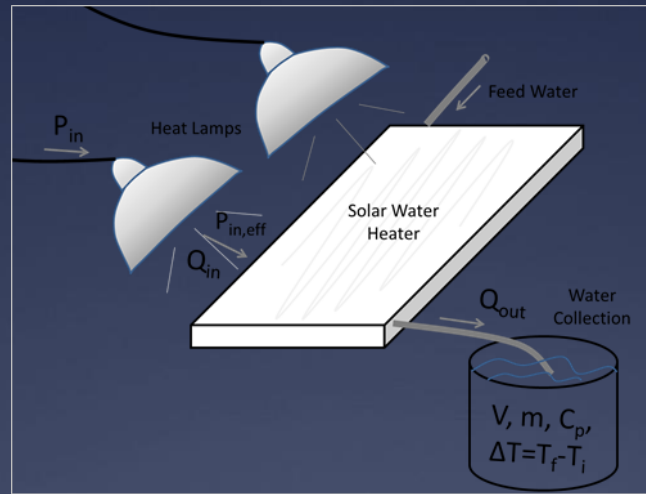


# Designing for a Sustainable WORLD



Cost and Efficiency Trade-offs  
in Solar Water Heater Design

# Appropriate technologies can improve the quality of life for developing communities

- \* A developing community does not have access to clean water, electricity and/or a waste disposal system
- \* Appropriate technologies can improve the quality of life for developing communities



Peruvian home

# Appropriate technologies can improve the quality of life for developing communities

\* What is an “appropriate technology”?



**Solar Dish Kitchen –**  
concentrates solar energy to  
cook food



**Q Drum –** a water container  
designed to roll easily



**Big Boda Load-Carrying Bicycle –**  
can carry hundreds of pounds of  
cargo

# Alternative energy can also help developing communities

- \* What are some examples of alternative energies?

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\* What are some examples of alternative energies?



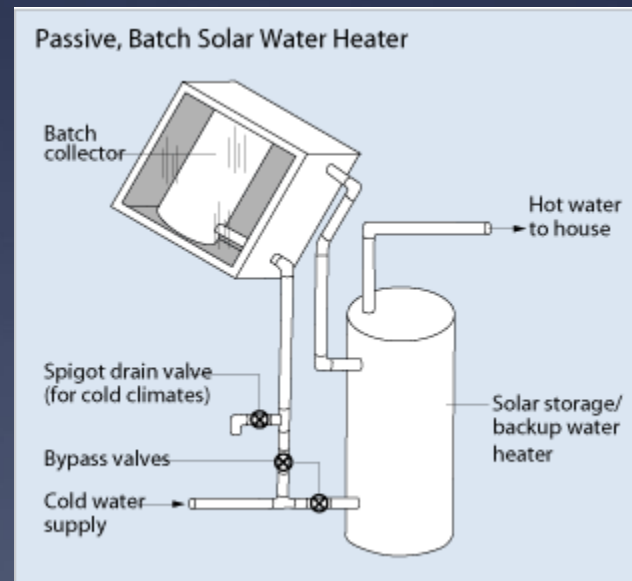
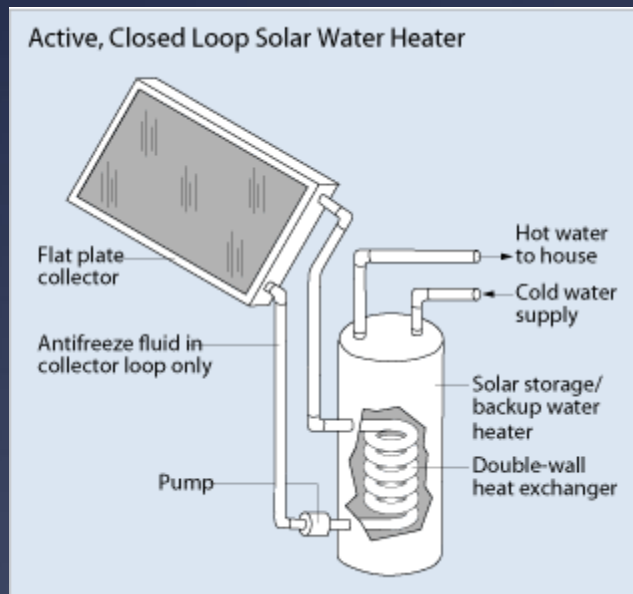
14 year old William designed a built a windmill make electricity



Peruvian home with passive solar heating to heat the home and water , using a Trombe wall and solar water heater

# Solar water heaters are sold on commercial markets around the world

- \* Here are a few examples of the types of solar water heaters available



# Energy Efficiency

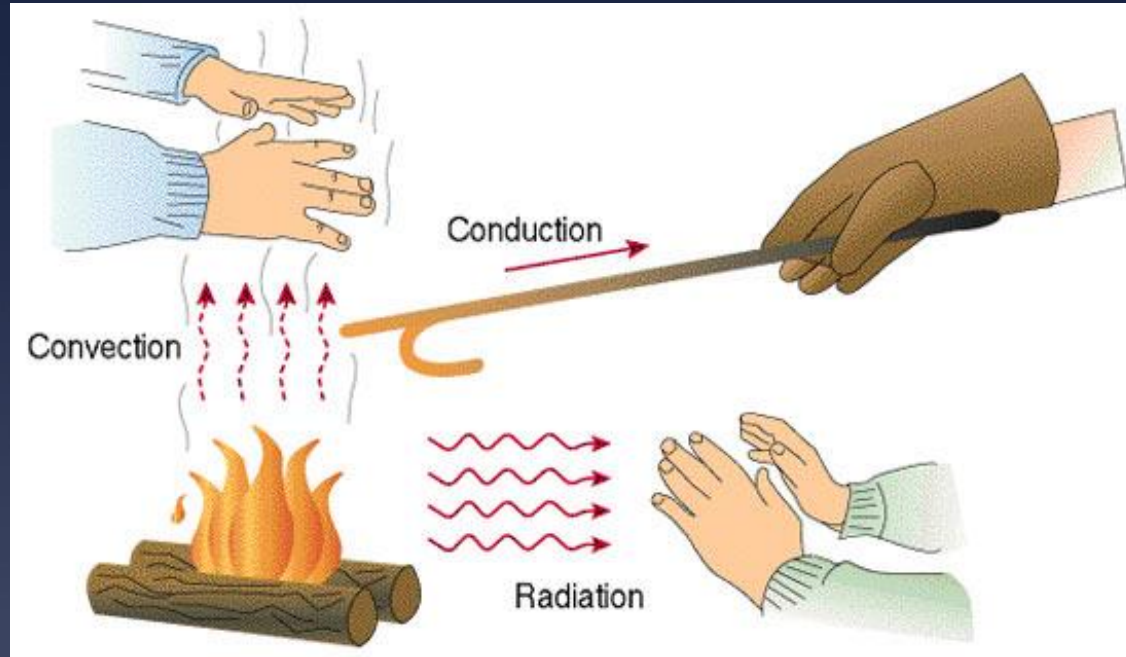
- \* Efficiency is a measure of work done or energy produced divided by energy or resources needed
- \* For solar water heaters we measure efficiency as

$$\text{Efficiency} = \eta = \frac{\text{Heat Energy Out}}{\text{Heat Energy In}} = \frac{Q_{out}}{Q_{in}}$$

- \* Engineers work hard to improve efficiency in all of their designs

# Heat Transfer Basics

- \* Conduction
- \* Convection
- \* Radiation



- \* Properties of different materials
  - \* Do certain colors absorb thermal energy better than others?
  - \* Do certain materials heat up faster than others?
  - \* Do some materials reflect energy better than others?



# Solar Water Heaters!

- \* Flat plate solar water heaters designed by college freshmen helped a school in Peru!

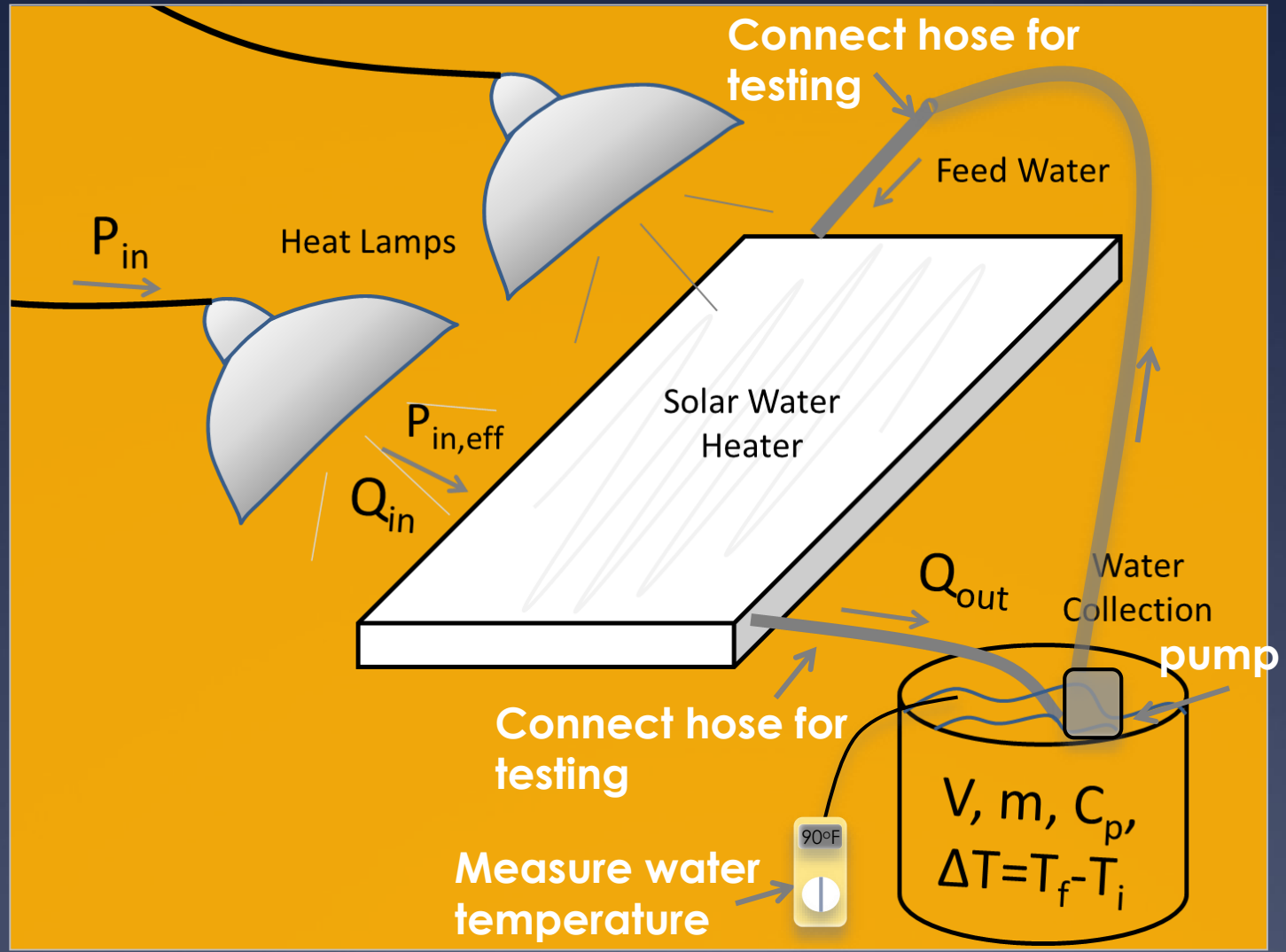


- \* We will be breaking up into groups and building flat plate solar water heaters

# Constraints for the design and testing of your solar water heaters

- \* The overall volume of the solar water heater must be between 4-6 ft<sup>3</sup>
- \* One gallon of water must cycle through the device a minimum of two times in 45 minutes
- \* Two, 250 Watt heat lamps can be placed however your team chooses, but the lamps cannot be closer than 12" to any point on the solar water heater
- \* Must be waterproof!

# Testing Setup



# Project Timeline

- \* Day 1 – Introduction and brainstorm ideas
- \* Day 2 – Create scaled drawings and budget for building
  - \* For drawing, include material labels and dimensions for at least two views (i.e. top and side)
  - \* For the budget, list exactly how much of what material you will need and the total cost. Use the Materials Budget Worksheet
- \* Days 3 – 5 – Build days
- \* Day 6 – Leak test
  - \* Make sure there are no leaks in you water heater before you seal it up
- \* Day 7 – Build Day
  - \* Fix leaks found or make other alterations before initial testing

# Project Timeline Continued

- \* Day 8 – Initial test
  - \* Record the temperature change of the water
  - \* Make a water temperature vs. time graph
- \* Day 9 – 10 – Modifications & efficiency calculations
  - \* Time for improvement! Think about how you can increase your efficiency or fix any problems
  - \* Calculate the final efficiency using the Solar Water Heater Efficiency Analysis Worksheet
- \* Day 11 – Final testing!
  - \* Record the temperature change of the water
  - \* Make a water temperature vs. time graph

# Project Timeline Continued

- \* Day 12- 13 – Compile results & make presentations
  - \* Calculate the overall efficiency from the final test
  - \* Complete the Final Budget and Efficiency Worksheet
  - \* Create a 6 minute PowerPoint presentation. Be sure to include temperature graphs, efficiencies, and budgets from the initial and final tests
- \* Day 14 – Final Presentations

# Materials List

• Newspaper	• Zip ties
• Tar paper	• Clear tubing
• Plexiglas	• Hot glue sticks
• 2"x4" wood	• Duct Tape
• Plywood	• Nails
• 1" ID PVC	• Screws
• 5/8" ID PVC	• Aluminum foil
• 5/8" PVC elbow/T connector	• Bubble wrap
• Rigid insulation	• 14 gauge wire
• Black spray paint	• 4 mm clear plastic sheeting
• Cardboard	• Plastic wrap

# Brainstorm Pointers

- \* Strive for quantity, not quality
- \* Encourage wild ideas!!!
- \* Withhold criticism
- \* Combine and/or piggyback on ideas (this is not an individual activity – work together!)
- \* Record all ideas



# Brainstorm Pointers

- \* You have 15 minutes to come up with at least 10 ideas – it does not matter how crazy they are!!!
- \* **As a group**, select the most promising design and create a detailed drawing that includes labels of materials and dimensions required
- \* Complete an initial budget sheet and include a total estimated cost for your device