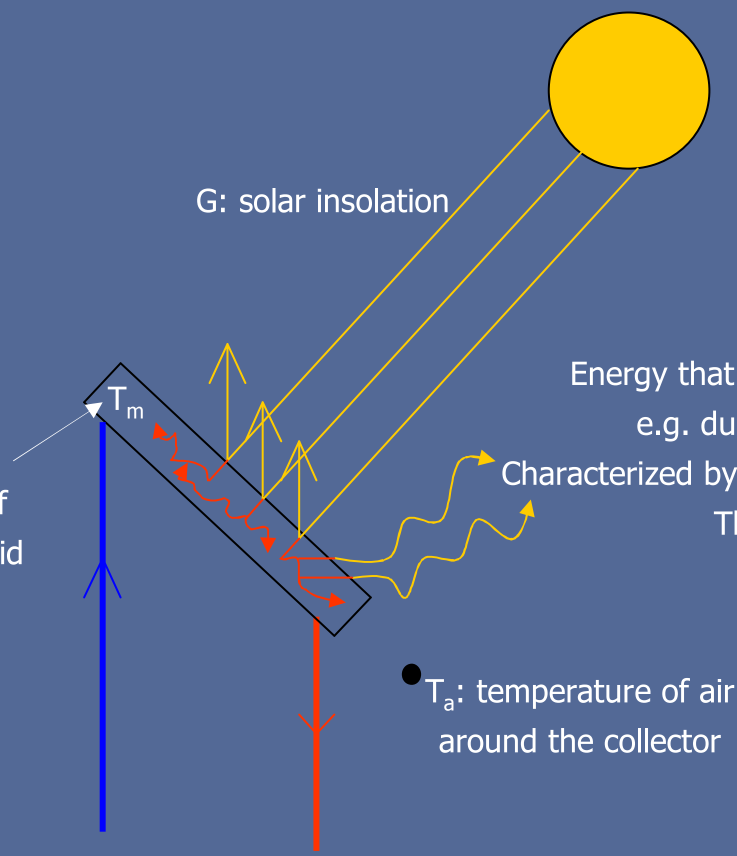
Solar Collector Heat Loss

heat loss of a collector: $Fr\ UL * (T_m - T_a)/G$

Fr UL in (W/m²/ºC)
Given by Industry

Delta T: Collector fluid T minus air T

Solar insolation (W/m²)



Solar Collector Parameters

Linear Efficiency Equation (how efficient is the collector in capturing the sun’s energy):

$$\eta = Fr(\tau\alpha) - Fr\ UL * (T_m - T_a)/G$$

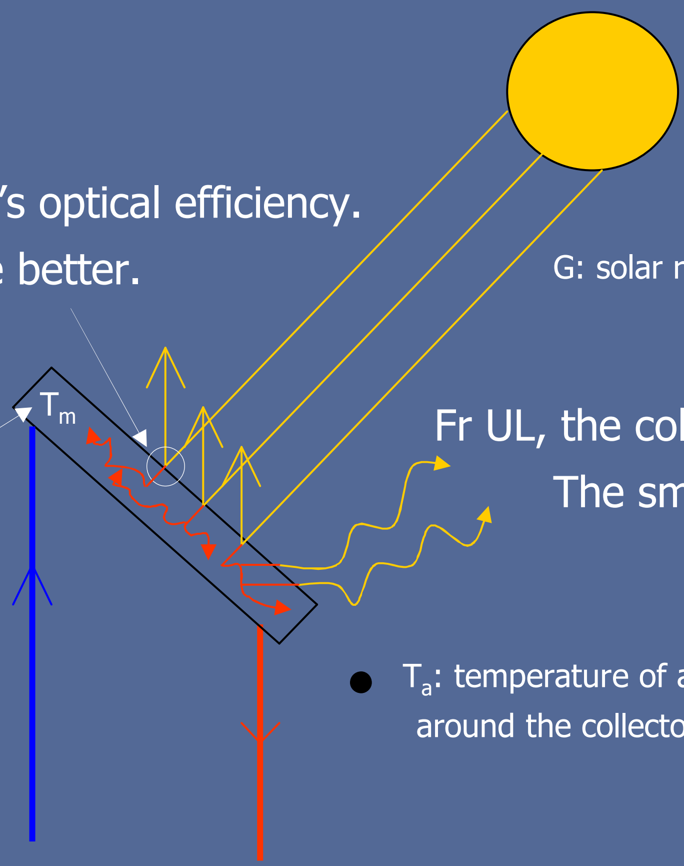
Collector efficiency = heat capturing capability - heat loss

Fr (tau alpha), the collector’s optical efficiency.
The higher, the better.

G: solar radiation

Fr UL, the collector’s thermal losses.
The smaller, the better.

temperature of
the collector fluid



T_a: temperature of air
around the collector

Solar Collector Efficiency Graph

E.g. A glazed collector has following parameters determined by SRCC test:

Fr (tau alpha) = 0.737 (y-intercept of graph)

Fr UL = 4.57 W/m²/ºC (slope of graph)

Put into efficiency equation:

$$\eta = 0.737 - 4.57*(T_m - T_a)/G$$

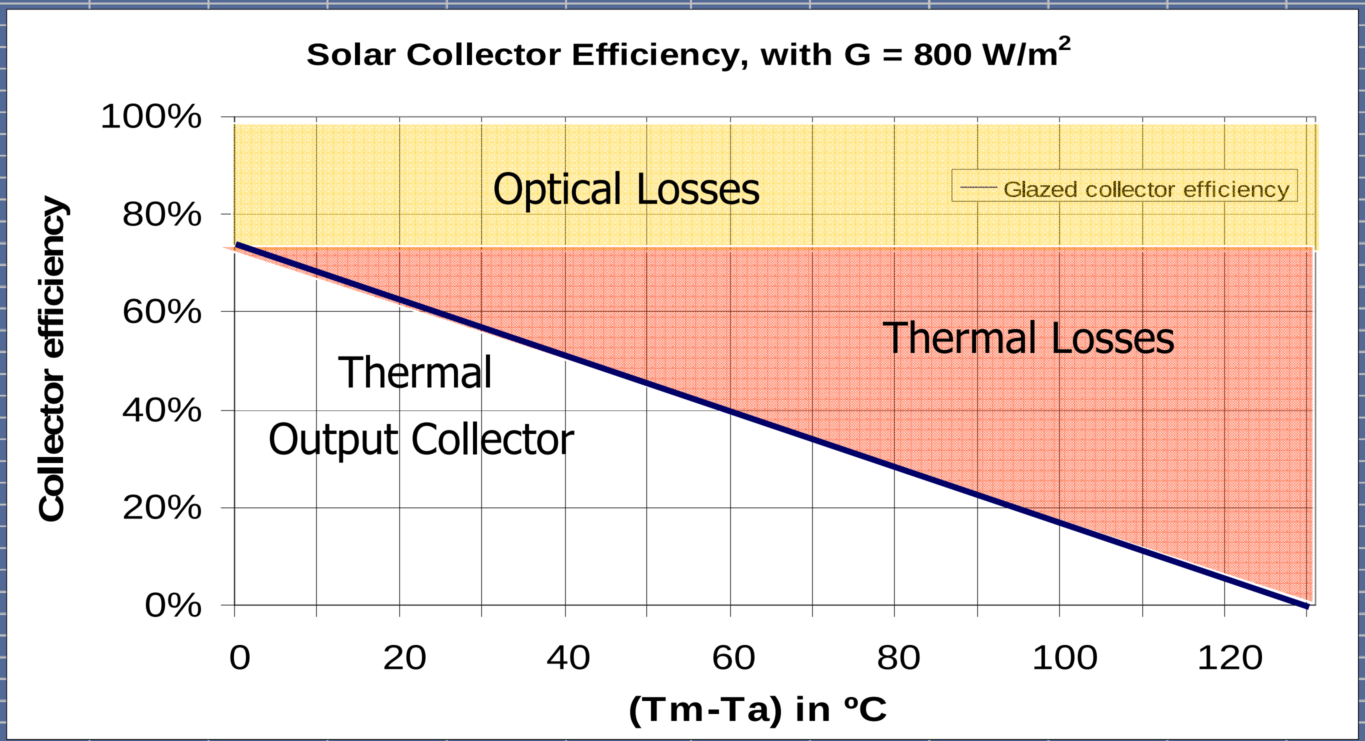


Photo Credit: Quixotic Systems Inc.

Solar Collector Performance

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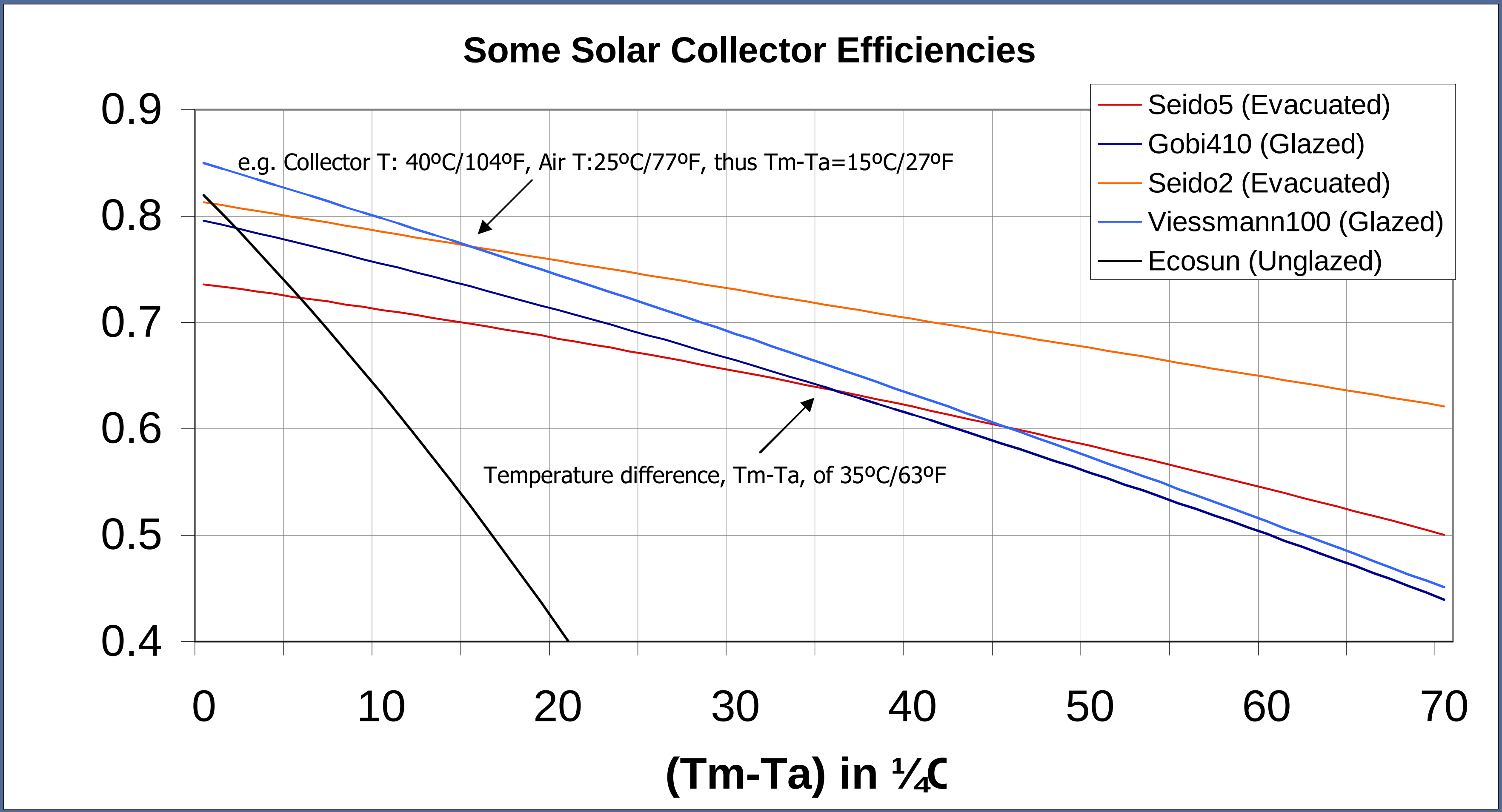

Solar Water Heating Project Considerations

- Factors for successful projects:
  - Large demand for hot water to reduce importance of fixed costs
  - High energy costs (e.g. natural gas not available)
  - No reliable conventional energy supply
  - Strong environmental interest by building owner/operator

- Daytime hot water loads require less storage
- Lower cost, seasonal systems can be financially preferable to higher-cost year-round systems
- Maintenance similar to any plumbing system, but operator must be committed to timely maintenance and repairs

MA and Federal Incentives

Residential Installations:

-National Grid rebate: 15%, capped at $1,500

-MA Tax Credit: 15%, capped at $1,000

- Federal Tax Credit of 30%, capped at $2,000

Commercial Installations:

-National Grid rebate: $3-$8 per 1st year therm output

-MA income tax deduction (i.e. a 9.5% tax credit)

-Federal Tax Credit of 30% (uncapped)

- 5-year accelerated depreciation (MACRS)

Interactions

-Must subtract rebate amount before tax credits calculated

-Must further reduce by half of tax credit amount before depreciation is calculated

Examples: Australia, Botswana and Sweden

Domestic Hot Water Systems

- Systems produce heat on cloudy days
- Systems provide 20 to 80% of hot water

Thermosiphon System, Australia

Photo Credit: The Australian Greenhouse Office

Homes, Malmö, Sweden

Photo Credit: Marie Andrén, Solar Energy Association of Sweden

House for Medical Staff in Rural Area, Botswana

Photo Credit: Vadim Belotserkovsky

Example: Boston
Commercial Hot Water Systems

Example: Sontheim, Germany
Residential Solar Energy Systems

Questions?

Solar Water Heating Project Analysis Module
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For further information please visit the RETScreen Website at
www.retscreen.net