

Problem Set 6

1. Carbon footprint. John Average is a fairly typical American. Your job is to calculate his “carbon footprint” for him. His carbon footprint is the amount of greenhouse gases (in CO₂-eq) emitted every year as a result of his activities. John A provides you the following information:

- Home electricity use = 800 kWh/month. For simplicity assume half of this electricity comes from coal-fired power plants, one-quarter from natural gas, and one-quarter from non-emitting sources (hydro, nuclear, etc). Assume the power plants are 35% efficient.
 - Home natural gas use for cooking and heating = 40 therm/month
 - Driving = 1,000 miles per month; John’s car has a fuel economy of 20 mpg
 - Flying = 2 round trips each year, 2500 miles one-way; the plane uses jet fuel and gets 40 mpg per passenger
 - Household garbage = 20 pounds of solid waste per week, sent to a landfill.
- a) Make a table with two columns: (i) activity (ii) annual emissions in metric tons of CO₂-equivalent. For the first four items, calculate the CO₂ emissions. For the garbage, calculate the methane emissions and convert to CO₂-eq using a 100-year GWP. In your table, rank the activities in the order of emissions, highest first. What are John A’s total emissions based on this information?
- b) Compare John A’s emissions to US per capita emissions.
- c) Name two significant activities for GHG emissions that are (indirectly) part of everyone’s carbon footprint but not mentioned in the list above.

Data you’ll need:

(1) Find the emission factors (i.e. the mass of CO₂ produced per unit of energy, mass, or volume of fuel) for coal, natural gas, gasoline, and jet fuel at

<http://www.eia.doe.gov/oiaf/1605/coefficients.html>. For coal, use the value for bituminous, and for natural gas, use the weighted national average for pipeline natural gas.

(2) Emission factor for solid waste = 0.05 g CH₄ per 1 g solid waste (very approximate – the actual factor varies widely depending on the organic content, the amount of recycling, whether there is landfill methane capture, and other factors)

(3) For US per capita, see

<http://2010.census.gov/news/releases/operations/cb10-cn93.html>

<http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8>

2. Cloud effect on albedo: Read pages 89-91 in COW, and do Exercise 2 on page 92.

3. Sea level rise: This problem explores sea level rise due to anthropogenic global warming.

- a. The IPCC mean estimate of global average surface temperature change (ΔT_s) for a doubling of pre-industrial CO_2 is 3°C . Estimate the sea level rise due to thermal expansion of seawater that has an increase in temperature of 3°C . Assume the *coefficient of thermal expansion* of seawater is 1.5×10^{-4} per $^\circ\text{C}$ (the density of seawater decreases by a factor of 1.5×10^{-4} for each $^\circ\text{C}$ of temperature change). You can assume that the area of the oceans remains constant.
- b. Estimate the sea level rise that would result from the melting of 20% of the Greenland ice sheet. Greenland contains 10% of land ice. (Ignore any change in the area of the oceans). Compare this to the sea level rise from thermal expansion. Also: how much would sea level rise if all polar sea ice were to melt?