IPRO 328

Application of Solar Thermal Technology in Large-Scale Buildings in the Urban Environment

Spring 2003

Keating Hall Project

- Keating is IIT's sports facility and houses two full-size basketball / volleyball courts, 4 racquetball courts, a weight room, and a 6-lane, 25-yard pool with both high and low diving boards.

OUR GOAL

- To propose a solar thermal solution for Keating Hall to reduce the heating load on existing sources (Mostly Natural Gas).

PRACTICALLY SPEAKING….

- It was decided that an inner wall should be installed behind the south wall, made of an insulated material so as to heat up the air in the cavity between two walls and prevent it from leaking out.

Inside view of the south wall

WHAT GOOD IS HOT AIR ?

The hot air trapped in the cavity between the two walls can:

- Contribute towards heating the Keating Hall in Winters, thus lowering the heating cost.
- Contribute towards cooling in summers by trapping the heat inside the cavity and not letting it out, thus lowering the cooling cost.

SELECTING MATERIAL FOR THE INNER WALL

- After much research, Kalwall® was selected to build the inner wall.
- Kalwall® has the least thermal resistivity as compared to other materials considered, such as fiberglass, tinted glass and clear glass.

ENERGY DETERMINED USING A RADIOMETER

Glass Type	Time of Day	Energy Outside (In front of wall)	Energy Inside
Tinted Glass	12:00 PM	16,919,568	162,688
	2:00 PM	18,058,386	488,064
Clear Glass	12:00 PM	16,431,504	12,852,364
	2:00 PM	17,082,256	13,340,429

Units for energy are BTU / hr * ft^2

Radiometer

ENERGY LOST THROUGH WINDOWS

Glass Type	Time of Day	Energy lost through windows
Tinted Glass	12:00 PM	56,554,471,103
	2:00 PM	59,299,833,778
Clear Glass	12:00 PM	12,079,595,770
	2:00 PM	12,628,668,305

Units for energy are BTU / hr * ft^2

POTENTIAL

- As expected, heat loss through tinted windows is significantly higher.
- Heat loss at 12:00 PM and 2:00 PM are similar.
- Indicates that a significant amount of energy can potentially be collected for longer periods of time during a winter day.

HEAT ACCUMULATION IN WINTER MONTHS

Window Type	Heat Accumulation (Btu/h), winter	
	With cavity (Kalwall)	Without cavity
Tinted Glass	30,222	57,841
Clear	31,343	62,031

HEAT ACCUMULATION IN SUMMER MONTHS

Window Type	Heat Accumulation (Btu/h), summer	
	With cavity (Kalwall)	Without cavity
Tinted Glass	7,953.29	15,126.74
Clear	8,272.285	16,323.96

COMPARISON

- Heat accumulation is significantly higher during winter months.
- Heat accumulated during the summer months is very small.
- If implemented, it is recommended that the windows on the south façade be changed to clear to increase useable heat.

COST ANALYSIS

Assuming tinted glass (for outer wall), sunlight for 5 hrs a day and 6 months each for winters and summers :

- Total Cost of installing the system is $103,050 (Kalwall® installation)
- Total savings for a year = $ 281 (Approx.)

WHAT IF CLEAR GLASS IS USED ?

Assuming clear glass (for outer wall), sunlight for 5 hrs a day and 6 months each for winters and summers :

- Total Cost of installing the system is $128,812 (Kalwall® + clear glass installation)

- Total savings for a year = $ 292 (Approx.)

PAYBACK TIME !

- For tinted glass – Kalwall® system,
    - Duration to recover the cost incurred on installing Kalwall® = 366 years (Approx.)
- For clear glass – Kalwall® system,
    - Duration to recover the cost incurred on installing Kalwall® + clear glass on the outer wall = 440 years (Approx.)

☹

CONCLUSION

- Due to the complexities involved in a project like this, uncertainty, and time constraints, the feasibility of the project is still unknown.

- From the theoretical calculations the heat accumulation through the windows is relatively small to contribute significant heating to a building of Keating Hall's size.

WHERE DO WE GO FROM HERE ?

- Further research is required before constructing the inner wall and it may be possible to use a different material besides the 3 inch thick Kalwall®.

- Payback time period needs to be reduced for such a project to succeed. It should (at least) not be in 100s of years!

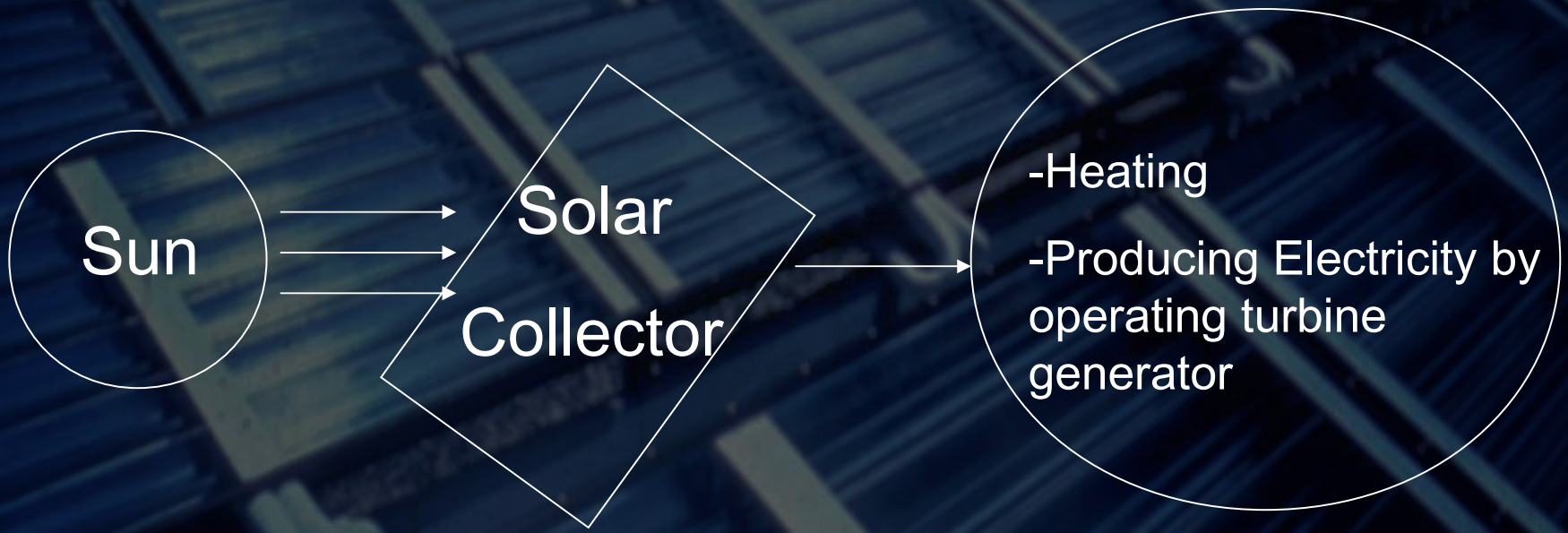
Machinery Hall Experiment

Objective

Construct and conduct an experiment to determine the actual outputs of solar thermal devices under Chicago operating conditions.

Solar Thermal Energy

- What is it?



Solar Thermal Energy

Solar Thermal Energy

- Advantages
  - Renewable natural resource
  - No pollution
  - The heated fluid can be stored
  - Cost saving by new technology
  - Reduction of imported fossil fuels
  - Availability
  - Tax credit

Solar Thermal Energy

- Disadvantages
  - Zone
  - Climate

Solar Thermal Energy

- History
  - 1767, “Hot box” by Horace de Saussure
  - 1891, “Climax” by **Clarence Kemp**
  - 1909, solar water heater by William J. Bailey
  - 1939, solar active house by MIT

William J. Bailey

Keating Hall Project

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Types of Solar Collector

1. Evacuation Tube

   - consists of rows of parallel glass tubes

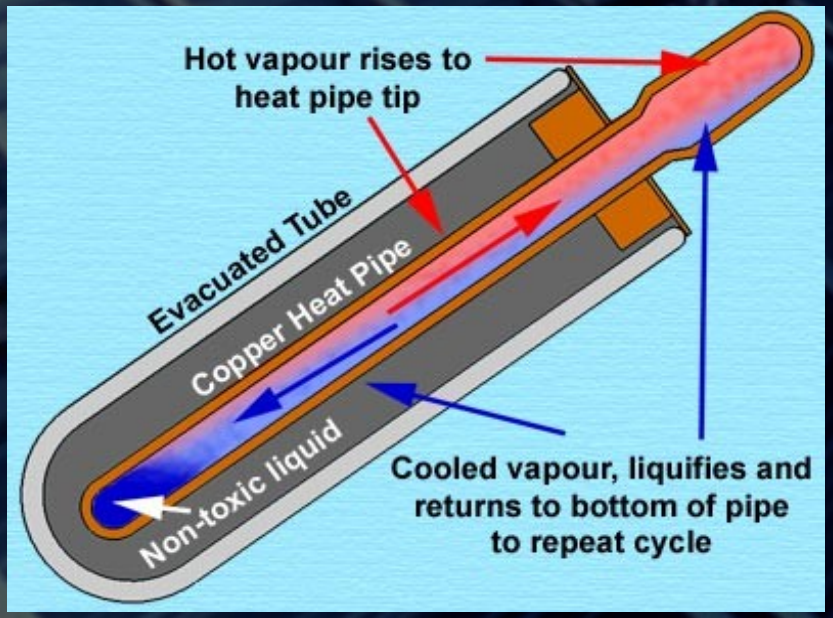
   - each tube about 2” diameter

   - makes higher temperature by eliminating convective and conductive heat loss

   - highly efficiency even in cold area

Types of Solar Collector

1. Evacuation Tube

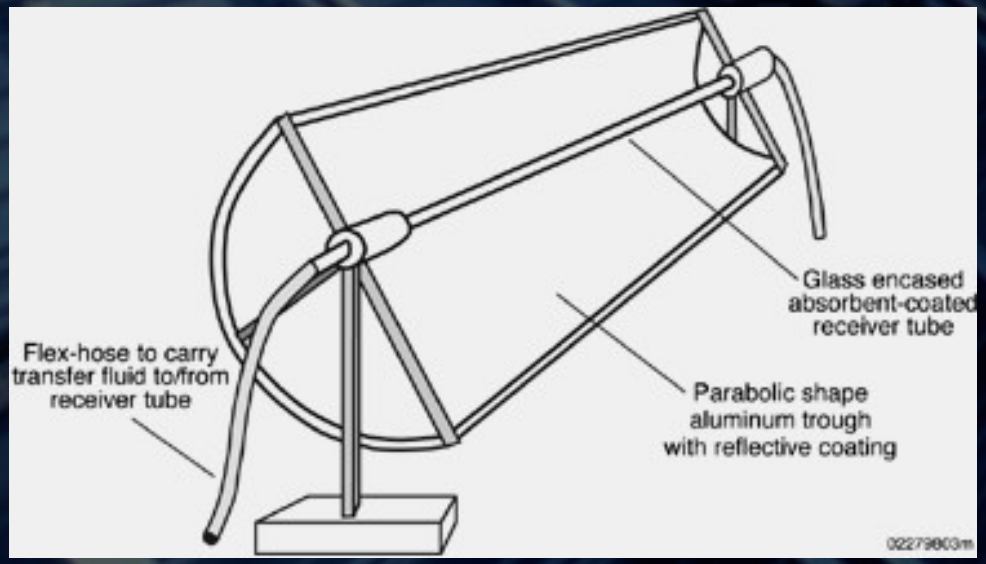


Types of Solar Collector

2. Trough (Concentrating) Collector
   - consists of parabolic trough with mirrored surface
   - used in commercial and institutional applications
   - slightly higher temperatures than the flat plate systems

Types of Solar Collector

2. Trough (Concentrating) Collector

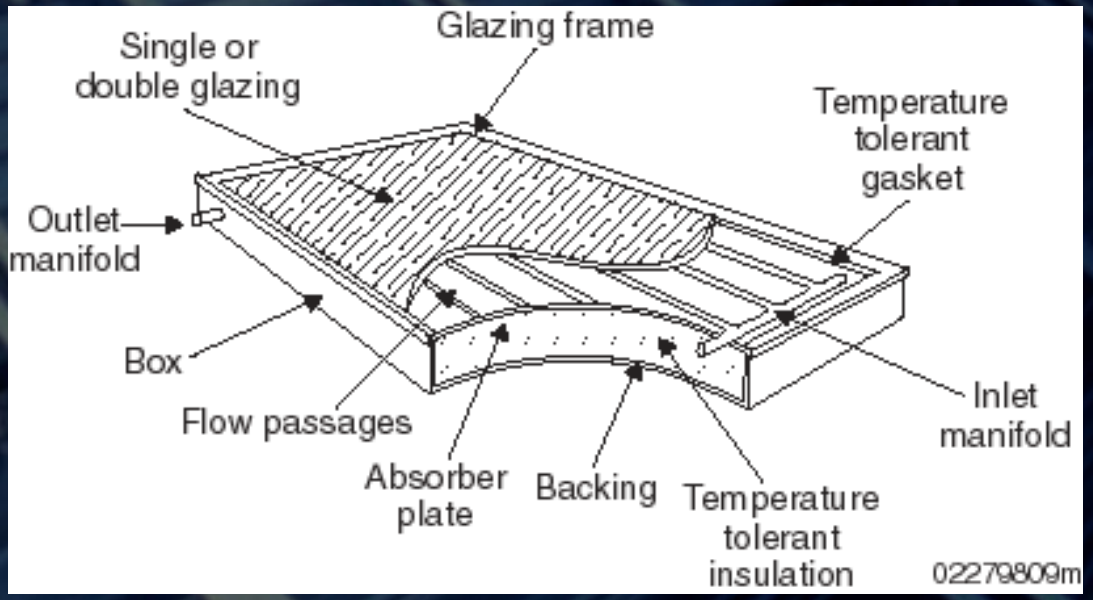


Types of Solar Collector

3. Flat Panel Collector
   - most commonly used
   - made of an insulated rectangular box containing a dark absorber plate covered by transparent glazing
   - ideal for residential use

Types of Solar Collector

3. Flat Panel Collector



Machinery Hall Experiment

Background

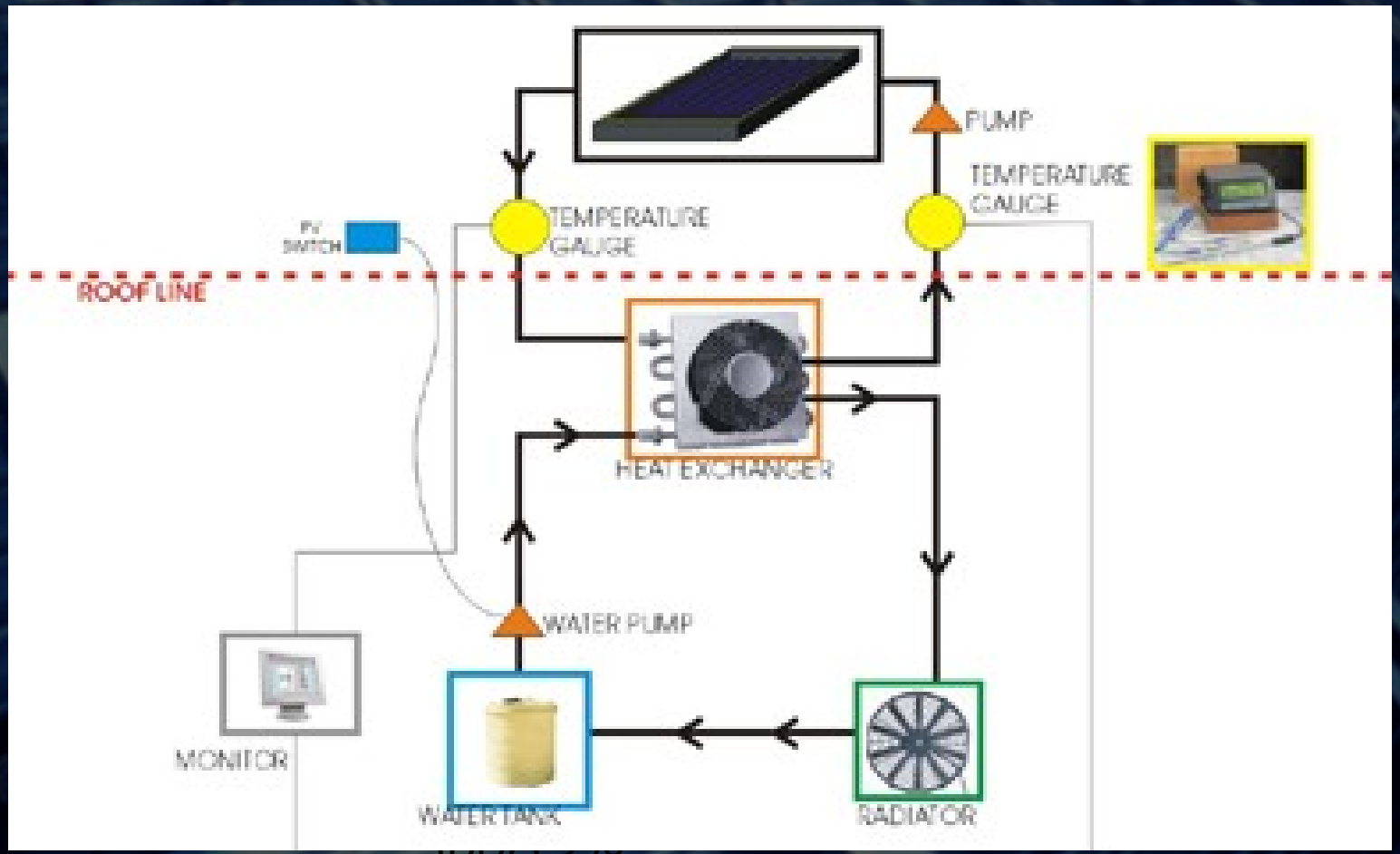
To construct flat panel collector and conduct an experiment to determine the actual outputs of solar thermal devices under Chicago operating conditions.

Machinery Hall Experiment

Why flat panel collector?

Machinery Hall Experiment

Flat Panel Collector



Machinery Hall Experiment

Flat Panel Collector

A. Mechanics

a. As sunlight strikes the absorber plate, the plate heats up changing solar radiation into heat energy

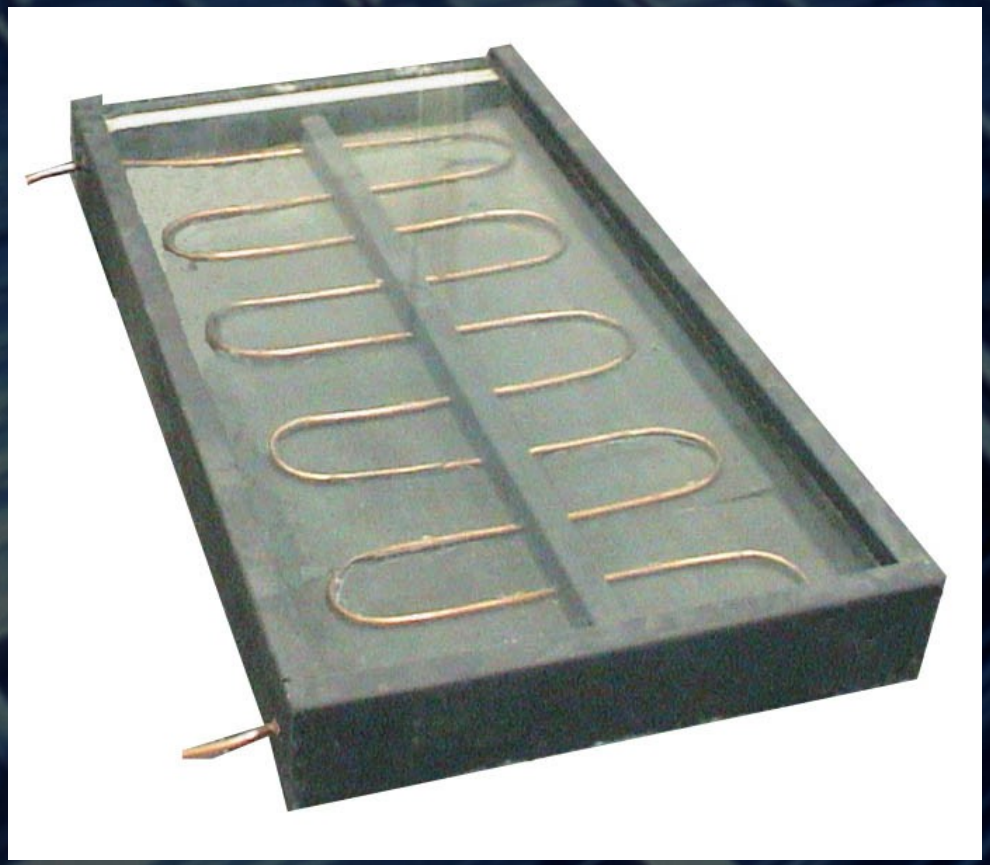
b. This heat transferred to liquid passing through flow tubes

c. Heat exchanger extracts solar energy from the collector loop and transfer it to the hot water tank

d. Cold water pumped into collector produces high efficiency

Machinery Hall Experiment

Flat Panel Collector



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Machinery Hall Experiment

Flat Panel Collector

B. Description

a. Insulated wood box with a glass glazing

b. Absorber plate: usually black and made of metal because heat conductivity

c. Liquid-flow type

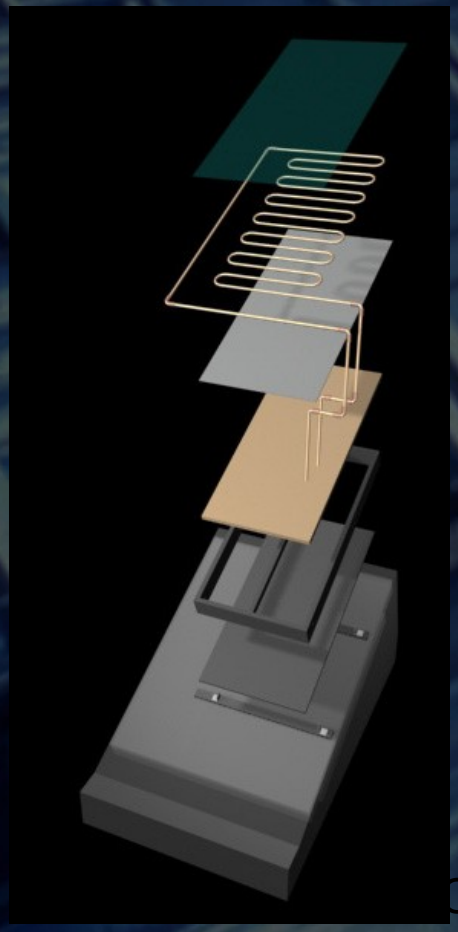
Machinery Hall Experiment

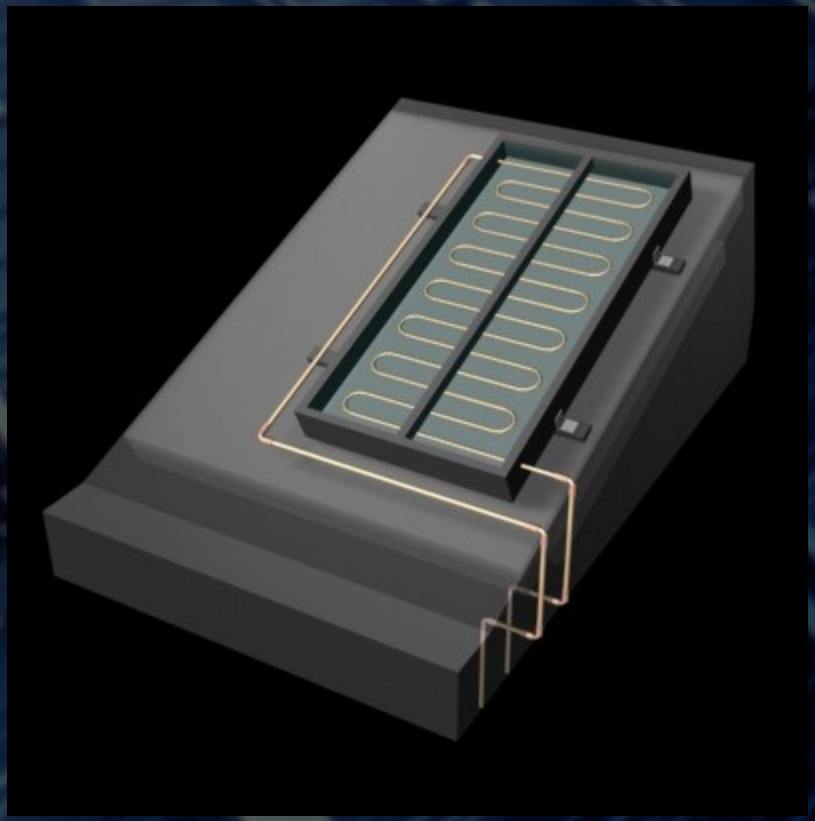
Flat Panel Collector

C. Cost

Machinery Hall Experiment

Flat Panel Collector





Machinery Hall Experiment

Flat Panel Collector

D. Other parts
   a. Heat Exchanger
   b. Water Pump
   c. Storage Tank
   d. Hobo
   e. Pipe

Machinery Hall Experiment

Flat Panel Collector

We did not end the Stone Age because we ran out of stone.

We do not have to wait until we run out fossil fuels to stop using them.

Thank you