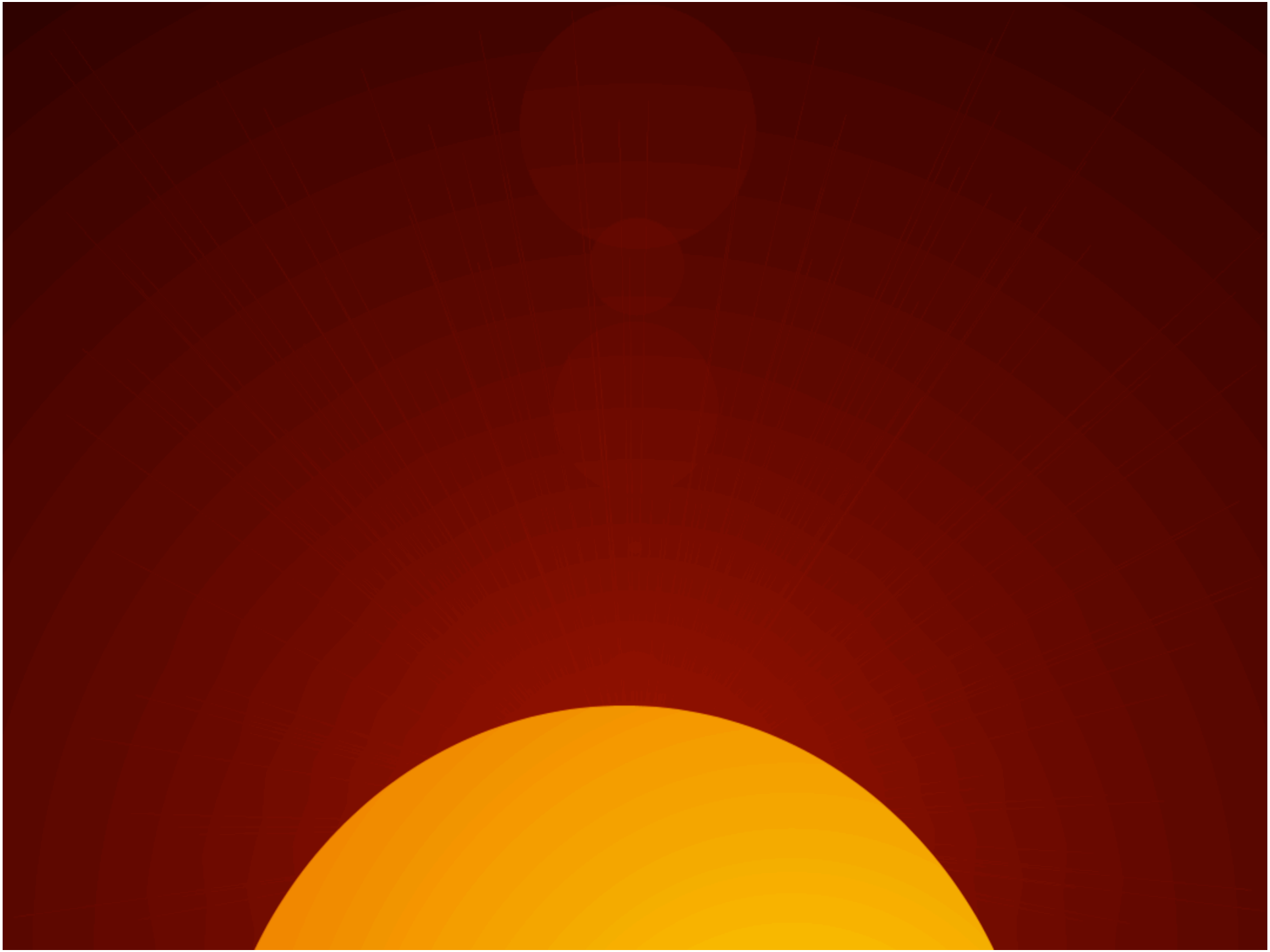
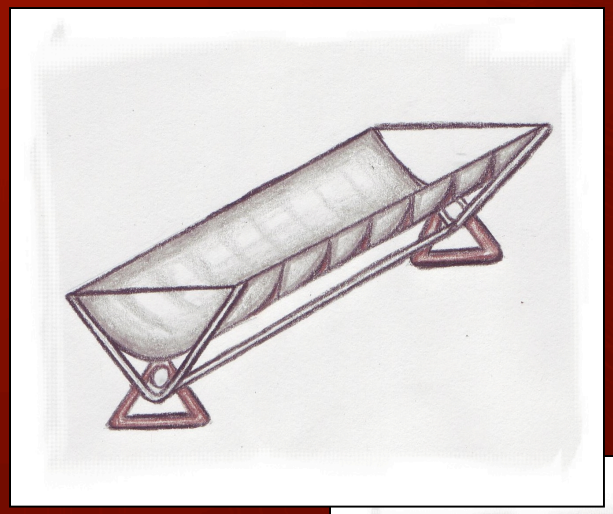
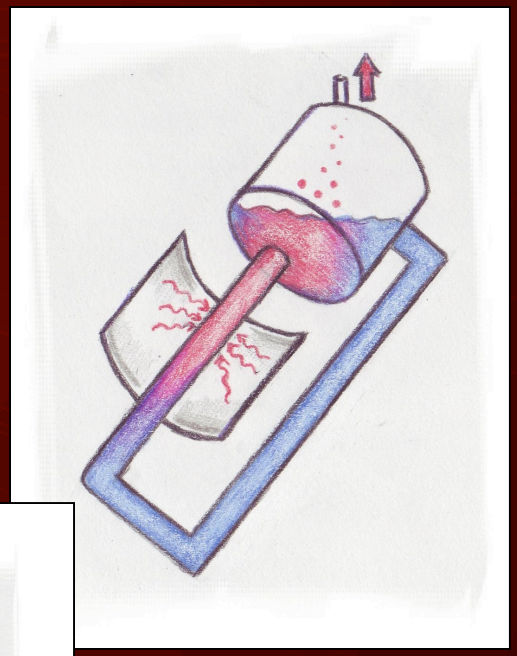


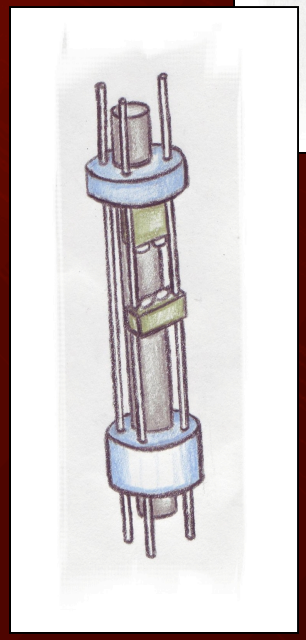
SOL PUMP

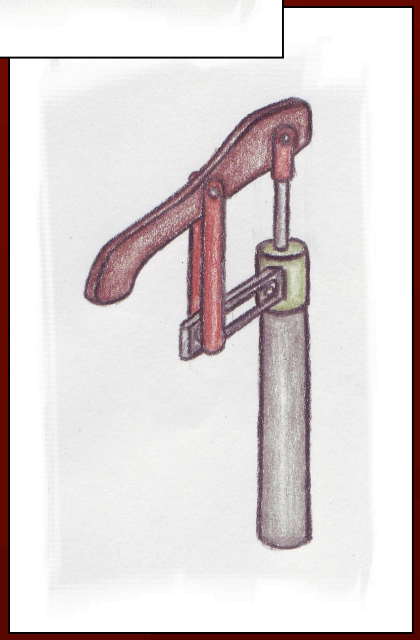
Toni Ferreira
Jennifer DeBoer
Meredith Silberstein
Ed Sharp
Jessica Chiafair
Beth Baniszewski
Kyle McKenney
Tom Hennessey
Nicholas Fahey
Moses Heywood
Javier Echenique
Jorge Padilla
Kirk Samaroo
Christina Bonebreak
Laura Nichols
Headley Jacobus

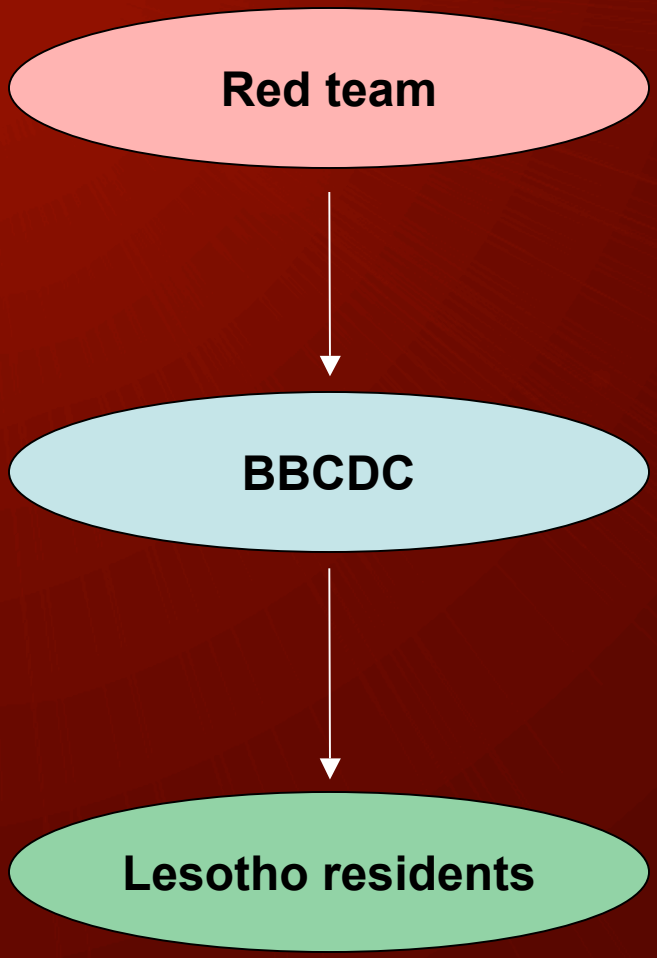
The System











Engineer proof of concept

Technology & research findings

Adapt & improve

Pass on knowledge & skills

Take knowledge to own villages

Customer Needs

Prioritized needs

1. Electricity
2. Refrigeration
3. Water pumping
4. Home heating
5. Grinding
6. Other

Requirements

- **Off-grid**
- **On-site construction**
- **Cost < $1000**

Initial trough improvements

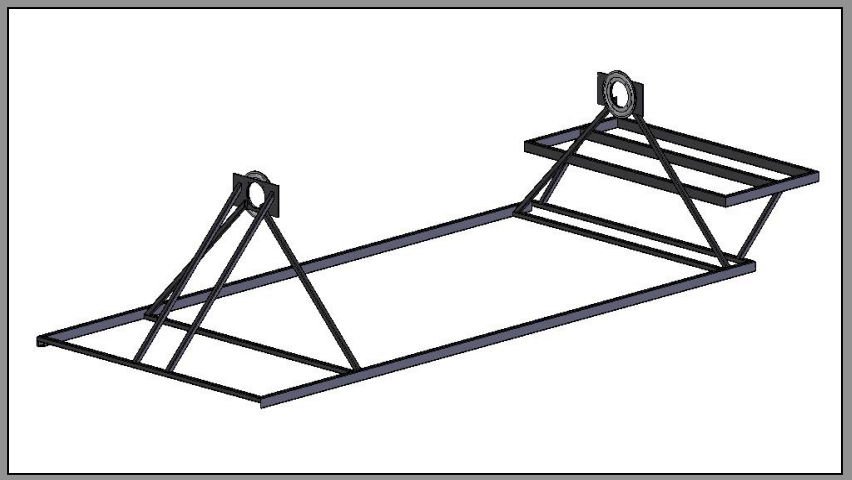
Lesotho

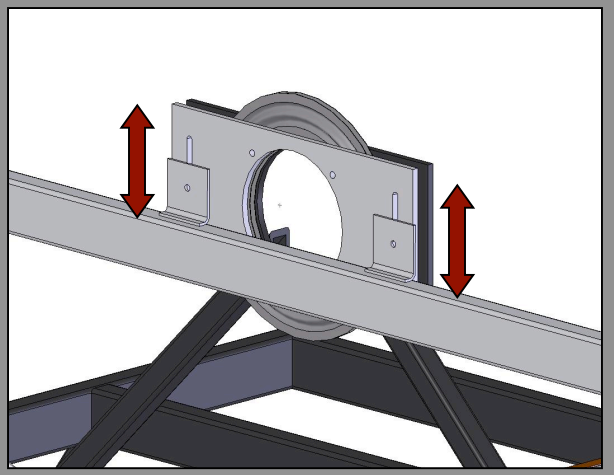
- Accurate parabola
- Requires hundreds of welds
- Two axis rotation
- Manual tracking
- Used to cook bread

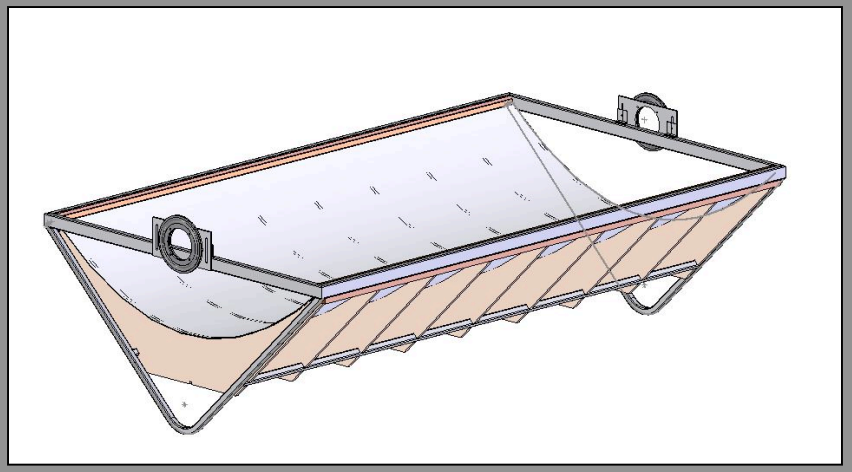
Design That Matters Lab

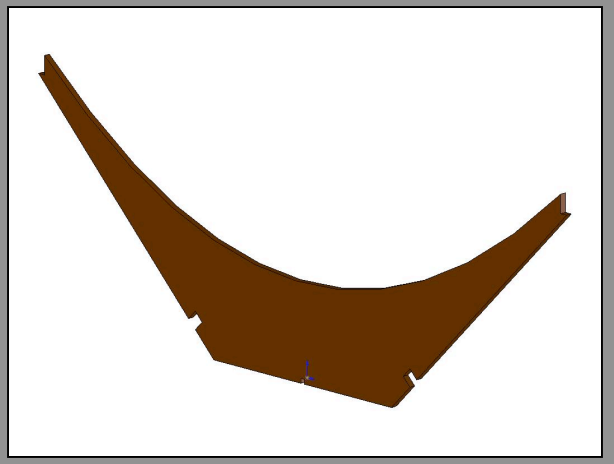
- Generates 15psi steam
- Six welds
- 5 point contact parabola
- One axis rotation

Our Construction







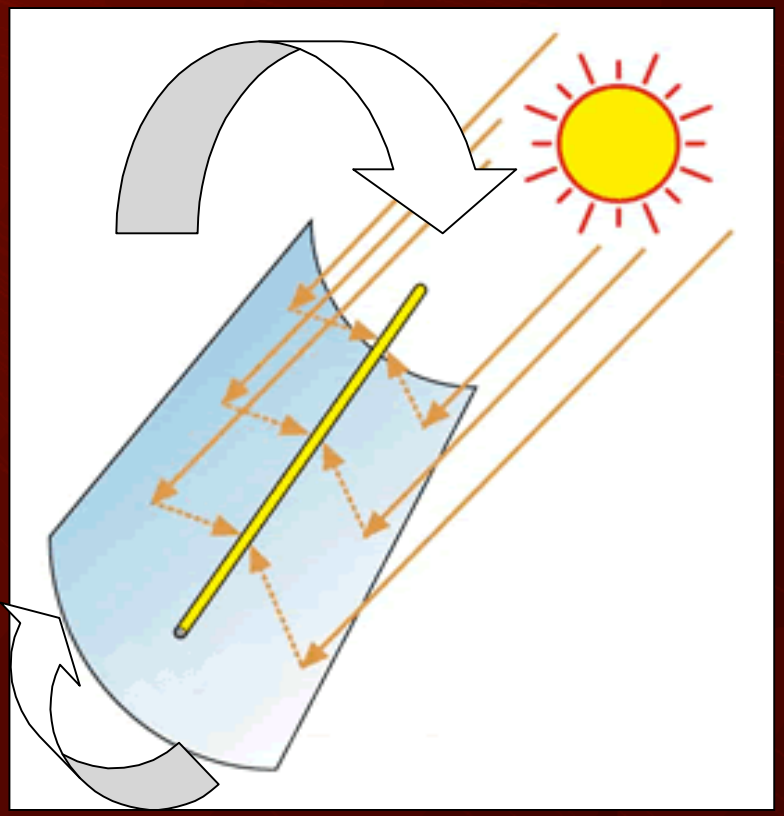


Initial Tracking Research

Issues considered

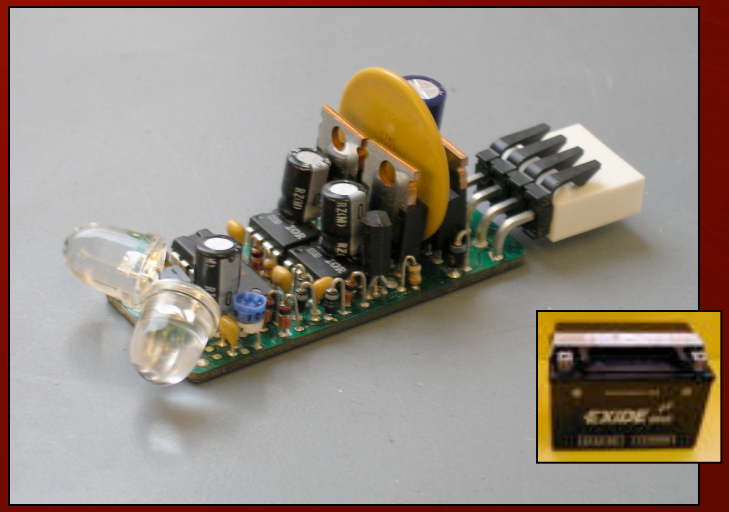
- One vs. two axis tracking
- Open loop vs. closed loop tracking
- Power, active vs. passive
  - PV cell
  - Battery
  - Other
- Construction of trough linkage
- Adjustable vertical angle

One axis tracks the sun across the sky every day



The other axis tracks the sun over its seasonal changes

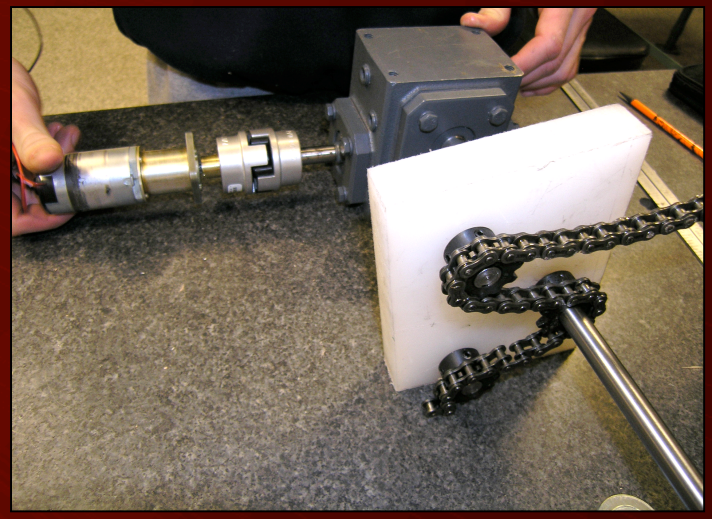
Tracking Implementation



- Small, cheap, durable
- Insensitive to passing clouds
- Automatically resets at end of day

Source: Duane C. Johnson

www.redrok.com



- Simple to construct

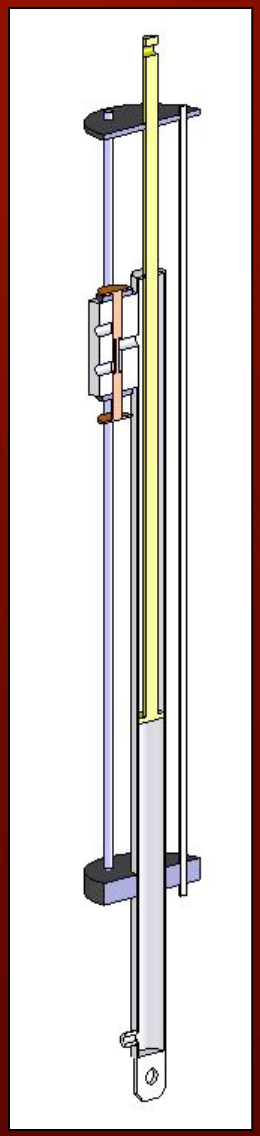
Boiler

- **Convective flow**
- **Refills automatically**
  - Magnetic actuator
  - Maintains pressure in vessel during refilling

Pump Evolution

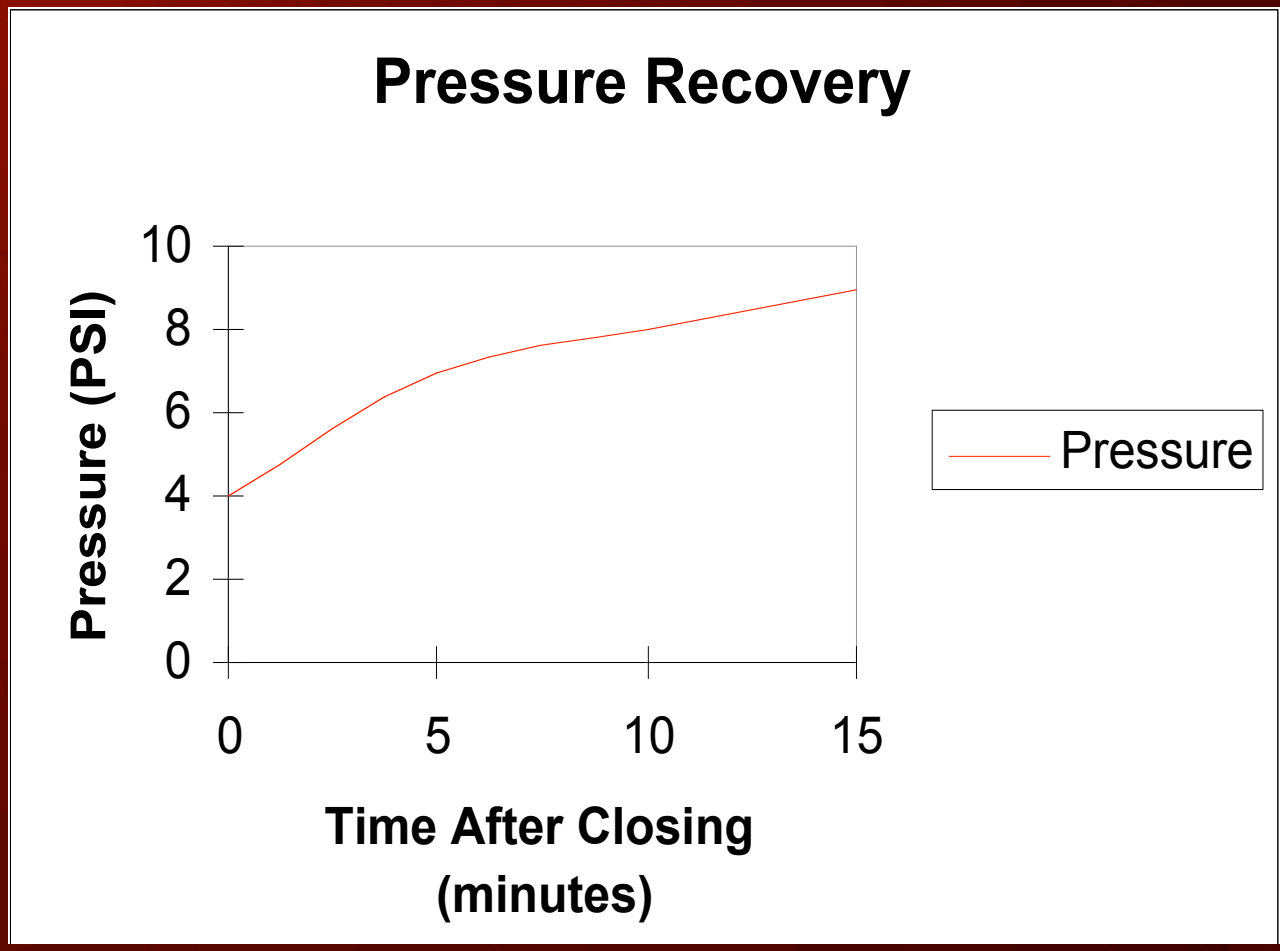
Pictures of pumps

Piston Pump-Final Implementation

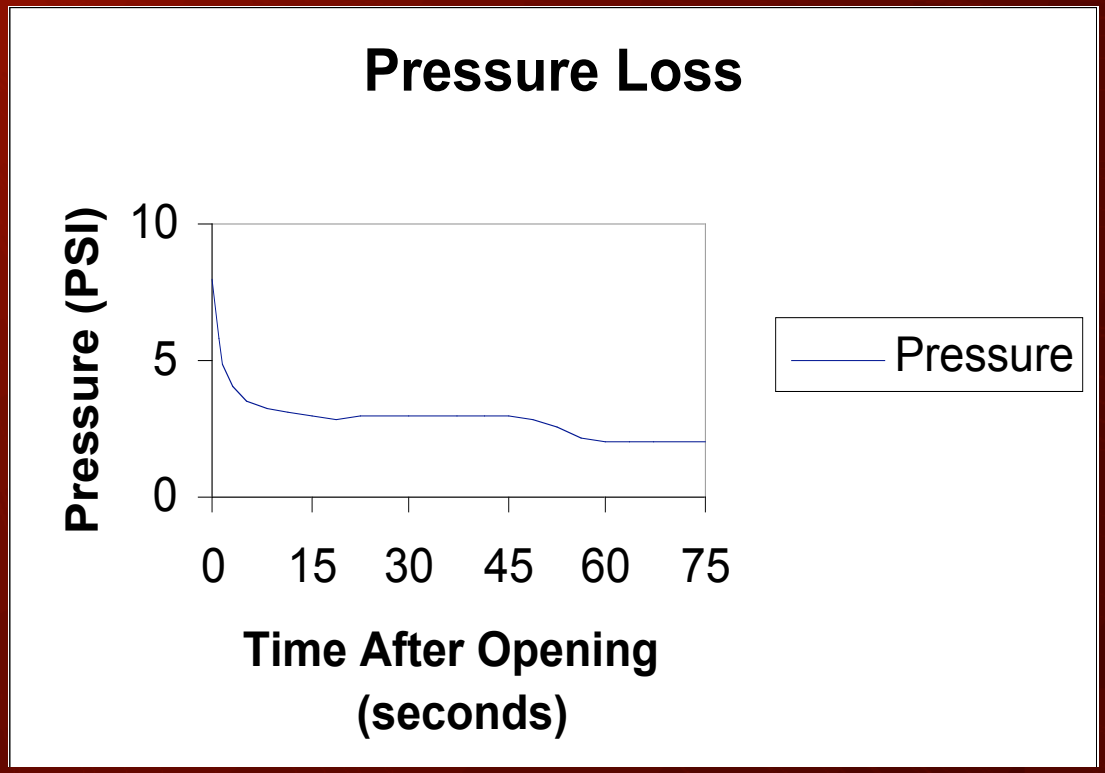


- Familiar technology
- Detachable for manual pumping
- Piston action shows potential for future applications

System Performance



System Performance



Potential improvements

- Higher possible output
- More ribs
- Pressure regulator
- Weaker magnet
- Better insulation

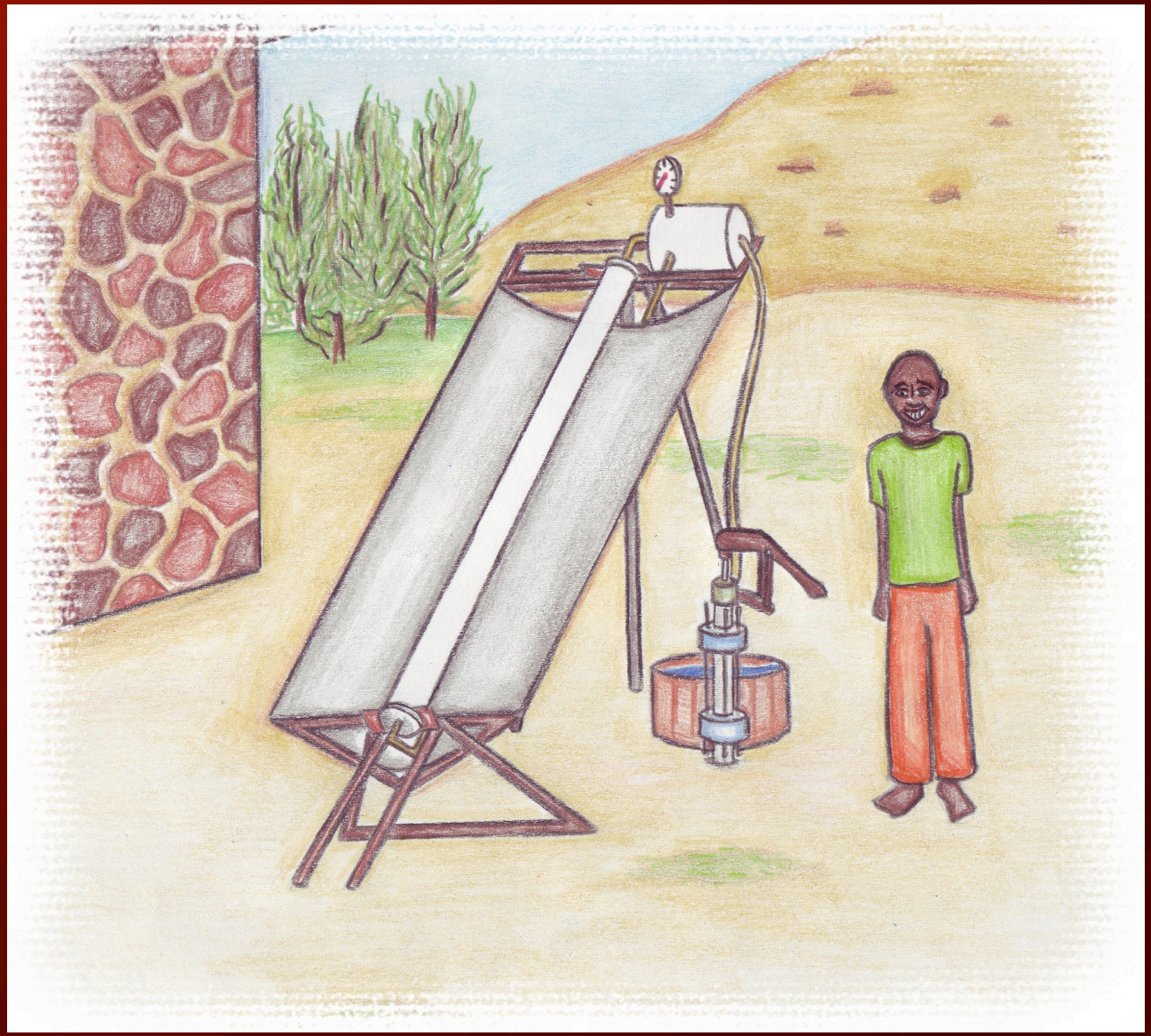
Cost Analysis

Reflective Sheeting	**$100**
Tracker	**$200**
Plywood	**$50**
Pressure Vessel	**$190**
Metal	**$250**

Customer demand *less than $1000*

Our prototype *$790*

Final implementation



Supp. #3-justification of battery for tracker

- Small amount of energy

Other Rejected Trough Applications

- **Sterilization**
  - Trough produces steam for autoclave
    - Insufficient demand; not defined as a customer need
- **Refrigeration**
  - Trough produces steam for heat exchanger
    - Similar product being designed by other 2.009 team
- **Biogas**
  - Trough heats bacteria, animal and other wastes to produce gas which can be captured and utilized as fuel
    - Safety issues with storage and transport of compressed gas
    - Sun alone produces enough energy to complete cycle

Supp. #4-sediments

Supp. #5-transportation

- Made to assemble on site
- Pump can be machined separately, easy to connect/disconnect

Supp. #6-assembly

Supp. #7-expansion of market

Safety Concerns

- Pressure release valve on pressure tank

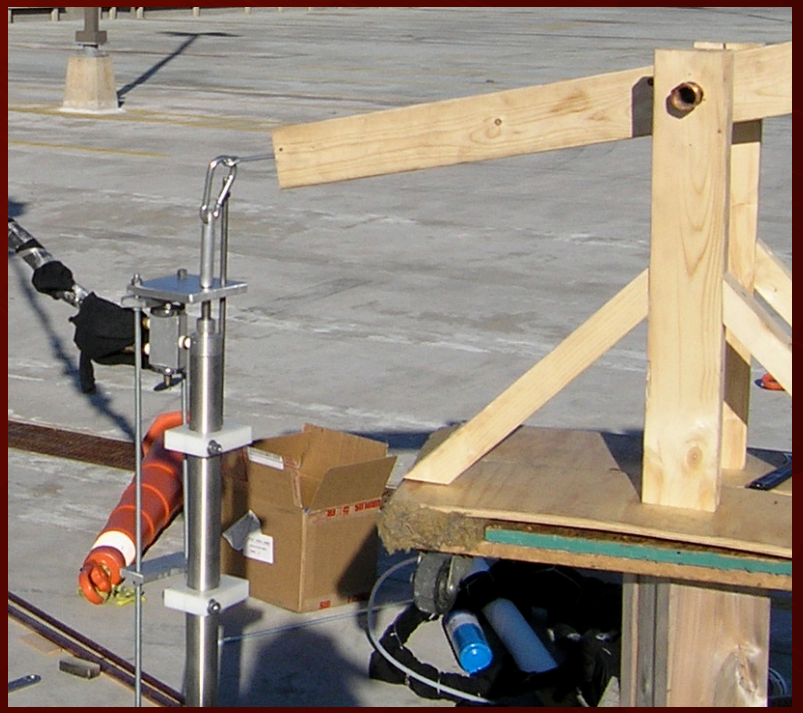
Supplemental slide #1-sizing of trough

Insolation map of southern Africa

MA	E. Wareham	4.48	3.06	3.99
MA	Boston	4.27	2.99	3.84
MA	Blue Hill	4.38	3.33	4.05
MA	Natick	4.62	3.09	4.10
MA	Lynn	4.60	2.33	3.79

Insolation averages for local stations

Supp. #2-comparison to electrical pump

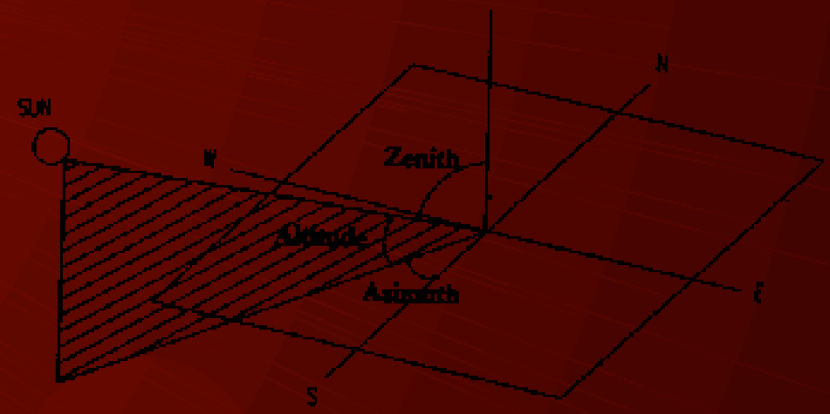


Supp. #3-justification of battery for tracker

Supp. #9-choosing sweep angle

Lesotho's high-end average insulation is ~6 kw-h/m^2.

The best sun would be collected for the three hours on either side of solar noon (11:58 SAST).



$a = \sin^{-1}(\sin d \sin f + \cos d \cos w \cos f)$

a-altitude angle

w-hour angle (45°)

f-latitude angle (-30°)

d-declination angle (23.45°)

a = 27.3° so the sweep angle is 120°.

Electricity in southern Africa

Lesotho Data

Pressure Loss

BBCDC

- Mission Statement: **To design and manage innovative learning environments for young men and women in Lesotho that elicit general engineering skills, manual capabilities, applied sciences and leadership and management abilities that address the needs of rural and urban development in Lesotho, and to pursue financial self-sustainability through self-reliance, commercial endeavor, and responsible environmental management.**
- Primary Fields of Operation: **Education, Self-reliance, Research and Development, Extension and**

Temperature Changes