Lecture 11, 4/20/2016

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

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A Simple and Objective Carbon Footprint Analysis for Alternative Transportation Technologies

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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

About UC MBEST

Reference Citation Style for report

citationref.pdf

IEEE Citation Reference
Given in class web site

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

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

From Dunlap., Energy and Environ. Research. 3(1).201.(2012)

Table 5. Efficiency analysis for hydrogen powered internal combustion engine vehicle showing net efficiency for conversion of primary energy (fossil fuel) to mechanical energy delivered to the vehicle's wheels. CHG = compressed hydrogen gas, LH_2 = liquid hydrogen

process	**efficiency**
fossil fuel → electricity	40%
electricity → hydrogen gas	70%
hydrogen gas → CHG/LH_2	80%
CHG/LH_2 → mechanical	17%
net efficiency	**4%**

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

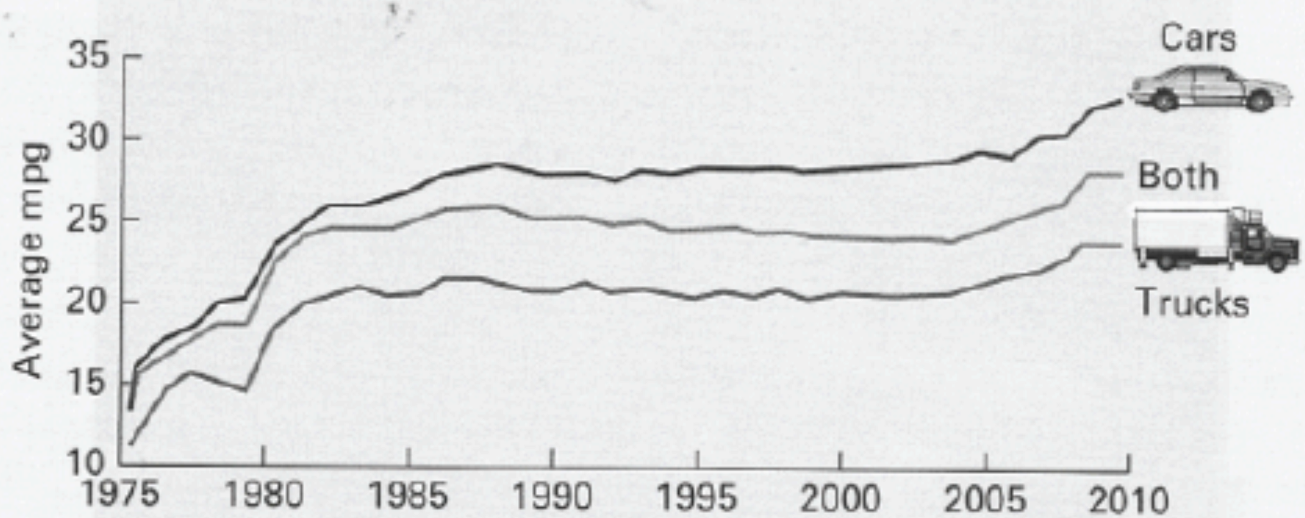
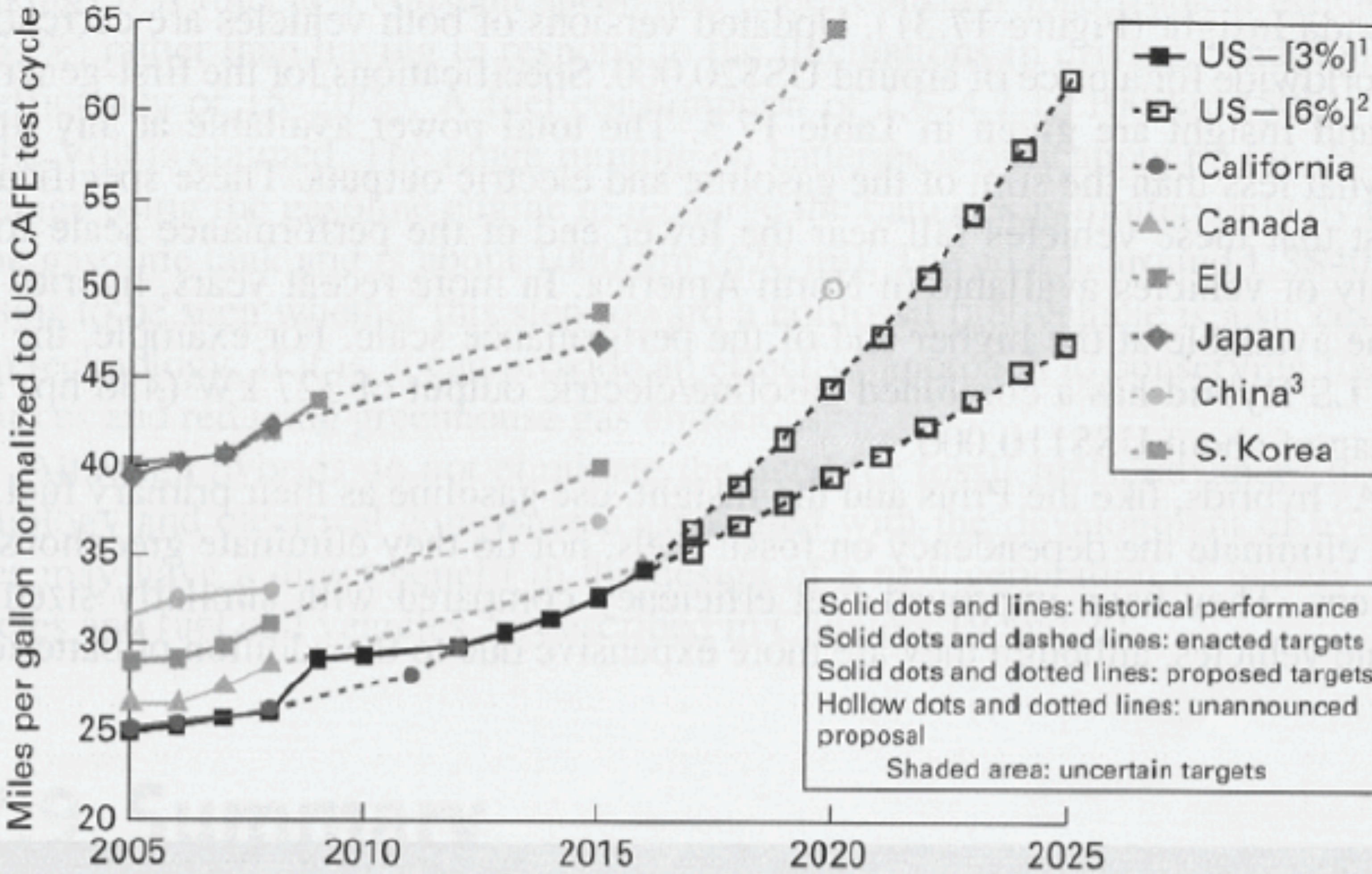


Figure 17.29: Average fuel economy of vehicles in the United States as a function of model year, 1975–2010, presented by the Pew Environment Group.



Based on http://www.pewclimate.org/federal/executive/vehicle-standards/fuel-economy-comparison

[1]Based on 3% annual fleet GHG emissions reduction between 2017 and 2025 in the September 30th NOI.
[2]Based on 6% annual fleet GHG emissions reduction between 2017 and 2025 in the September 30th NOI.
[3]China's target reflects gasoline fleet scenario. If including other fuel types, the target will be higher.

Figure 17.30: Average fuel economy for passenger vehicles in different countries. Historical data for 2005 to 2010 and projected data until 2025.

Date	Electricity (kWh)	% Chg	Demand (kW)	% Chg	Natural Gas (Therms)	% Chg	Total Energy (MBtu)	% Chg	Annual Usage Trend	% Chg
09/10	10,359	+ 36.8	11	N/A	16	N/A	36.9	+ 42.9	46.7	+ 41.9
10/10	12,120	+ 37.1	11	N/A	83	+ 668.3	49.6	+ 58.8	47.3	+ 43.8
11/10	12,389	+ 33.4	11	N/A	134	+ 440.3	55.6	+ 62.9	47.7	+ 45.0
12/10	13,737	+ 37.3	10	N/A	193	+ 159.3	66.2	+ 59.2	48.1	+ 46.1
01/11	12,619	+ 29.3	10	N/A	178	+ 204.3	60.8	+ 55.4	48.0	+ 45.9
02/11	10,972	+ 23.6	10	N/A	199	+ 187.0	57.4	+ 57.2	48.6	+ 47.8
03/11	11,554	+ 21.6	10	N/A	147	+ 230.2	54.2	+ 46.9	48.8	+ 48.3
04/11	10,518	+ 20.6	10	N/A	68	+ 284.1	42.7	+ 35.4	48.2	+ 46.6
05/11	10,523	+ 5.8	10	N/A	48	+ 188.1	40.7	+ 14.3	48.0	+ 46.0
06/11	10,491	+ 14.1	10	N/A	20	+ 260.5	37.8	+ 18.5	48.3	+ 46.6
Period Total	115,282	+ 25.0	11	N/A	1,085	+ 236.8	501.9	+ 45.7		
07/11	11,026	+ 53.3	11	N/A	2	N/A	37.8	+ 54.2	48.2	+ 46.4
08/11	N/A	N/A	N/A	N/A	N/A	N/A	2.5	- 90.3	45.2	+ 37.3
YTD Total	11,026	+ 53.3	11	N/A	2	N/A	40.4	- 20.2		

City of Santa Cruz, Municipal Wharf
Energy Cost Report -- Year Ending 08/2011

Date	Electricity Cost	Demand Cost	kVAR Cost	Power Factor Cost	Total Elec Cost	Natural Gas Cost	Total Energy Cost	% Chg	Annual Cost Trend	% Chg
09/10	$2,129	0	0	0	$2,129	$29	$2,158	+ 53.1	$2,094	+ 41.0
10/10	$2,428	0	0	0	$2,428	$88	$2,516	+ 55.6	$2,104	+ 41.7
11/10	$1,956	0	0	0	$1,956	$136	$2,092	+ 47.7	$2,176	+ 46.6
12/10	$2,142	0	0	0	$2,142	$201	$2,343	+ 56.0	$2,195	+ 47.8
01/11	$1,990	0	0	0	$1,990	$188	$2,178	+ 48.9	$2,188	+ 47.3
02/11	$1,745	0	0	0	$1,745	$220	$1,965	+ 49.3	$2,189	+ 47.5
03/11	$1,887	0	0	0	$1,867	$157	$2,044	+ 44.4	$2,189	+ 47.4
04/11	$1,775	0	0	0	$1,775	$74	$1,849	+ 37.2	$2,177	+ 46.6
05/11	$2,165	0	0	0	$2,165	$57	$2,222	+ 24.6	$2,167	+ 45.9
06/11	$2,194	0	0	0	$2,194	$35	$2,230	+ 29.2	$2,173	+ 46.4
Period Total	$20,412	0	0	0	$20,412	$1,186	$21,598	+ 44.0		

City of Santa Cruz, Municipal Wharf
Energy Use Report -- Year Ending 04/2012

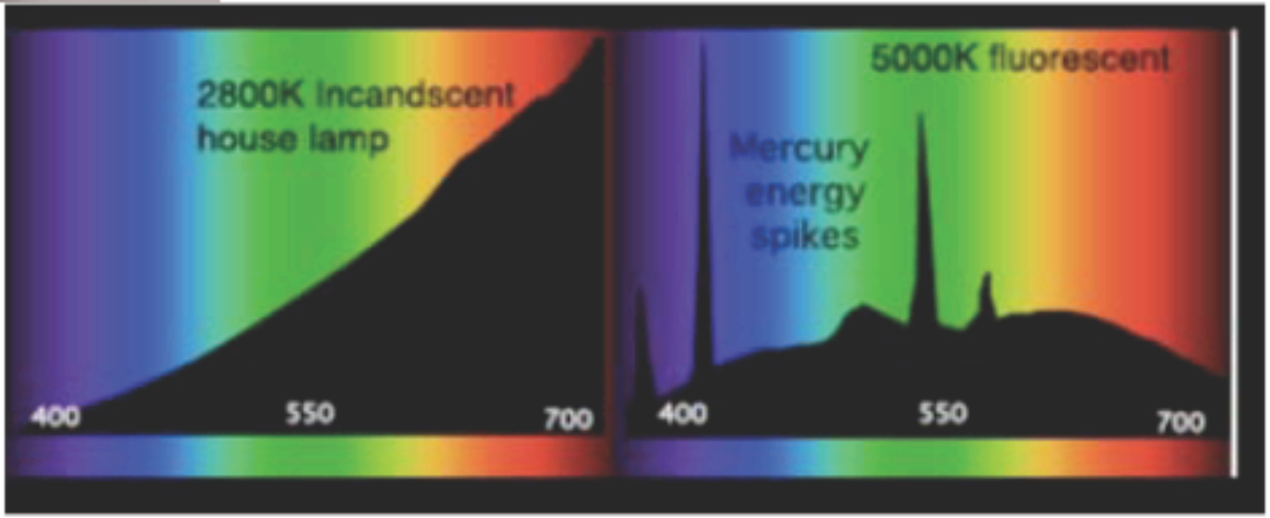
Date	Electricity (kWh)	% Chg	Demand (kW)	% Chg	Natural Gas (Therms)	% Chg	Total Energy (MBtu)	% Chg	Annual Usage Trend	% Chg
05/11	10,523	+ 5.8	10	N/A	48	+ 188.1	40.7	+ 14.3	48.0	- 46.0
06/11	10,491	+ 14.1	10	N/A	20	+ 260.5	37.8	+ 18.5	48.3	- 46.6
Period Total	21,015	+ 9.8	10	N/A	68	+ 206.4	78.5	+ 16.3		
07/11	11,026	+ 53.3	11	N/A	2	N/A	37.8	+ 54.2	48.2	- 46.4
08/11	11,866	+ 56.4	11	N/A	1	N/A	40.6	+ 55.8	48.4	- 46.9
09/11	11,527	+ 52.2	10	N/A	7	N/A	40.0	+ 54.7	48.6	- 47.7
10/11	11,635	+ 31.6	10	N/A	22	+ 108.8	41.9	+ 34.3	48.0	- 45.8
11/11	11,800	+ 27.1	10	N/A	198	+ 608.5	60.0	+ 75.7	48.3	- 46.9
12/11	12,868	+ 28.7	10	N/A	371	+ 399.0	81.0	+ 94.9	49.6	- 50.6
01/12	13,617	+ 39.6	10	N/A	362	+ 520.7	82.7	+ 111.3	51.4	- 56.2
02/12	11,382	+ 31.4	10	N/A	248	+ 257.0	63.6	+ 74.3	51.9	- 57.8
03/12	11,809	+ 24.3	10	N/A	253	+ 467.8	65.6	+ 78.0	52.9	- 60.7
04/12	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	49.3	- 49.9
YTD Total	107,531	+ 37.1	11	N/A	1,465	+ 418.8	513.4	+ 73.5		

Cost	Cost	Cost	Factor Cost	Elec Cost	Gas Cost	Energy Cost	Chg	C
$2,165	0	0	0	$2,165	$57	$2,222	+ 24.6	
$2,194	0	0	0	$2,194	$35	$2,230	+ 29.2	
$4,359	0	0	0	$4,359	$93	$4,452	+ 26.9	
$2,293	0	0	0	$2,293	$18	$2,311	+ 67.5	
$2,475	0	0	0	$2,475	$17	$2,492	+ 73.2	
$2,381	0	0	0	$2,381	$21	$2,403	+ 70.4	
$2,364	0	0	0	$2,364	$36	$2,400	+ 48.4	
$1,920	0	0	0	$1,920	$196	$2,115	+ 49.3	
$2,060	0	0	0	$2,060	$357	$2,417	+ 60.9	
$2,187	0	0	0	$2,187	$353	$2,540	+ 73.6	
$1,857	0	0	0	$1,857	$251	$2,108	+ 60.2	
$1,947	0	0	0	$1,947	$228	$2,175	+ 53.7	
N/A	N/A	N/A	N/A	0	N/A	0	N/A	
$19,484	0	0	0	$19,484	$1,473	$20,962	+ 61.8	

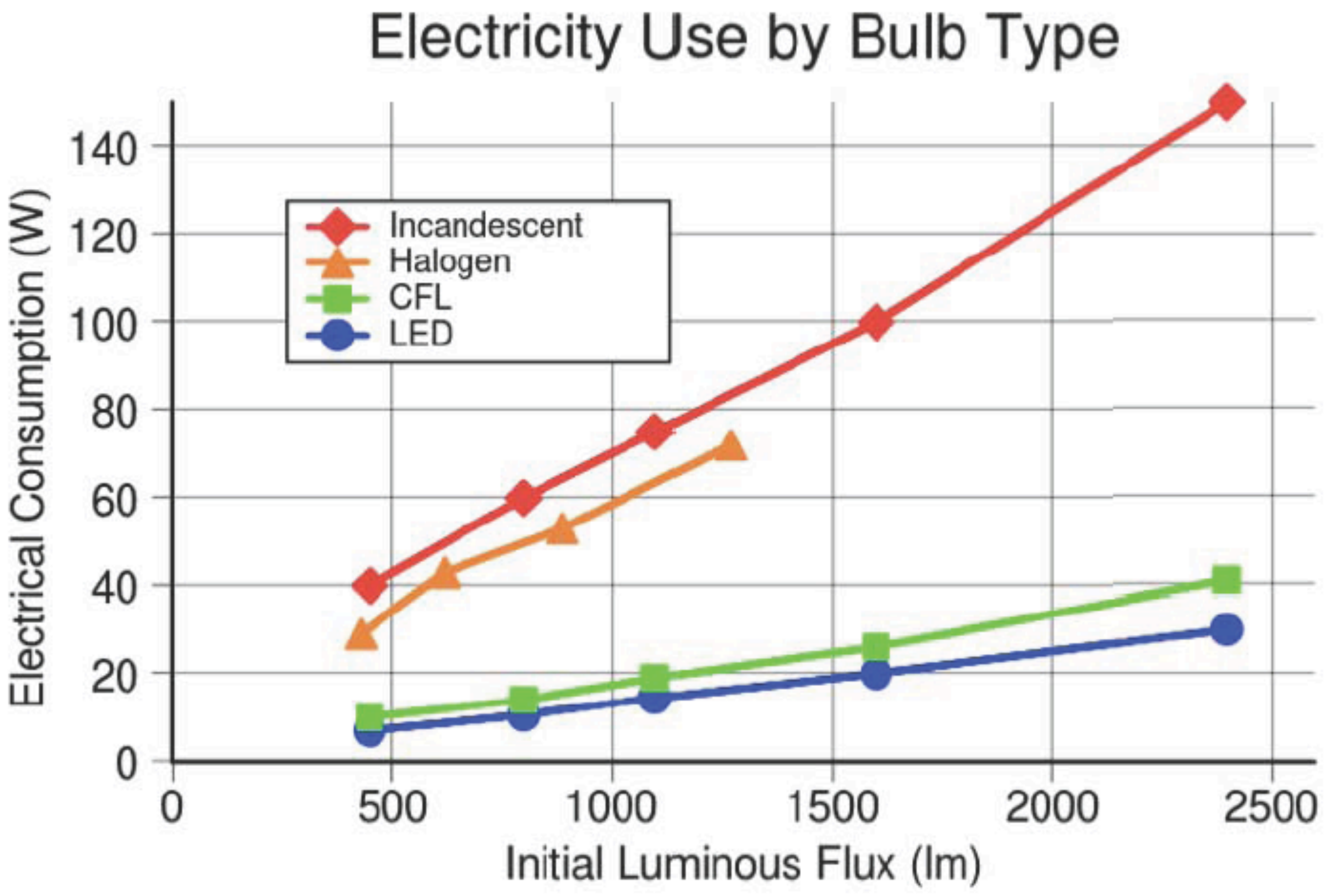
UCSC Campus energy use.pg.1

	annual electricity use in Kwhr	2,010.00	2,011.00	2,012.00	2,013.00
E01201	Village Trailers B & C Loops	28,320	24,000	24,720	12,600
E02101	Village Trailers: Upper Grounds	145,080	146,880	140,520	66,720
E02901	Village Trailer A2	9,515	8,435	10,669	5,178
E03101	Village Trailer A1	2,394	1,742	1,325	407
E03401	Village Lighting	7,515	7,380	6,466	2,153
E06701	Cooling Tower #4	0	36,849	379,549	36,312
E07901	Utility Services Trailer	5,261	5,241	3,570	2,195
E09601	Emergency Response Center	183,510	194,823	244,634	79,522
E09602	Emergency Response Center	189,293	192,832	221,609	95,129
E09801	Interdisciplinary Science Bldg-ISB	695,723	722,759	716,226	196,471
E10301	Stonehouse & Granary	5,259	4,785	4,060	1,285
E10401	Granary Day Care Center	3,759	3,449	2,634	726
E10601	Carriage Development Trailers	0	0	0	0
E10602	Carriage House & Trailers	32,926	34,969	35,126	14,377
E10603	Lower Campus Master	437,520	435,880	440,160	185,720
E10801	Cardiff House Womens Center	17,271	16,553	15,027	5,781
E11101	CNG Plant	14,061	9,606	13,683	5,005
E11102	TAPS Garage and Barn H	132,177	132,455	153,269	62,205
E11201	Barn Theater	38,602	937,805	37,566	15,608
E11202	Barn Theater & Cook House	66,960	56,480	53,440	20,240

Compact Fluorescent lighting



Wavelength in nm



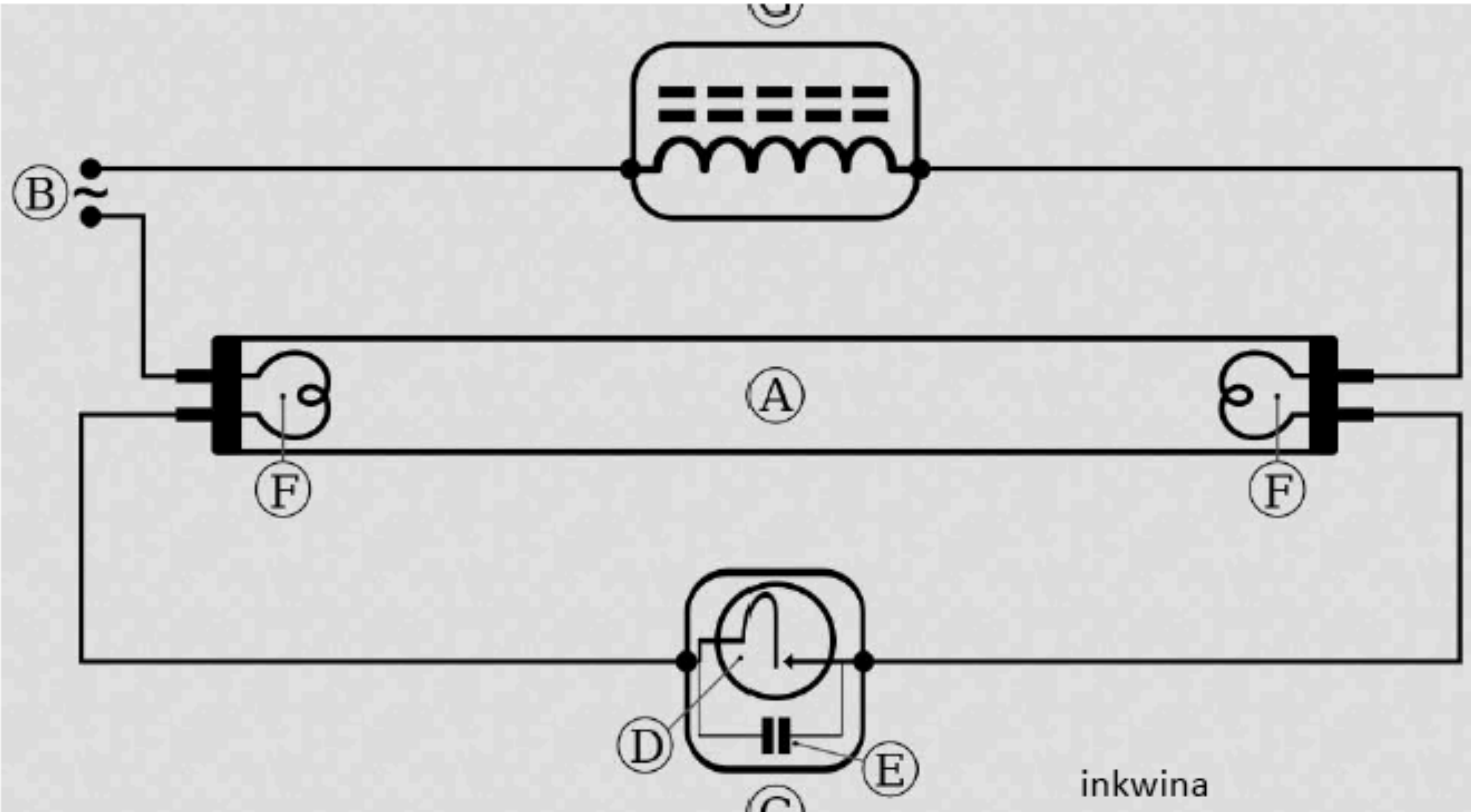
Electricity Use by Bulb Type
Incandescent
Halogen
CFL
LED
Electrical Consumption (W)
0
20
40
60
80
100
120
140
0
500
1000
1500
2000
2500
Initial Luminous Flux (lm)

Electrical power equivalents for differing lamps[34]

Minimum light output (lumens)	Electrical power consumption (Watts)		
	Incandescent	Compact fluorescent	LED
450	40	9–11	6–8
800	60	13–15	9–12
1,100	75	18–20	13–16
1,600	100	24–28	18–22
2,400	150	30–52	30[35]
3,100	200	49–75	Not available
4,000	300	75–100	Not available

http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_lumens

Fluorescent lamp



Compact fluorescent lights

- Energy converted to light, 90% (compare to 10% for incandescent bulb). Remainder is heat.
- Contains Hg, so disposal can be a problem

  (of all CFL sold in US/year, contribution of about 0.1% of total Hg emission into atmosphere)

  Lifetime: 8000 hours (compare to incandescent ?). LED is about 30,000 hours

Energy Cost Savings

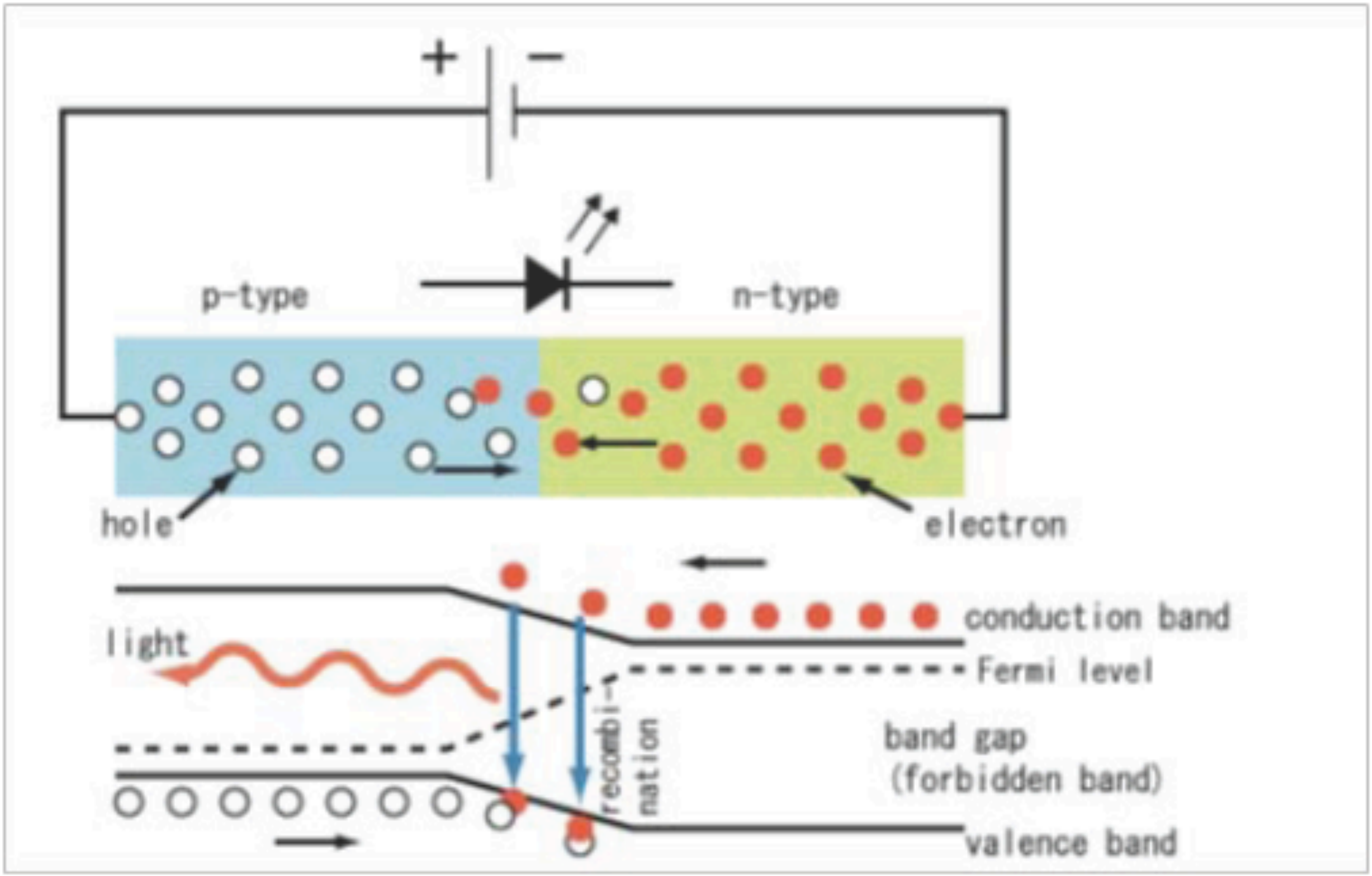
- 9 W CFL bulb has expected life of 8000 hours. What is the savings in energy costs?

- 9W CFL has same light output as 40 W incandescent bulb, so a savings of 31 watts.
  - Over 8000 hours, energy is E = 8000hrsX.031 kWatt = 248 kWhr

  - If electricity costs $0.10/kWhr, savings is: $24.80.

Therefore, if bulb costs less than $24.80, you save money with a CFL over an incandescent bulb (this doesn't include cost of incandescent bulb)

Light emitting diodes (LED)



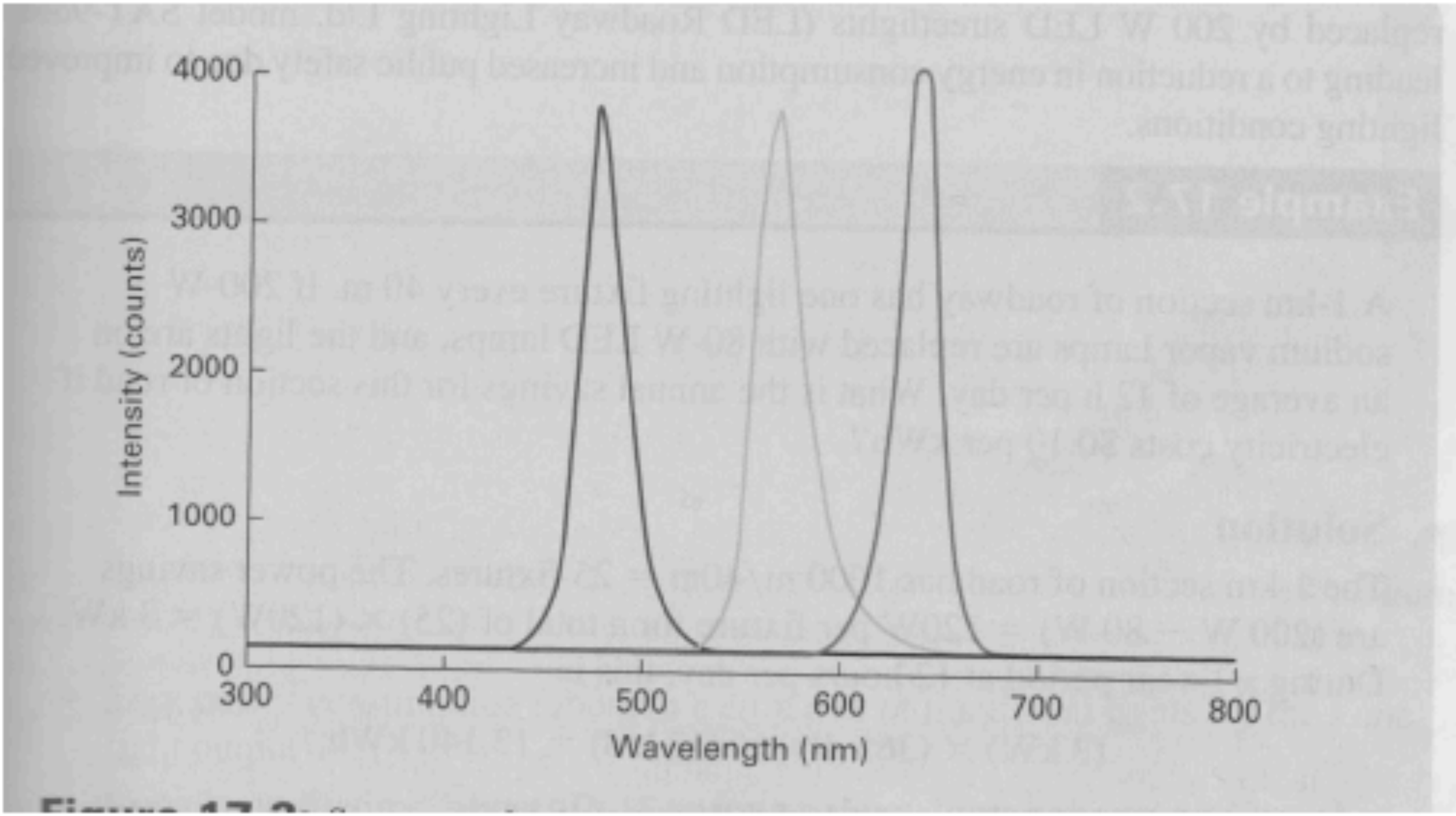
Opposite to a solar cell, where light is absorbed and a voltage/current is produced

LED technical issues

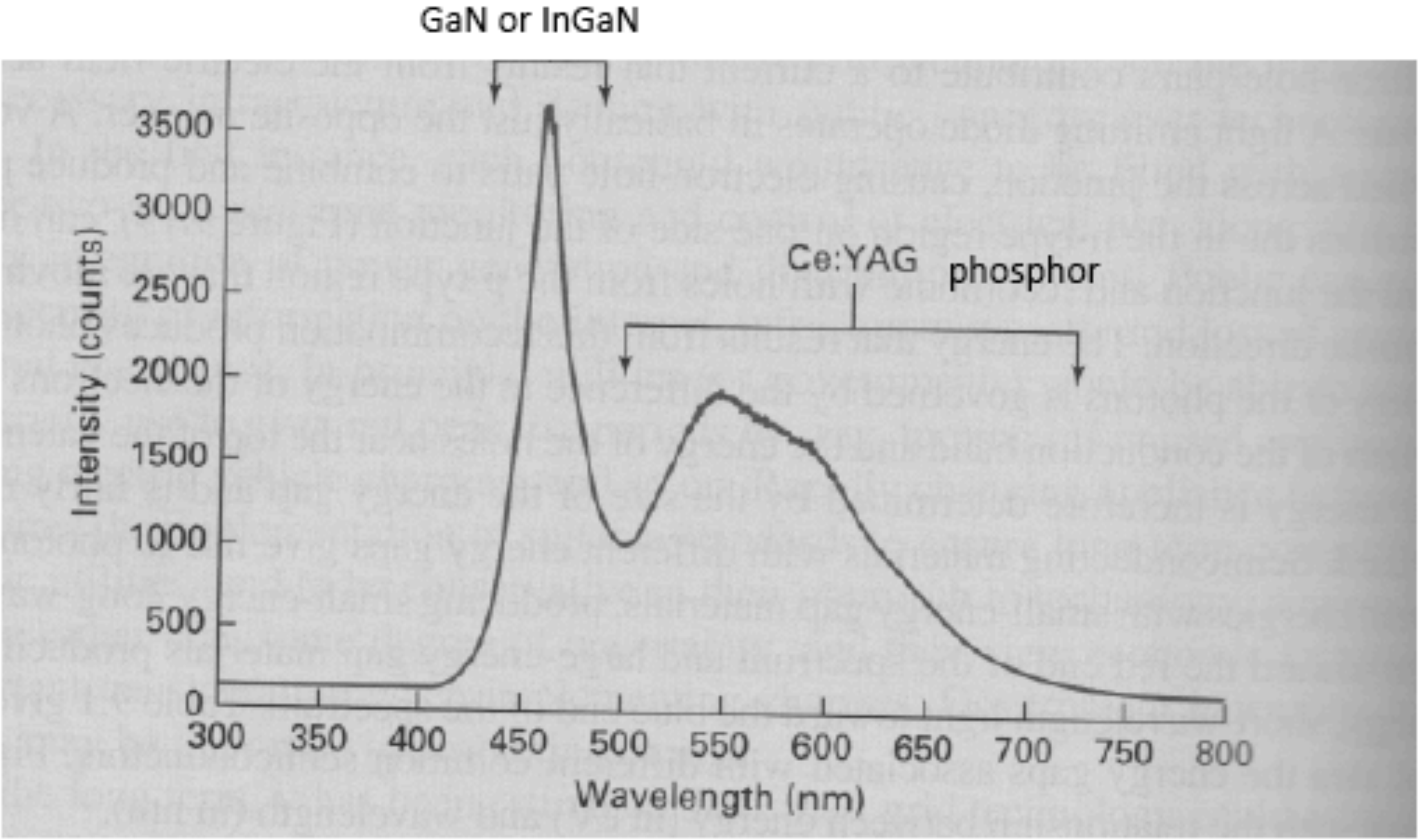
- Color of light output depends upon the “band gap”
- have to tune the band gap to get colors from blue to red
- Band gap is narrow.

- Direct or indirect(using phosphors) light production

Multicolor LED's



Alternative method of creating white light LED's



From Dunlap

has lighting every 40 m. If a 200 W Na vapor lamps is replaced with a 80 W LED lamps (which has equivalent light output) and lights are on 12 hrs./day. What is the annual savings in electricity? Assume electricity costs \$0.10/kwh.

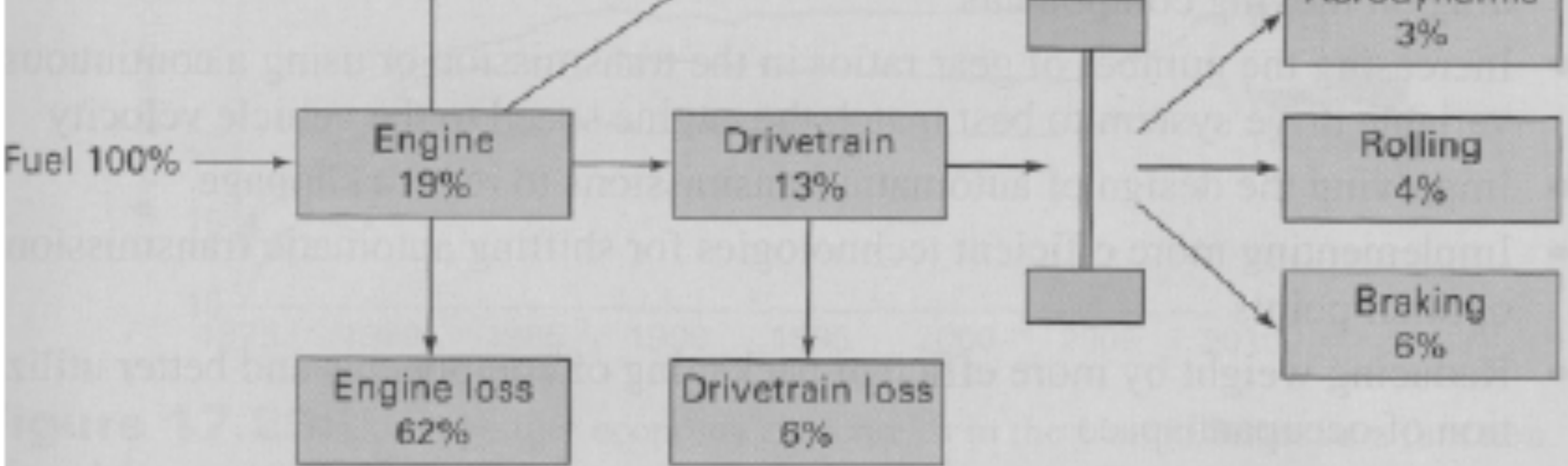
$$\# \text{ lamps} = \frac{10^3 m}{40 m} = 25 \text{ lamps}$$

$$\text{power savings} = 200 - 80 = 120 \text{ watts/lamp.}$$

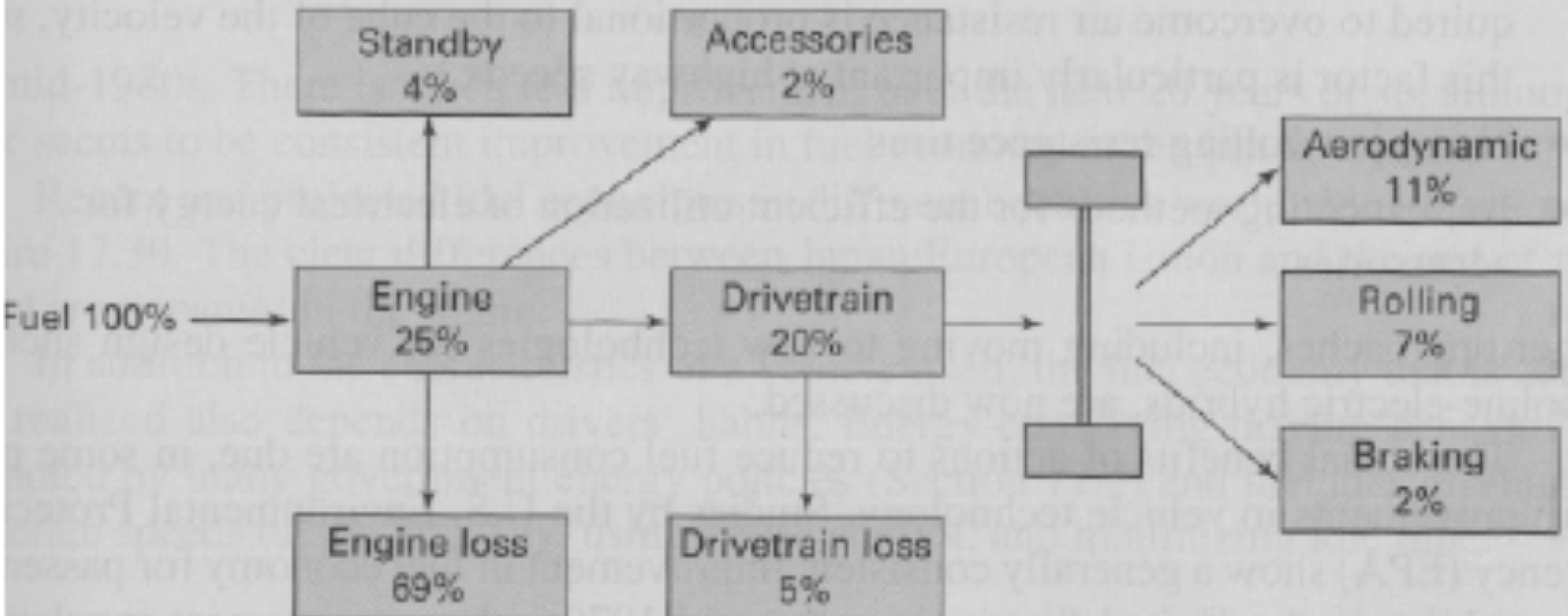
$$\therefore \text{total power savings} = 25 \times 120 \text{ watts} = 3 kW$$

for 1 year at 12 hrs/day

$$\text{energy saved } E = 3 kW \times 365 \frac{\text{days}}{\text{yr}} \times 12 \frac{\text{hrs}}{\text{day}} = \underline{\underline{13,140 \text{ kwh}}}$$



Urban driving



- Developing more efficient computer control of engine operating conditions, tha is, operating temperature and fuel distribution
- Using thinner and/or lower-friction engine oils and lubricants to reduce viscous drag on moving components
- Increasing the number of gear ratios in the transmission or using a continuousl variable drive system to best match the engine speed to the vehicle velocity
- Improving the design of automatic transmissions to reduce slippage
- Implementing more efficient technologies for shifting automatic transmissions optimal points
- Reducing weight by more efficient packaging of components and better utilization of occupant space
- Reducing weight, particularly of moving parts, by utilizing advance materials
- Utilizing more aerodynamic designs to reduce air resistance (The power required to overcome air resistance is proportional to the cube of the velocity, so this factor is particularly important at highway speeds.)
- Using low rolling resistance tires
- Implementing methods for the efficient utilization of electrical energy for

Take Home Quiz, due Monday, 5/18/15

- 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.