ATM S 111, Global Warming: Who's Responsible?

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Day 30: August 2, 2010

Today: Who's Responsible?

- How much are average emissions for:
  - Citizen of the world
  - Average American
  - Nations of the world
- Which sectors do emissions come from?
  - Transportation
  - Electricity generation
  - Industry
- "Carbon efficiency"

Carbon Dioxide vs Other Pollutants

- Most pollution is felt near the source
  - Air quality near urban centers or coal power plants
  - Water quality near mining, etc
- CO_2 is **not** like this!
  - Since CO_2 stays in the atmosphere for so long, everyone's emissions affect **everyone** else
    - Truly a global problem
- So it makes sense to think about **who's responsible**

How Much Carbon Dioxide Is There?

- Total amount of carbon dioxide in the atmosphere: 3000 gigatonnes
- World emissions: over 30 gigatons per year
  - 1 gigaton = 1 billion metric tons
    - And one metric ton is a little more than a regular ton (2000 pounds)

Gigatonnes…

- Confession: I hate dealing with really big numbers like this
  - I think they're hard to put into our everyday experience
  - Say a company advertises they cut emissions by 500 pounds of CO_2 per day: is this a lot or a little??
- It's important to know the numbers too, but let's first talk about an easier way to visualize emissions

The “Carbon Blanket”

- What if all the CO2 in the atmosphere sank to the surface of the Earth and was in one layer of gas
  - Forming a carbon blanket all over the globe
- It would be 3.2 meters (10.5 feet) thick
  - Preindustrial (1750) thickness was 2.3 m (7.5 feet)
  - 1990 thickness was 2.9 m (9.5 feet)

Adding to the Carbon Blanket

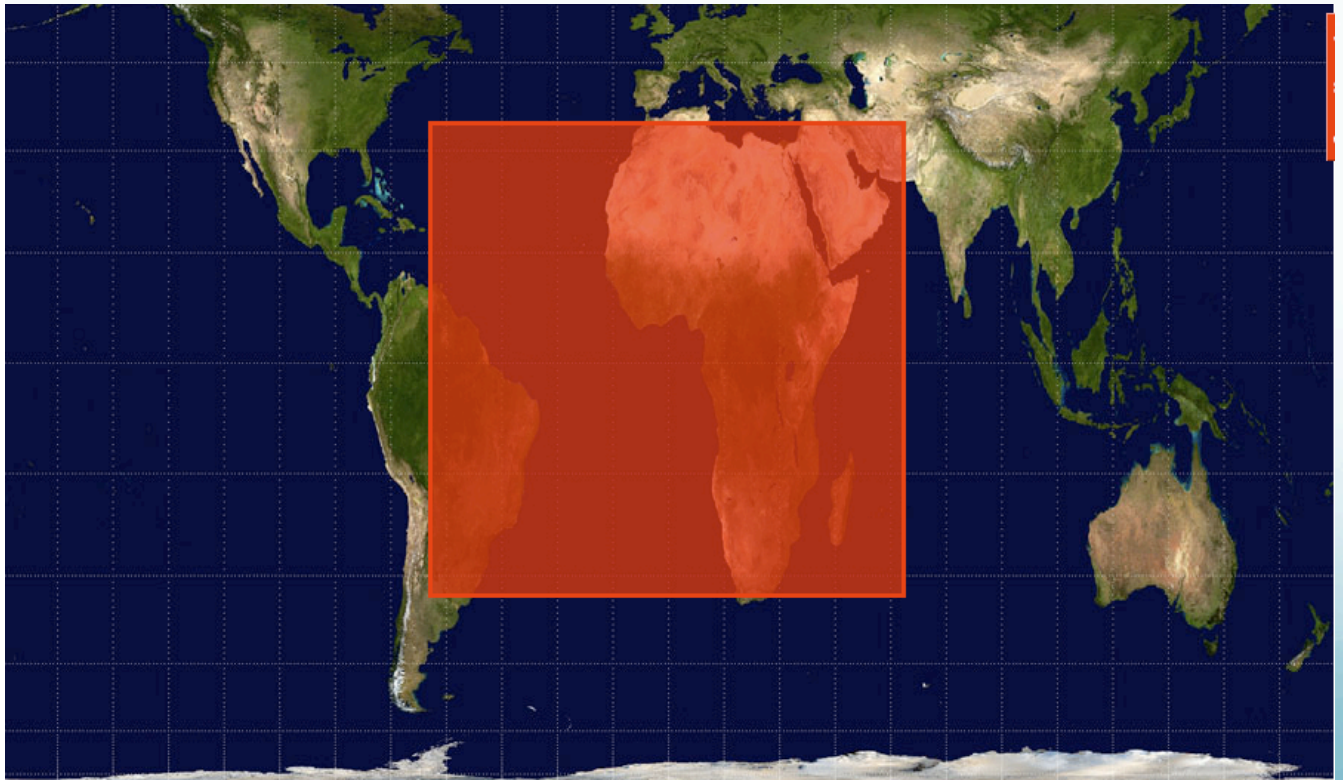
- Each year we emit the equivalent of 3.2 cm (1.26 inches) to the blanket
  - A little over a foot per decade…

What Happens to CO_2 Emissions?

- Not all of those emissions go into the atmosphere though
  - A little less than 50% does actually…
- 25% goes into the ocean
  - Unfortunately this leads to ocean acidification (a future topic)
- 30% goes into land ecosystems
- So around 6 inches per decade is added into the blanket…

Pieces of the Blanket: China

- We can divide up the quilt into sections based on who's doing the emitting...
  - Note: my numbers are from 2006 (CDIAC), while the book uses 2004 data



China: 20.2%

6.1 gigatons per year

Source of images: carbonquilt.org

USA

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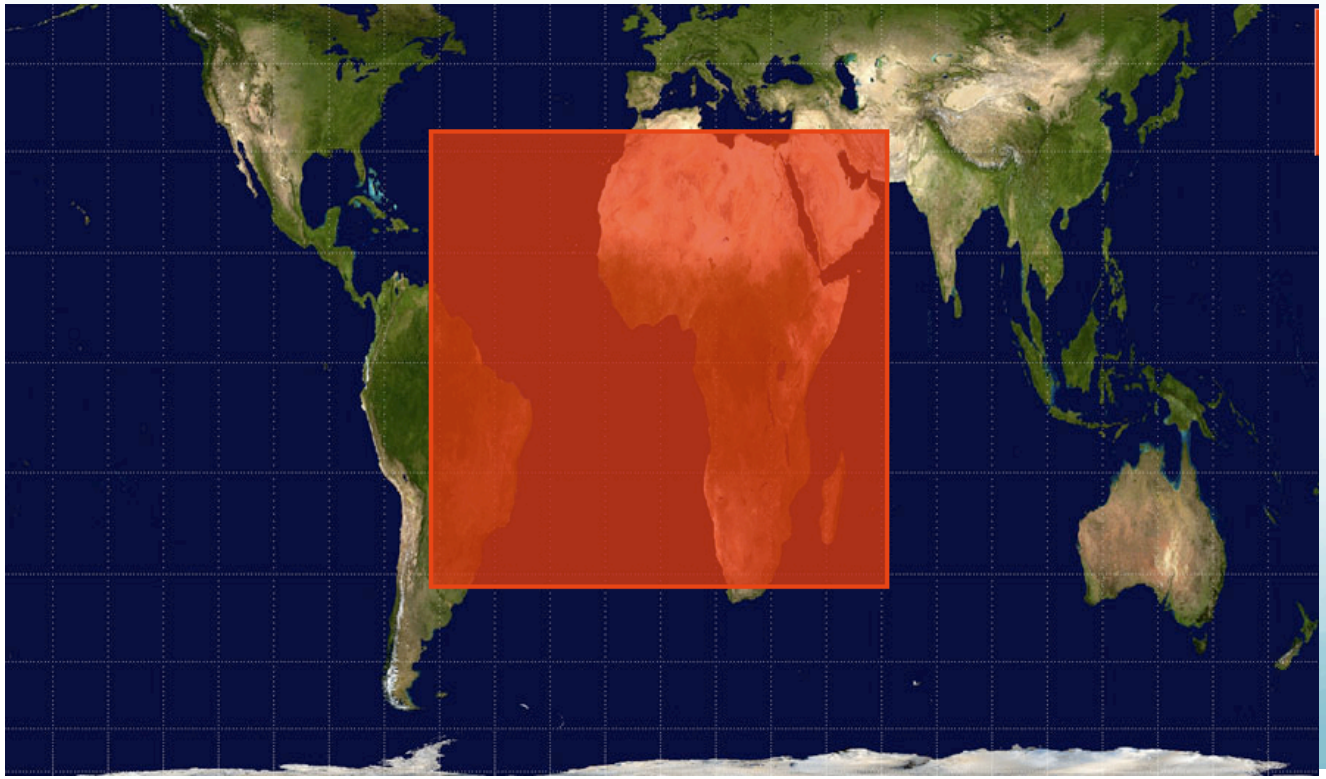

USA: 19.2%

5.8 gigatons per year

Source of images: carbonquilt.org

Canada

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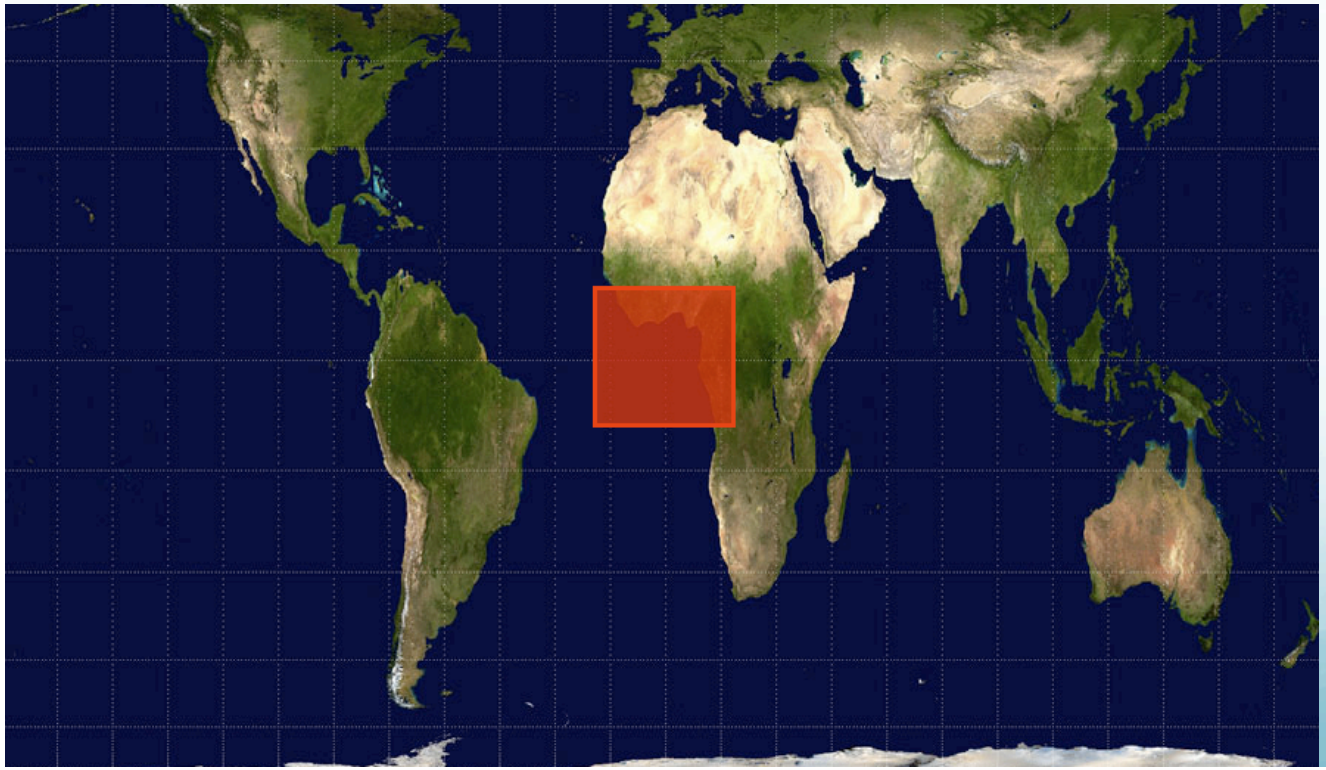

Canada: 1.6%

0.5 gigatons per year

Source of images: carbonquilt.org

Bangladesh

- We can divide up the quilt into sections based on who's doing the emitting...
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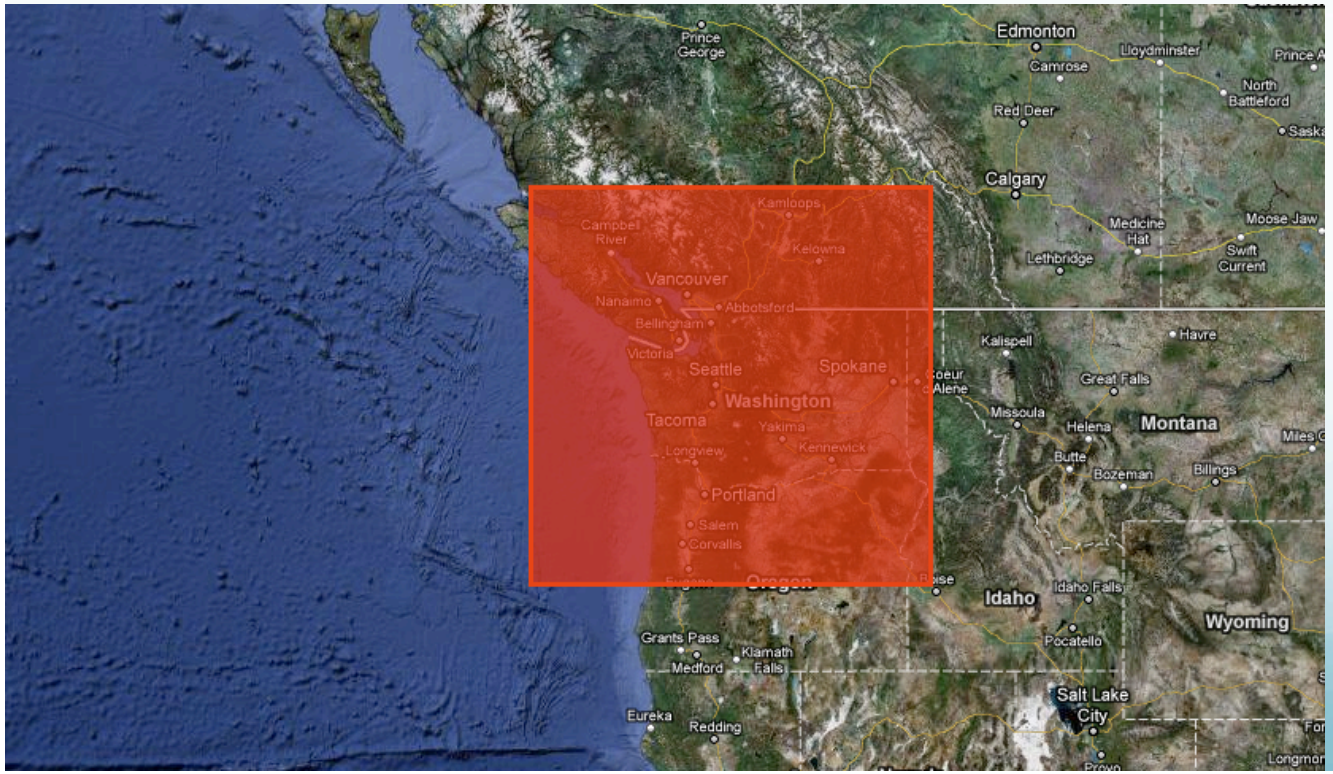

Bangladesh: 0.1%

41 million tons per year

Source of images: carbonquilt.org

Somalia

- We can divide up the quilt into sections based on who's doing the emitting...
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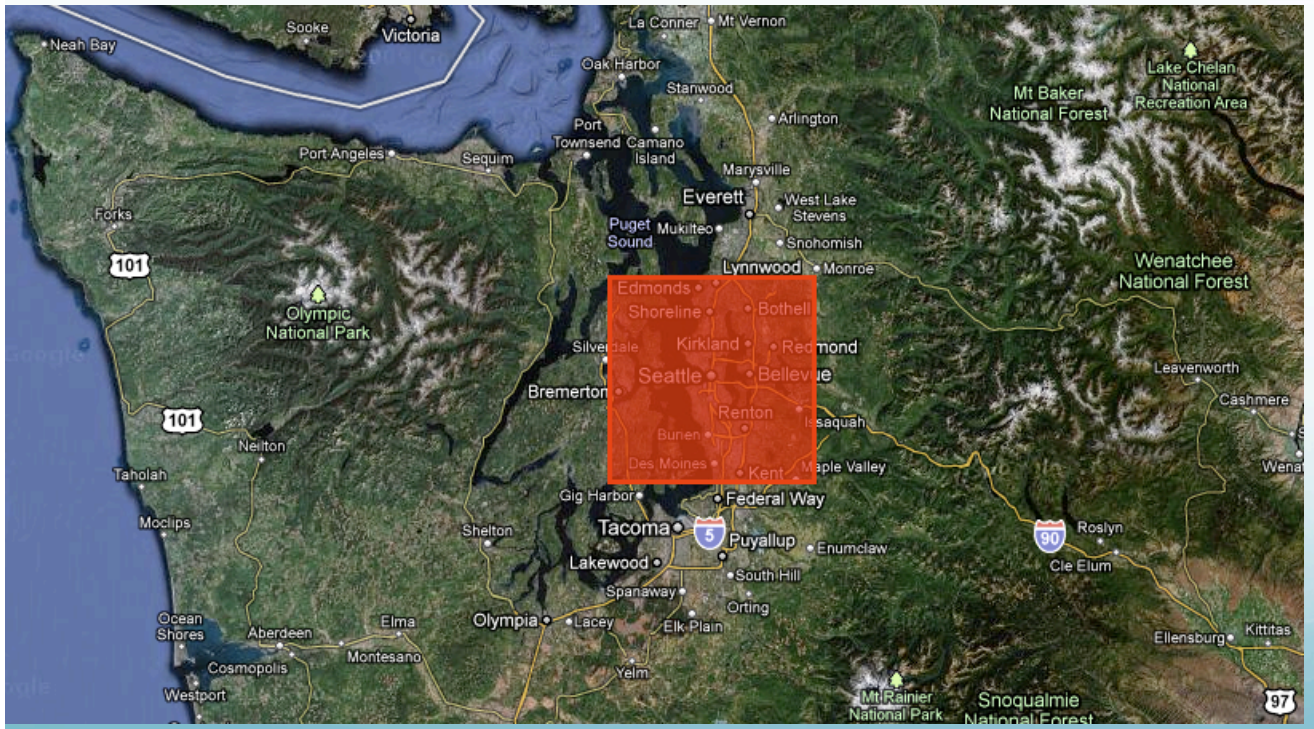


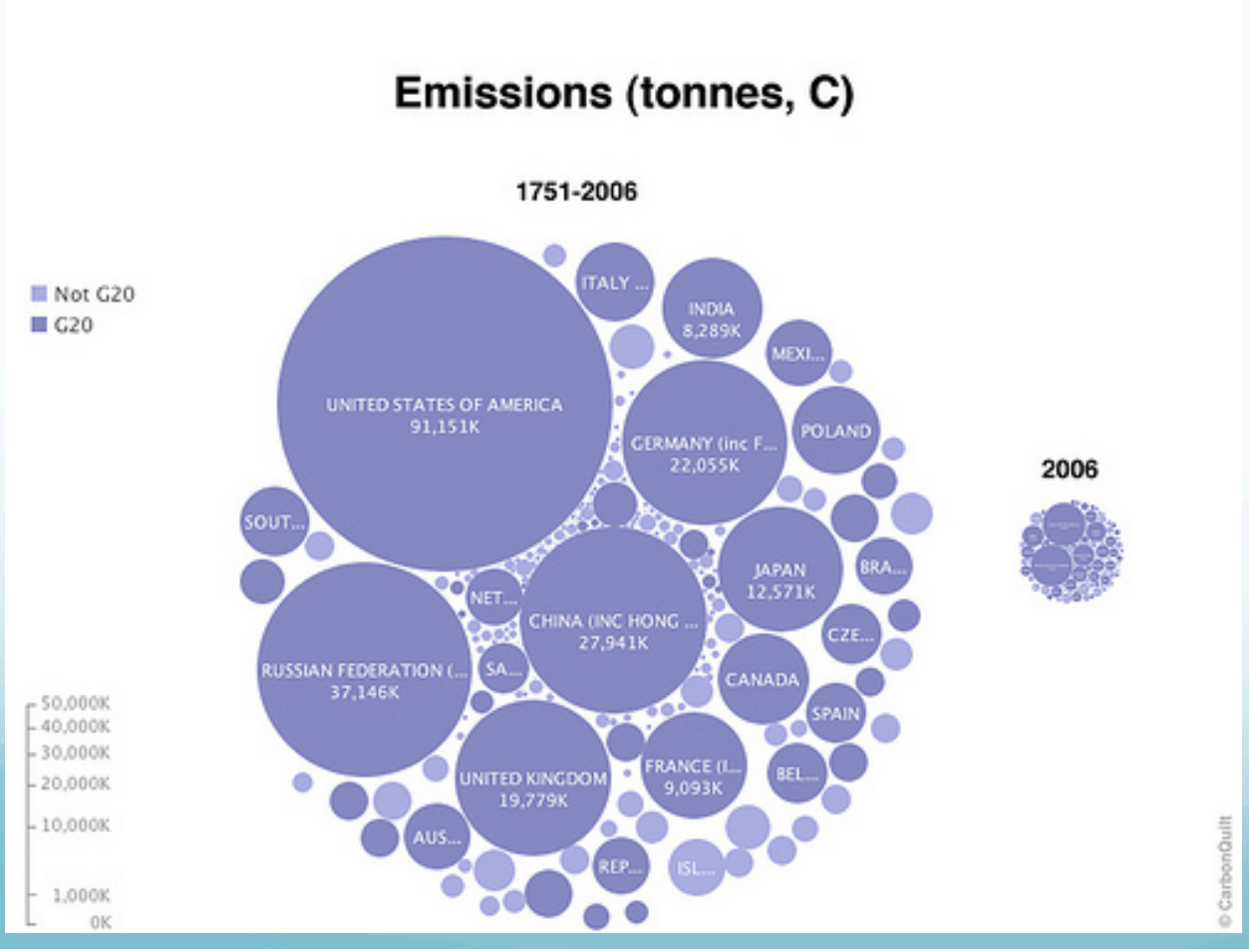
Somalia: 0.0004%

172 thousand tons per year

Source of images: carbonquilt.org

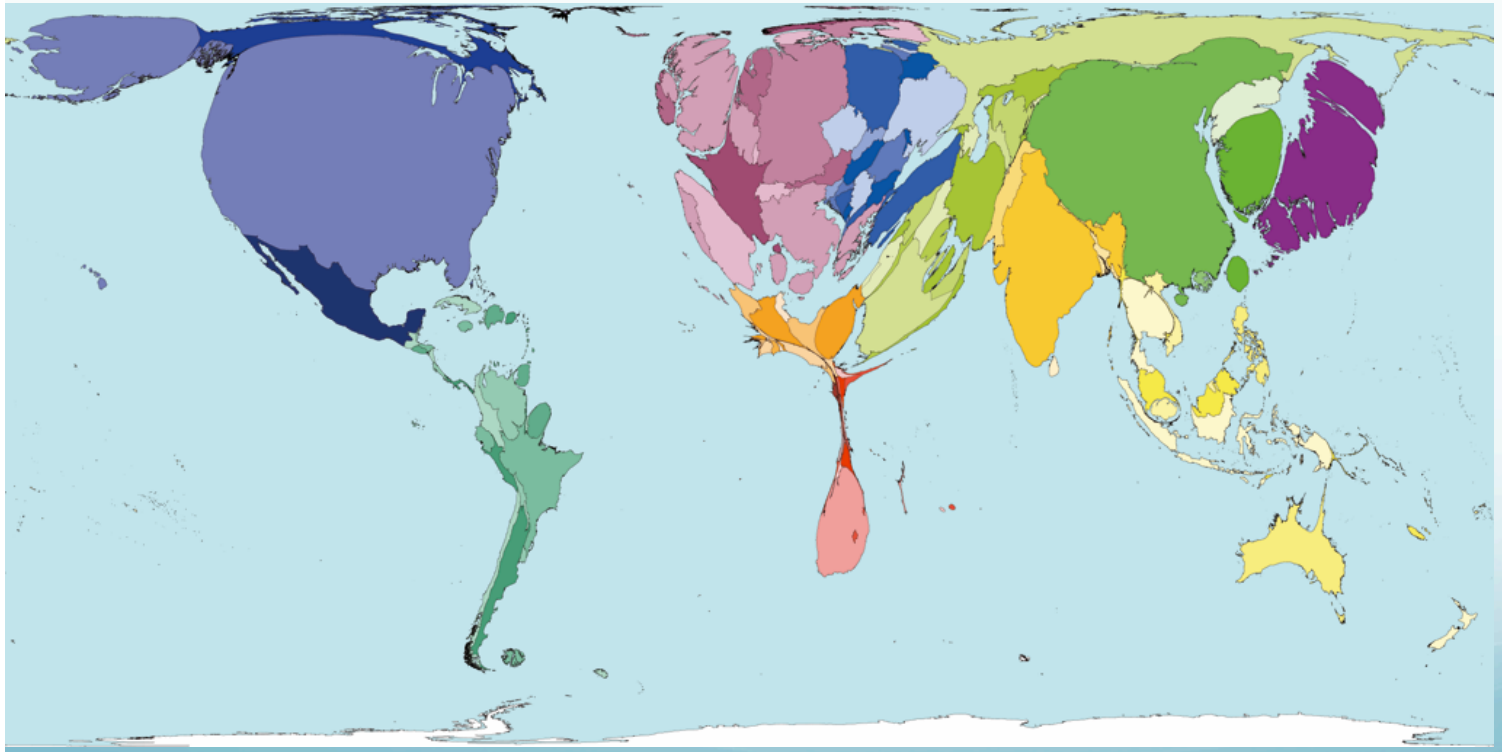
Cumulative Emissions

- Since CO_2 has a long lifetime, a more accurate carbon quilt would be divided by cumulative emissions.
- Carbonquilt.org doesn't have this option…



National Emissions

- Another way to look at national carbon dioxide emissions
  - Area of each country is made proportional to its emissions



Source of images: WorldMapper

Per capita emissions

- **Note:** The book has a typo in the figure on page 41 (columns 2 and 3)
  - Should be mass of **carbon** instead of mass of **carbon dioxide**
  - Multiply by 3.67 to get the right numbers for mass of carbon dioxide

Individual Share: World Average

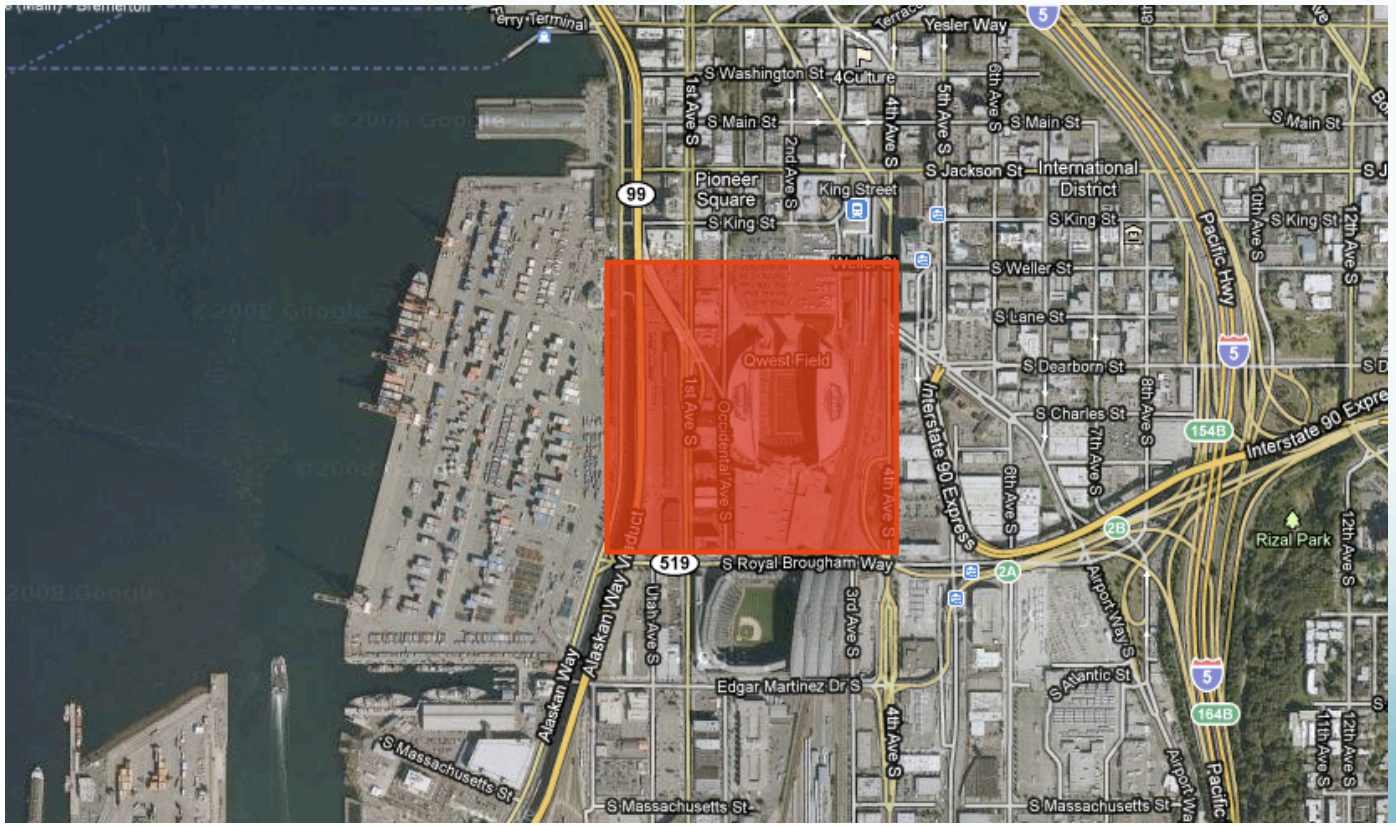
- Per capita matters though
  - Some of these countries are so large because they have large populations

World per capita emissions:
4.6 tonnes per year

Over 25 pounds per day

Our Individual Share: USA

- Per capita matters
  - Some of these countries are so large because they have large populations

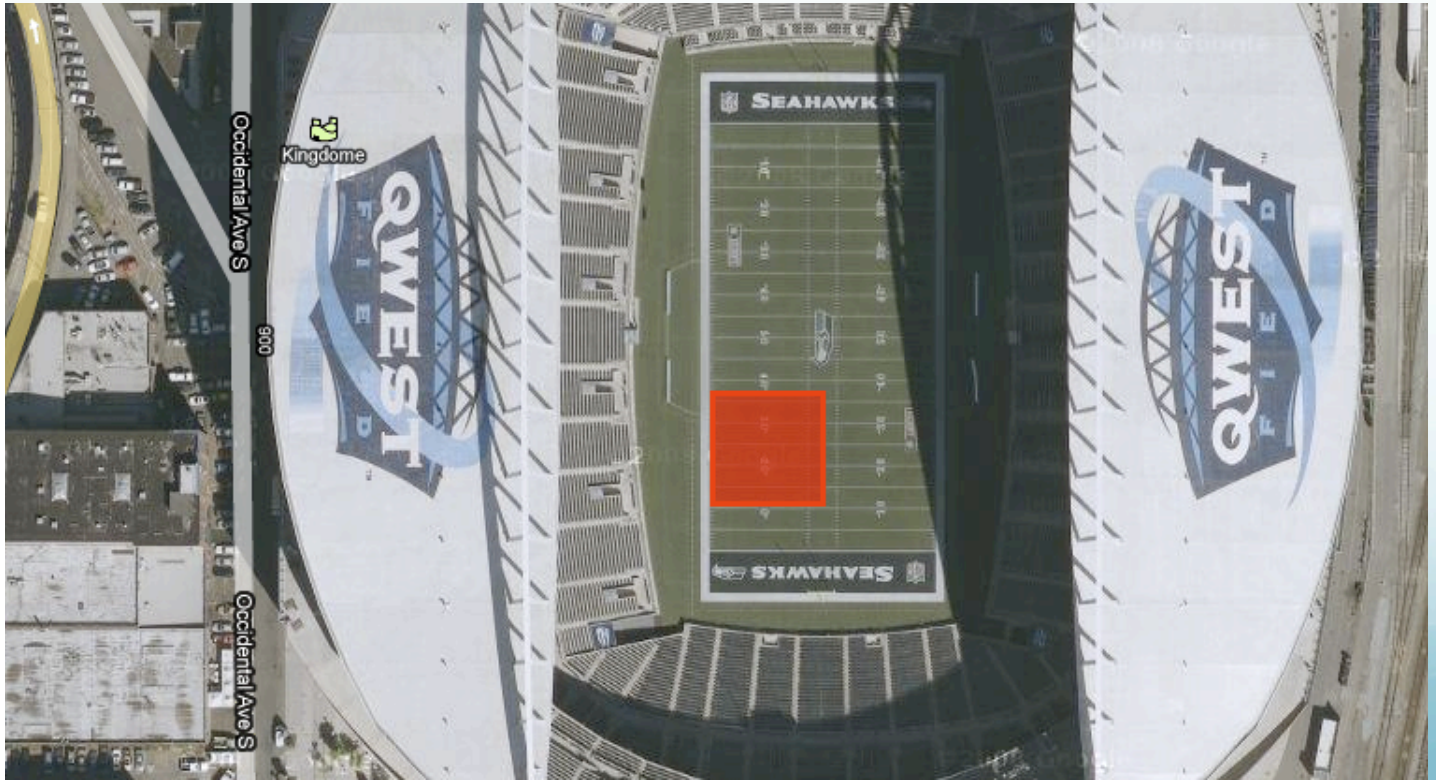


USA per capita emissions:
19 tonnes per year

Over 100 pounds per day

Our Individual Share: Somalia

- Per capita matters though
  - Some of these countries are so large because they have large populations



Somalia per capita emissions:
37 kg per year

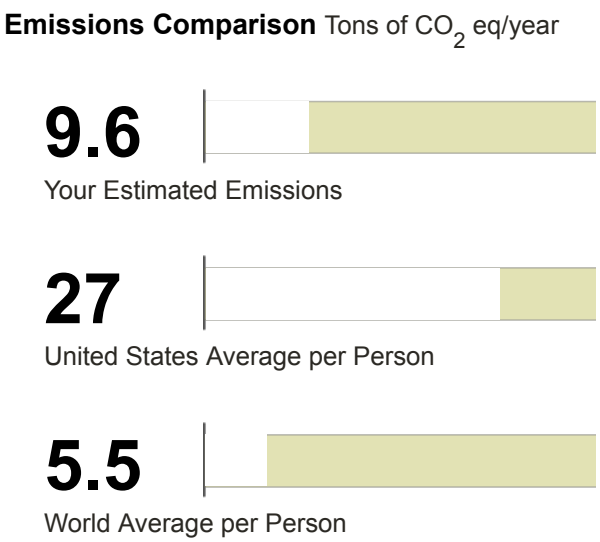
Less than 100 pounds per year

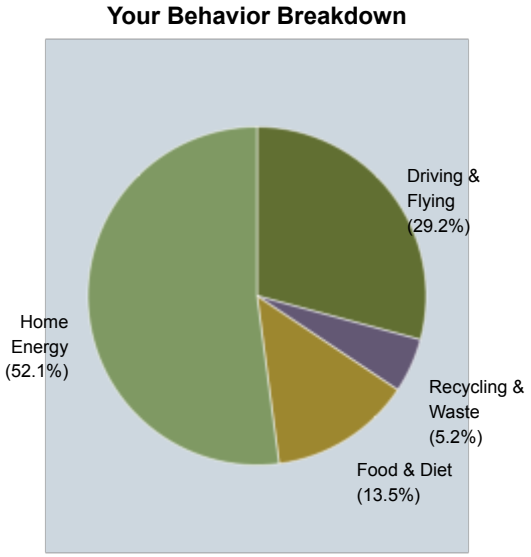
Problems with per capita

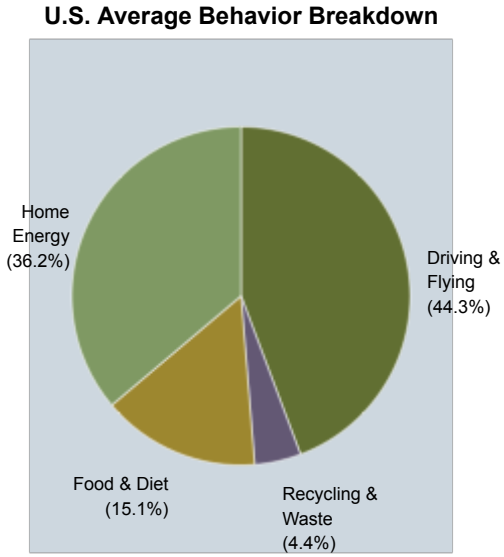
- Measuring emissions per capita is more fair to countries that have large emissions because they have large populations.
- But there are huge variations on individuals' contributions within countries.
- Ex: My carbon footprint...

Problems with per capita

- Variations from the national average can be huge.
- Much of this is due to climate and electricity sources (both work in my favor).
- Lifestyle choices can have some impact.
- Another important determinant of carbon footprint...

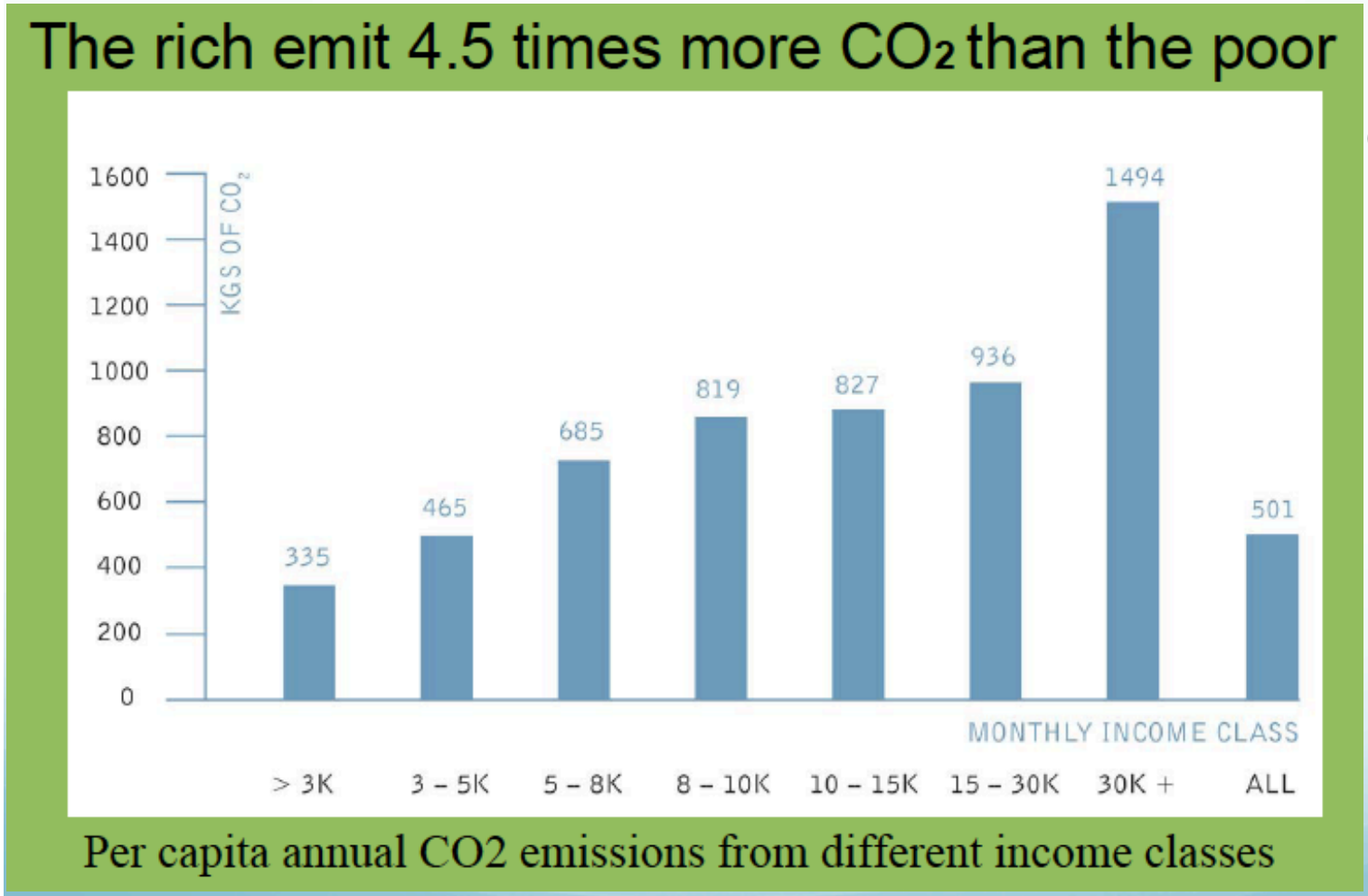






Problems with per capita

- Within a given country, the wealthiest have a much larger ecological footprint than the poor.



From a survey (by Greenpeace) of 819 Indian households.

Problems with per capita

- Within a given country, the wealthiest have a much larger ecological footprint than the poor.
- This is the case in developed countries as well as developing ones.

TABLE 1 Canadian household consumption and ecological footprint (GHA/CAP)

	Poorest 10%	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6
Food	2.06	2.15	2.14	2.14	2.14	2.16
Housing	1.51	1.82	1.79	1.73	1.88	1.98
Mobility	0.36	0.62	0.88	1.04	1.20	1.43
Goods	0.56	0.74	0.82	0.85	0.93	1.00
Services	0.55	0.68	0.71	0.74	0.79	0.82
Size of ecological footprint	**5.03**	**5.66**	**6.34**	**6.48**	**6.93**	**7.36**

	Decile 7	Decile 8	Decile 9	Richest 10%	Total consumption
Food	2.15	2.16	2.13	2.24	2.13
Housing	2.06	2.19	2.31	3.40	2.16
Mobility	1.55	1.74	2.17	3.23	1.43
Goods	1.09	1.16	1.33	2.11	0.97
Services	0.83	0.89	0.95	1.48	0.74
Size of ecological footprint	**7.67**	**8.12**	**8.87**	**12.42**	**7.49**

From the Canadian Centre for Policy Alternatives, 2008

Note this is *ecological* footprint (in hectares), not carbon footprint

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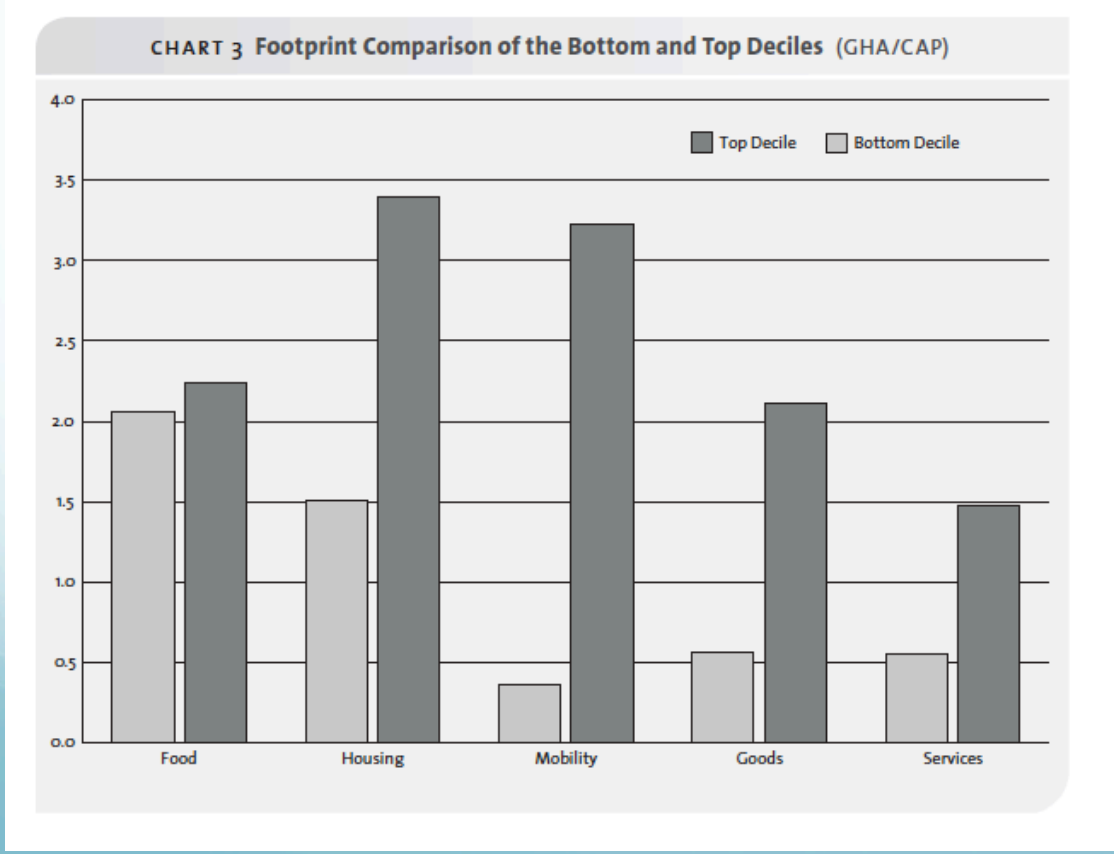
Problems with per capita

- In Canada, travel and housing account for the greatest difference (rich people have big houses and travel a lot).
- Little difference in food consumption.



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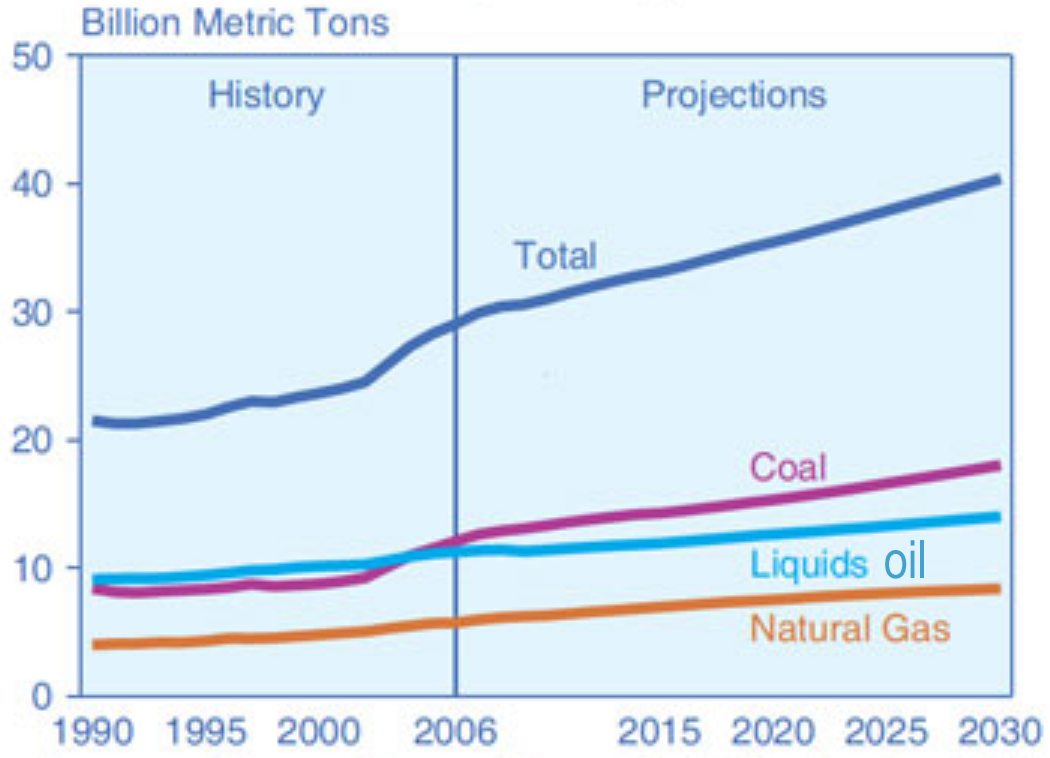
And Canadians in the poorest 10% still have 3x the ecological footprint of the average Chinese (7x the average Indian)

What Makes Up the Emissions?

Figure 81. World Energy-Related Carbon Dioxide Emissions by Fuel Type, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2006* (June-December 2008), web site www.eia.doe.gov/iea. **Projections:** EIA, World Energy Projections Plus (2009).

Burning one gallon of gas = 8.7 kg of CO_2

Coal and oil makes up 80% of worldwide emissions

Oil for transportation
Coal for electricity

What Makes Up the Emissions?

- Primary sources:
  - Industry: 40%
  - Transportation: 22%
  - Buildings: 30%
  - Agriculture: 4%

US Emissions Sources

- Electricity: 42%
- Transportation: 32%
- Industry: 15%
- Residential: 6%
- Commercial: 4%

- 2008 data, EPA

US Emissions Sources

- If you distribute electricity use into the other sectors:
- Transportation: 32%
- Industry: 27%
- Residential: 21%
- Commercial: 19%

- 2008 data, EPA

Trends in Energy Use

- Industry is getting more efficient
- Residential is getting worse
  - Partially due to significantly larger home sizes
- Transportation is getting worse
  - More cars on the roads, longer driving distances

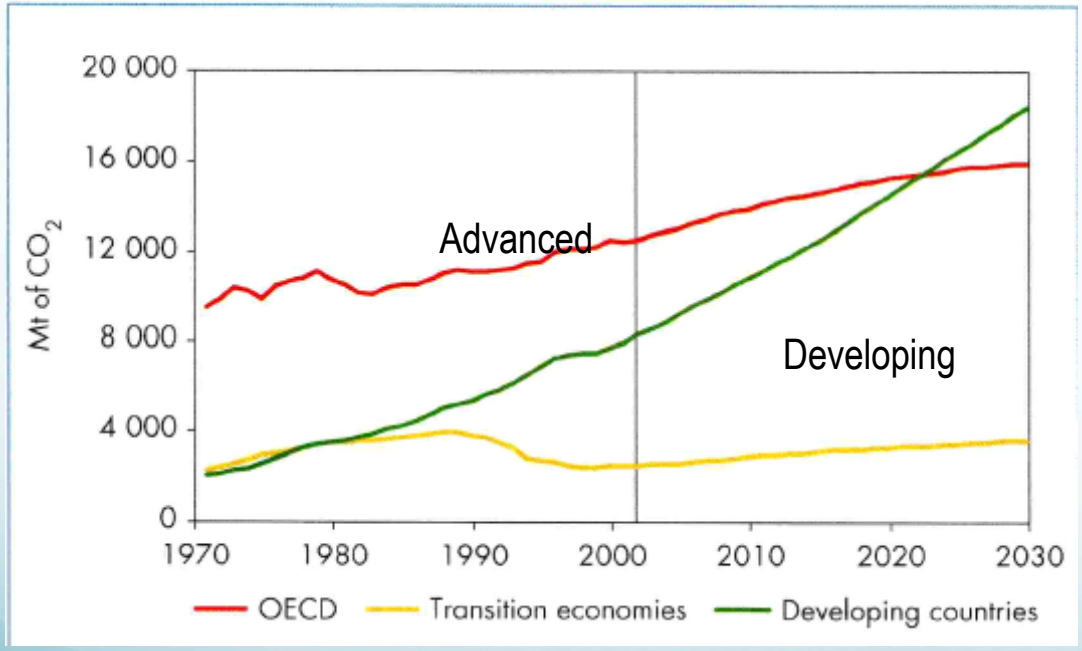
Measuring Emissions

- Different ways to cut up the emissions pie
  - Total emissions of a country
    - Countries with large population (China, US) tend to be high
  - Per capita emissions
    - US is still high here!
  - Per economic output emissions
    - The **developed** world appears much lower on this list as compared with the per capita emissions list

Future of Emissions for Developing Nations

- In around 20 years, the developing world will surpass developed countries in CO_2 emissions

Figure 2.15: **World Energy-Related CO_2 Emissions by Region**



Developing nations will be a massive energy market in the future...
What fuels will they use?
(this plot assumes no additional regulations)

OECD = Organization for Economic Cooperation and Development
includes 30 countries, mostly industrialized

How About in Seattle?

- Recent study by Brookings Institution says Seattle is 6th best in the country (5.7 tons CO_2 each per year)
  - Hydroelectric power means small electricity emissions
  - Relatively mild climate means small home heating
  - Surprisingly, Los Angeles was #2 in this study
- Study did not include industrial emissions, or airplane travel
  - Also only CO_2, no methane, etc
  - No emissions associated with where we get food & goods either

Discussion Questions

- How should emissions be quantified –
  - for measuring reductions?
  - for thinking about who is responsible for global warming?
- What factors in a person's carbon footprint are within their control? For those that aren't, is it possible to change that so that we *do* have more control over our carbon footprint?