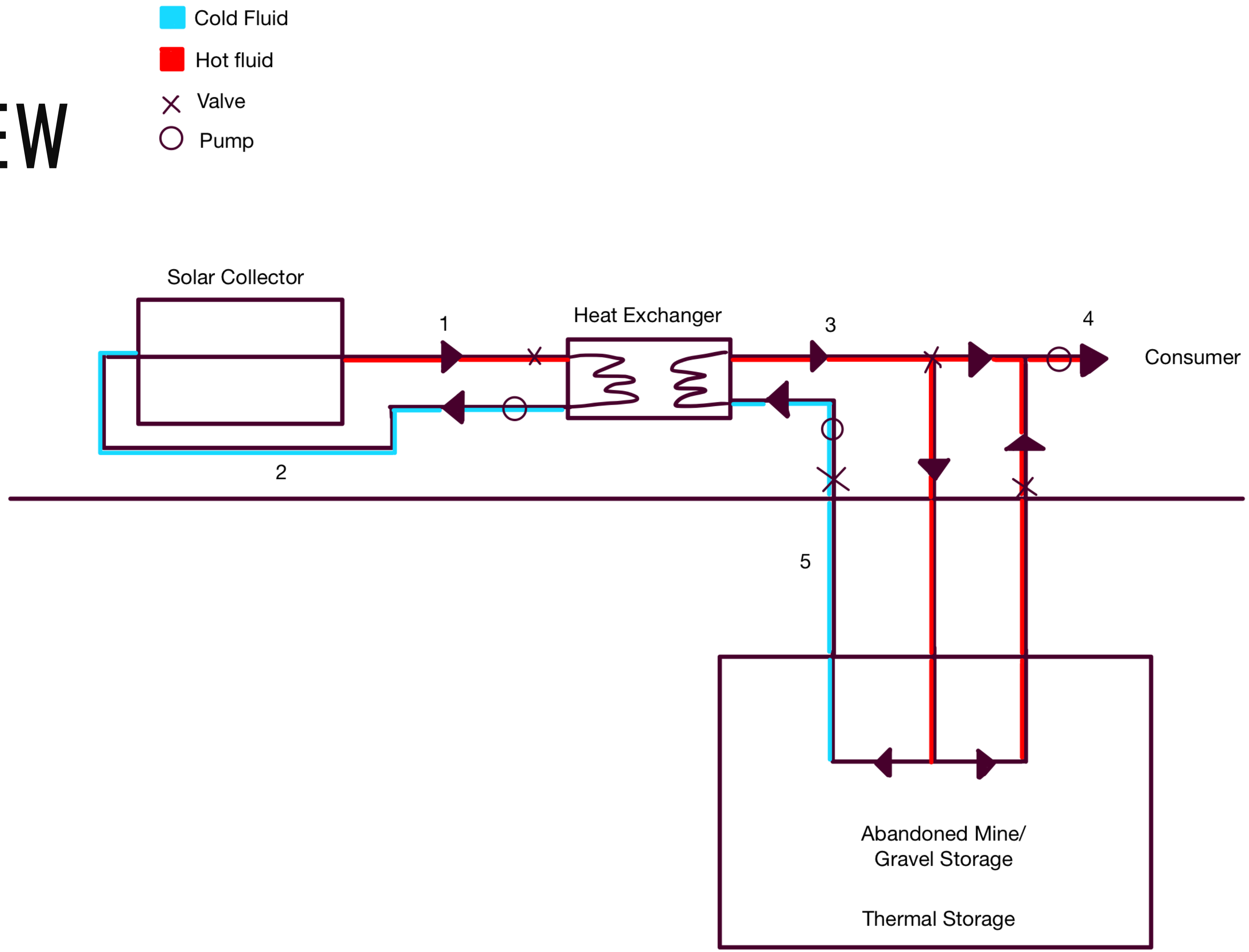
# SOLAR ROCKS

Thermal Analysis Presentation
Part 1

# OVERVIEW



Cold Fluid
Hot fluid
Valve
Pump
Solar Collector
1
Heat Exchanger
3
4
Consumer
2
5
Abandoned Mine/
Gravel Storage
Thermal Storage

# SOLAR COLLECTOR (2 TO 1)

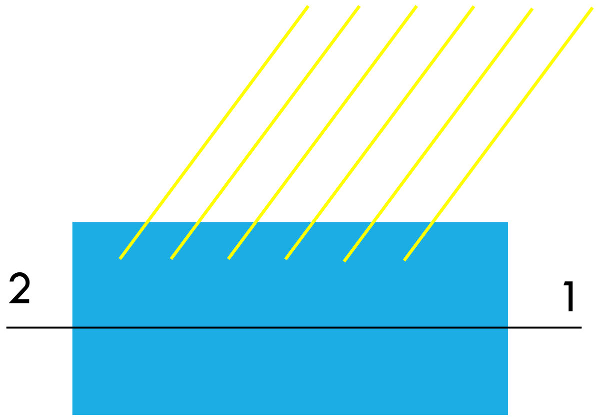



Figure 1.

Assuming 10m long solar collector with 75% optical efficiency, 1000 W/m^2 direct irradiation, .025 m^3/s volumetric flow rate, 350C inlet temperature, and 27 C ambient air temperature:

Using Solar grade HTF (oil)-

Tout=77C

Usable Energy=613 W

Water-

Tout=75C

Usable Energy=621W

Note: Further analysis stopped because units need to be checked

**Possibility of ordering a small-scale parabolic trough. Awaiting return contact.**

# HEAT EXCHANGER (5 TO 3)

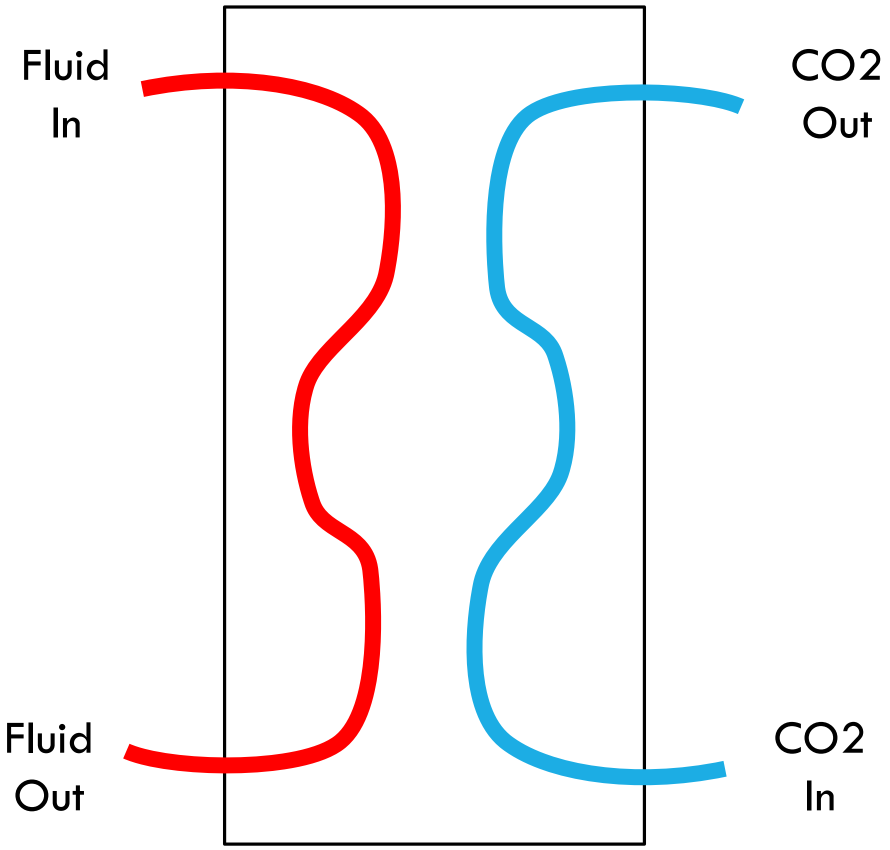



Figure 2.

- Hot working fluid enters one side and heats the cold $CO_2$ on the other.
- Shell and Tube design is preferred.
- Several sources for purchase are being considered.
- Estimate is around the $800 range.

# THERMAL STORAGE ANALYSIS- OPTION 1

Lumped Capacitance approach:

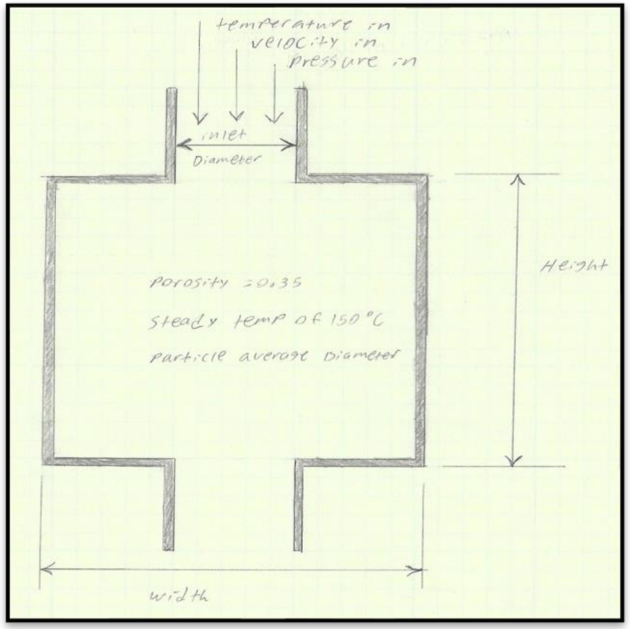
Governing Equations:

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-\frac{hA_S t}{\rho V c}}$$

$$\tau = \frac{\rho V c}{h A_s}$$

$$Q = \rho V c \theta_i \left[1 - e^{-\frac{t}{\tau}}\right]$$

| | | | |
|---|---|---|---|
| T | Temperature of the Spheres | V | Volume of the chamber |
| Ti | Initial sphere temperature | c | Specific heat of the fluid |
| T∞ | Temperature of the fluid in the chamber | t | Time that has passed |
| h | Heat transfer coefficient | τ | Thermal time constant |
| As | Surface are of the sphere | Θi | Initial temperature Vs. Fluid Temperature |
| P | Density of the fluid | | |




Treat each sphere as an individual lump capacitance.

Break into sections of the chamber and numerically compute.

# THERMAL STORAGE ANALYSIS- OPTION 2

Packed Bed Approach:

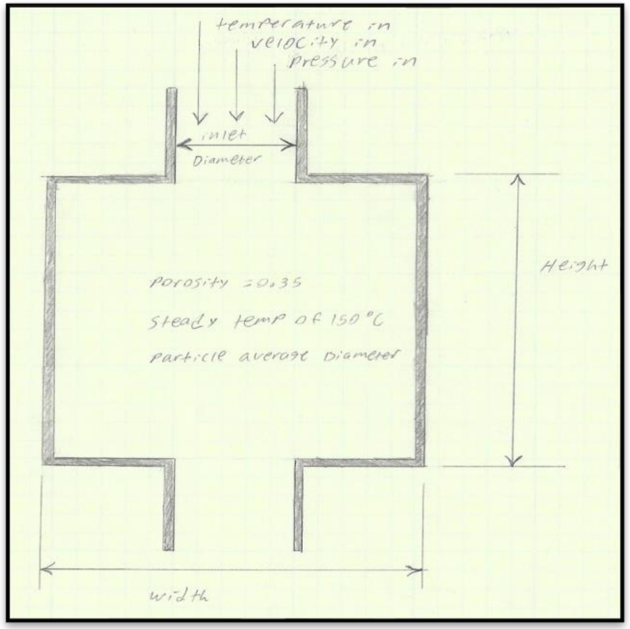
Governing Equations:

$$\frac{T_s - T_o}{T_s - T_i} = e^{-\frac{hA_{p,t}}{\rho V c_p A_{c,b}}}$$

$$\Delta T_{lm} = \frac{(T_s - T_i) - (T_s - T_o)}{\ln\left(\frac{T_s - T_i}{T_s - T_o}\right)}$$

$$q = hA_{p,t}\Delta T_{lm}$$

| | | | |
|---|---|---|---|
| Ts | Steady state material temperature | V | Volume of the chamber |
| Ti | Inlet temperature | Cp | Specific heat of the fluid |
| To | Outlet temperature | Apt | total surface area of the packed bed |
| ΔTlm | Log mean temperature | Acb | cross sectional area of the packed bed |
| h | heat transfer coefficient | P | Density of the fluid |




This approach assumes a steady packed bed temperature.

Errors in the code make this hard to determine if it is accurate.

# BIBLIOGRAPHY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