Lecture 12, 4/22/2016

Read: R.A.Dunlap, Energy and Environmental Research.3(1). 2013.pp33-39.

Personal Energy Audit Due: May 9

Sign out for kill a watt meters

Homework#3: assigned next week

Project Topics/groups: May 2

No class: April 27,29

Personal Energy Audit

The goal of this project is for students to get a full picture of the supply and demand of energy used in their daily life. While working on this report, students will identify all energy services and their energy sources, obtain records of their energy usage, determine the energy consumption for each service, analyze the information, compare, draw conclusions and make recommendations.

Two parts:

- report (due in class)
- on-line questionnaire (completed on campus)

Report Format

- Abstract
- Introduction (should include information about the student)
- Calculations
  - List of energy services and sources
  - Transportation
  - Hot water consumption
  - Electricity usage (Wh/week)
    - Calculated from labels
    - Measured with "Kill a Watt" meter
      - When appliances are on
      - When appliances are off
- Analysis
  - If student has access to their PG&E bill and Smart Meter
    - Look for peaks of energy consumption, what do they consist of? What appliances were on during those particular hours.
    - How does your home compare to others
    - How does your energy consumption vary with weather
  - If student does not have access to their PG&E bill
    - Make a plot of energy consumed throughout the week
    - Make a plot of peak outside temperatures throughout the week
    - Compare the two plots for similarities
- Conclusion (should include qualitative and quantitative analysis summary from previous section). It has to answer specific list of questions.

Calculations and Analysis
List of energy services and sources

Services	Sources
Water Heating	Natural gas
Space Heating	Natural gas
Lighting	Electricity
....	....

Calculations and Analysis Transportation

Driving

5 mi daily Scotts Valley to Santa Cruz
10 mi * 4 days/week = 40 mi / week
Car: 30 miles / gallon
1.33 gallons = 5 L of gas / week
35 MJ/L energy content 86 Octane gas
35 MJ/L * 5 L = **175 MJ**
Carpool: 175 MJ / 2 = **87.5 MJ**

Busses, Trains

1.6 MJ / km for each passenger

Hot Water Consumption

Heat Energy

- $Q = m \times c_p \times (T_1 - T_2)$
  - c_p : specific heat constant, 4190 J / kg C
  - T_1 : temperature of the hot water
  - T_2 : temperature of the cold water

Example

James uses 50 L of hot water per day from an electric hot water system. The water is heated from 18C to 60C.

The heat energy contained in the water,

$Q = m \times c_p \times (T_1 - T_2)$

Efficiency of Electric Water Heater is 0.7 to 0.8

Efficiency of Gas Water Heater is 0.6 to 0.75

Energy Conversion (to energy audit)

1 calorie = 4.184 J / amount of energy to raise 1 gm of water 1 °C /

but "food" calorie = 1 kcal (10^3 calories) ⟸
kilo is always deleted !

∴ 2000 cal/day ⟹ 2000 kcal = 2×10^6 cal ⟹ 8.368×10^6 J
⟫ avg food consumption ~ 8 MJ energy //

history / 1 cal = amount of energy to raise 1 gm H_2O by 1°C —
1 BTU = amount of energy to raise 1 lb H_2O by 1°F —

Electricity Usage

Appliance	#	Power (W)	Daily Usage (h)	Daily Energy (Wh)	Weekly Energy (Wh)	Weekly Energy (J)
Computer	1	120	3	**360**	2520	**9.07 M**
Vacuum Cleaner	1	1000	0.14	**140**	140	**0.5 M**
Electric Drill	1	600	0.07	**42**	42	**0.15 M**
Total				**542 W*h**		**9.72 MJ**

Electricity Usage

Confirmed with "Kill a Watt" meter

- When appliances are **on**
- When appliances are **off**

Conclusion

Should include qualitative and quantitative analysis summary from previous sections

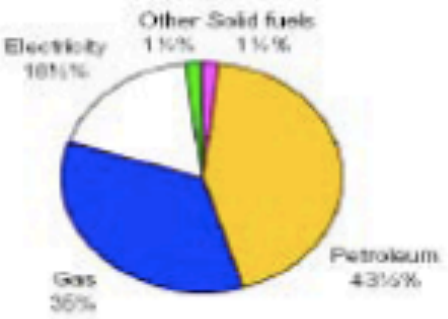
Should answer the following set of questions:

- Which energy services are the biggest energy users?
- How would you expect energy use for each service to change though out the year?
- Any surprises or noteworthy points?
- From working on this project, would you now consider alternative energy sources for particular services?
- From the calculations above, suggest a replacement for one of the high energy appliances? How much would it off set your energy consumption by?
- Would you now consider a habit or lifestyle change?
- Compare your results to the data collected by David MacKay.

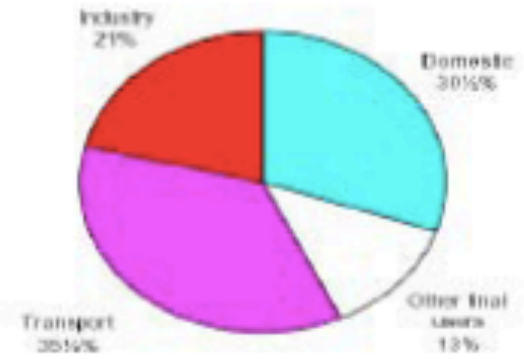
Conclusion

- Compare your results to the data shown below.

Average Power Consumption (UK)



2004



125 kWh/day (Europe)
250 kWh/day (USA)

(Not including embodied energy in imports nor solar energy used by agriculture)

For CO_2 pollution, divide by 10:
100 kWh/day $\simeq$ 10 tonnes CO_2/y

Based on http://www.pewenvironment.org/news-room/fact-sheets/history-of-fuel-economy-one-decade-of-innovation-two-decades-of-inaction-329037

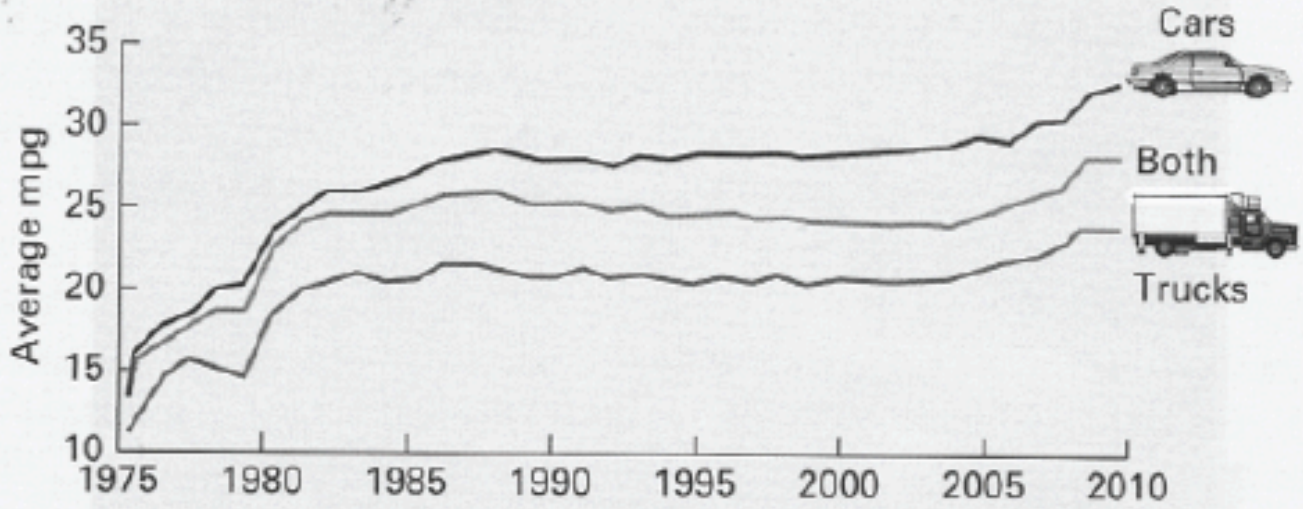


Figure 17.29: Average fuel economy of vehicles in the United States as a function of model year, 1975–2010, presented by the Pew Environment Group.

consider typical car in US —

1. what is reduction in CO_2 emissions for a 2010 vehicle vs 1996 vehicle during lifetime (250,000 km)?

2. consider following two cars.

	gas use	price
Honda Civic DX (auto)	34	$16,600
Honda Civic hybrid	44	$24,150

if maintenance costs are equal,
how many miles would hybrid need to be driven to outweigh higher cost?

soln /

1. CO_2 emissions / MJ = 6.9×10^{-2} kg / MJ of fuel

energy content of gasoline = 132 MJ / gal

assume 250,000 km lifetime $\Rightarrow$ 155,343 mi

(1 km = 0.62 mi)

In 1996 / avg mileage $\approx$ 27.5 mpg
In 2010 / $\approx$ 22.5 mpg

$\therefore$ 5 mpg difference

over life of car, difference in amounts of gas used:

$$\frac{155{,}343 \text{ mi}}{5 \text{ mpg}} = 31{,}064 \text{ gal}$$

∴ energy use difference:

$$31{,}064 \text{ gal} \times 132 \text{ MJ/gal} = 4.11 \times 10^6 \text{ MJ}$$

∴ diff. in CO_2 emissions

$$= 4.11 \times 10^6 \text{ MJ} \times 6.9 \times 10^{-2} \text{ kg/MJ}$$

$CO_2 = 316$ tons (at kg = 1.13×10^{-3} tons)

Solns / (2) work

2. hybrid vs non-hybrid.

44 mpg vs 34 mpg $\Rightarrow$ 10 mpg difference

\$24,150 vs \$16,600 $\Rightarrow$ \$7,550 difference

If gas costs \$4.00/gal then $\frac{7,550}{\$4} = 1887.5$ gal

If gas costs \$3.00/gal then $\frac{7550}{\$3} = 2516.7$ gal

If gas costs \$2.00/gal then $\frac{7550}{\$2} = 3775$ gal

∴ with a 10 mpg difference

at \$4/gal you get 13,875 miles more for hybrid

at \$2/gal you get 37,750 miles more for hybrid

Pumped hydro on campus

Bifacial solar street lights with battery storage (on campus)

Bifacial solar street lamps on the wharf, additional efficiency available from reflection off the ocean

Small module wave generation on the wharf: possibilities

Solar panels on all parking lots on campus, including energy storage

A biodigester on campus for for utilizing excess compost and forest waste

Solar electric buses on campus

Energy efficiency measures on campus

Solar farm at the MBEST campus

* COSTS MUST REFLECT TIMELINE
  ~~how will~~ how will costs change?
  how will technology change?

* "STATEMENTS" — MUST be backed up by a source

  eg ("... solar panels can last at least 30 years..." — REF?)

* "ASSUMPTIONS" - what is the justification for the assumption?

* CITATIONS - no more than half can include

Reference Citation Style for report

IEEE Citation Reference

ieeecitationref.pdf

Given in class web site

IEEE Publications uses *Webster's College Dictionary*, 4th Edition. For guidance on grammar and usage not included in this manual, please consult *The Chicago Manual of Style*, published by the University of Chicago Press.

http://www.chicagomanualofstyle.org/home.html

Take Home Quiz, due Monday, 4/25/16

- In a local store, find the price of a 60W incandescent bulb and a CFL and LED bulb with the equivalent light output (in lumens). Based on a use of 4 hours/day and an electricity cost of $0.11/kWhr, calculate the payback period for each of these bulbs compared to the incandescent bulb.

  Note: you must consider the lifetime of the bulbs in your calculation.