Climate Change workshop on **Energy costs**

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A. Cost of imported oil in US?
B. Impact on environment if everyone uses energy at the US rate?
C. Cost to decentralize US electricity with renewable energy?
D. Availability of solar energy?

A. The USA uses 21 million barrels of crude oil per DAY, about half of it for gasoline. 60% of it is imported. A barrel of crude oil costs about $80 in 2006.

How much do we pay for imported gasoline?

$$\frac{21}{2}\times 10^{6}\,\frac{barrels}{day}\left(\frac{3}{5}\right)\$80 \sim \$480\,million/day\left|\frac{365\,days}{year}\right| \sim \$200\,billion/year$$

Compare this to the cost of the current US war in Iraq, estimated at $2 billion dollars per WEEK: $2 billion/week * 50 weeks/year ~ $100 billion/year. *(That war is not providing cheap oil after all, among other things.)*

B. What will be the impact on the environment if everyone uses energy at the US rate? The current burden, or amount of CO2 in the atmosphere, is about 380 ppm (and the historical peak over the last 5 ice ages was 280 ppm).

Data: World population ~ 6 billion people.
US emissions ~ 5 tons of C per person per year.
Global emissions now ~ 6 billion tons C/year.

If everyone used energy at the US rate, global emissions would be (Flux in ppm/yr)

$$\text{Flux} = 5*6 = 30\text{ billion tons C}/\text{year}\left|\frac{\sim 1\text{ppm CO}_2}{2\text{ billion tons C}}\right| \sim 15\text{ ppm CO}_2/\text{year}$$

Steady state: Assume that the Burden = Flux * Lifetime of CO_2 in atmosphere
Data: Lifetime of CO_2 in atmosphere = T ~ 100 years

$$Burden = \frac{15\,ppm}{yr}\times 100\,yr = 1500\,ppm$$

Half this amount of CO_2 in the atmosphere would be catastrophic, and a peak target of no greater than 580 ppm is recommended to avert global disaster.

Therefore the solution is not simply population control – it must involve significant DECREASES in CO2 emissions by the worst polluters.

C. What would be the cost to decentralize all US electricity generation with renewable energy?

Data: Number of people in the US ~ 300 x 10^6 = 3 x 10^8
Number of homes ~ 10^8

Estimate cost per home ~ $20,000 to outfit with solar panels, etc.

Total cost ~ \$2 x 10^4 * 10^8 ~ \$2 x 10^{12} = \$2000 billion

Compare this to the cost of war in Iraq: \$2 billion/week * 50 weeks/year = \$100 billion/year = \$$10^{2+9}$ = \$$10^{11}$. So it would take the budget for about \$2 x 10^{12} / \$$10^{11}$ = 20 years of war to convert all US homes to solar – quite a lot.

D. How much solar energy is available? Compare to current electricity use.

The power received by the Earth from the Sun = intensity * area = S* π R^2 (about half the Earth absorbs at a time, with an effective area equivalent to a disk), where the intensity of solar radiation received by the Earth is S = 1370 watts/m^2 and the radius of the Earth is R = 6.4 x 10^6 m.

$$\text{Power received} = 1370\frac{W}{m^2}\pi\left(6.4\times10^6 m\right)^2 \sim 2\times10^{17}W$$

If solar panels are about 10% efficient, then what fraction of the solar power incident on Earth would have to be harvested to meet our electricity needs?

Power available ~ 10^{16} W

Number of people on Earth ~ 6 x 10^9. Assume each person needs 2 kW for a good standard of living. Then we need a total of

Power needed = 6 x 10^9 * 2 x 10^3 W ~ 10^{13} W

Fraction of solar power we must harvest:

$$\frac{Power\ needed}{Power\ available} \sim \frac{10^{13}W}{10^{16}W} \sim 10^{-3} = 0.003 = 0.3\%$$

This would probably leave enough solar energy for growing plants and animals and keeping the biosphere happy.

Extra: How much area would it require in solar panels?