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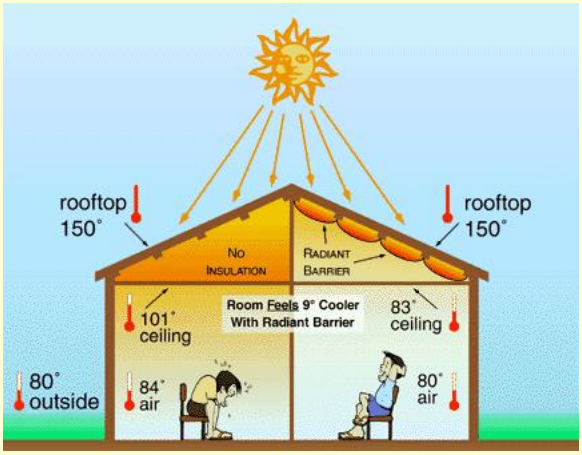

Conservation

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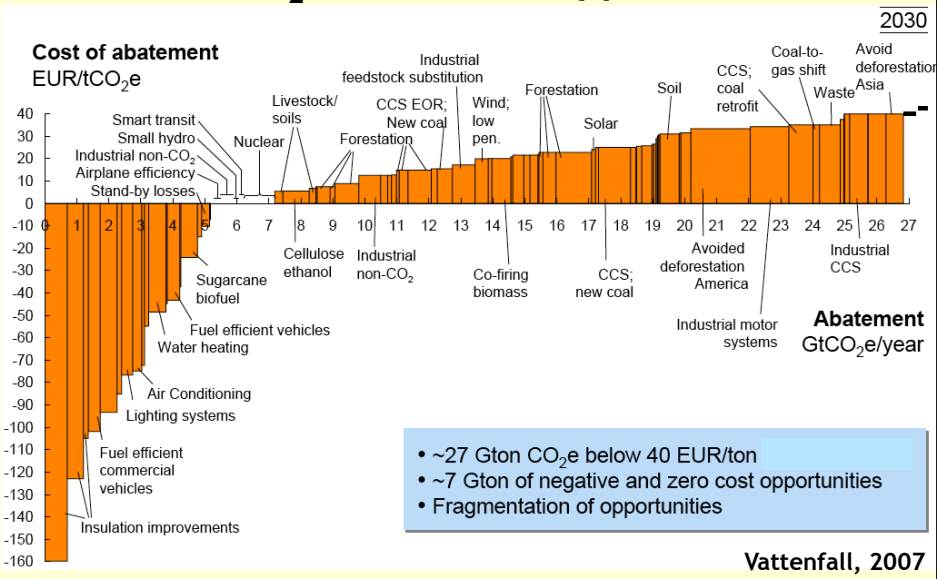
Global CO_2 Abatement Opportunities



- ~27 Gton CO_2e below 40 EUR/ton
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities

Vattenfall, 2007

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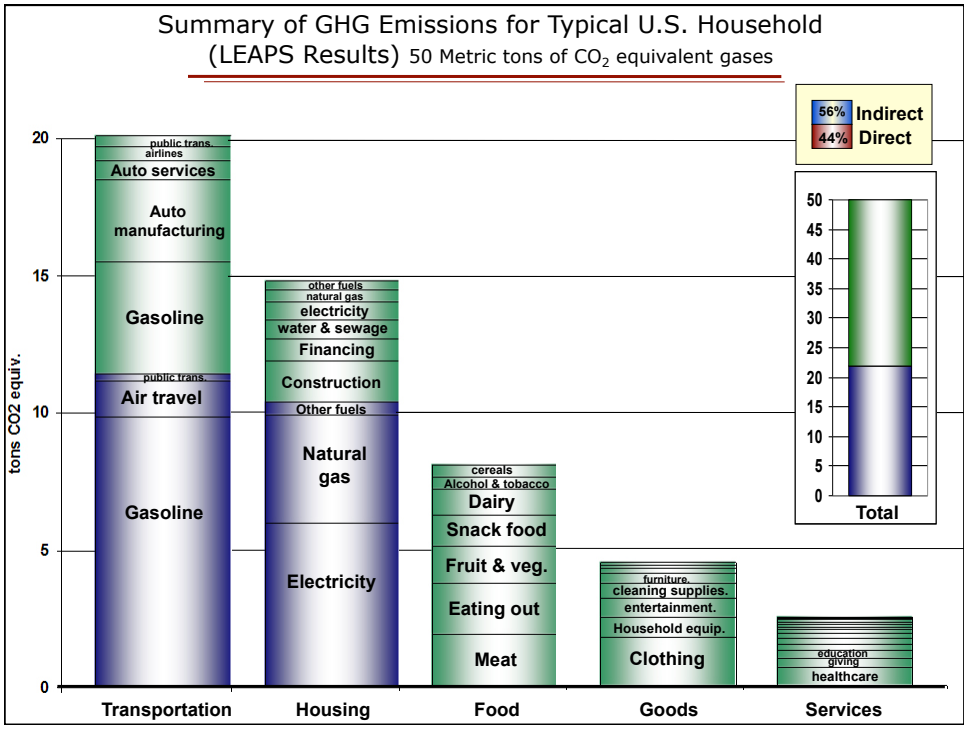

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Overview

- U.S. Energy usage increased exponentially from 1850-1975 (~ 4.3%/ year)
- Early 1970 projections were U.S. needed 160 QBtu/year by 2000, but reality was only 100 QBtu/year. What happened?
- 1973: Arabs organized to *reduce* oil production.
  - Cost $0.25 bbl to get oil out of ground & price was $2/bbl
  - Very quickly price went to $12/bbl => factor of 5-6 increase
  - U.S. introduced legislation
    - *CAFE (Corporate Average Fuel Efficiency)*
    - *Insulation standards for houses/refrigerators (R values)*
    - *55 mph freeway speed limit and many other conservation standards*
  - Thought would need massive nuclear expansion, but conservation worked much better than expected
- 1978: 2nd "oil crisis", price doubled to $24/bbl
  - stayed ~ $30/bbl until a few years ago (Still ~ 1$/bbl to get oil: => Texans got rich)
- Estimate aggressive conservation now could bring us to 60 QBtu/year; Conservation cheapest way out of energy crisis!

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Focus on household energy

- 22% energy in households, 21% transportation, 33% industrial, 18% commerical
- In U.S. space heating is number one use: 47% of household energy
- Insulation! Insulation! Insulation!
  - If insulation was perfect no energy would be needed! Heat on a cold day once and then energy conservation would keep the air warm! Is this ideal possible?
- Typical U.S. house (not San Diego!) in cold season
  - *17% heat lost through walls*
  - *16% heat lost through windows*
  - *21% lost through basement walls and floor*
  - *5% lost through ceiling*
  - *3% lost through doors*

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Heat loss equation

- Heat energy lost in one "season" is:

$$Q = 24\ A\ \text{degree-days}/R_{tot}$$

  - Q is energy in Btu
  - A is area of wall or window or ceiling, etc. in ft^2
  - R_{tot} is "R" factor or insulation factor, depends on material and thickness
  - Degree-days = SUM over season of (65^0F- outside temp)
- Most important thing is where you live (how cold it is in winter)
  - Miami FL: 170 degree-days (in one year)
  - Los Angeles 2000 degree-days
  - San Francisco 3000 degree-days
  - NY,NY: 5000 degree-days
  - Denver, CO 6000 degree-days
  - Madison, WI 7300 degree-days
  - Barrow Alaska 20,000 degree-days

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R values are listed at Home Depot, etc.

- Formula means big R-value => less heat loss
- More area => more heat loss
- More degree days => more heat loss
- Good thing about R-values is they add: $R_{tot} = R_1+R_2+R_3$, etc
- Example R values:
  - Glass window, 1/8 inch: 0.03
  - Drywall, 1/2 inch: 0.45
  - Plywood, 3/4 inch: 0.95
  - Concrete (per inch): 0.08
  - Brick (per inch): 0.2
  - Fiber glass ins (per inch): 3.7
  - Urea foam (per inch) 5.25
  - Insulating board: 2.06
  - Inside air layer 0.68
  - Outside air layer 0.17
- $Q = 24\ A\ \text{degree-days}/R_{tot}$

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Example: Heat loss through wall in Reno

- Assume wall is 20ft by 8 ft
- w/o insulation: wall is made of insulating board, 3.5 inch empty gap and drywall
  - R_{tot} = outside air layer (.17) + insulating board (2.06) + inside air layer (.68) + another inside air layer (.68) + drywall (.45) + inside air layer (.68) = 4.72
  - Q = 24 x (20ft * 8 ft) * 6000 degree-days/4.7 = 4.9 million Btu
- with insulation: add fiber glass insulation in 3.5 inch gap
  - $R_{tot} = R_{tot}$(above) + 3.5inch *3.7 -2(.68)= 4.7+13 = 16.3
  - Q(insulation) = 1.41 million Btu => save 3.5 million Btu for this one wall!
  - With natural gas at ~ $13/MBtu => save $13 x 3.5 = $45.50 each year by insulating this one wall.
- Note glass wall would have R=.17+.03+.68=0.88 => 26 million Btu or cost $388/year in heating!
- Note: similar for air conditioning required for cooling when hot

Insulation only helps if heat can't run out through open doors, windows or cracks

- Called air infiltration: typical house has air infiltration of once per hour => need to reheat entire house each hour, gives about 1/3 of total heat loss
- Weather stripping leaky doors, windows, etc; close chimney flue can reduce greatly
- BUT if too good: radioactive Radon gas and carbon monoxide can build up; especially in basements
- Also note, new furnaces should be > 90% efficient, old ones more like 50%; they put 1/2 of heat out vent
- Finally, lowering inside thermostat helps; Formula says lowering temp by n ^{0}F reduces heating cost by a factor of $n/(T_{inside}-T_{outside})$

Fireplace or woodburning stove?

- Woodburning stoves and fireplaces are not really energy conservers!
- Woodburners are typically only 40-60% efficient; can save money only if have supply of free fire wod
- Open fireplaces mostly have negative efficiencies! They actually remove heat from most houses!
  - If central heating is on, heated indoor air is drawn into fire place and out chimney. Warmer near fire, but rest of house gets colder.
  - Can use fireplaces with glass doors; doors heat up and radiate some heat into room; newer fireplaces have these, now you know why!

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Household appliances in order of energy use

• Electric Water heater	~ $550/year
• Central air conditioner	~ $335/year
• Refrigerator	~ $116/year
• Clothes washer (inc hot water)	~ $112/year
• Dishwasher (inc hot water)	~ $96/year
• Clothes dryer	~ $92/year
• Lights	~ $88/year
• Electric Range	~ $70/year
• Microwave oven	~ $18/year
• Television	~ $16/year
• Home computer	~ $13/year
• Coffee maker	~ $10/year
• Stereo and radio	~ $8/year

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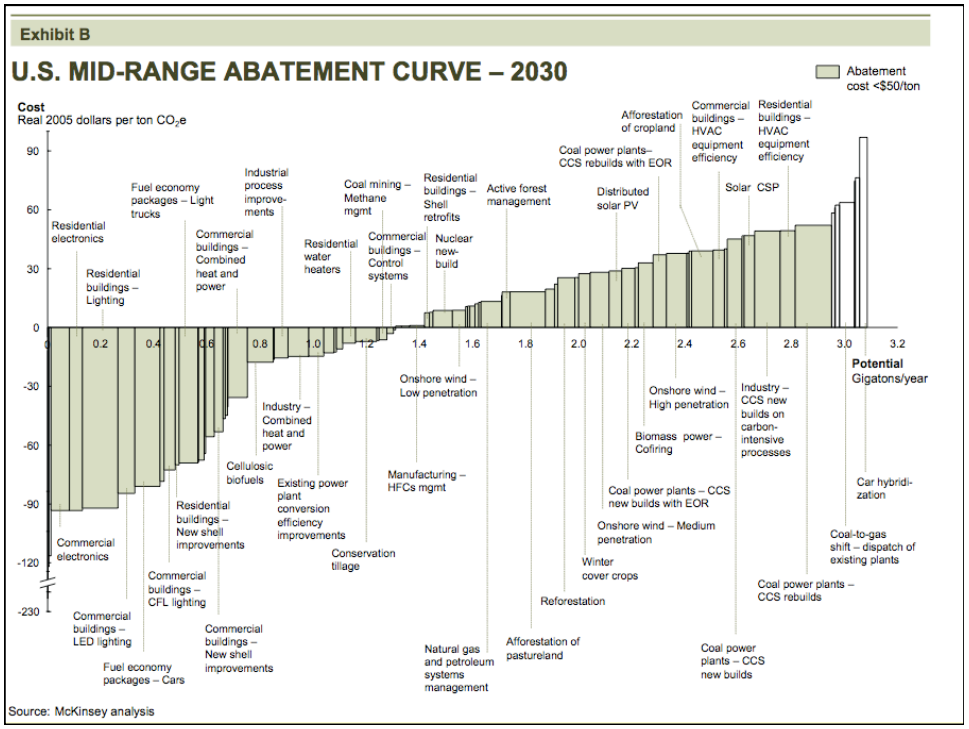
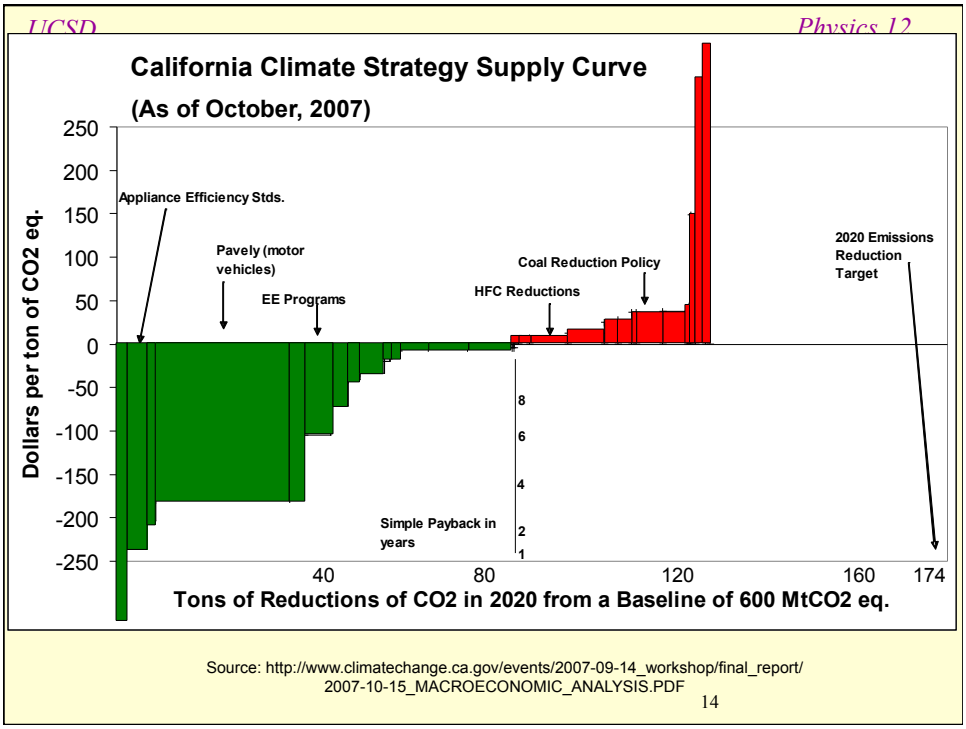
Recycling

- Aluminum cans take ~7100 Btu to make, ~2500 Btu if recycled
- Glass bottles used once take ~3900 Btu, recycled 2400 Btu, refilled ~600Btu
- Recycling works for Al since Al costs ~$130/lb => most Al is recycled; glass and paper not so valuable so much less recycled
- Paper vs. Plastic? How to tell?
  - Simple rule of thumb: pick the one that weighs less!
  - e.g. if paper cup weighs more than plastic cup probably means it used more resources and is worse for the environment!
  - (exception: toxic substances (lead, poisons, etc.))





Source: http://www.climatechange.ca.gov/events/2007-09-14_workshop/final_report/2007-10-15_MACROECONOMIC_ANALYSIS.PDF

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