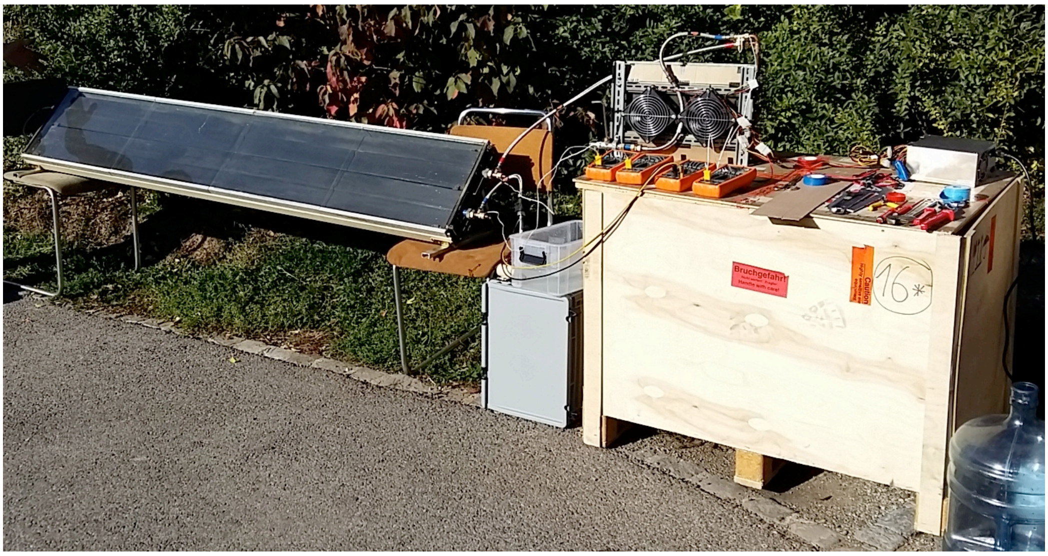
Laboratory session

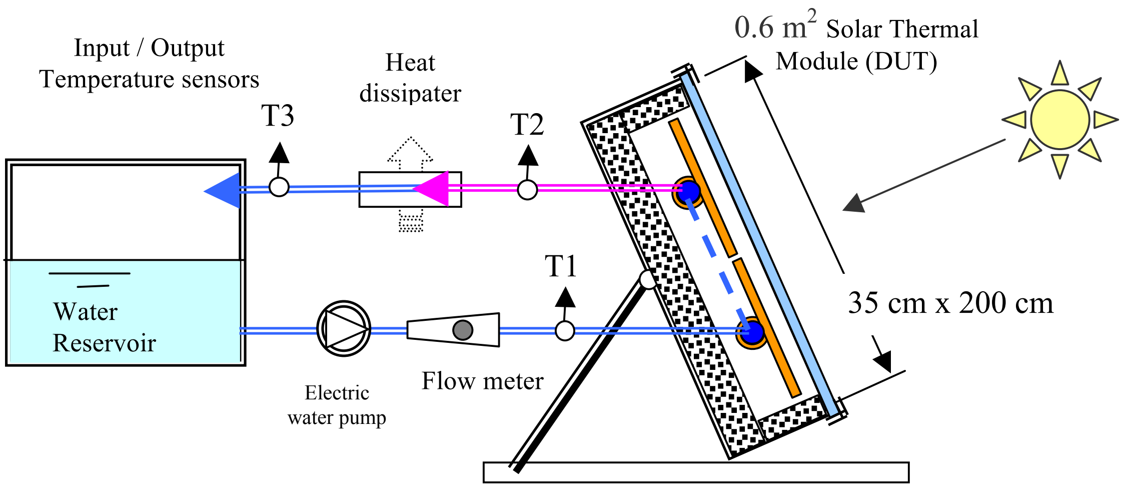
Test of a flat plate thermal solar module of the CERN Solar Club



View of the test setup of the solar thermal module

Module description

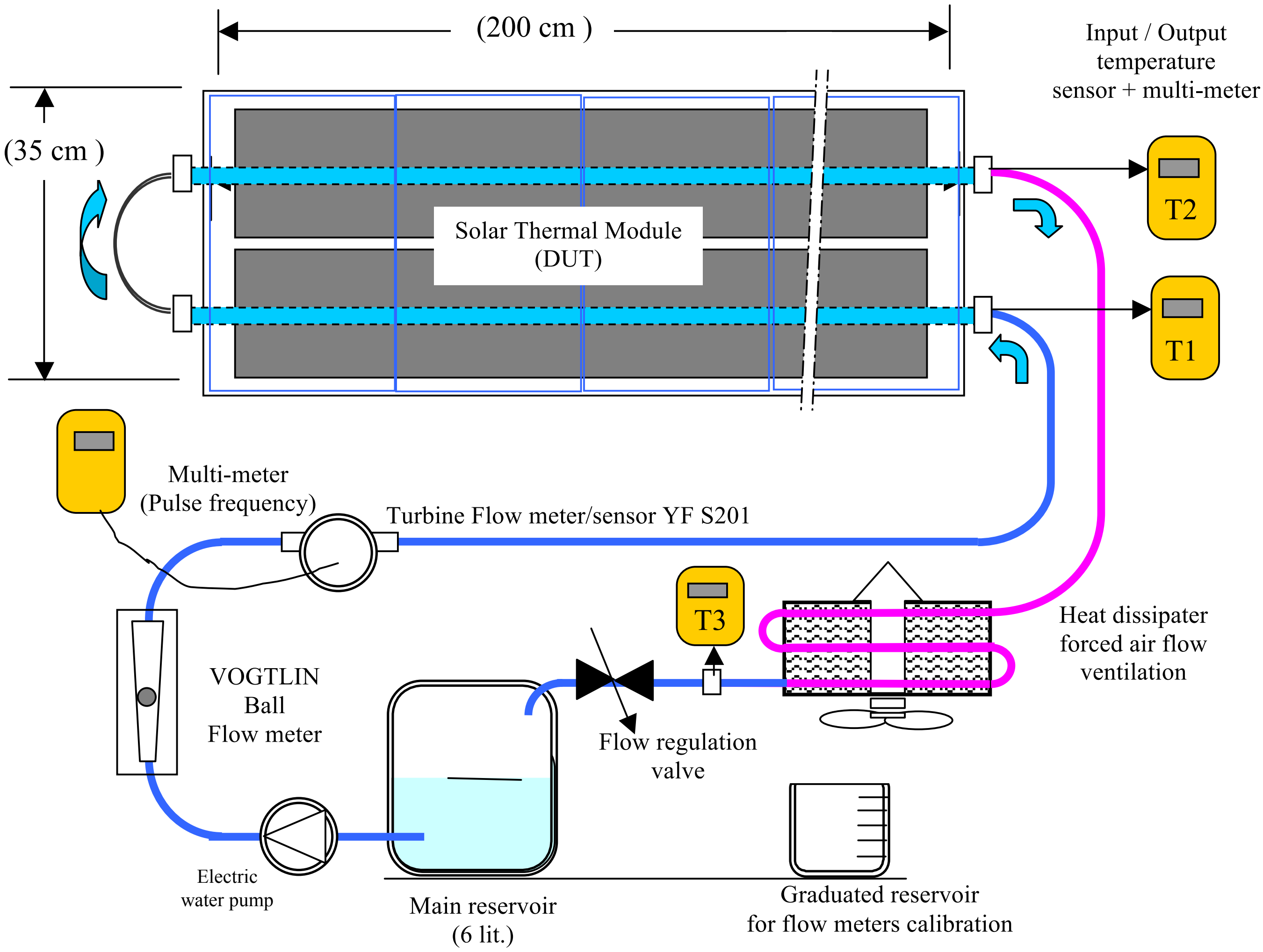
The flat plate thermal solar module (Device Under Test) has two parallel aluminum absorbers with a black selective coating. The surface of each absorber (heat collector) is 15 cm by 200 cm = 0.3 m^2 or 0.6 m^2 for the module. Along the backside each absorber has a tube for the recovery and circulation of the heat transportation fluid (water). On each end of an absorber the tube is equipped with alternatively a male and a female ¾" connector. The absorbers are placed in an insulated box made with a double wall of thin laminated iron plates filled with expanded isolation foam (2 cm thickness).



Schematic test bench configuration

The front side of the box oriented to the sun is covered by a 3 mm glass sheet (for safe transportation split into 4 plates of 35 cm x 50 cm). The outer dimensions of the module are 2 m length, 36 cm width and 7.5 cm height for a total weight of 20 kg.

The module is placed horizontally and tilted in the direction of the sun. Behind or next to the panel (so we don't produce shadow on it), are placed the water reservoir (6 liters) with the pump and 2 flow-meters (turbine-Hall-sensor + VOGTLIN ball flow meter), a water-air heat exchanger, 3 temperature sensors, connection tubes and the multimeters for the measurements.



General layout of the test setup

Main components description:

Flow meters
There are 2 flow meters in the circuit: a ball-flow meter and a turbine flow meter. Because the real water flow is sometimes close or below the lower limit (1 l/min) of the turbine flow sensor, we have install a supplementary ball flow meter.

The turbine flow sensor has a propeller with a small magnet and a Hall Effect sensor which gives a pulse for each turn of the propeller or 2.22 ml/turn (450 pulses/lit.). Flow (lit/min) = pulse frequency (Hz) / 7.5.

The flow sensor has a red wire for the power supply (5-24Vdc and 15 mA @ 5V dc), black wire for the mass and a yellow wire for the signal (pulse). A calibration is necessary for an error < 10%! Working range 1-30 l/min. Temperature range: 25-80°C

The extracted thermal power Q depends on the mass water flow rate (M) across the solar panel, the specific heat of water C= 4.18 J g^{-1} K^{-1} and the temperature difference (ΔT).

$$Q = M * C * \Delta T$$

Example: For a flow rate of 35.9 ml/s and a temperature difference of 2°C,
Q = 35.9 g/s * 4.18 J g^{-1} K^{-1} * 2K = 300 W.

For a larger temperature difference (ΔT), the flow rate (M) and consequently the pulse frequency (Hz) of the flow sensor should be proportionally smaller.

Measurements of the frequency (flow meter) and the temperatures are made with the same multi-meter types (Proster Digital Multimeter VC99):

Proster Digital Multimeter VC99

Circulation pump

Ball flow mter
The VOGTLIN ball flow meter is a hydromechanical meter with a direct reading. The vertical height of the ball, in the conical glass tube, is proportional to the water flow rate.

The calibration of the flow meters or the measurement of the flow rate (volume or mass of water / unite of time) is be made with a graduated recipient (volume/mass) and a chronometer.

Circulation pump
3M New TE089 Solar pump Brushless motor DC 12V / 500 mA for water (100°C max)
Maximum flow rate : 6,5 L / min, 0.3 bar

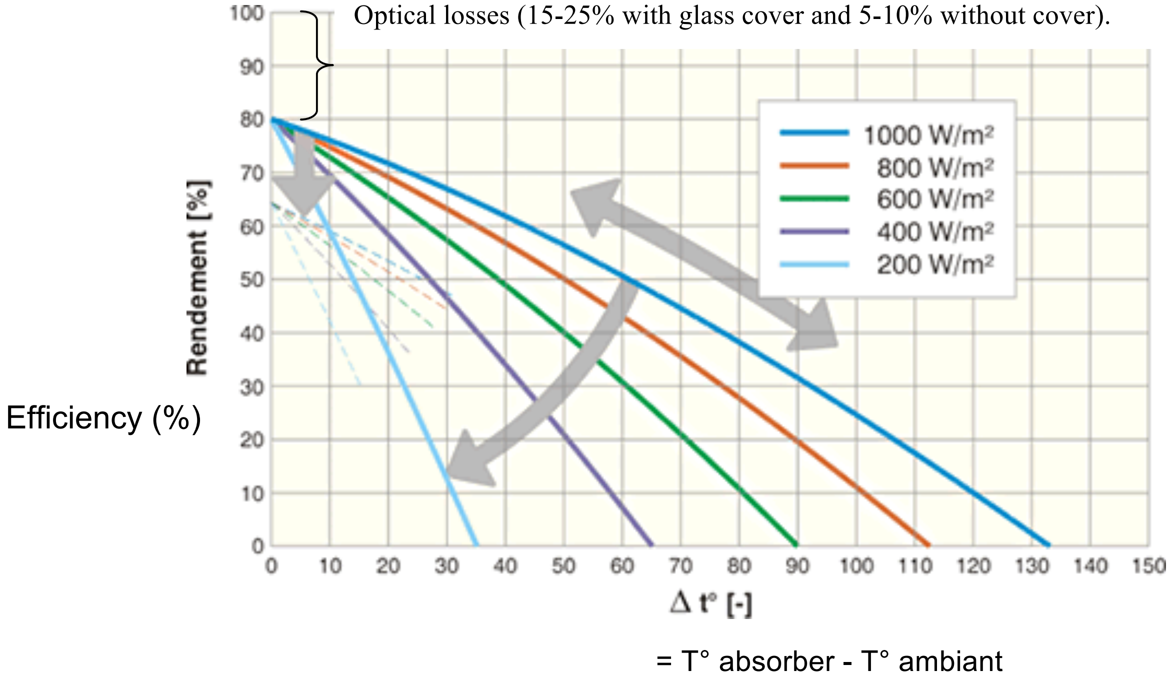
Heat dissipater

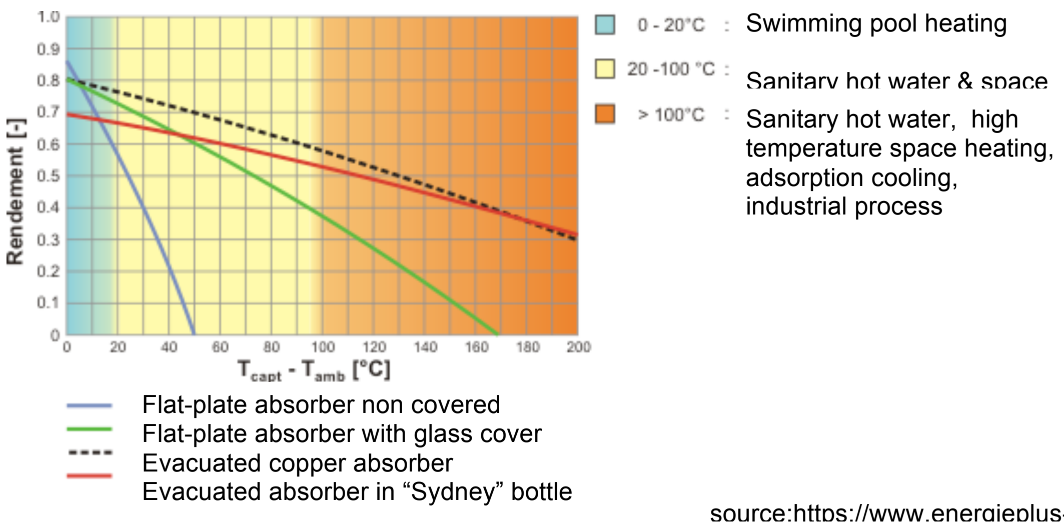
The heat dissipater cools again the heated water coming from the solar panel before it returns to the reservoir. So the water has always the same input temperature entering the solar panel. The heat dissipater is a water-air radiator with air flow forced by 2 ventilators.

Efficciency measurements of the solar thermal module

With a standard (AM 1.5) incident solar radiation of 1000 W/m^2 and a panel efficiency of some 50 % the module (2 absorbers = 0.6 m^2) would produce 300 W heating power.

For comparison, we can make the measurements with and without the glass cover (greenhouse effect) which influences the optic losses as well as the convection and conduction losses.





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