Thermal Energy

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Goal and Objectives

Goal:
To develop a solar thermal energy storage (TES) system that collects and stores solar radiation to generate electricity.

Objectives:
1. Effective thermal storage (stores water);
2. Thermoelectric generator (TEG) to convert thermal energy to electricity;
3. Mobile phone application to indicate energy availability in the system.
4. Solar collector with sun tracking mechanism;

Motivation

At remote locations where electricity demand is low and intermittent, solar radiation is a cost-effective source of power generation. Though solar photovoltaic (PV) panels have been increasingly popular, they are not practical to provide spinning reserve or to generate electricity at night. In order to maintain a stable energy grid, a TES system needs to be incorporated; an accordingly new mean of solar radiation collection is also required.

Innovation

- 100% clean and renewable energy input
- Unlike PV panels, our device generates electricity 24 hours a day
- TES+TEG is a replacement of battery where electricity demand is low and intermittent
- Requires little to no maintenance

Current Status

- General design completed
- CAD model completed
- Mobile phone app coding in progress
- Thermocouple assembly (for app) completed

Next Step

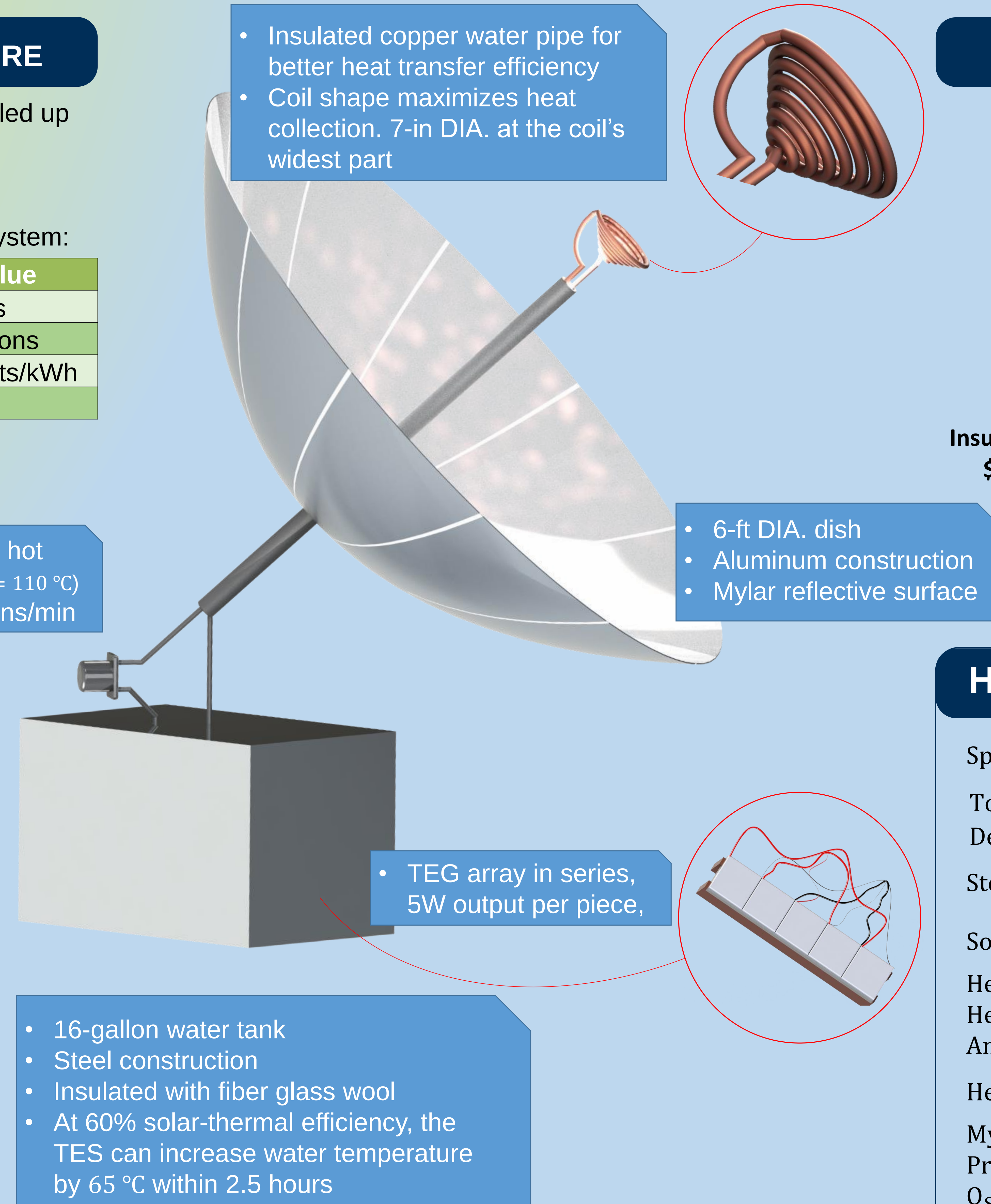
- Choose and test insulation material
- With smaller water tank, acquire temperature data for more accurate analysis and full-size water tank design

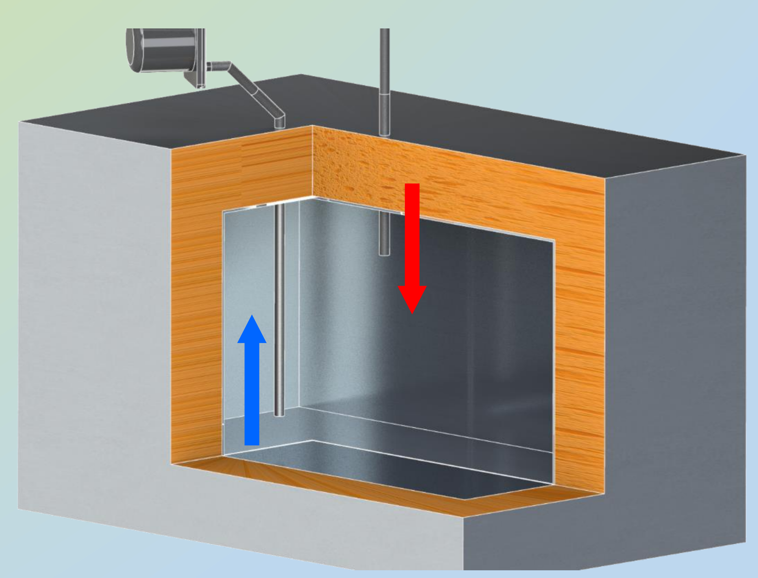
The Bigger Picture

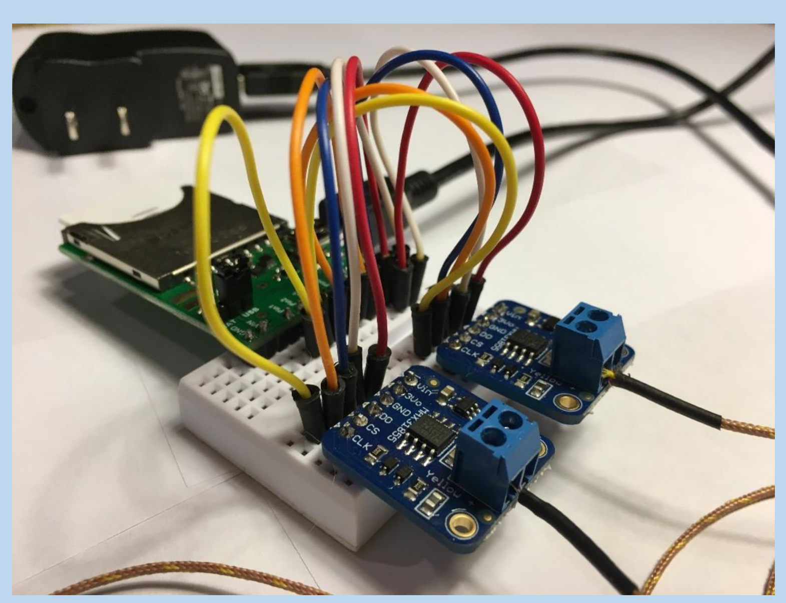
Our prototype can be easily scaled up for higher thermal storage and electricity demand.

An example of a **larger scale** system:

Specification	Value
Daily Heating Time	9 Hours
TES Volume	60 Gallons
Current Electricity Cost	12 Cents/kWh
Payback Time	1 Year



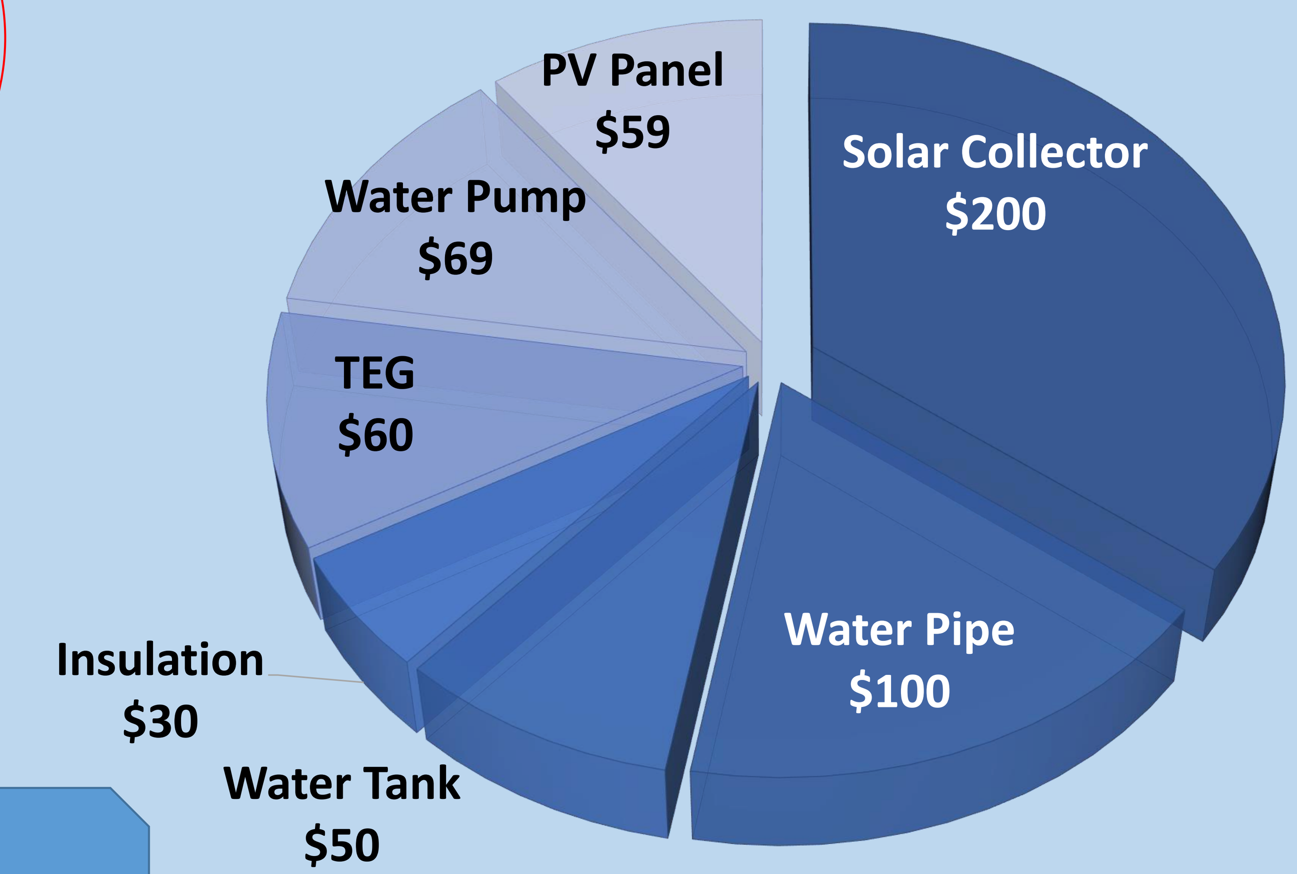

Water Tank Cutaway View


Thermocouple Assembly

Timeline

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
General Design	■	■						
CAD	■	■						
Solar Collector Fabrication		■	■	■				
Thermal Storage Fabrication				■	■			
TEG Installation					■	■		
Field Test and Finalization						■	■	■

Estimated Cost



Prototype Total Cost: $568

Heating Surface Safety Analysis

Specific Heat of Water: $C_{p,H_2O} = 4183\ [\frac{J}{kg} \cdot K]$

Total Energy Required: $Q_{in\ (total)}$ [J]

Desired Temperature Difference: ΔT [℃]

Stefan − Boltzman Constant: $\sigma = 5.67 \times 10^{-8}\ [\frac{W}{m^2} \cdot K]$

Solar Heat Flux: $P \approx 1000\ [\frac{W}{m^2}]$

Heating Surface Area (Coil): $A = 0.02\ [m^2]$

Heating Surface Temperature: T_s [℃]

Ambient Temperature: $T_\infty \approx 20$ [℃]

Heat Transfer Coefficient of Ambient Air: $h = 2\ [\frac{W}{m^2} \cdot K]$

Mylar's Reflectivity: $R = 0.98$

Projection Area of the Dish: $A_D = \pi r^2 = 2.63 m^2$

$Q_{Sun} = P \cdot A_D \cdot R = 1000 \times 2.63 \times 0.98 = 2886.68W$

$Q_{Sun} = q_{rad} + q_{conv}$

$Q_{Sun} = \sigma {T_s}^4 A + h(T_s - T_\infty)A$

$T_s = 1226K = 985°C$

985°C < 1085°C (Melting Temperature of Copper)

Safe ✓

Contact Information
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