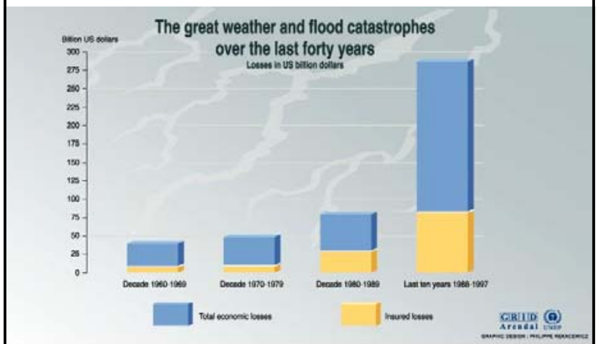
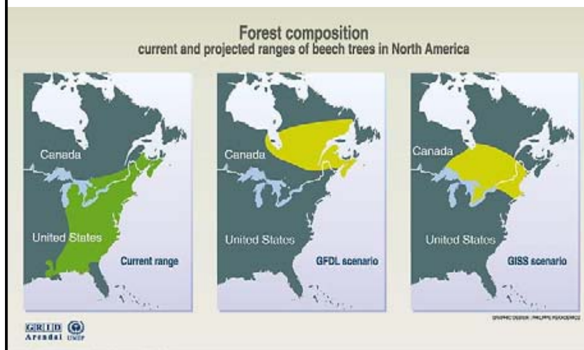
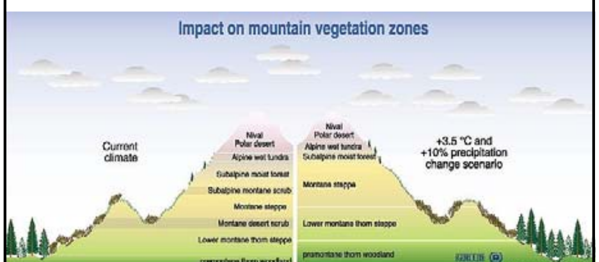


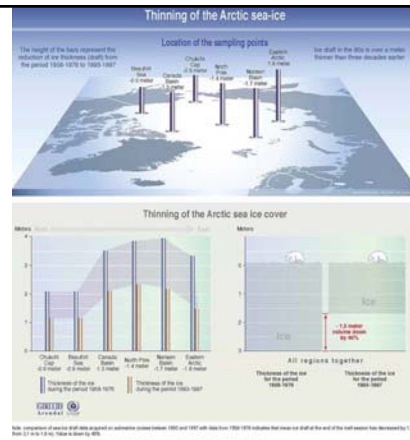
Source: Munich Re Group, 1998.

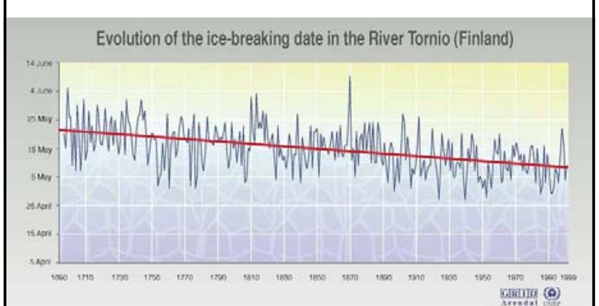


Source : US Environmental Protection Agency (EPA), 1998.

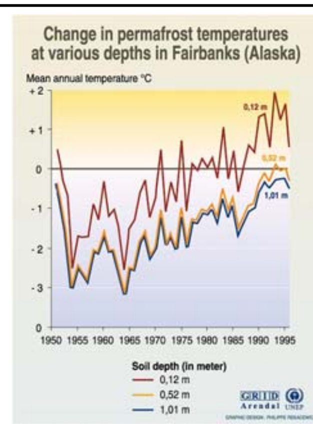


Sources: Martin Beniston, Mountain environments in changing climates, Routledge, London, 1994; Climate change 1995, Impacts, adaptations and mitigation of climate change, contribution of working group 2 to the second assessment report of the Intergovernmental panel on climate change (IPCC), UNEP and WMO, Cambridge press university, 1996.

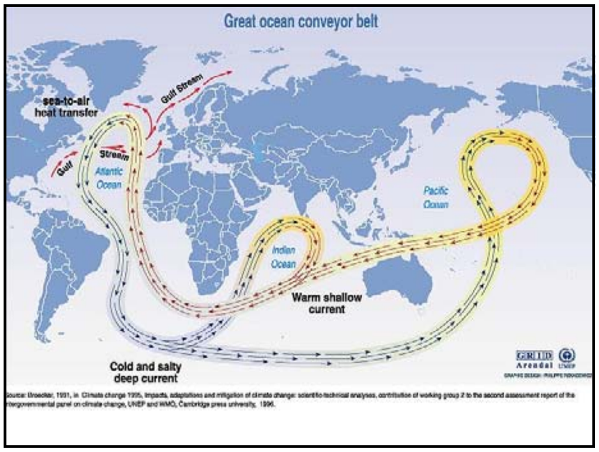


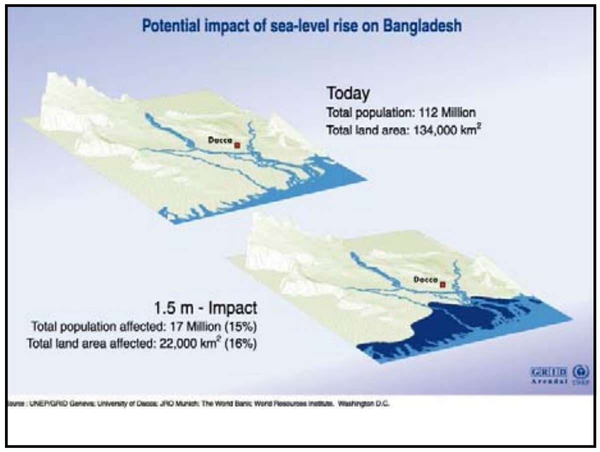


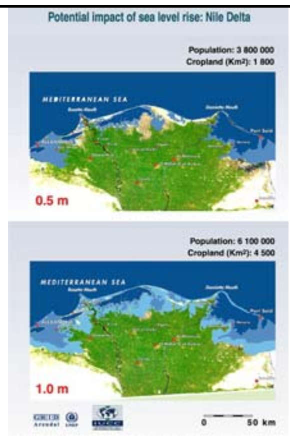
Source: Trends in the finnish Environment 1997, fig. 1.7, updated in February 2000.

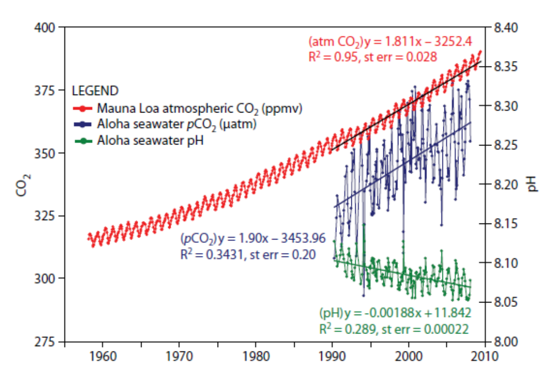


Source: Romanovsky, in Impacts of global climate change in the Arctic regions, IASC, Tromsø, April 1999.







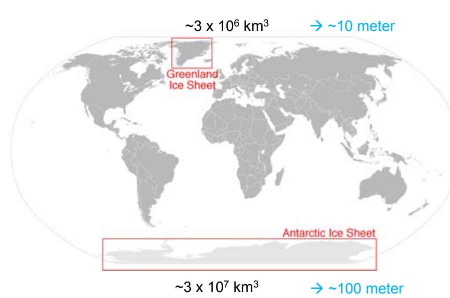


OCEANS:

Mass: 1.4×10^{21} kg
Area: 3.6×10^{8} km^2
Average depth: ~4 km

How much ice needs to melt to raise the level by 1 cm?

Enough to add 3.6×10^{8} km^2 x 10^{-5} km =
3.6×10^{3} km^3 of water
= ~ 4×10^{3} km^3 of ice

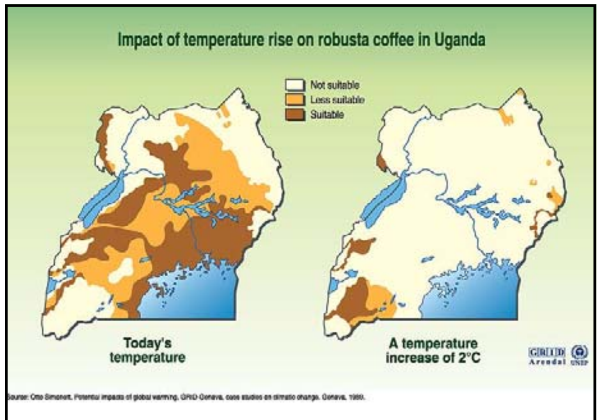


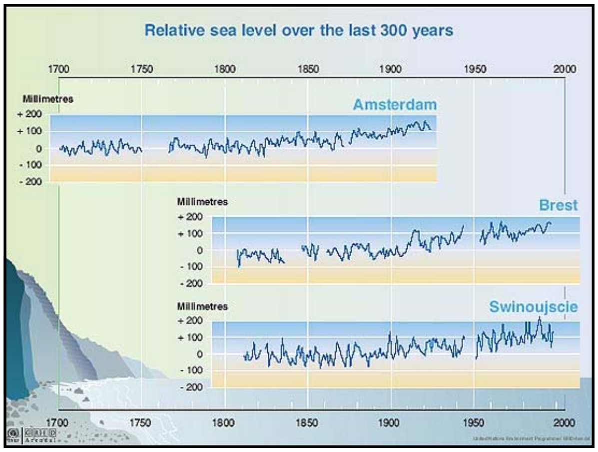
OCEANS:

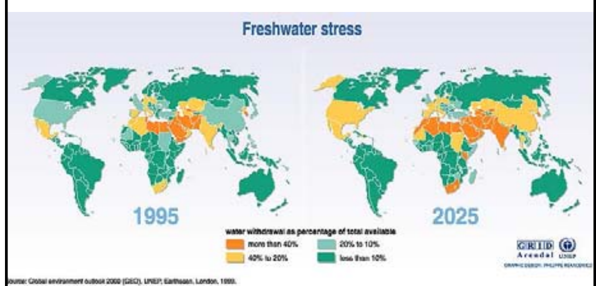
Mass: 1.4×10^{21} kg
Area: 3.6×10^{8} km^2
Average depth: ~4 km

What temperature change will raise the level by 1 cm?

expansion coefficient:
between 0 (at 3 C) to 2×10^{-4} K^{-1} (at 20 C)







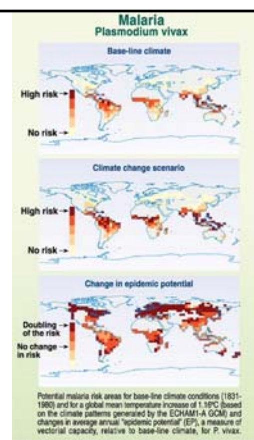
Disease	Vector	Population at risk (million)[1]	Number of people currently infected or new cases per year	Present distribution	Likelihood of altered distribution
Malaria	Mosquito	2,400[2]	300-500 million	Tropics and Subtropics	Highly likely
Schistosomiasis	Water snail	600	200 million	Tropics and Subtropics	Very likely
Lymphatic Filariasis	Mosquito	1 094[3]	117 million	Tropics and Subtropics	Likely
African Trypanosomiasis (Sleeping sickness)	Tsetse fly	55[4]	250 000 to 300 000 cases per year	Tropical Africa	Likely
Dracunculiasis (Guinea worm)	Crustacean (Copepod)	100[5]	100 000 per year	South Asia, Arabian Peninsula, Central-West Africa	Unknown
Leishmaniasis	Phlebotomine sand fly	350	12 million infected, 500 000 new cases per year[6]	Asia, Southern Europe Africa, Americas	Likely
Onchocerciasis (River blindness)	Black fly	123	17.5 million	Africa, Latin America	Very likely
American Trypanosomiasis (Chagas disease)	Triatomine bug	100[7]	18 million	Central and South America	Likely
Dengue	Mosquito	1,800	10-30 million per year	All Tropical countries	Very likely
Yellow Fever	Mosquito	450	more than 5 000 cases per year	Tropical South America Africa	Likely

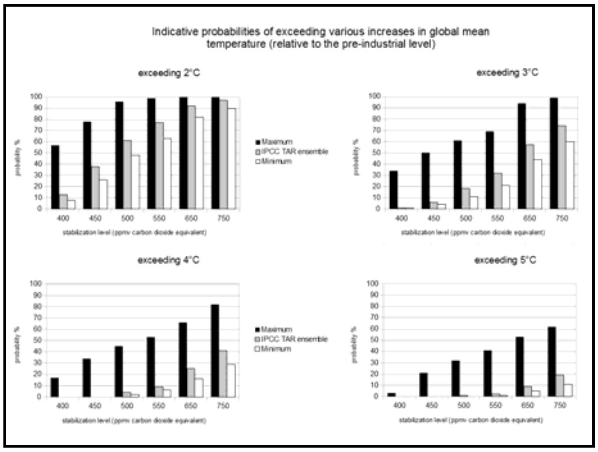
Highly likely · Very likely · Likely · Unknown

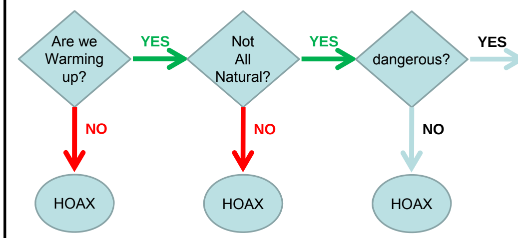
1. Top three entries are population-prorated projections, based on 1989 estimates.
2. WHO, 1994.
3. Michael and Bundy, 1995.
4. WHO, 1994.
5. Ranque, personal communication.
6. Annual incidence of visceral leishmaniasis; annual incidence of cutaneous leishmaniasis is 1-1.5 million cases/yr (PAHO, 1994).
7. WHO, 1995.

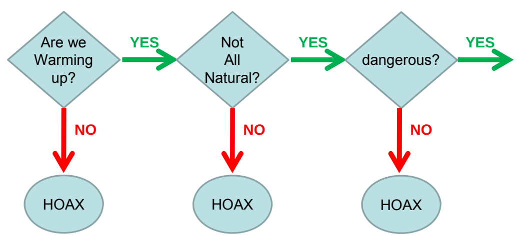
Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change. UNEP and WMO, Cambridge press university. 1996.

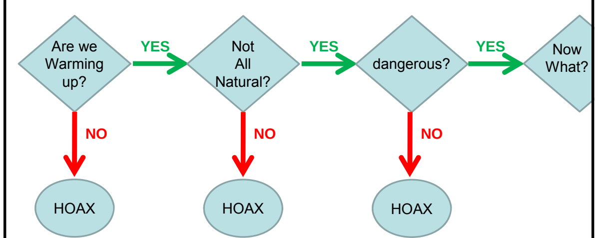
GRID Arendal UNEP





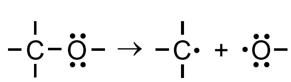






Covalent Bond Energy

- Covalent bond energy is measured by the energy required to break the bond.
- The bond enthalpy, Δ(X-Y) is the average ΔH for breaking one mole of X-Y bonds in the gas phase:



$\Delta(\text{C-O}) = \Delta H$
$= 358\ \text{kJ}$

- When one mole of X-Y bonds is formed, the enthalpy change is – ΔH(X-Y).

Bond Enthalpies and Bond Lengths

As bond order increases, the bond enthalpy increases **and the bond length decreases**.

Δ(C–C) = 348 kJ	0.154 nm
Δ(C=C) = 614 kJ	0.134 nm
Δ(C≡C) = 839 kJ	0.120 nm
Δ(C–O) = 358 kJ	0.143 nm
Δ(C=O) = 799 kJ	0.123 nm
Δ(C≡O) = 1072 kJ	0.113 nm

Bond Enthalpies and ΔH_{rxn}

Consider the reaction of H_2 and O_2 to form H_2O:

H–H + H–H + O=O

→ H–O–H + H–O–H

ΔH for breaking bonds = 2 Δ(H–H) + Δ(O=O)

ΔH for forming bonds = 4×- Δ(O–H)

ΔH_{rxn} = 2 Δ(H–H) + Δ(O=O) - 4 Δ(O–H)

$\Delta H = \sum \Delta$(bonds broken) - $\sum \Delta$(bonds formed)

Bond Enthalpies and ΔH_{rxn}

Estimate ΔH for the combustion of CH_4:

CH_4 (H–C–H with H above and below) + 2 O=O

→ O=C=O + 2 H–O–H

ΔH = 4 Δ(C–H) + 2 Δ(O=O)

- 2 Δ(C=O) - 4 Δ(O–H)

= [4(413) + 2(495) - 2(799) - 4(463)] kJ

= -808 kJ

Comparing fuels

- **Natural gas**:
  $CH_4 + 2O_2 \rightarrow CO_2 + 2\ H_2O$
  ΔH=-**808** kJ/mol
- **Coal**:
  $C + O_2 \rightarrow CO_2$
- **Oil**:
  $C_{20}H_{42} + 30½O_2 \rightarrow 20CO_2 + 21\ H_2O$

Comparing fuels

- **Natural gas**:
  $CH_4 + 2O_2 \rightarrow CO_2 + 2\ H_2O$
  ΔH=-**808** kJ/mol
- **Coal**:
  $C + O_2 \rightarrow CO_2$
  ΔH=-**393.5** kJ/mol
- **Oil**:
  $C_{20}H_{42} + 30½O_2 \rightarrow 20CO_2 + 21\ H_2O$

Comparing fuels

- **Natural gas**:
  $CH_4 + 2O_2 \rightarrow CO_2 + 2\ H_2O$
  ΔH=-**808** kJ/mol
- **Coal**:
  $C + O_2 \rightarrow CO_2$
  ΔH=-**393.5** kJ/mol
- **Oil**:
  $C_{20}H_{42} + 30½O_2 \rightarrow 20CO_2 + 21\ H_2O$
  ΔH=-13315 kJ/mol
  ΔH=-**666** kJ/mol.CO_2

Comparing fuels

Production of 1 GigaJoule of energy releases:

- **Natural gas**:
  (10^9 J ÷ 808,000 J/mol) x 0.044 kg/mol =
  54.5 kg CO_2

Comparing fuels

Production of 1 GigaJoule of energy releases:

- **Natural gas**:
  (10^9 J ÷ 808,000 J/mol) x 0.044 kg/mol =
  54.5 kg CO_2
- **Coal**:
- **Oil**:

Comparing fuels

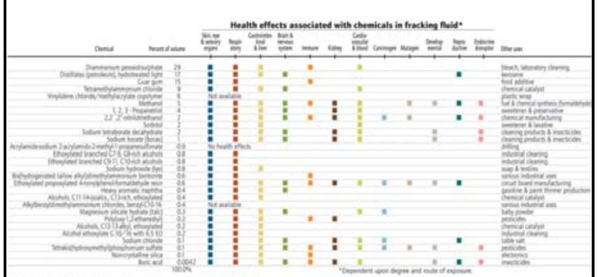
Production of 1 GigaJoule of energy releases:

- **Natural gas**:
  (10^9 J ÷ 808,000 J/mol) x 0.044 kg/mol =
  54.5 kg CO_2
- **Coal**:
  112 kg CO_2
- **Oil**:
  66 kg CO_2

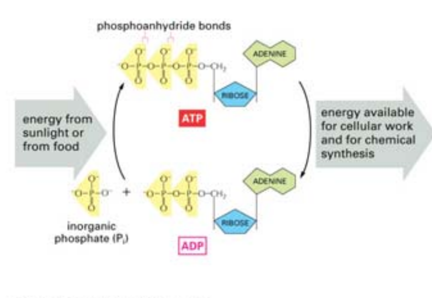
- **Natural gas**:
  $CH_4 + 2O_2 \rightarrow CO_2 + 2\ H_2O$
  ΔH=-808 kJ/mol
- **Coal**:
  $C + O_2 \rightarrow CO_2$
  ΔH=-393.5 kJ/mol
- **Oil**:
  $C_{20}H_{42} + 30½O_2 \rightarrow 20CO_2 + 21\ H_2O$
  ΔH=-13315 kJ/mol
  ΔH=-666 kJ/mol.CO_2

Production of 1 GigaJoule of energy

- **Natural gas**:
  54.5 kg CO_2
- **Coal**:
  112 kg CO_2
- **Oil**:
  66 kg CO_2

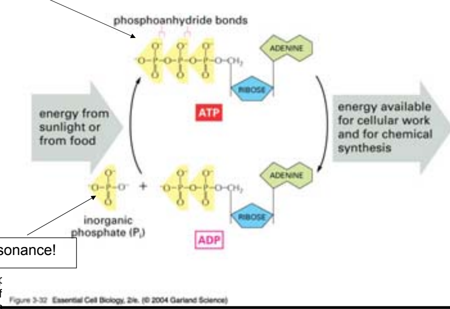


ATP energy



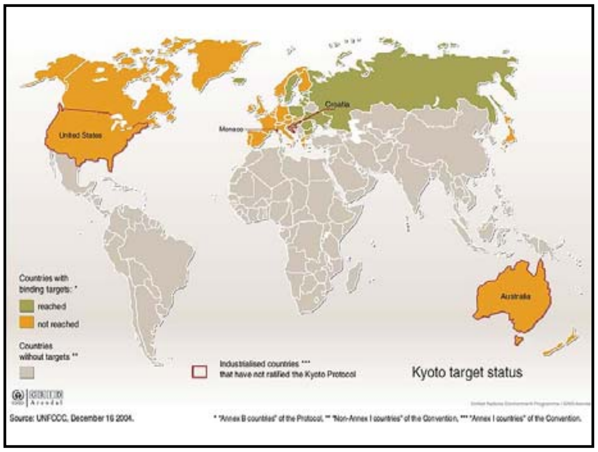
ATP energy

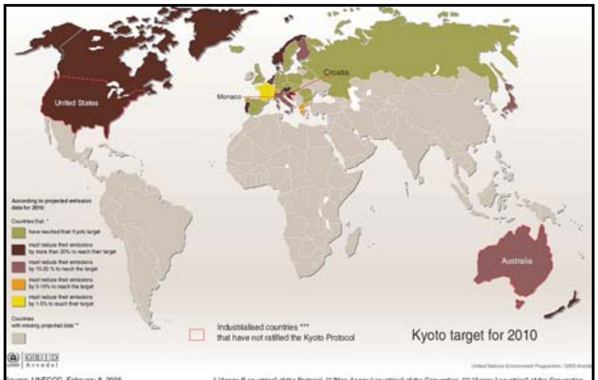
Repulsion weakens these bonds

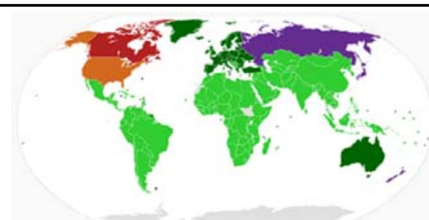


Resonance!

Cop
Miff

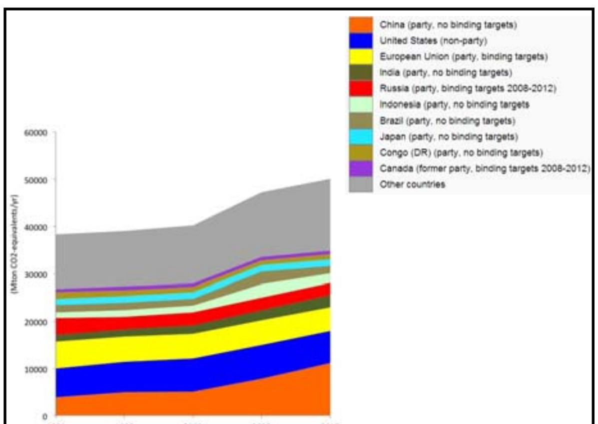


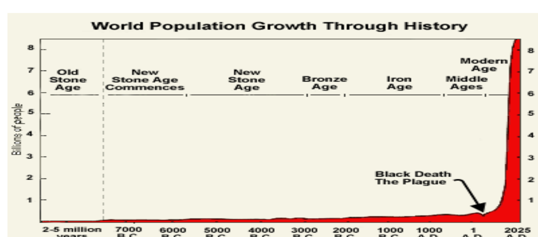




Kyoto Protocol participation map
(commitment period: 2013-2020)

- Parties; Annex I & II countries with binding targets
- Parties; Developing countries without binding targets*
- States not Party to the Protocol
- Signatory country with no intention to ratify the treaty, with no binding targets[1]
- Countries that have renounced the Protocol, with no binding targets*[2]
- Parties with no binding targets in the second period, which previously had targets*[3]





October 12, 1999: 6 billion!

December, 2012: 7 billion!

Now doubling every 61 years

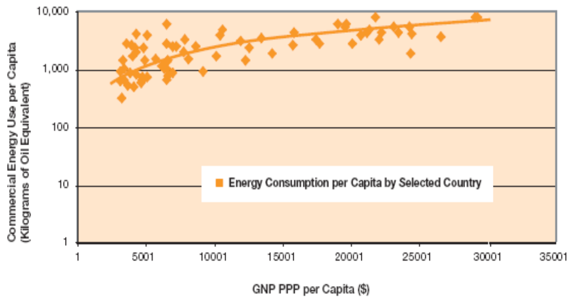


Figure 2. Energy Consumption Has a Strong Link with National Income.

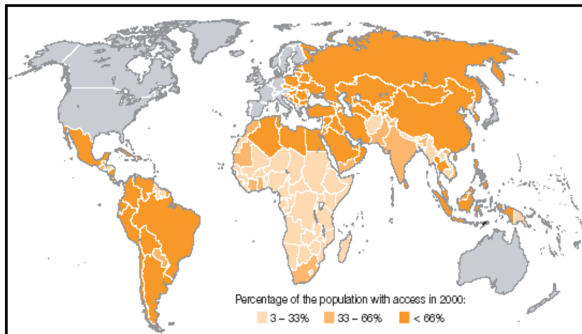
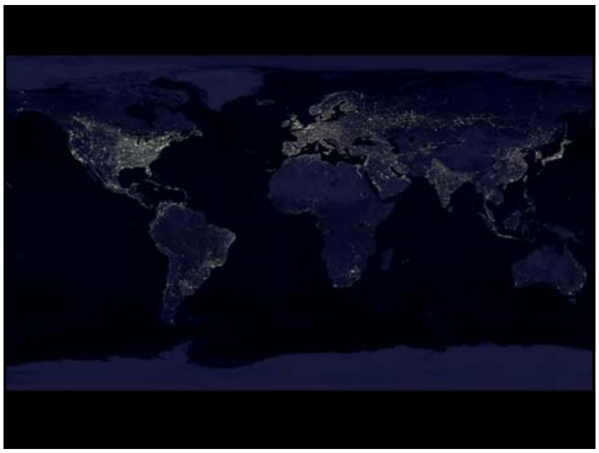
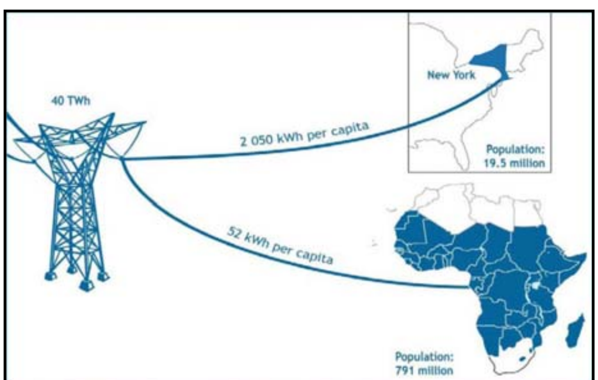


Figure 1. Many People in Developing Countries Lack Electricity.





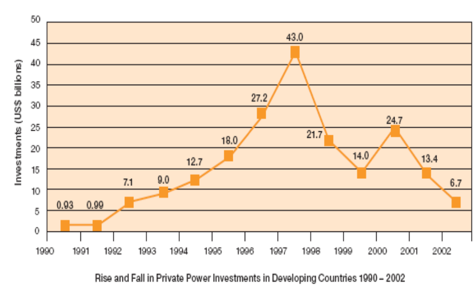
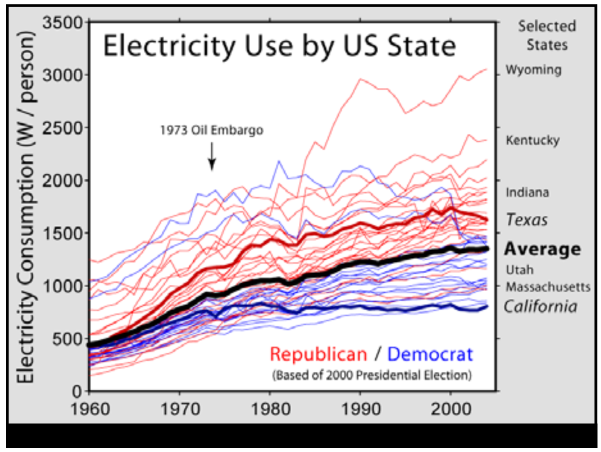


Figure 4. Trends in Private Investments in Electricity in Developing Countries 1990-2002 (US$ billions)

1000 kilowatt-hours of electricity is equivalent to the average amount of electricity consumed per month by:

- 1 resident of the United States.
- 2.3 residents of Europe.
- 7.6 residents of Mexico.
- 7.4 residents of South America.
- 12.35 residents of the Far East
- 26.3 residents of Africa.

.



1000 kilowatt-hours of electricity is equivalent to the energy stored in each of the following:

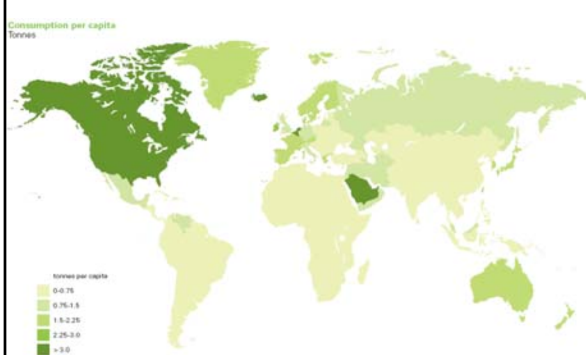
- 574 **fast-food meals** .
- 34 **pieces of firewood**.
- 28.5 **gallons of gasoline**.
- 274**pounds of coal.**
- 34 **therms of natural gas** .
- **lead-acid battery weighing 61110 pounds.**

1000 kilowatt-hours of electricity production emits the following pollutants:

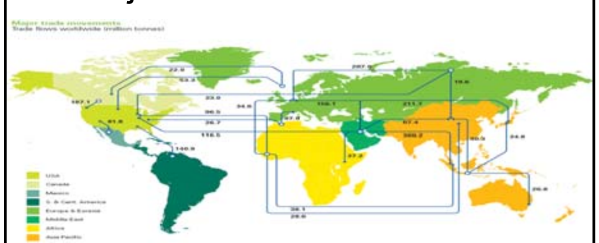
	Kg	Ping pong balls
CO_2	782.5	14960000
SO_2	1.9	35900
NO_X	1.6	30530

And require 422 gallons of cooling water

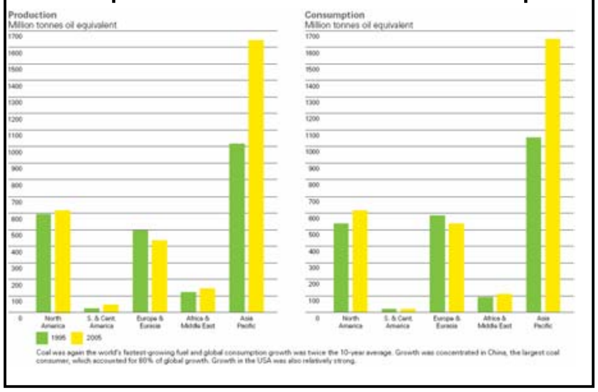
Oil consumption per capita

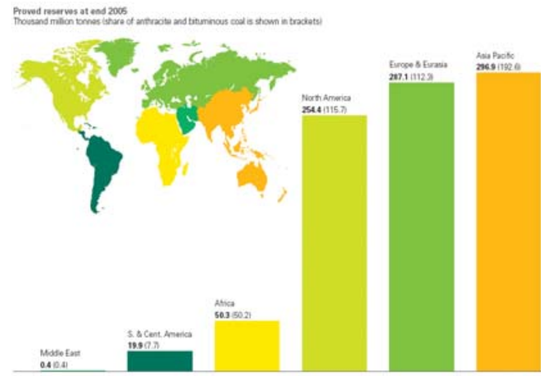


Major oil trade movements

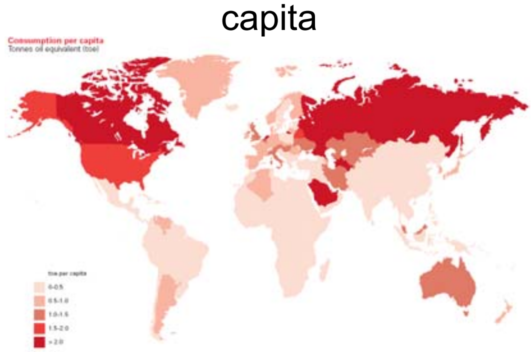


Coal production - Coal consumptior

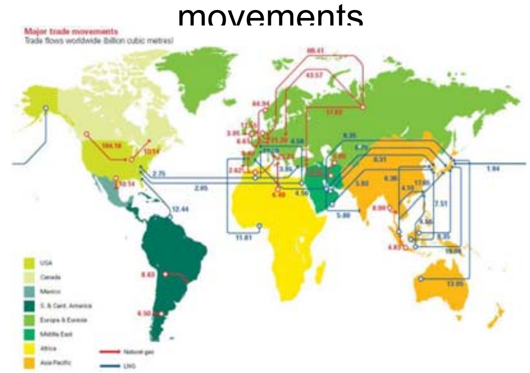


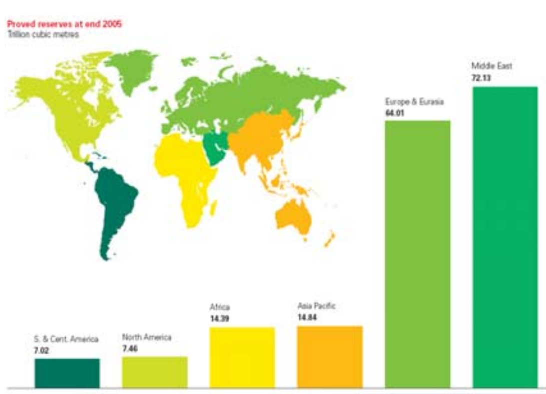


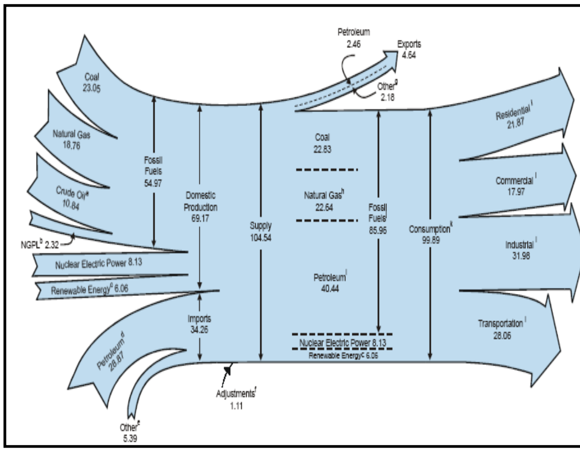
Natural gas consumption per capita

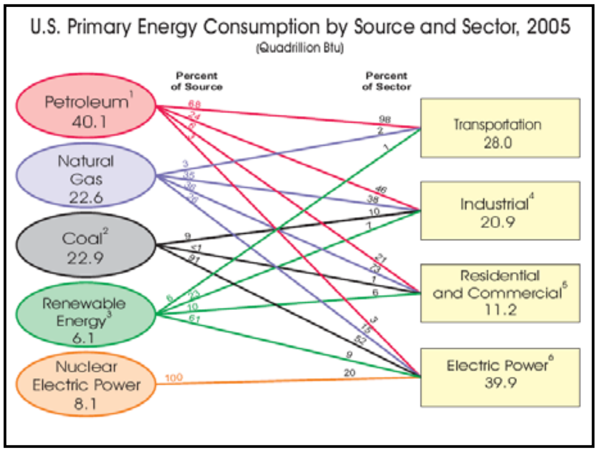


Major natural gas trade movements

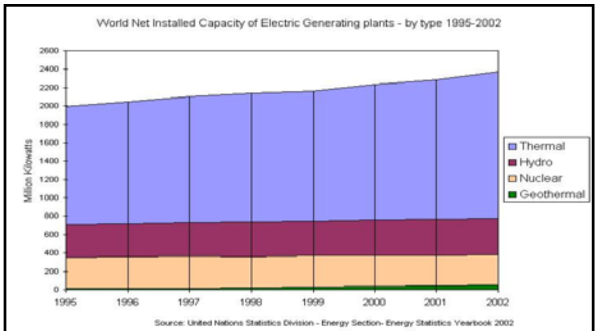






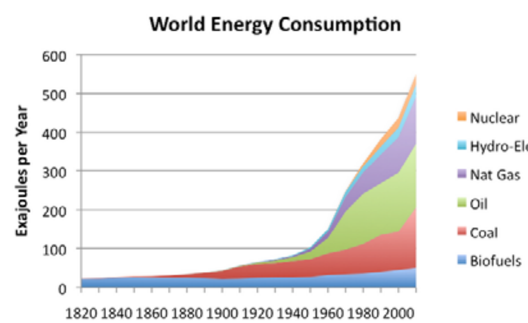


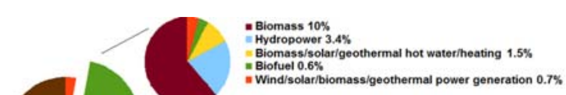
1000^m	10^n	Prefix	Symbol	Short scale	Long scale	Decimal
1000^8	10^{24}	yotta-	Y	Septillion	Quadrillion	1 000 000 000 000 000 000 000 000
1000^7	10^{21}	zetta-	Z	Sextillion	Trilliard	1 000 000 000 000 000 000 000
1000^6	10^{18}	exa-	E	Quintillion	Trillion	1 000 000 000 000 000 000
1000^5	10^{15}	peta-	P	Quadrillion	Billiard	1 000 000 000 000 000
1000^4	10^{12}	tera-	T	Trillion	Billion	1 000 000 000 000
1000^3	10^9	giga-	G	Billion	Milliard	1 000 000 000
1000^2	10^6	mega-	M	Million		1 000 000
1000^1	10^3	kilo-	k	Thousand		1 000
$1000^{2/3}$	10^2	hecto-	h	Hundred		100
$1000^{1/3}$	10^1	deca-	da	Ten		10
1000^0	10^0	(none)	(none)	One		1
$1000^{-1/3}$	10^{-1}	deci-	d	Tenth		0.1
$1000^{-2/3}$	10^{-2}	centi-	c	Hundredth		0.01
1000^{-1}	10^{-3}	milli-	m	Thousandth		0.001
1000^{-2}	10^{-6}	micro-	μ	Millionth		0.000 001
1000^{-3}	10^{-9}	nano-	n	Billionth	Milliardth	0.000 000 001
1000^{-4}	10^{-12}	pico-	p	Trillionth	Billionth	0.000 000 000 001
1000^{-5}	10^{-15}	femto-	f	Quadrillionth	Billiardth	0.000 000 000 000 001
1000^{-6}	10^{-18}	atto-	a	Quintillionth	Trillionth	0.000 000 000 000 000 001
1000^{-7}	10^{-21}	zepto-	z	Sextillionth	Trilliardth	0.000 000 000 000 000 000 001
1000^{-8}	10^{-24}	yocto-	y	Septillionth	Quadrillionth	0.000 000 000 000 000 000 000 001



~ 2 TerraWatts = 2 x 10^{12} Watts (2000 million K)

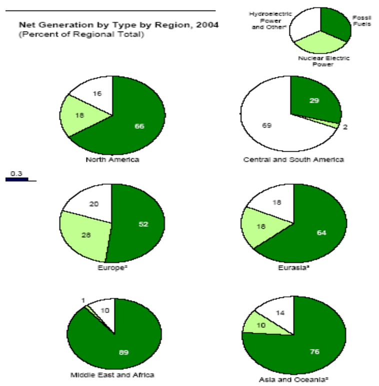
Per Year: 2 x 10^{12} x (60x60x24x365) = ~ 60 x 10^{18} Joules = 60 ExaJoules

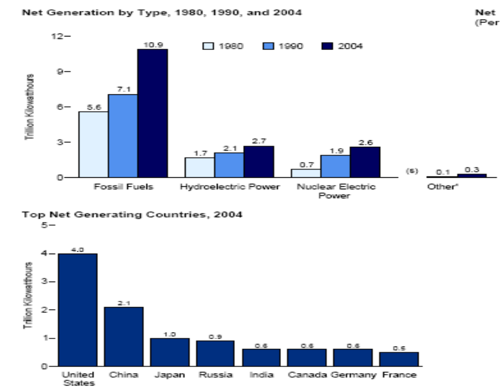




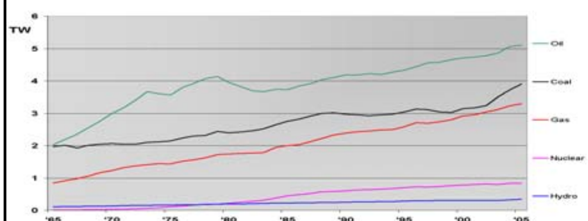
Total World Energy Consumption by Source (2009)

Limiting the global temperature rise at 2%, considered as a high risk level by the Stockholm Environmental Institute, **demands 75% decline in carbon emissions in the industrial countries by 2050**





World energy consumption



In 2009, world energy consumption decreased for the first time in 30 years (-1.1%) or 130 Mtoe (Megaton oil equivalent), as a result of the financial and economic crisis (GDP drop by 0.6% in 2009).

This evolution is the result of two contrasting trends. Energy consumption growth remained vigorous in several developing countries, specifically in Asia (+4%). Conversely, in OECD, consumption was severely cut by 4.7% in 2009 and was thus almost down to its 2000 levels.

In North America, Europe and CIS, consumptions shrank by 4.5%, 5% and 8.5% respectively due to the slowdown in economic activity. China became the world's largest energy consumer (18% of the total) since its consumption surged by 8% during 2009 (from 4% in 2008).

Oil remained the largest energy source (33%) despite the fact that its share has been decreasing over time. Coal posted a growing role in the world's energy consumption: in 2009, it accounted for 27% of the total.

In 2008, total worldwide energy consumption was 474 exajoules (474×10^{18} J=132,000 TWh). This is equivalent to an average annual power consumption rate of 15 terawatts (1.504×10^{13} W)

The potential for renewable energy is:
- solar energy 1600 EJ
- wind power 600 EJ
- geothermal energy 500 EJ
- biomass 250 EJ
- hydropower 50 EJ
- ocean energy 1 EJ

More than half of the energy has been consumed in the last two decades since the industrial revolution, despite advances in efficiency and sustainability.

According to IEA world statistics in four years (2004–2008) the world population increased 5%,

annual CO_2 emissions increased 10% and gross energy production increased 10%.

Most energy is used in the country of origin, since it is cheaper to transport final products than raw materials.

In 2008 the share export of the total energy production by fuel was:
- oil 50%
- gas 25%
- hard coal 14%
- electricity 1%

The term solar constant is the amount of incoming solar electromagnetic radiation per unit area, measured on the outer surface of Earth's atmosphere, in a plane perpendicular to the rays. The solar constant includes all types of solar radiation, not just visible light.

It is measured by satellite to be roughly 1366 watts per square meter, though it fluctuates by about 6.9% during a year—from 1412 W m^{-2} in early January to 1321 W m^{-2} in early July, due to the Earth's varying distance from the sun.

For the whole Earth, with a cross section of 127,400,000 km^2, the total energy rate is 174 petawatts (1.740×10^{17} W), plus or minus 3.5%.

This value is the total rate of solar energy received by the planet; about half, **89 PW, reaches the Earth's surface.**

Per hour: $3600 \times 89 \times 10^{15} = 3 \times 10^{20}$ J

Earth electricity use per year 70 EJ = 7×10^{19} J

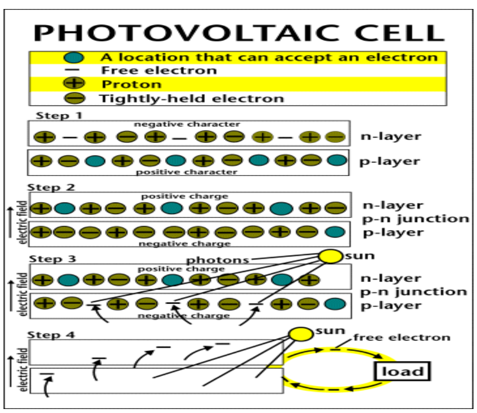
Total surface area of earth $\approx 5.1 \times 10^{14}$ m^2
Land $\approx$ 25% $\approx 1.3 \times 10^{14}$ $m^2 \approx$ 13 Gha

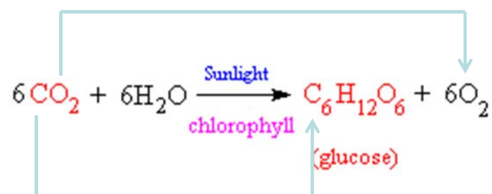
(1 hm = 10^2 m; 1 ha = 1 hm^2 = 10^4 m^2)

Need a fraction of 1 hr/ I year = 1/(24x365) = ~ 10^{-4}

This is ~ 5×10^{10} m^2 = 50,000 km^2
Or~ 200 x200 km

NB: India: 3.3×10^6 km^2





$$E = \frac{11880}{\lambda[nm]} \text{ kJ/mol}$$

$$\lambda = 675 \text{ nm}$$

$$\rightarrow \text{E=176 kJ/mol}$$

NB: Reduction of CO_2 requires 480 kJ/mol

2 photosystems:
8 photons /cycle.
QY for each step can approach 100%
8 mol of red photons:

$$E = \frac{11880}{\lambda[nm]} \text{ kJ/mol}$$

$\lambda = 675$ nm

$\rightarrow$ E=176 kJ/mol

8E=1408 kJ/mol

---

2 photo systems:
8 photons /cycle.
QY for each step can approach 100%
8 mol of red photons: 1400 kJ

---

2 photo systems:
8 photons /cycle.
QY for each step can approach 100%
8 mol of red photons: 1400 kJ
Reduce 1 mol of CO_2: 480 kJ
maximum efficiency: 34%
Realistically:
sugar cane: 1%
rice, potatoes, soybeans } 0.1%

PAR = photosyntehtically active radiation

400-700 nm --- 43%

8 PAR photons fix 1 CO_2

Total efficiency --- realistically about 0.25% on average

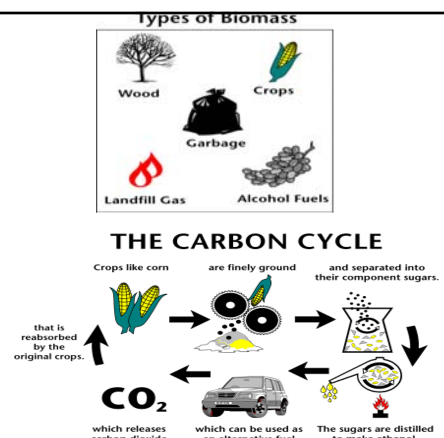
India: 3.3×10^6 km^2

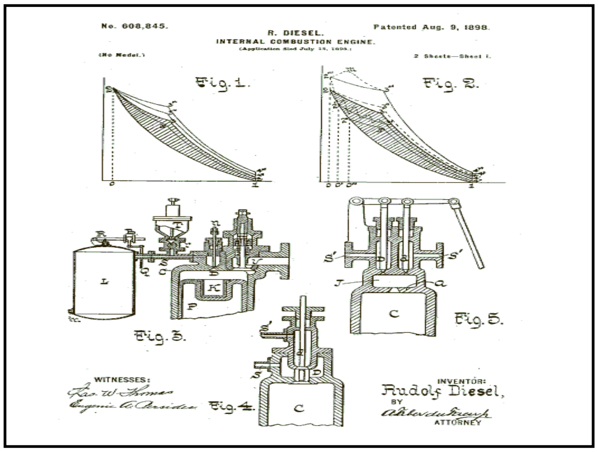
Plant 2/3 → 3.2×10^{19} J per year

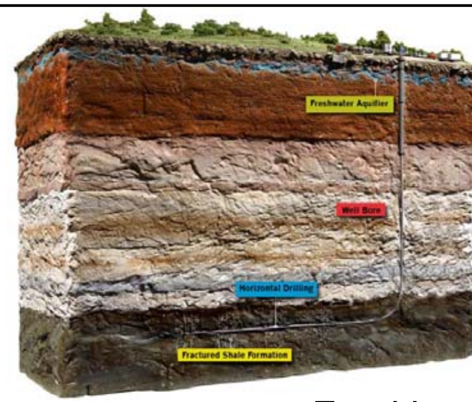
Approximate present land use:

	Million hectares
Total Land	13,000
Forest & savannah	4,000
Pasture & Range	3,100
Cropland	1,500
Total Food	4,600

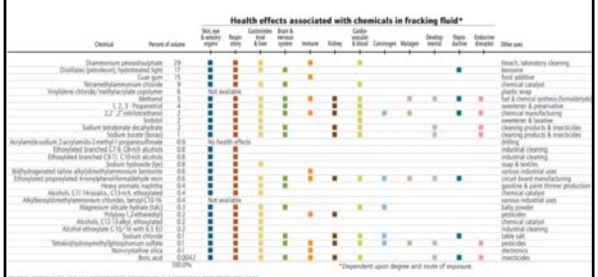
~11% of earth's surface produces food

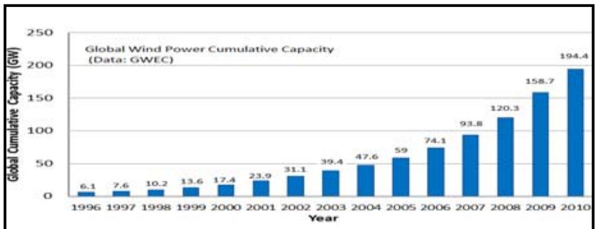


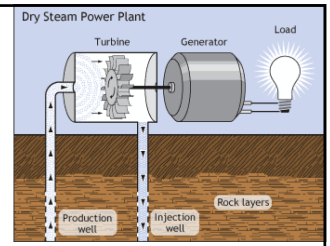




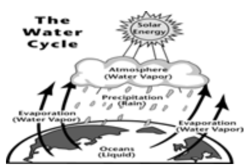
Fracking

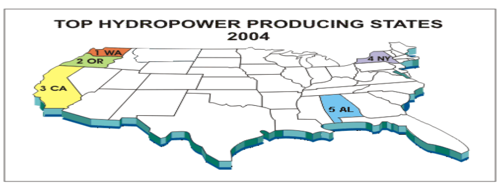

Health effects associated with chemicals in fracking fluid*

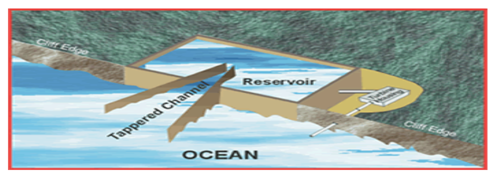

Global Wind Power Cumulative Capacity
(Data: GWEC)
Global Cumulative Capacity (GW)
250
200
150
100
50
0
6.1
7.6
10.2
13.6
17.4
23.9
31.1
39.4
47.6
59
74.1
93.8
120.3
158.7
194.4
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Year

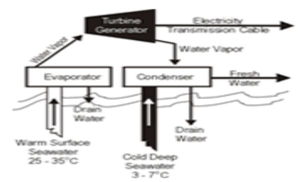

Dry Steam Power Plant
Turbine
Generator
Load
Rock layers
Production well
Injection well

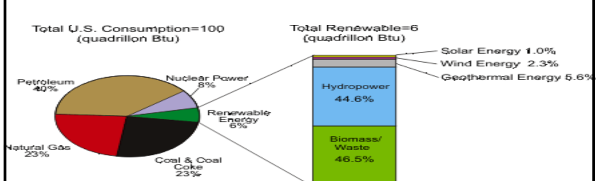

Ring of Fire
Europe
Asia
Africa
North America
Atlantic Ocean
Indian Ocean
Pacific Ocean
South America
Australia

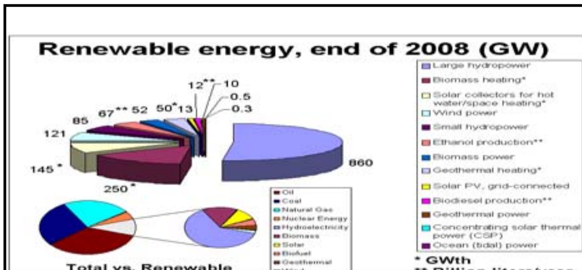

The Water Cycle
Solar Energy
Atmosphere (Water Vapor)
Precipitation (Rain)
Evaporation (Water Vapor)
Evaporation (Water Vapor)
Oceans (Liquid)


TOP HYDROPOWER PRODUCING STATES
2004
1 WA
2 OR
3 CA
4 NY
5 AL


Cliff Edge
Reservoir
Tappered Channel
OCEAN
Cliff Edge


Turbine Generator
Electricity Transmission Cable
Water Vapor
Water Vapor
Evaporator
Condenser
Fresh Water
Drain Water
Drain Water
Warm Surface Seawater 25 - 35°C
Cold Deep Seawater 3 - 7°C


Total U.S. Consumption=100 (quadrillion Btu)
Total Renewable=6 (quadrillion Btu)
Petroleum 40%
Nuclear Power 8%
Renewable Energy 6%
Natural Gas 23%
Coal & Coal Coke 23%
Solar Energy 1.0%
Wind Energy 2.3%
Geothermal Energy 5.6%
Hydropower 44.6%
Biomass/ Waste 46.5%


Renewable energy, end of 2008 (GW)
860
250 *
145 *
121
85
67 **
52
50 *
13
12 **
10
0.5
0.3
Total vs. Renewable
Large hydropower
Biomass heating*
Solar collectors for hot water/space heating*
Wind power
Small hydropower
Ethanol production**
Biomass power
Geothermal heating*
Solar PV, grid-connected
Biodiesel production**
Geothermal power
Concentrating solar thermal power (CSP)
Ocean (tidal) power
* GWth
** Billion liters/year

Silicon Valley Power
2011 POWER CONTENT LABEL

ENERGY RESOURCES	2011 SVP POWER MIX	2010 CA POWER MIX** (for comparison)
Eligible Renewable	**25.1%**	**13.7%**
-- Biomass & waste	0.4%	2.4%
-- Geothermal	2.8%	4.6%
-- Eligible Hydro	5.7%	1.7%
-- Solar	0.0%	0.3%
-- Wind	16.2%	4.7%
Coal	**12.9%**	**7.7%**
Large Hydro	**22.8%**	**10.8%**
Natural Gas	**16.1%**	**41.9%**
Nuclear	**0.0%**	**13.9%**
Other	**0.0%**	**0.0%**
Unspecified sources of power*	**23.1%**	**12.0%**
TOTAL	**100.0%**	**100.0%**

* "Unspecified sources of power" means electricity from transactions that are not traceable to specific generation sources.

** Percentages are estimated annually by the California Energy Commission based on the electricity sold to California consumers during the previous year.

For specific information about this electricity product, contact Silicon Valley Power. For general information about the Power Content Label, contact the California Energy Commission at 1-800-555-7794 or http://www.energy.ca.gov/sb1305/index.html

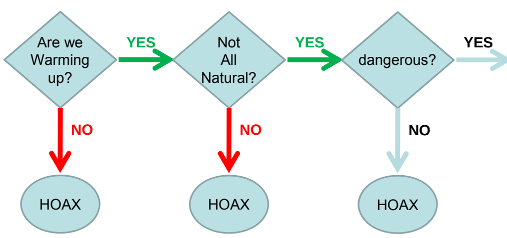
POWER CONTENT LABEL

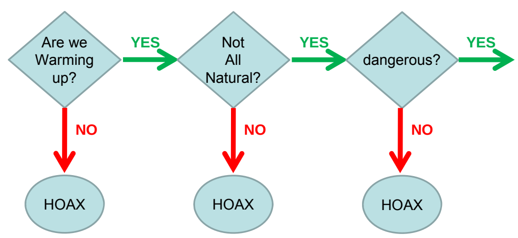
ENERGY RESOURCES	2011 SCE POWER MIX (Actual)	2011 CA POWER MIX**
Eligible Renewable	**19%**	**14%**
-- Biomass & waste	1%	2%
-- Geothermal	9%	5%
-- Small hydroelectric	1%	2%
-- Solar	1%	0%
-- Wind	7%	5%
Coal	8%	8%
Large Hydroelectric	7%	13%
Natural Gas	27%	37%
Nuclear	24%	16%
Other	0%	0%
Unspecified sources of power*	**15%**	**12%**
TOTAL	**100%**	**100%**

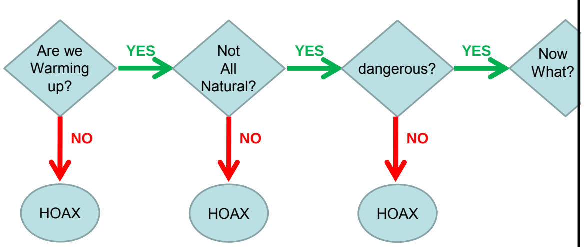
* "Unspecified sources of power" means electricity from transactions that are not traceable to specific generation sources.

** Percentages are estimated annually by the California Energy Commission based on the electricity sold to California consumers during the previous year.

For specific information about this electricity product, contact Southern California Edison. For general information about the Power Content Label, contact the California Energy Commission at 1-800-555-7794 or www.energy.ca.gov/consumer.







Available alternative energy estimates