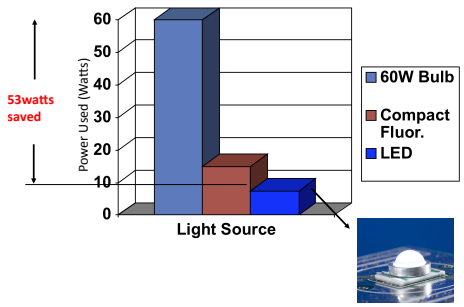
Class 15 Cost of Conserved Energy
Cost of Carbon Abatement
Pete Schwartz, *Cal Poly Physics*

We **want** to Conserve Energy (and save money)
We **want** to Reduce CO_2 Emissions
This requires **Investment** (costs money)

3.5 WLED Lights, ~ $10

White LED and Compact Fluorescent vs. 60Watt Light Bulb



So, you save how much energy with an LED?
$P_{incandescent} - P_{LED}$ = 60W – 7W = 53W (not wasted in heat)

You use a light 3 hours per day?, You SAVE:
(365 d/y)*(3 h/d)*(0.053kW) = 58 kWh/yr

However, this wasn't free, because you had to buy a $10.00 light bulb.

You could divide the two and see that it costs you 17 cents / kWh For one year. However, the bulb will last 50,000 hours… or about 46 years at this rate. However, the money today is worth more to you than the money in years to come, so you take out a loan to pay for the bulb and calculate how much it costs each year… take out a 30 year loan at 7%: Loan payments are $0.80 per year. So the cost of conserved energy is ¢1.39 / kWh!

What do I compare this to?

Cost of Conserved Energy (CCE)
(Megawatts and Negawatts)

CCE = [annualized investment ($/year)]/[conserved energy (kWh/year)]

= $/kWh

Example:

$100 additional cost for a more efficient refrigerator which saves 250 kWh/year

It lasts 10 years, if the interest/discount rate is 5%,

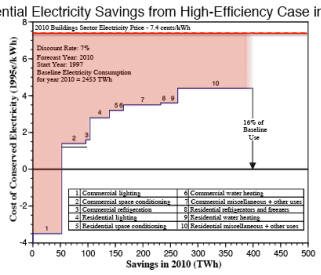
$$CRF = \frac{r}{1-(1+r)^{-t}}$$

then the CRF = 0.13/year and the

CCE = ($100)(0.13/year)/($250kWh/yr) = $0.05 kWh

Costs of Conserved Energy

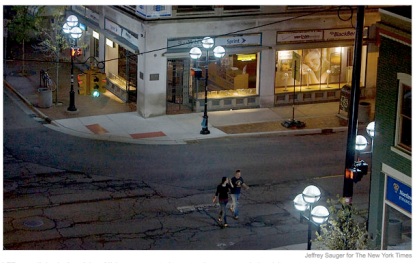
Potential Electricity Savings from High-Efficiency Case in 2010



~$0.05 / kWh
~ 400 TWh
~ 10^9 kWh
$0.05 * 400 x 10^9
- $20 Billion

A classic *negawatt analysis*

Green Promise Seen in Switch to LED Lighting



Jeffrey Sauger for The New York Times

LED streetlights in Ann Arbor, Mich., are expected to cut maintenance and electricity costs.

By ELISABETH ROSENTHAL and FELICITY BARRINGER
Published: May 29, 2009

To change the bulbs in the 60-foot-high ceiling lights of Buckingham Palace's grand stairwell, workers had to erect scaffolding and cover precious portraits of royal forebears.

So when a lighting designer two years ago proposed installing light emitting diodes or LEDs, an emerging lighting

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By Degrees

Cost of Abated Carbon (dioxide): Revisit our LED example:
LED light consumes 58 kWh/yr *less*

Assume electricity from NG single cycle: efficiency: 1/3 (33%)

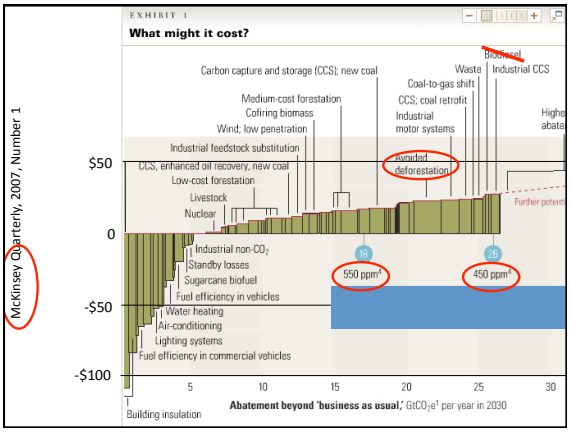
Carbon intensity of NG (*thermal*):
15 g(C) / MJ_{th} = 198 g $(CO_2)/kWh_{th}$

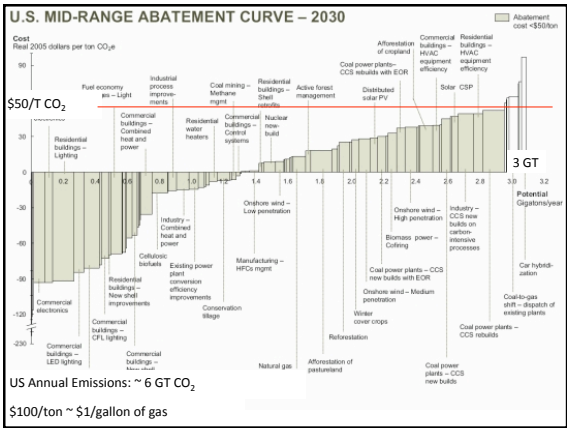
Carbon intensity of electricity:
198 g $(CO_2)/kWh_{th}$ / (1/3) = 594 g$(CO_2)/kWh_e$

Total Carbon Saved: 594 g$(CO_2)/kWh_e$ * 58 kWh/yr = 34.5 kg / yr

Investment: $0.80/yr in loan payments for lightbulb
Energy Costs *saved*: ($0.074 / kWh_e) * (58 kWh/yr) = $4.30
Total Annual Cost of this Conservation is: $0.80 - $4.30 = - $3.50

Cost of Abated Carbon: – $3.50 / 34.5 kg = -$0.10/kg = -$100/Ton





US Annual Emissions: ~ 6 GT CO_2

$100/ton ~ $1/gallon of gas

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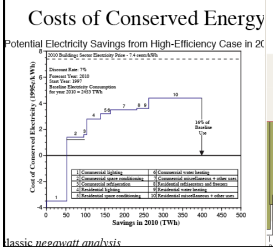

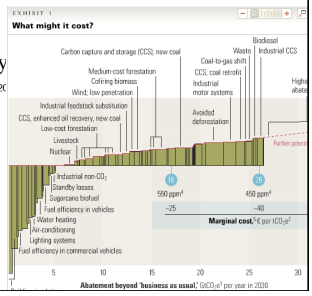

lassic *negawatt analysis*

San Pablo, Tacana, Guatemala

http://guateca.com

Electricity

Photovotaics
$4/W = Q30/W

microhydro
$4/W = Q30/W

Services:

Showers 4 kW •1 h/d •4 kWh/d	5 bulbs: 500W *10 h/d 5 kWh/d	Cooking, H_2O 2 kW *0.5 h/d 1 kWh/d	3 Computers 30 W * 4 h/d 0.36 kWh/d	3 Cell Phones 4 W * 2 h/d 0.024 kWh/d

Total Energy: 10.1 kWh/d. Average Power: 422 W, per family
System Cost: $1688 = Q13,500 per house

But if each family cooks and showers at the same time, the system demand will be 6.5 kW per family at that moment.
System Cost: $26,000 = Q200,000 per house

Priorities:
1) Displace Electricity with other energy sources
2) Manage the local grid to prevent people from using too much electricity at once
3) Increase efficiency
4) Generate Renewable Electricity

Electricity

microhydro
$4/W = Q30/W

Services:

Heat with Solar or Chimney Waste Heat Cost: $100	Natural Sun 10 h => 4 h LED lights 2 kWh=> 0.08 kWh	Conserve **0.5 h => 0.1 h** **1 => 0.2 kWh**	3 Computers 30 W * 4 h/d 0.36 kWh/d	3 Cell Phones 4 W * 2 h/d 0.024 kWh/d

Total Energy: **0.7 kWh/d**. Average Power: **30 W**, per family

Cost for microhydro: 30W * $4/W = ~$120 per family, ~$12,000 for the village

Cost (per family) for displacement, management, efficient use of electricity:

$100	**Smart Grid coordination**
$100	**Solar or Chimney Heater**
$200	**Natural Day lighting**
$ 75	**LED lights**
$100	**Improved Stove**
$575	**Total Investment in efficiency**

Total: $575 + $120 = $695 per family: less than $1600 per family and much less than $26,000 per family