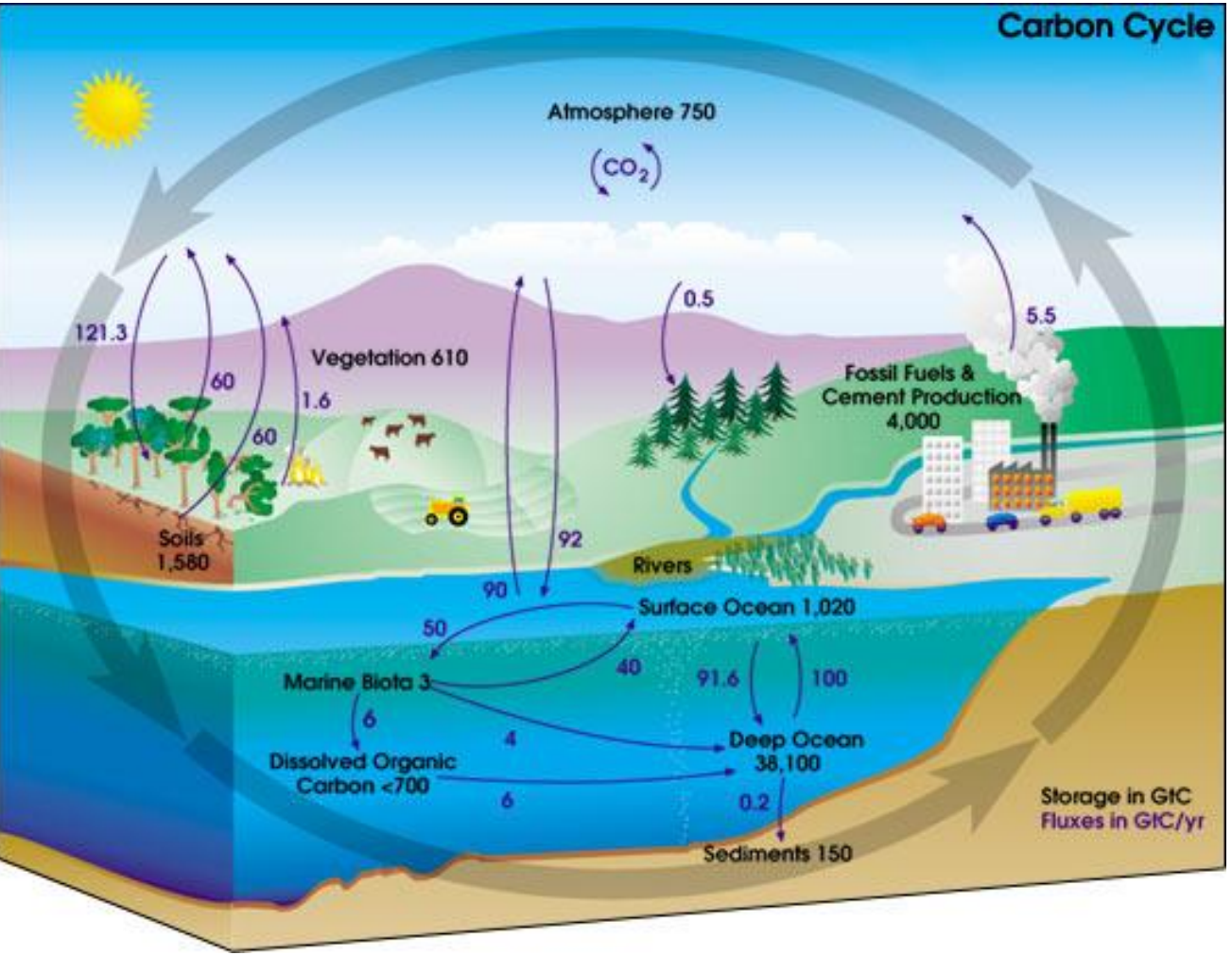
PUBHLTH 397 BH

Case Study 4:
Ecology and Health, different perspective from developing and developed countries

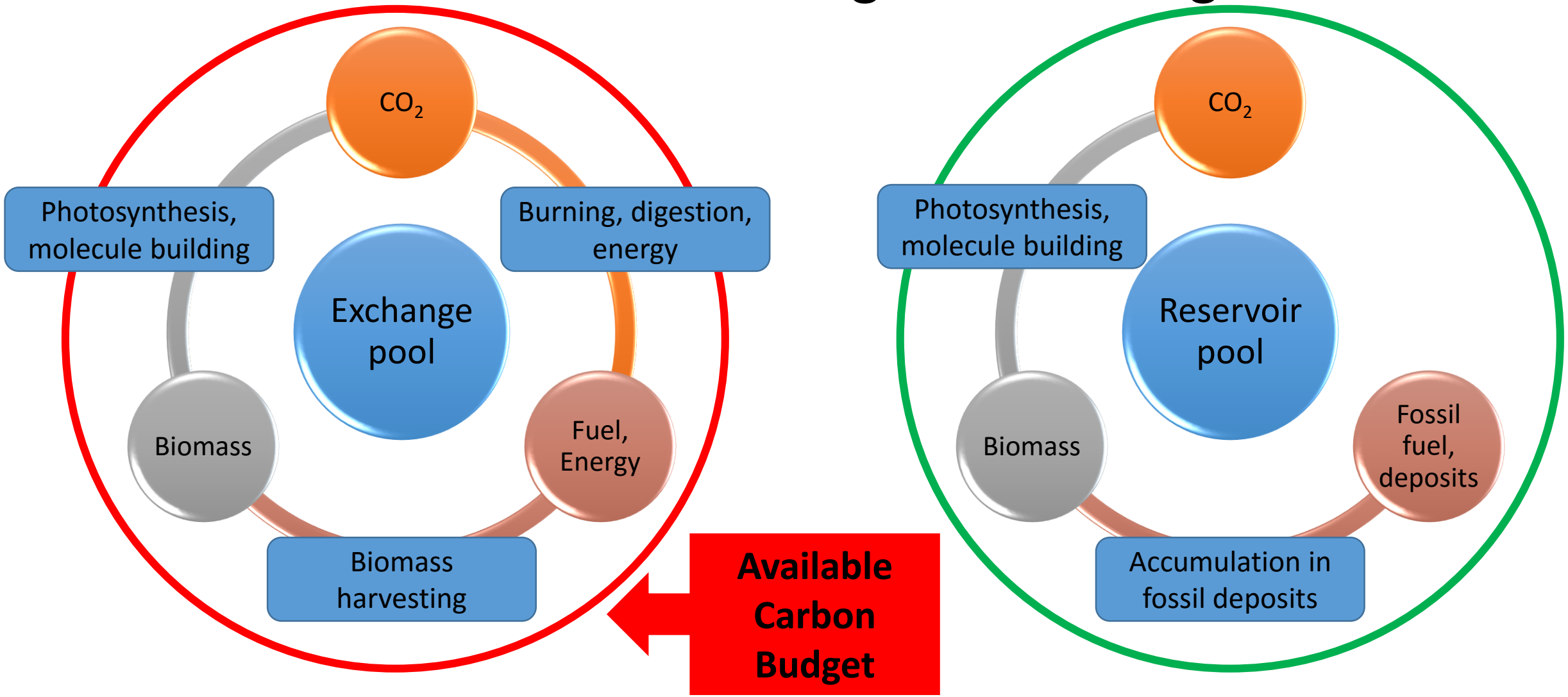
November 19, 2015

Global carbon budget

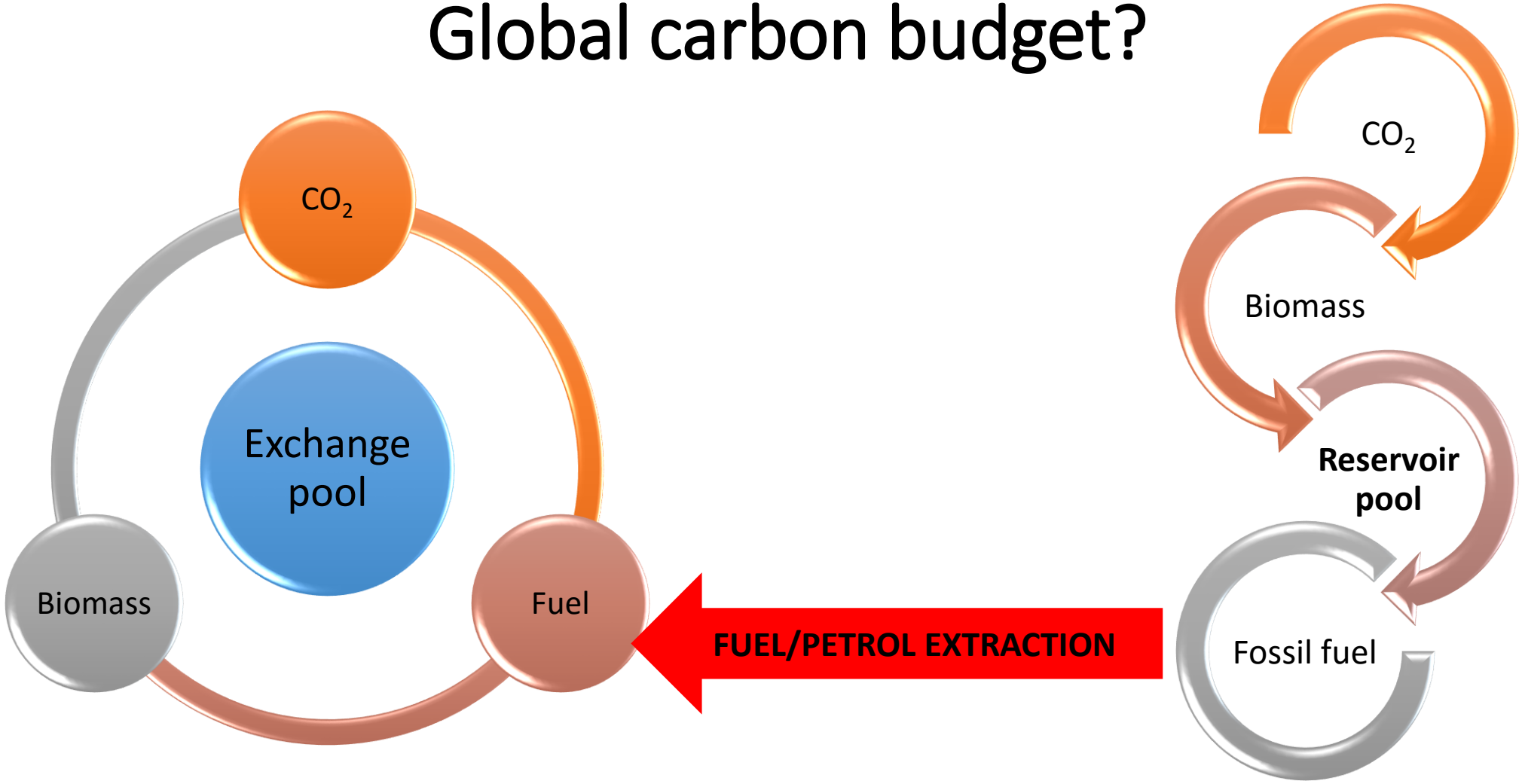


- Total carbon in the environment does not change
- Environment can be seen as the planet
- There are two main carbon pools, an exchange pool and a reservoir pool
- Carbon has a cycle like nitrogen, oxygen and even water

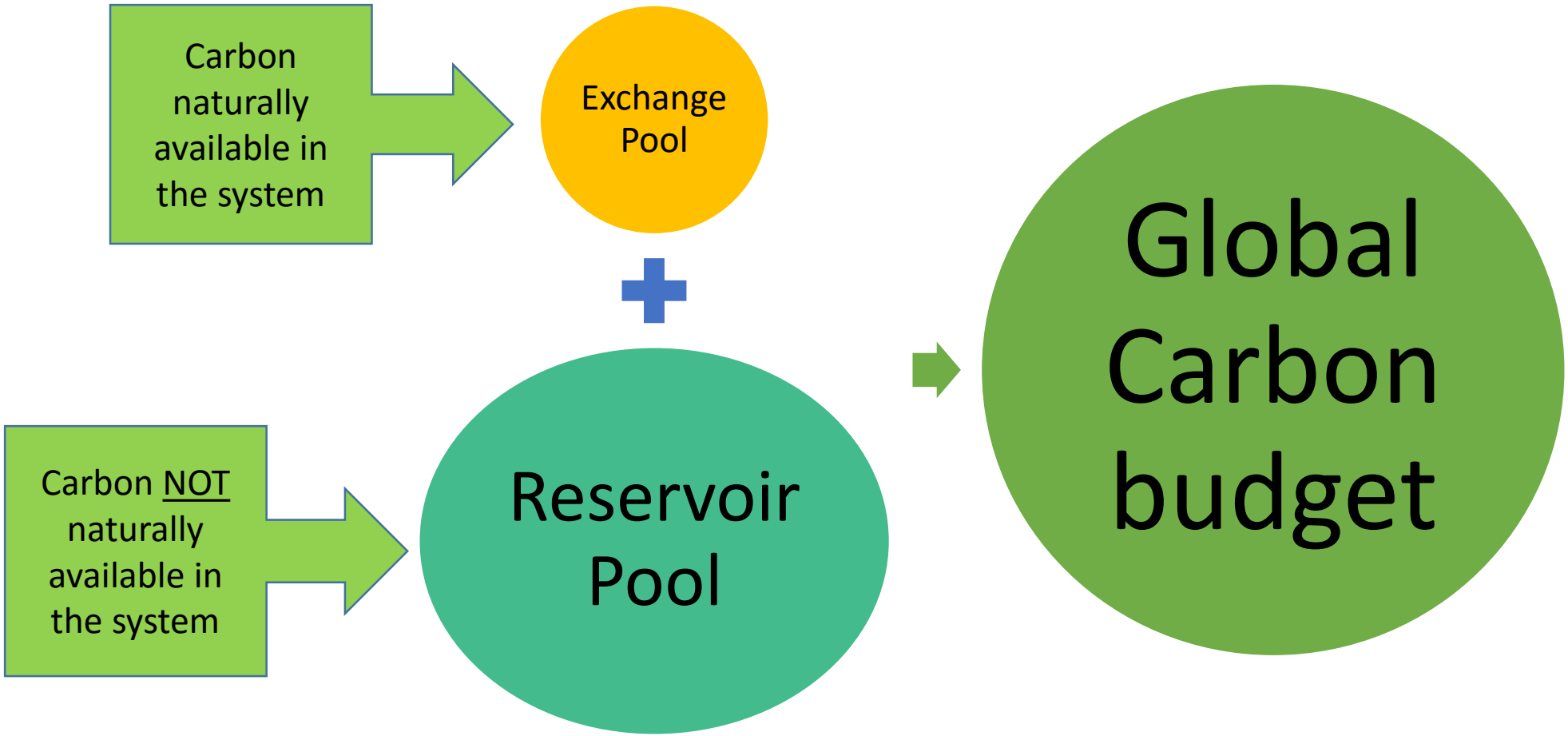
Carbon Cycle
Only the exchange pool involved
Global carbon budget unchanged



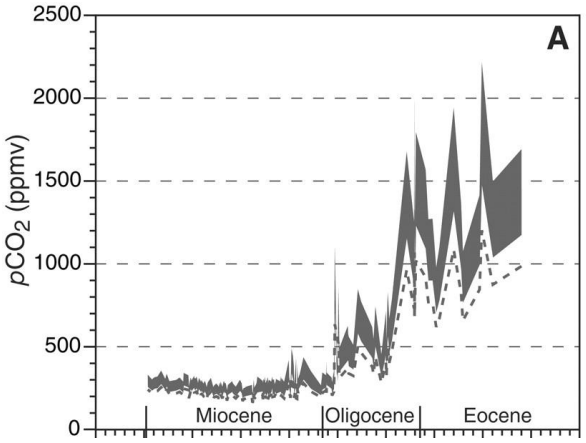
Carbon Cycle
Use of fossil fuel from reservoir pool
Global carbon budget?



Carbon cycle
Impact of the use of fossil fuel in global carbon budget



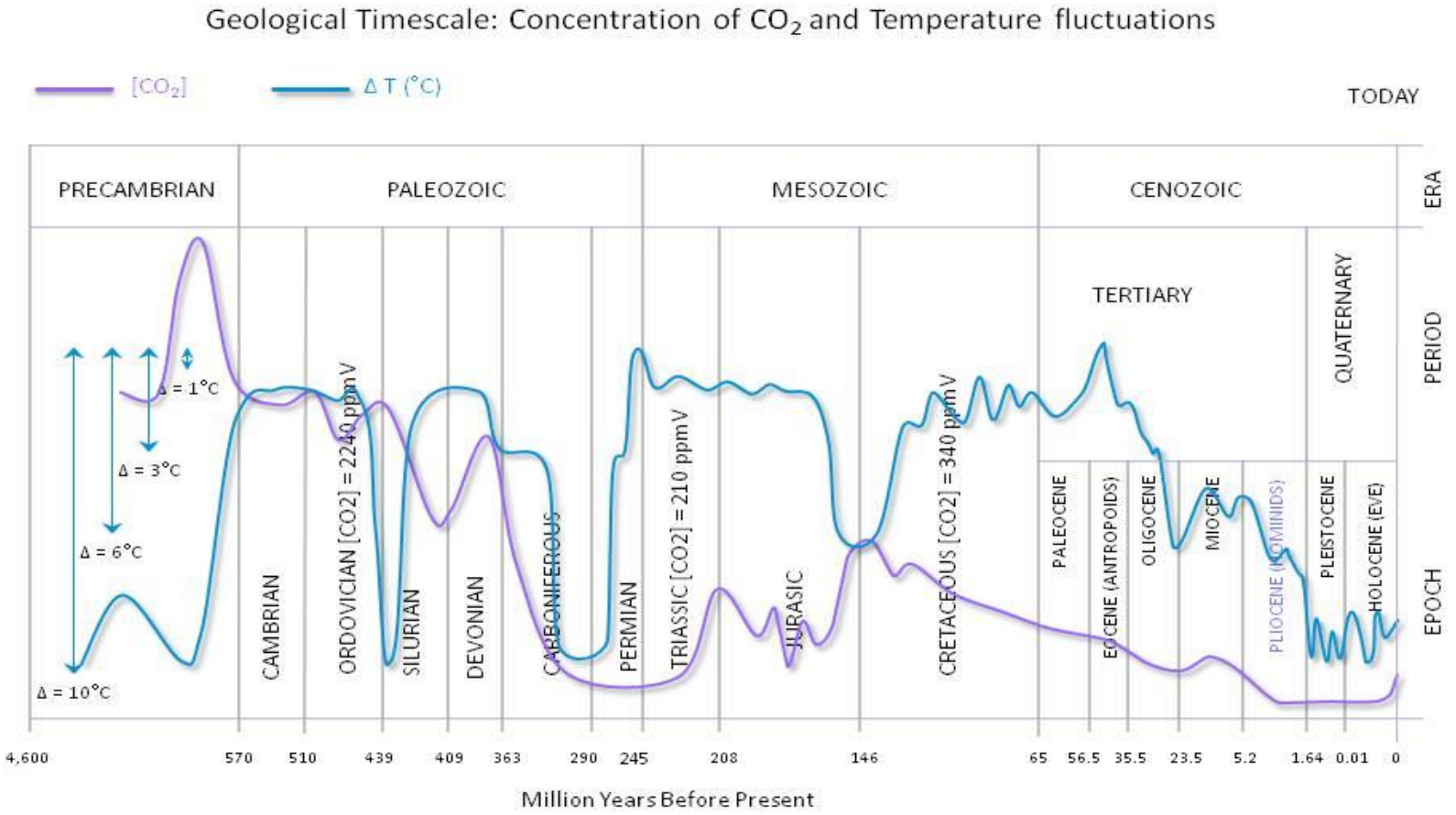
Where does all that carbon come from?



- Prehistorical eras had significantly higher concentration of CO_2
- CO_2 was in the atmosphere and dissolved in oceans, rendering them acid
- Anaerobic bacteria, green algae and plants later on, fixed the CO_2 into biomass
- Available carbon budget was still high, until fossil reservoirs formation
- Fossil carbon (coal, oil, gas) and other deposits, made a part of the carbon inaccessible to the cycle, depleting the atmosphere of CO_2 and de-acidifying the oceans

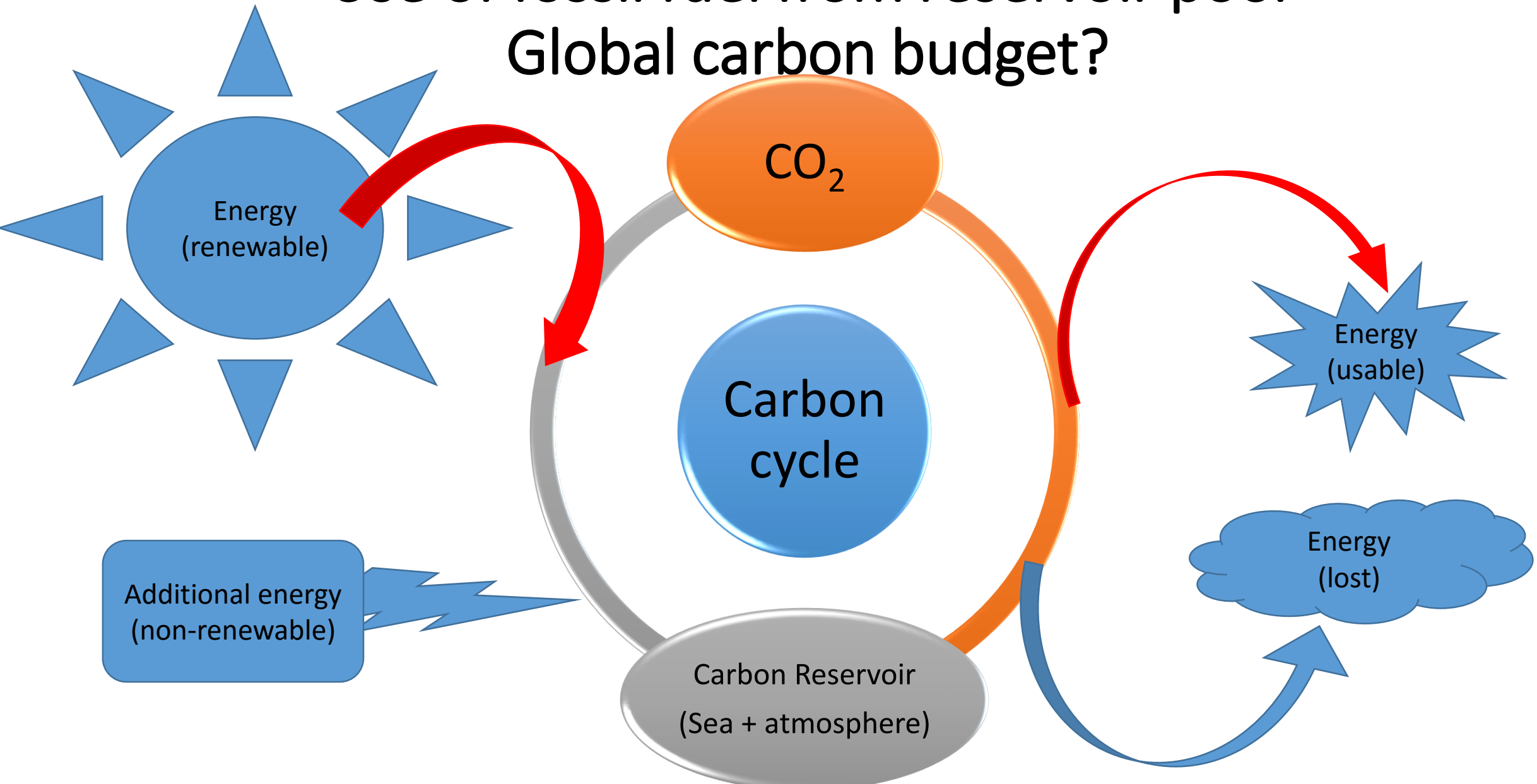
So, what if most of the carbon was put back in the atmosphere as CO_2?

- CO_2 is a greenhouse gas, it traps the heat in the atmosphere
- Small changes in its concentration can cause major changes in climate and weather (Global Warming)
- Actual CO_2 production is much faster than the naturally occurring cycle



1- *Analysis of the Temperature Oscillations in Geological Eras* by Dr. C. R. Scotese © *2002.* 2- Ruddiman, W. F. 2001. *Earth's Climate: past and future*. W. H. Freeman & Sons. New York, NY. 3- Mark Pagani *et all. Marked Decline in Atmospheric Carbon Dioxide Concentrations During the Paleocene*. Science; Vol. 309, No. 5734; pp. 600-603. 22 July 2005. *Conclusion and Interpretation* by Nasif Nahle ©2005, 2007. *Corrected on 07 July 2008 (CO2: Ordovician Period).*

Carbon Cycle
Use of fossil fuel from reservoir pool
Global carbon budget?



What is energy?

- Ability to do work
- Units of Newtons (kg m s^{-2})
- Examples of work
  - Lifting a weight from one height to another
  - Cooling a warm space
  - Slowing a moving vehicle
  - Organising atoms into proteins
  - Boiling water

What is power?

$$W = \frac{J}{s} = \frac{N \cdot m}{s} = \frac{kg \cdot m^2}{s^3}$$

- Work done over time
- Units of Watt (W) = Joules (N•m) per second

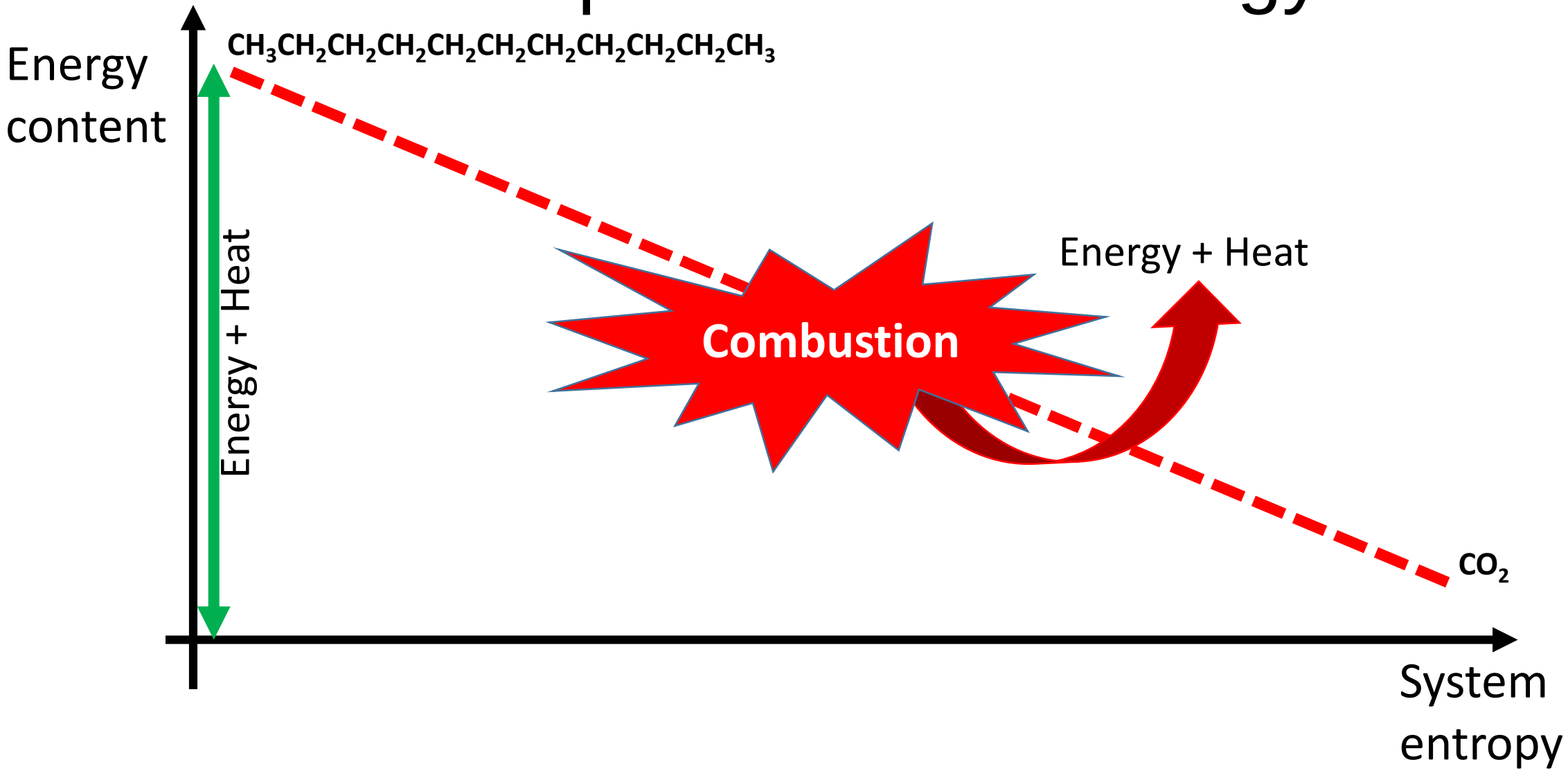
Why do we need energy and carbon?

- To grow and survive, all living things need energy and “building blocks”, the main source of both are carbon based compounds
- Plants can use the CO2 in the air to build hydrocarbons using the energy from the Sun
- Energy is required to modify anything in a system, from moving objects, to heating the environment, or to transform matter

How do we obtain energy?

- Depending on the source, the energy content varies
- Several kind of energies: kinetic, gravitational, chemical, thermal, electric…
- *Energy cannot be made or destroyed, but can only be converted from one form to another*
- Each passage from a form to another involves a loss of energy into the system as heat (entropy)
- Entropy defines the “disorder” of a system and will always to increase without addition of energy to the system

How do we obtain energy?
Example: chemical energy



What is our system?

- Planet Earth can be considered as a system, the sun functions as an external energy source
- All the actions and reactions are confined to our system
- The entropy of a closed system can only increase

Sources of Energy

Non-Renewable

- Coal
- Petroleum
- Nuclear

"Single use" energy source, once used, its energy content cannot be restored without the use of more energy.

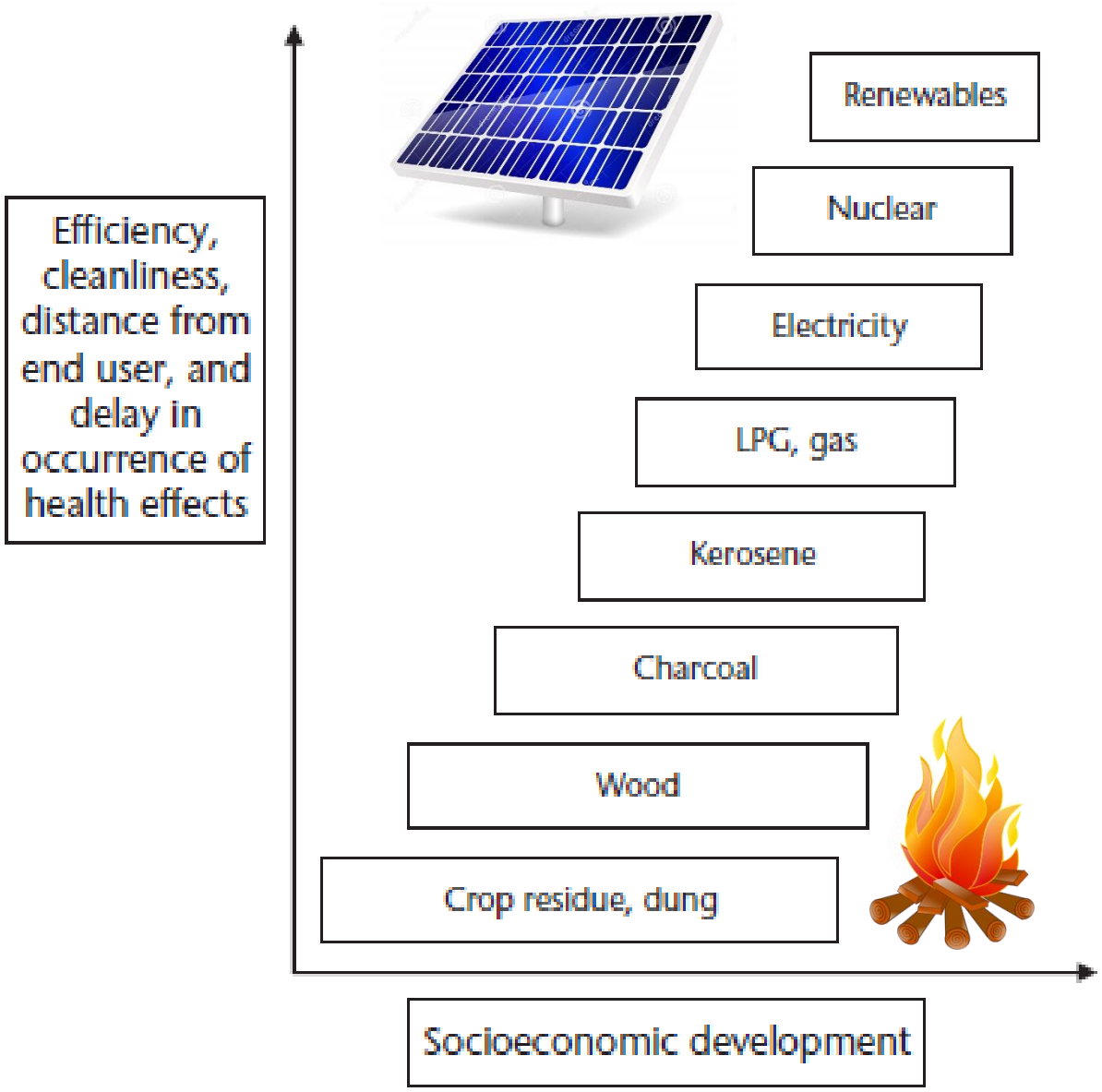
Renewable

- Sunlight
- Hydro
- Geothermal
- Wood
- Wind
- Wave

- Biodiesel
- Ethanol

Dependent from a primary source that is external to our system (Sun), or significantly more abundant (geothermal). Therefore its energy content can regenerate without the need of energy from the system or the extracted energy is not significant.

The Energy Ladder

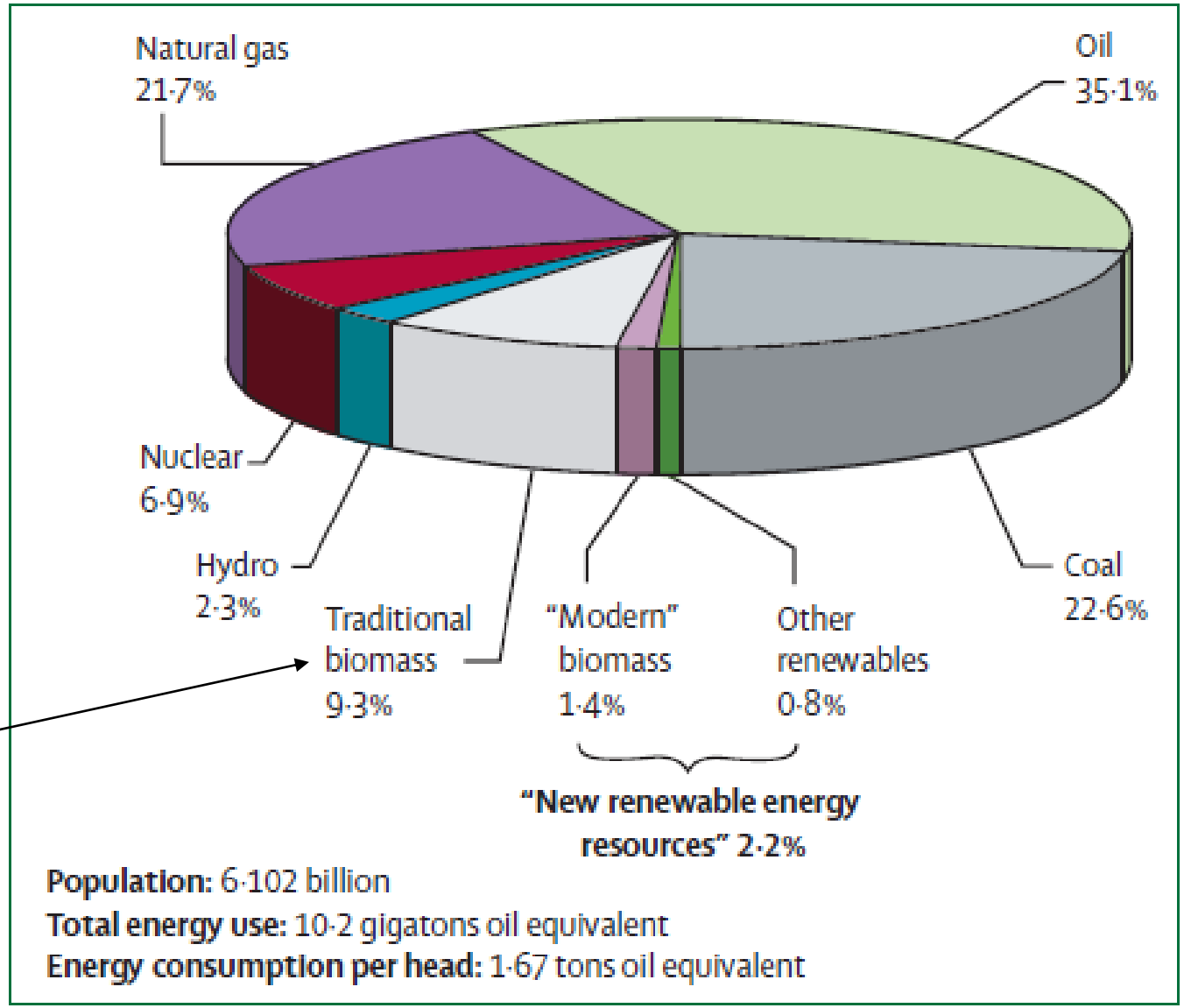


Compare pollutant emissions from the different energy sources.

Health effects of energy production are fewer and delayed for higher-income consumers.

Lower-income users are subject to more immediate and severe health effects.

Global Energy Use



Mainly by developing countries

~ 80% of human energy use is based on fossil fuels.

Exponential usage since the industrial revolution in the 1800s.

Energy and Health

- Energy production affects different populations in different ways

- Developing countries rarely produce clean energy (e.g. China uses coal as primary source of energy)
  - Health effects are widespread, mostly short-term and local
  - Health effects are caused both from household sources (household fuels) and from community sources (coal fired power plants)

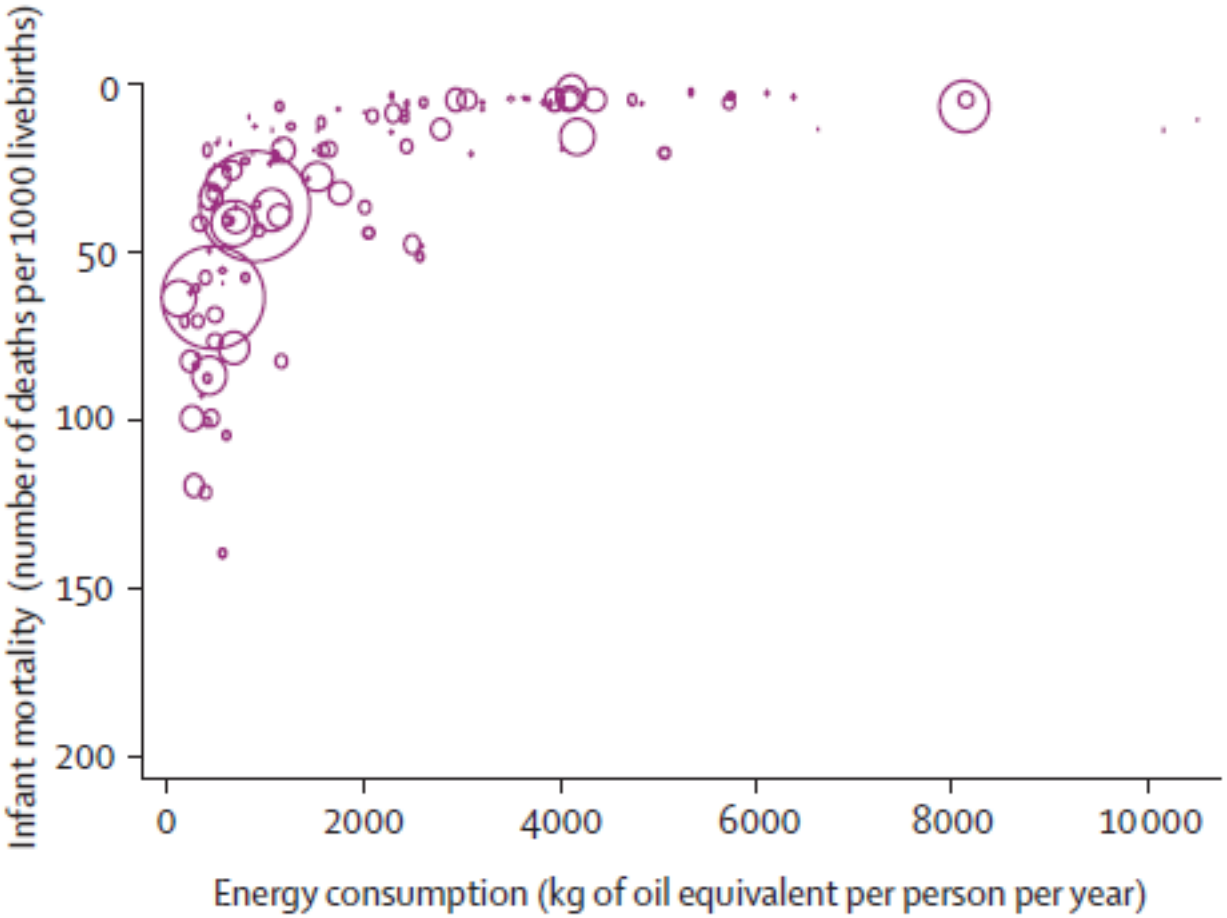
- Developed countries can produce clean energy (i.e. more refined fuels and better energy extraction technology)
  - Health effects are more delayed and indirect, they aren't always directly related to the emissions (Global Warming, Climate Change)
  - Health effects are caused mostly from community and global sources (CO_2 emission, PM and air pollution from industry and transport, less abundant in developing countries)

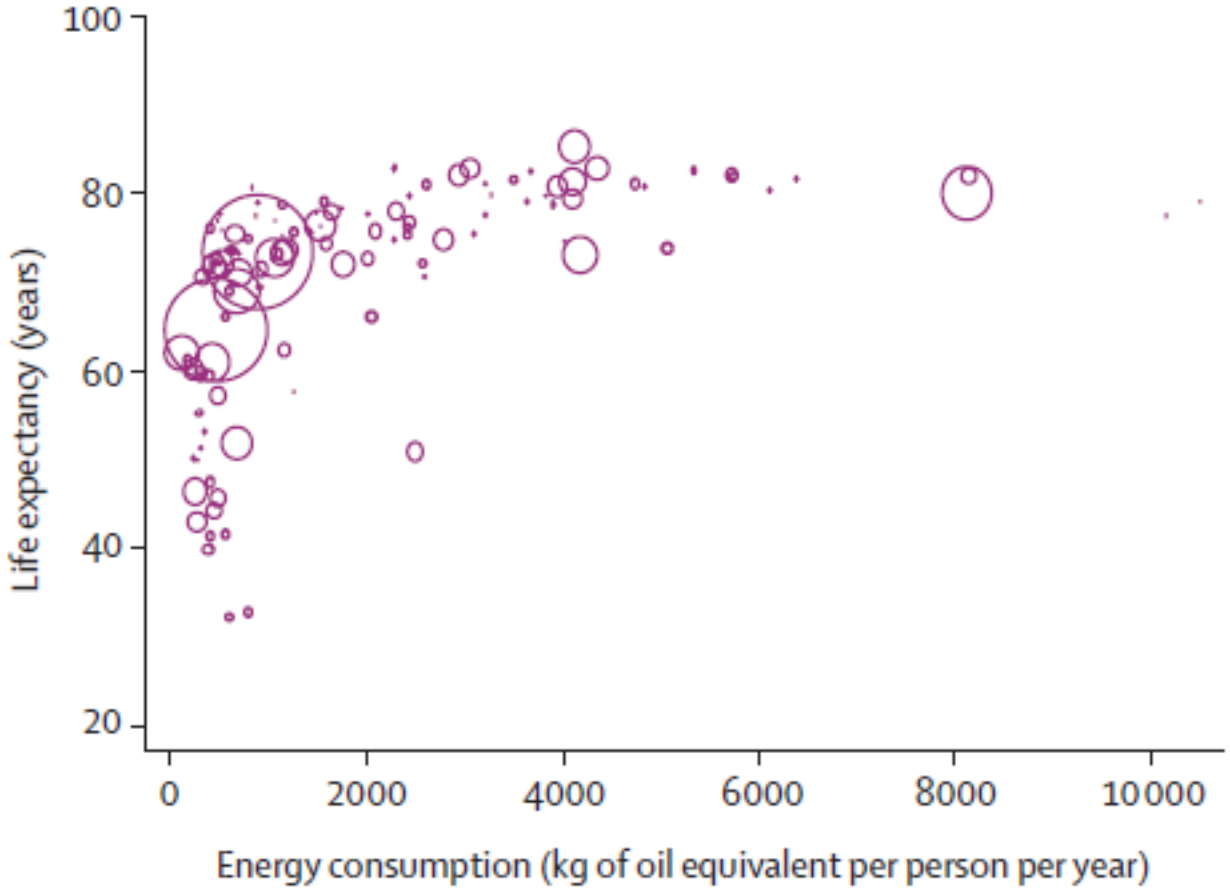
Energy and Health

- Energy production, transmission and consumption are associated with direct and indirect potential harms to health (and the environment).
  - *Direct*: Depend on the source of energy production and point of production in the life cycle
  - *Indirect*: environmental degradation, climate perturbations, income inequality, geopolitical destabilization

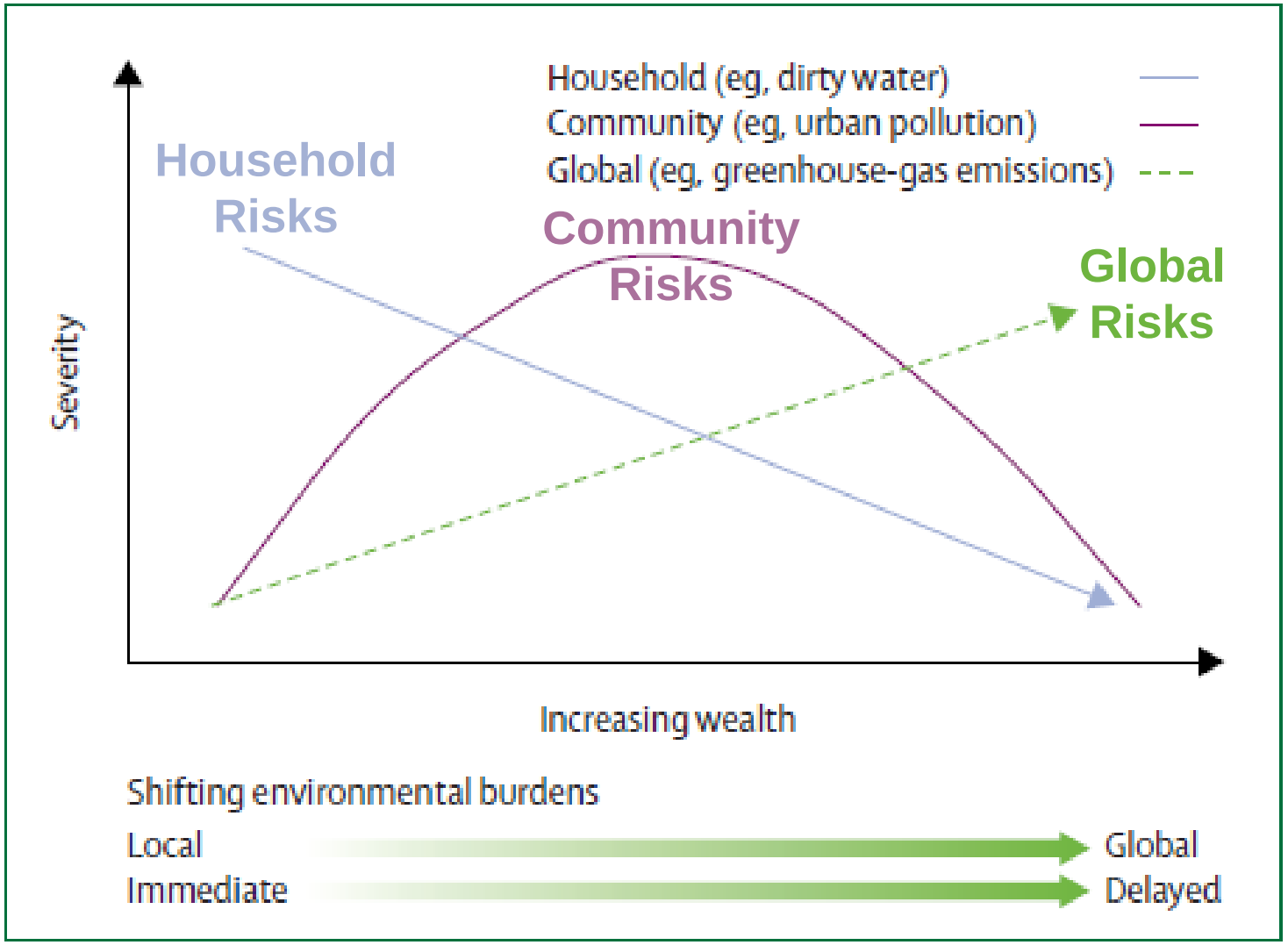
Energy and Health

- Association between energy consumption and health
  - Greater energy availability has been related to longer life expectancy and improved health





Energy and Health



BUT for some global risks, pattern is similar to household risks – mainly affecting the poor

Push for Increased Biomass Use

More than 2.4 billion people rely on biomass and coal for most household energy needs.

Used in developed countries – subsidies offered in the United Kingdom ($1400)

Log Stove

Pellet Stove

Pellet Boiler

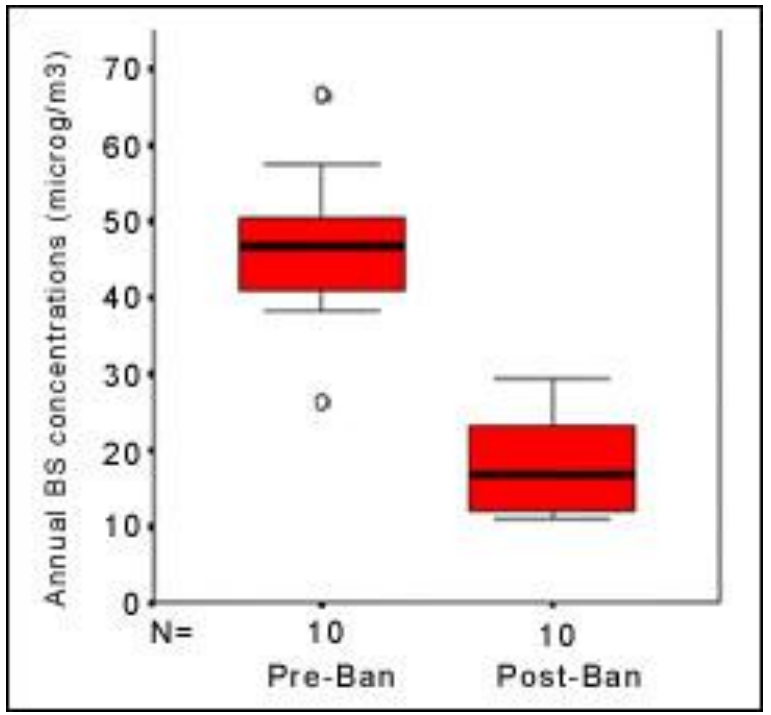
Centralised Boiler

The Dublin Coal Ban

Ban of coal used for household heating in 1990 in Dublin

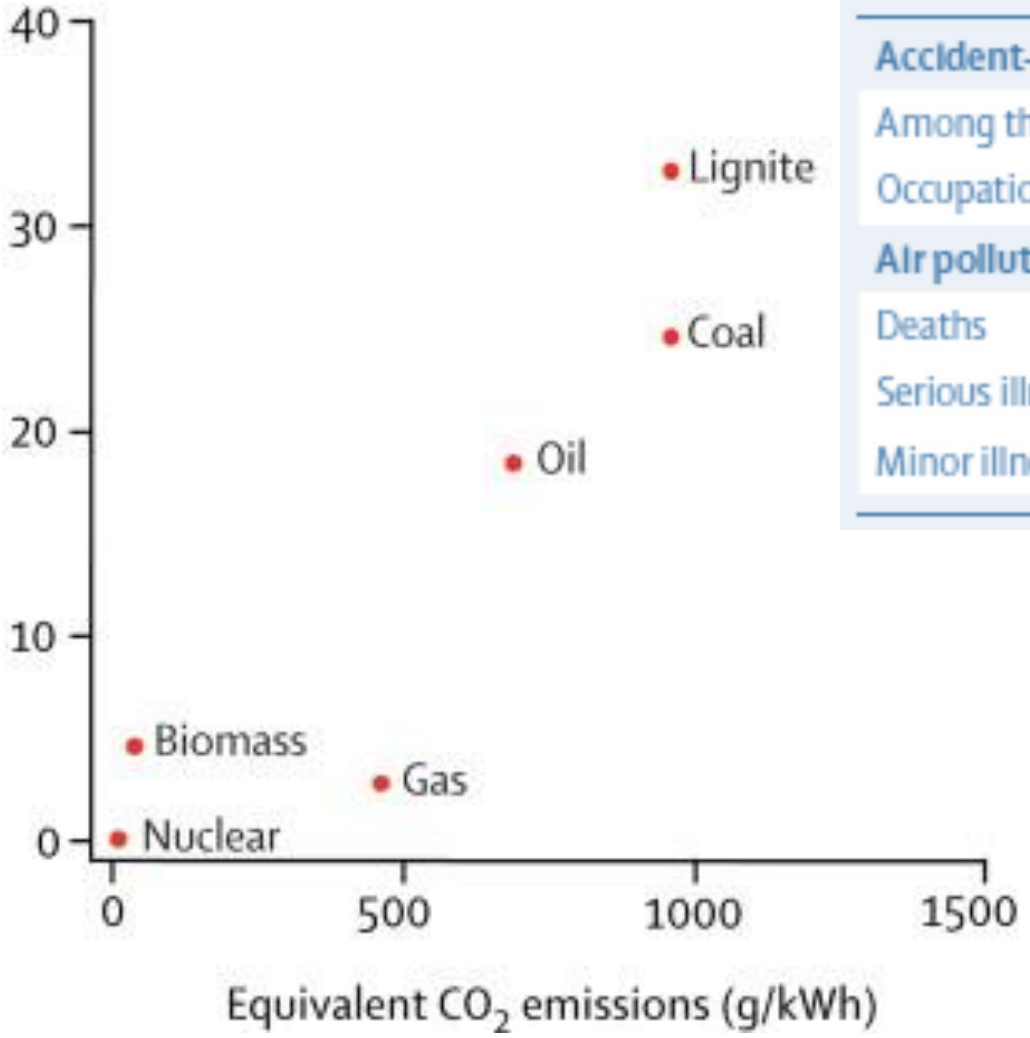
After the ban…

- Black smoke concentrations declined by 35 µg/m3
- Death rates decreased by 5.7 %



The Energy Ladder and Health

Deaths and accidents from air pollution involving workers and the public per TWh *in Developed Countries*



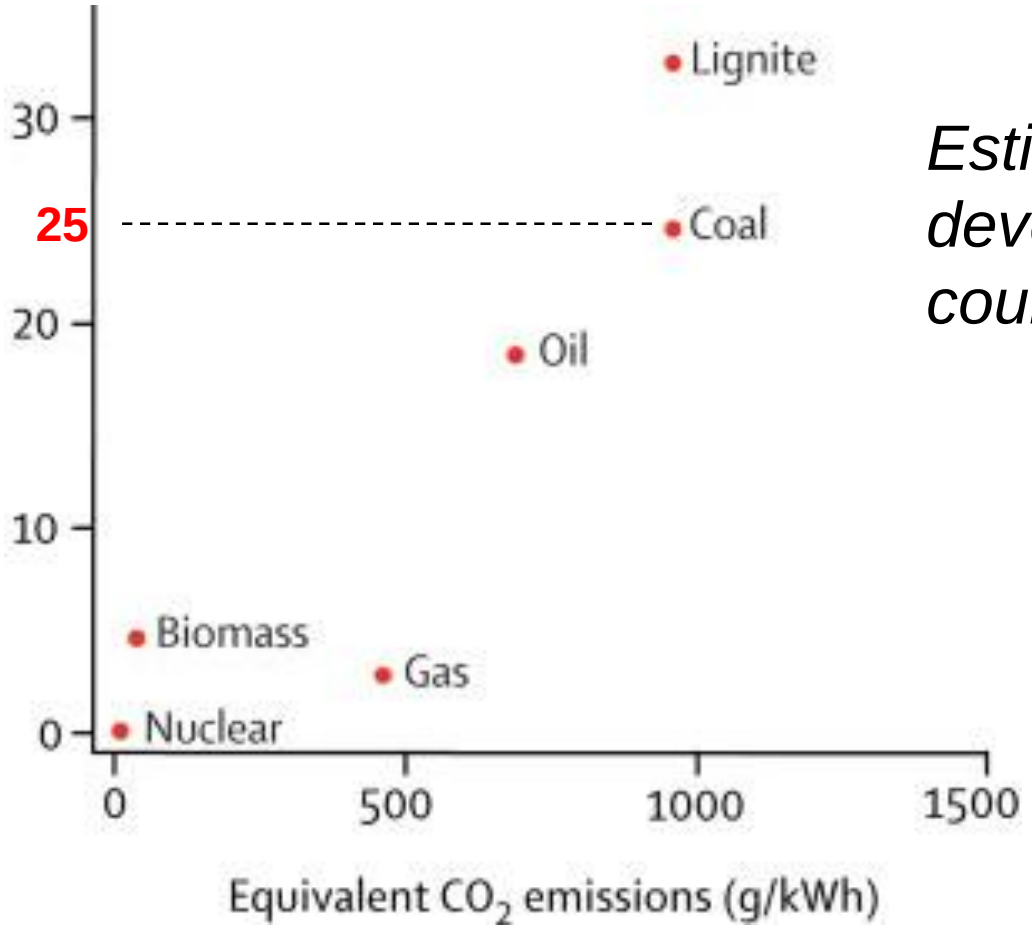
	Cases	Percentage due to coal
Accident-related deaths		
Among the public	6	44%
Occupational	13	99%
Air pollution		
Deaths	3778	85%
Serious illness	35 186	84%
Minor illness	1 853 152	94%

0.014% of total deaths in England/Wales related to respiratory and circulatory diseases

Energy in the Developing World

16 of the 20 cities with the worst air pollution globally are in China

Shandong province estimated ~77 deaths per TWh from a coal-fired plant.



Estimate for developed countries.

Health Effects of Renewables

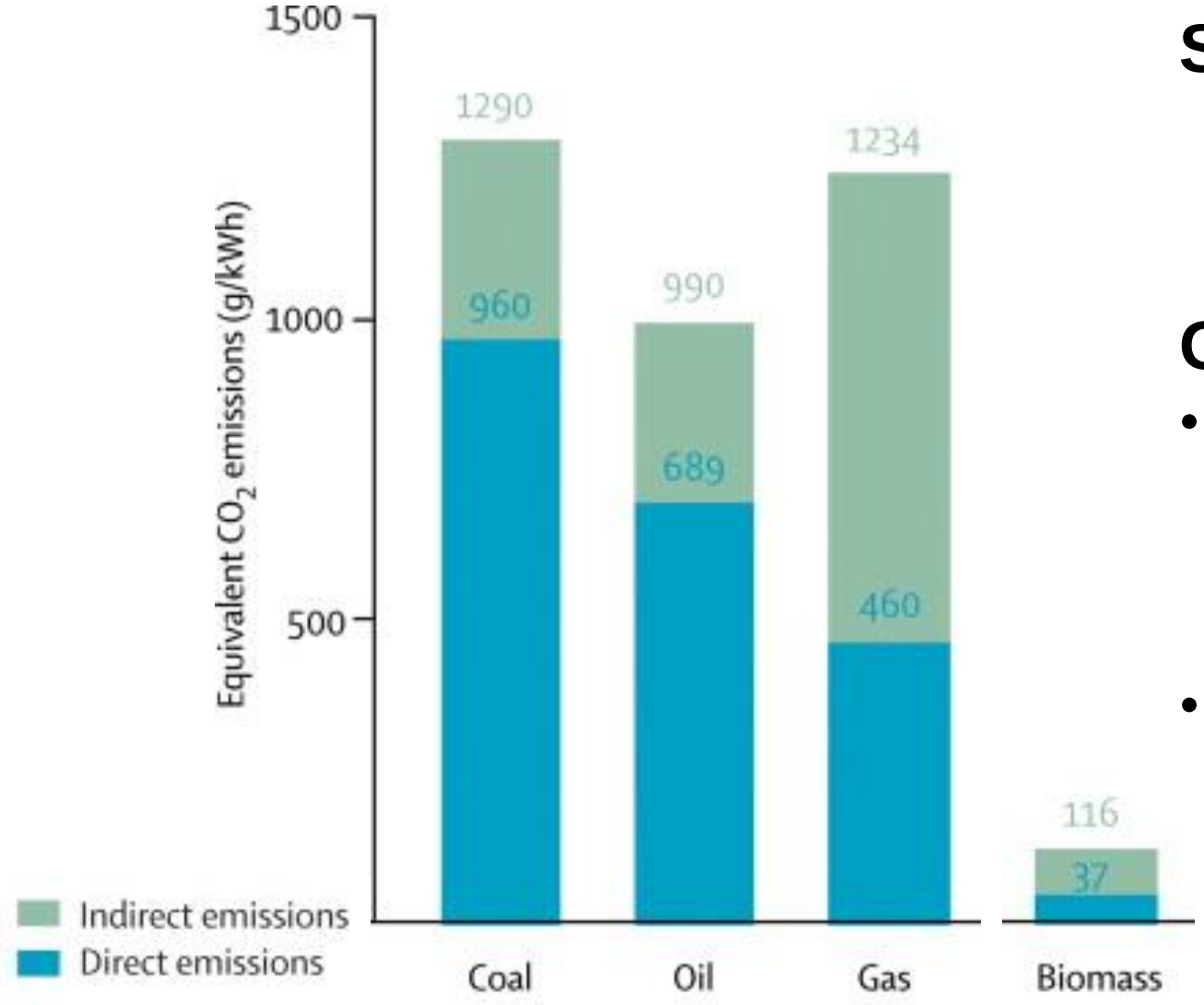
Renewable Energy Sources

- Solar
- Hydroelectric
- Wind
- Wave
- Biofuel
- Surface Heat
- Tidal
- Geothermal

Caveats of Renewables

- Low energy density – power/m^2
- Intermittent
- Location constraints
- Long distance transmission
- Environmental effects
- Aesthetic effects

Biomass Energy



Source of Indirect CO_2 Emissions?

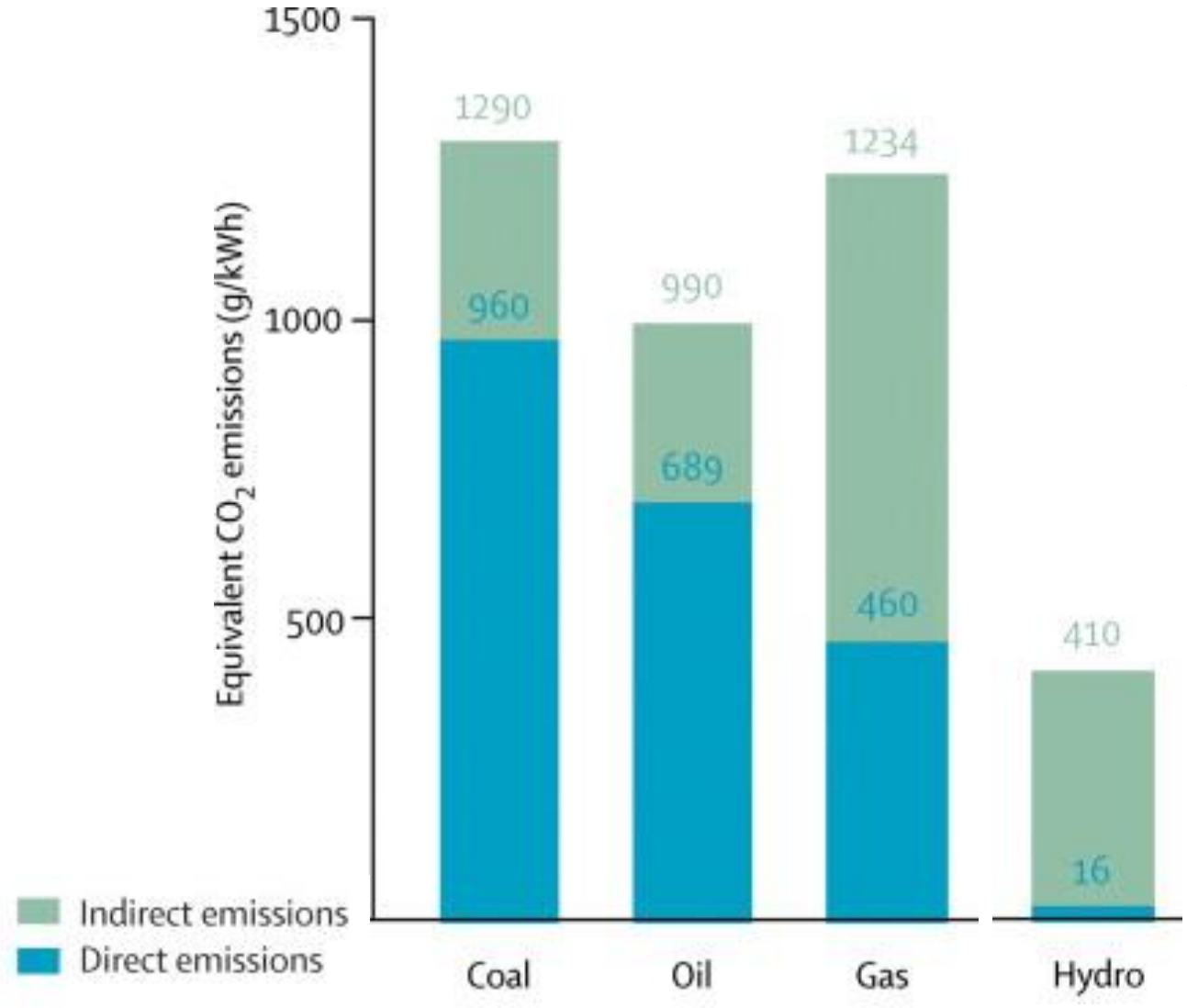
- Crop planting, growth, refining

Other caveats

- Usefulness as major energy source limited by inefficiency of photosynthesis

- Energy from productive cultivated crops ~1 W m-2

Hydroelectric Energy



- 48 000 large dams globally
- 20% of the world's electricity
- Constant source of energy
- No direct combustion source

Source of Indirect CO_2 Emissions?

- Construction of the dam
- Relocation of displaced people
- Decay of submerged vegetation

Solar Energy

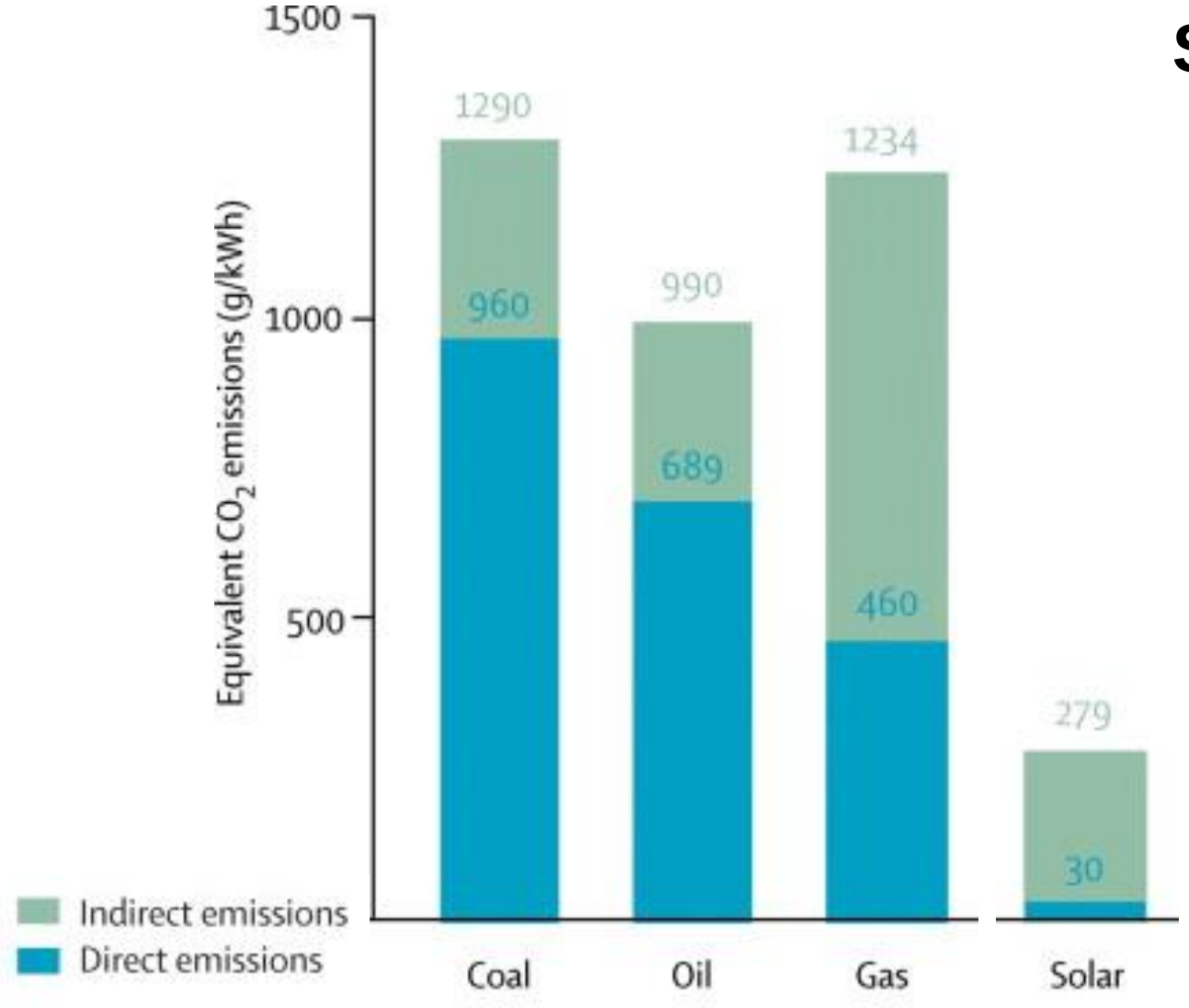
Solar energy is a great resource

- 3.9×10^{24} J energy reflected on the Earth's surface – 1% sufficient for global needs
- Solar energy is virtually infinite (the life of a star is much longer than the one of a planet)
- The source is external to the Earth, the energy is produced away from the system "earth", therefore, no CO_2 or other emissions in the system

BUT…

- Current technology ~10-15% efficient
- Costly and intermittent supply
- Global average of 10-45 W m^{-2}
- Storage of energy requires batteries (metal poisoning, need of replacement, efficiency)
- Sun radiation is not uniform on the planet

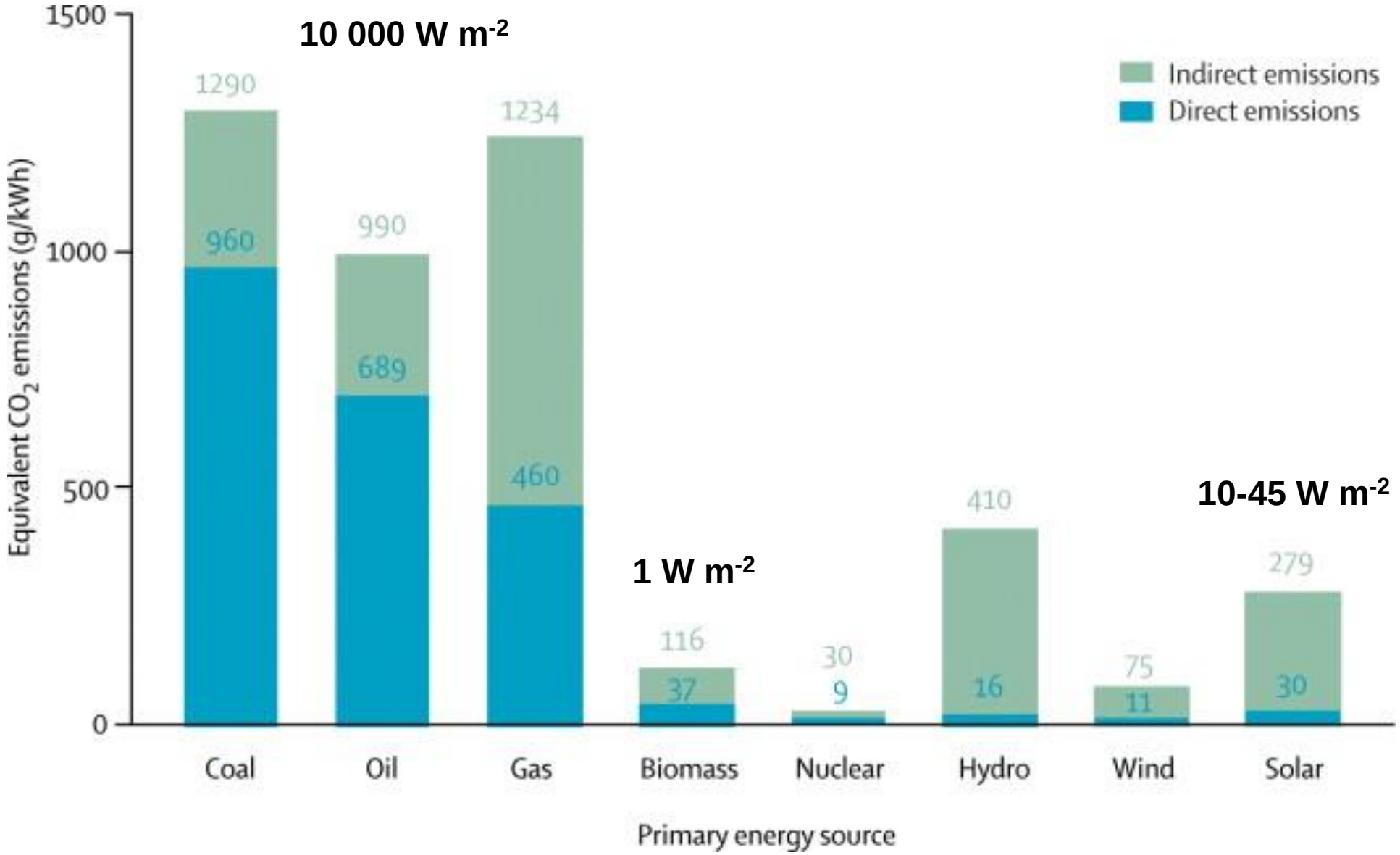
Solar Energy



Source of Indirect CO_2 Emissions?

- Research and Development
- Construction of the cells
- Materials and construction of solar farms
- Development of transmission lines

Contrasting Energy Sources



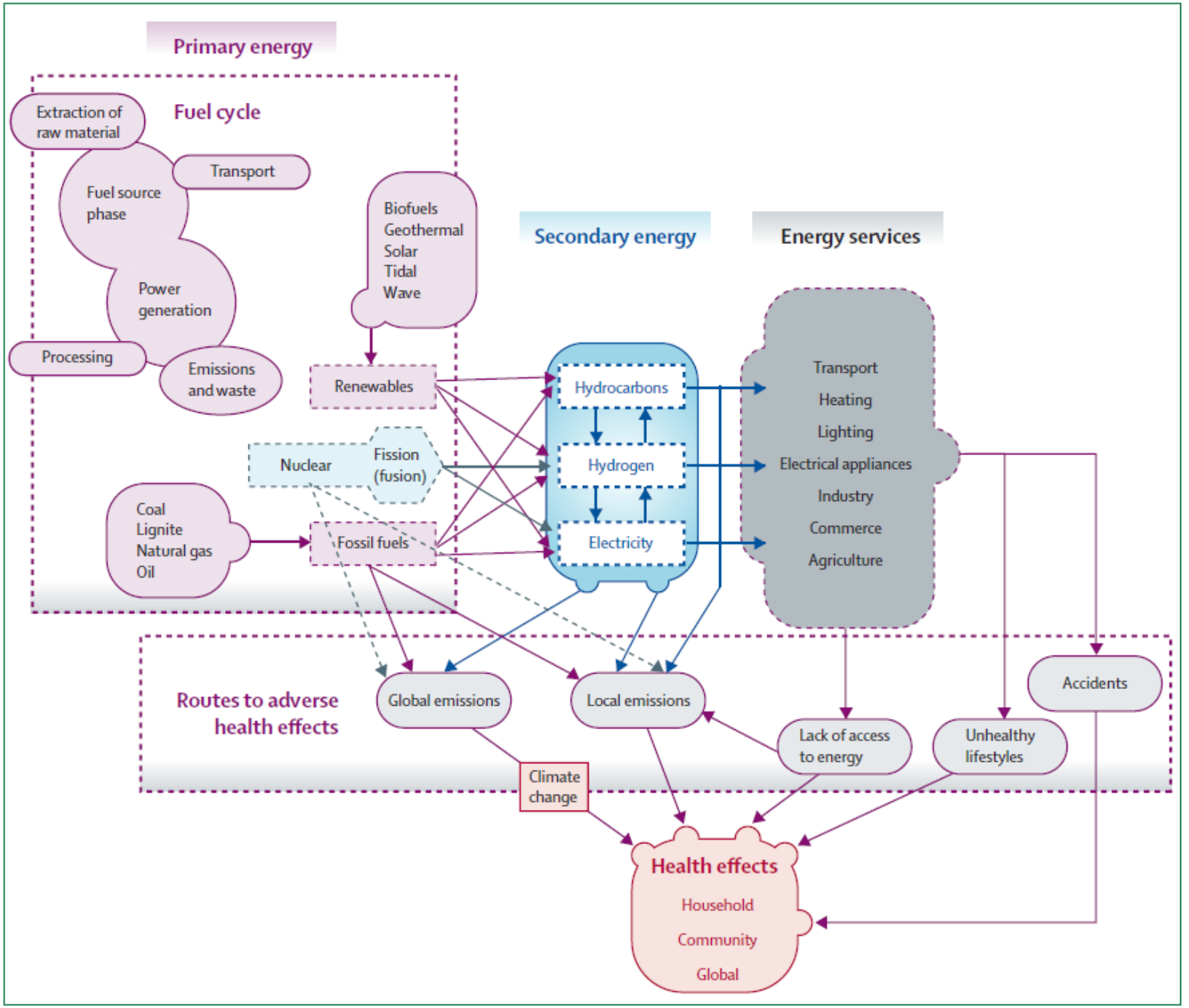
Final Thoughts

- *Different countries have different concerns for air pollution*
  - *Develop**ing** vs. develop**ed** countries, Health effects vs. Global warming*
- *Substituting clean fuel in place of dirty fuel is not the only change that can increase well being.*
  - *Key to distance energy generation facility from users, implementation of electrical appliances, improve energy production methods.*
- *Critical to assess health effects from all stages of the fuel cycle*
  - *Mining, transportation, waste disposal*
- *Different perspectives should be kept in mind*
  - *Global carbon budget, reservoir pool and exchange pool imbalance*

Pick a technical innovation that reduces work and improves energy efficiency.

I.e. Energy efficient car
Improved building insulation

How might a health impact assessment influence the ultimate value of the innovation?



Wilkinson et al. (2007)
***Lancet* 370: 965–78**