Energy Labs

Energy labs

- **PV panels: PV efficiency**
- **Solar thermal panels: power output and efficiency, thermal camera**
- **Cottage hot water heater: thermal camera, look for leaks**
- **Tea maker: power, kWh, cost per cup of tea, egauge, kill-a-watt**
- **Superthermos: radiation, conduction, convection, R value**
- **Monitoring and conservation lab: egauge, skyspark (10.0.0.25:8080), vampire loads**
- **ROI-TCO lab: wind, pv, solar thermal**

Outside labs-need sunlight:

————Solar array lab:

1. walk up to the huge solar array above the elab with a meter stick and a few friends
2. measure the inside (blue) part of one of the panels in meters (not inches)
3. calculate the area in m^2 of one panel
4. count the panels
5. return to the comfort of the elab
6. look on the weather station (see below) for solar radiation
7. look on the egauge (see below) for power output on the egauge
8. calculate the solar radiation falling on the blue parts of all of the panels added up
9. divide the energy on the egauge by the total solar radiation
10. determine the efficiency of the total solar array

- Solar radiation sensor:
- https://tempestwx.com/station/169148/grid
- http://10.14.62.1
- Energy monitor at the elab: (green is energy in, red is energy used)
- http://10.14.8.1/62979/classic.html

Calculations:

- Single panel area: _____m2
- number of panels: _____
- Total array area (area of one panel x number of panels): _____m2
- Solar radiation: _____W/m2
- Total ideal power from array: (total area x solar radiation): _____Watts
- Recorded actual power: _____Watts
- Efficiency: (actual power/ideal power. x 100) _____%

questions:

1. how could you increase the efficiency of the panels?
2. if you could increase this by 5%, how many kW would this be?
3. if the array produces energy an equivalent of 5 hours per day at max power, how many kWh is this?
4. at $0.40 per kWh how much money is this?
5. If you could improve the efficiency of the array by 5%, how much money would this be per day?

———Solar thermal power lab:

You will determine the power and efficiency of a solar thermal (hot water) panel

1. measure the dimensions of the glass part of the solar panel in meters
2. determine the area of the panel in m^2
3. turn on the pump on the power strip above the panel
4. adjust the water flow to where the water coming out of the top of the panel is almost too hot to touch
5. measure the temperature of the water going into the panel using one of the thermometer units (contact or infrared)
6. increase and decrease the flow and notice the difference-why?

Questions:

1. If the solar insolation is 1000 W/m2, how many watts are available for heating water in this panel? (multiply area by the insolation)
2. If the power output of the panel is 4500W, what is the efficiency for this panel?
3. How does this compare to the PV panels?
4. what did you notice about the flow rate and the temperature difference?
5. Which would you choose for your green home: PV or solar thermal?
6. what are the advantages and disadvantages of each?
7. consider storage of PV and solar thermal-compare each

————Cottage hot water heater lab:

- You will be QUIETLY investigating the solar hot water tanks in several faculty cottages.
- These are private homes, so no talking or joking around.
- you will be using a very expensive, delicate heat camera, take care of it, and do not touch the lens, focus is the outer ring.

1. Carefully open the solar hot water heater tank outside cottage 4 and 5
2. Take photos of the plumbing in each case, email to me and to the occupants: rburchell@hpa.edu (cottage 5) and jbamba@hpa.edu (cottage 4)
3. Using the thermal cameras, look at each hot water heater for heat leaks
4. Determine which pipes go up to the solar thermal panel, and which ones come back down
5. Diagnose the setup and make suggestions for better insulation to save heat
6. Take photos of the thermal camera display and email these to the same folks (above)
7. Look on the skyspark server (see above) to determine when this heater is on and why
8. Check to see if the greybox timer (that is what they are called, no joke) is set to the correct time
9. Explain why this is important
10. One of the faculty cottage water heaters has a serious leak. Use skyspark to find this heater

questions:

1. what steps could you take to reduce the heat lost in the tank?
2. if the tank holds 80 gallons, how many liters is this?
3. to heat the tank uses 4.5 kW for 4 hours each day, how many kWh is this?
4. at $0.40 per kWh, how much does this cost each day, month and year?
5. If you could insulate the tank saving 20% of this, how much money would you save?
6. you are a business person, there are 320 million people in the US, and average 3 people per home. If you could save this same amount of money for them, how much is this?
7. If you sell an insulating blanket for each tank for $40, and it costs you $5, how much money would you make from the entire country buying your awesome product?

Inside labs----------

————ROI-TCO lab:

- We will study three renewable energy sources you might include in your green home
- Wind: can run 24 hours per day
- PV: can be stored by batteries
- Solar thermal: stored in insulated tanks

Wind Power:

1. cost of a small wind turbine: $500
2. power output: 400 Watts (convert to kW)
3. realistic hours per day: 12
4. calculate $ per day earned by the device
5. calculate days to recover cost of device (ROI= return on investment)
6. if the device operates for 5 years, calculate the TCO (total cost of ownership)
7. If the device fails before the ROI, what is the TCO?
8. what are the benefits and negatives for wind?

PV (photovoltaic):

1. cost of a single panel: $400
2. power output: 400W (convert to kW)
3. hours per day: 5
4. $ per day earned by the device
5. ROI
6. TCO if panels last for 20 years
7. what are the benefits and negatives for PV?

Solar thermal:

1. cost of a single panel: $800
2. power output: 4.5 kW
3. hours per day:5
4. $ per day earned by the device
5. ROI
6. If the panel lasts 50 years, what is the TCO?
7. what are the benefits and drawbacks of solar thermal?
8. If a solar thermal panel is 90% efficient, and a PV panel is 15% efficient, with limited roof space, which would you choose for your home?

————Energy monitoring lab:

You will be using very sophisticated monitoring systems to evaluate energy use in the dorms and faculty cottages

1. You will need to be on the "hpa-students" wifi network, and go to http://10.0.0.25:8080 to start
2. Login as guest/guest
3. Host: upper campus
4. select “campus”
5. upper left corner, look for “select”
6. select a building to evaluate

7. looking at the dorms, what patterns do you notice about use?
8. which dorm is using the most energy every day? why?
9. look at the faculty cottages. If a hot water heater uses 4.5 kW, when do these turn on?
10. which cottage has a leaky or non-insulated hot water heater? how can you tell?
11. which buildings have an air conditioner installed? how can you tell?
12. now switch to the elab, what is the power used by the air conditioners at the elab?
13. how can you tell an air conditioner from a refrigerator (tough one!)
14. switch over to 10.14.8.2 on the elab network
15. look at the loads by panel: A B and C
16. If C is usually lights, how can you tell?
17. If the B panel is usually power outlets, how can you tell?
18. The A panel is Air conditioning and water treatment-how much power does the HVAC system use and when?
19. use the thermal camera to find vampire loads
20. turn the hot water heater on and off, and verify the load recorded on 10.14.8.2

questions:

1. what advice would you give to a homeowner who wants to reduce their electrical bill?
2. what is demand metering and why is it important for this study?

——————cost of tea lab:

- You will use two devices to measure energy use: the server at http://10.14.8.2 and the kill-a-Watt devices
- You will be measuring the power and energy used to heat water for tea, using two of the hot water heater thingys.

1. fill the hot water heater thingy with water, to about 1 liter (1000 grams)
2. measure the temperature of the water
3. connect the heater to a kill-a-Watt meter and measure voltage, power and current
4. start your timer, and time how many seconds it takes to heat the water to boiling (100°C)
5. repeat this with another hot water heater, and compare the number of seconds it takes to boil
6. convert seconds into hours (divide by 3600)
7. convert Watts to kW (divide by 1000)
8. multiply kW by hours to get kWh for your tea adventure in both cases.
9. If each cup of tea is about 100 ml, how many cups of tea could you get from each event?
10. divide the cost to heat by the number of cups of tea.
11. imagine that Starbuck or Surfcamp says they need to raise prices for tea because of energy, can the be true?
12. how can you conserve energy (and money) in your home when making tea?

13. compare your results and calculations with the meter with your estimate by looking at http://10.14.8.2
14. advanced stuff:
    1. 1 liter of water is 1000 grams
    2. calculate the change in degrees C from cool water to boiling (100°C)
    3. multiply this by 1000 to get calories
    4. multiply calories by 4.18 to get joules
    5. multiply Watts recorded by seconds to get joules from electricity
    6. which of these joule values is higher and why?

———Superthermos lab:

You will use various containers to evaluate conduction, radiation and convection

This is similar to a demonstration we did in the first semester, this time you will measure values to determine R, the thermal transmission (emissivity) of your home.

1. Fill several containers with boiling water (amount is not critical)
2. set your timer and measure the temperature every minute for at least 15 minutes, longer is better.
3. measure the room temperature
4. calculate the difference between boiling water (100°C) and the final temperature for each container
5. use the exponential decay formula (below) to determine k for your each container
6. 1/k is R, the emissivity of each container
7. calculate R for each container and explain the differences
8. what can you use from in the design of your green home?

Exponential decay formula:

- Tt = To(e^-rt)
- Tt/To = e^rt
- ln (Tt/To) = rt
- (ln (Tt/To))/t = r
- 1/r = K

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