

# Climate Change and Sustainable Use of Resources

R'09 Davos, September 15, 2009

Helga Weisz & Wolfgang Lucht

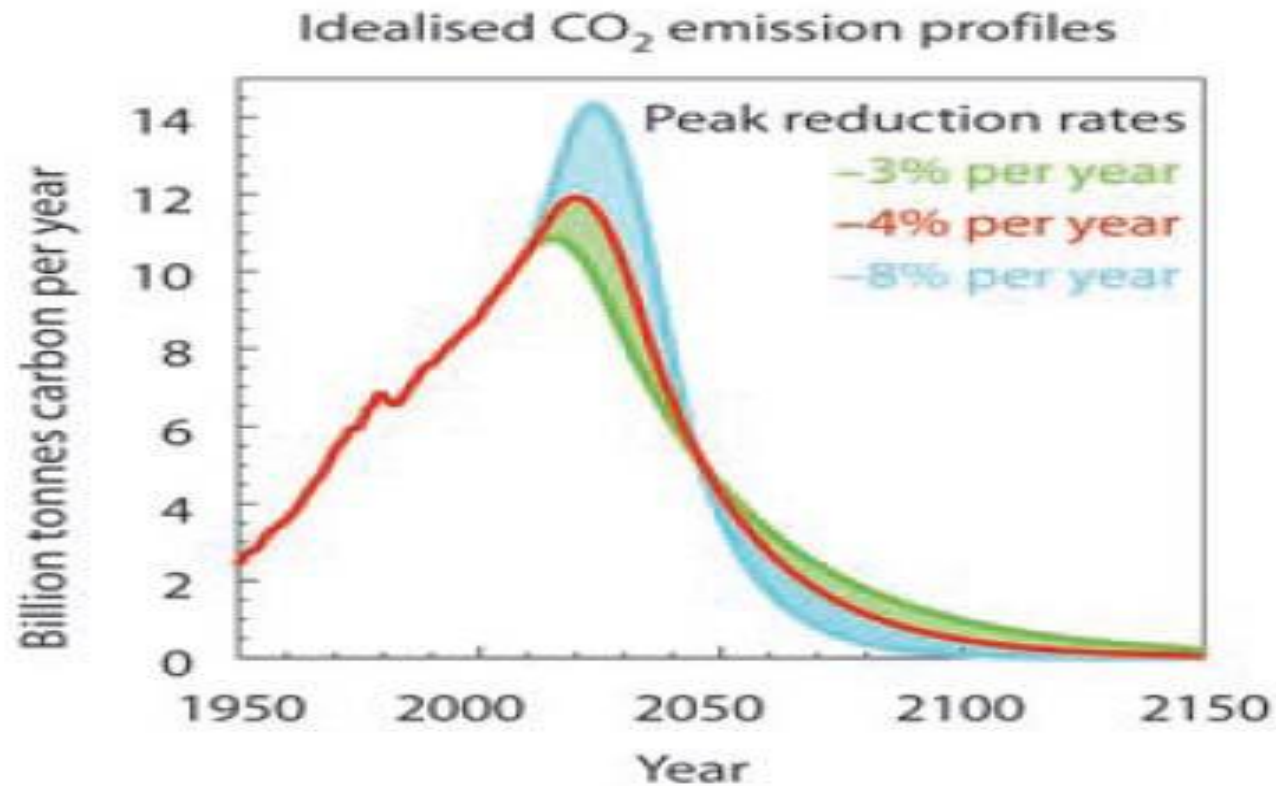
# Justification

- Climate change is on top of the political agenda
- In parallel international initiatives emerge on sustainable resource use policies (2004 3R initiative by G8, 2005 EU communication on sustainable use of resources, 2007 OECD report, 2007 UNEP panel, 2009 World Resource Forum).
- There are important links between climate change and resource issues, some are obvious, some are less obvious, however they remain underexplored

# Climate change: the 2 °C target

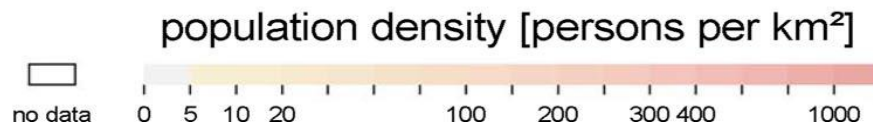
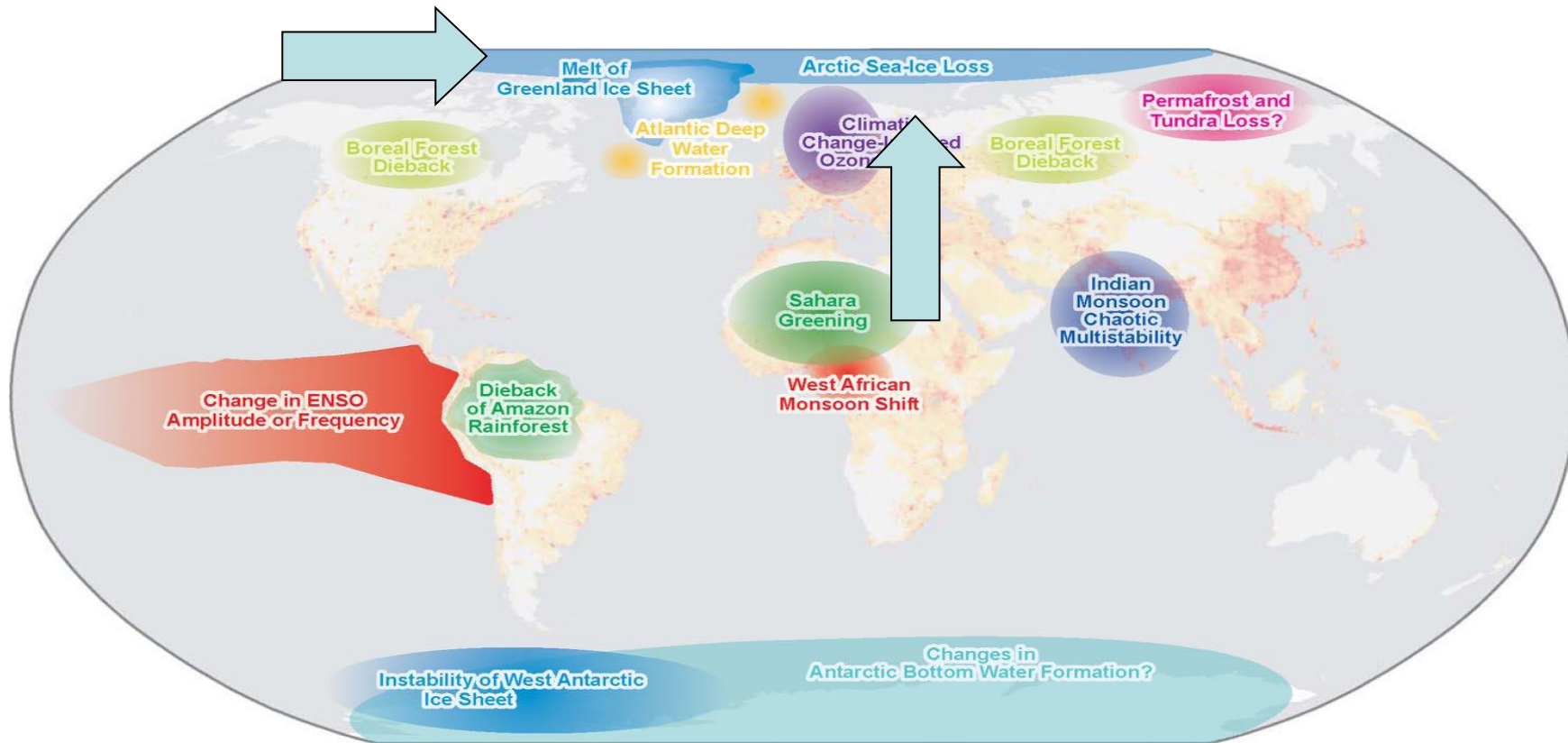
- Climate change is happening and it is a consequence of GHG emissions since the industrial revolution. Past GHG emissions have committed us to warming of app. 1 °C.
- Political acceptance of the 2 °C target by 16 industrial nations on G8 summit in July 2009
- Recent evidence shows that cumulative budgets of CO<sub>2</sub> are a robust indicator for the expected warming and that cumulative CO<sub>2</sub> emissions alone must stay beyond one **trillion ton** (10<sup>12</sup> t) to keep warming at around 2 °C (Meinshausen et al. Nature 2009, Allen et al. Nature 2009).
- Humanity has already released half of that since pre-industrial times.
- This calls for near time emission targets as the higher emissions are allowed to be in 2020 the lower they will need to be in 2050 to stay with the 2 °C target.

# A sense of urgency

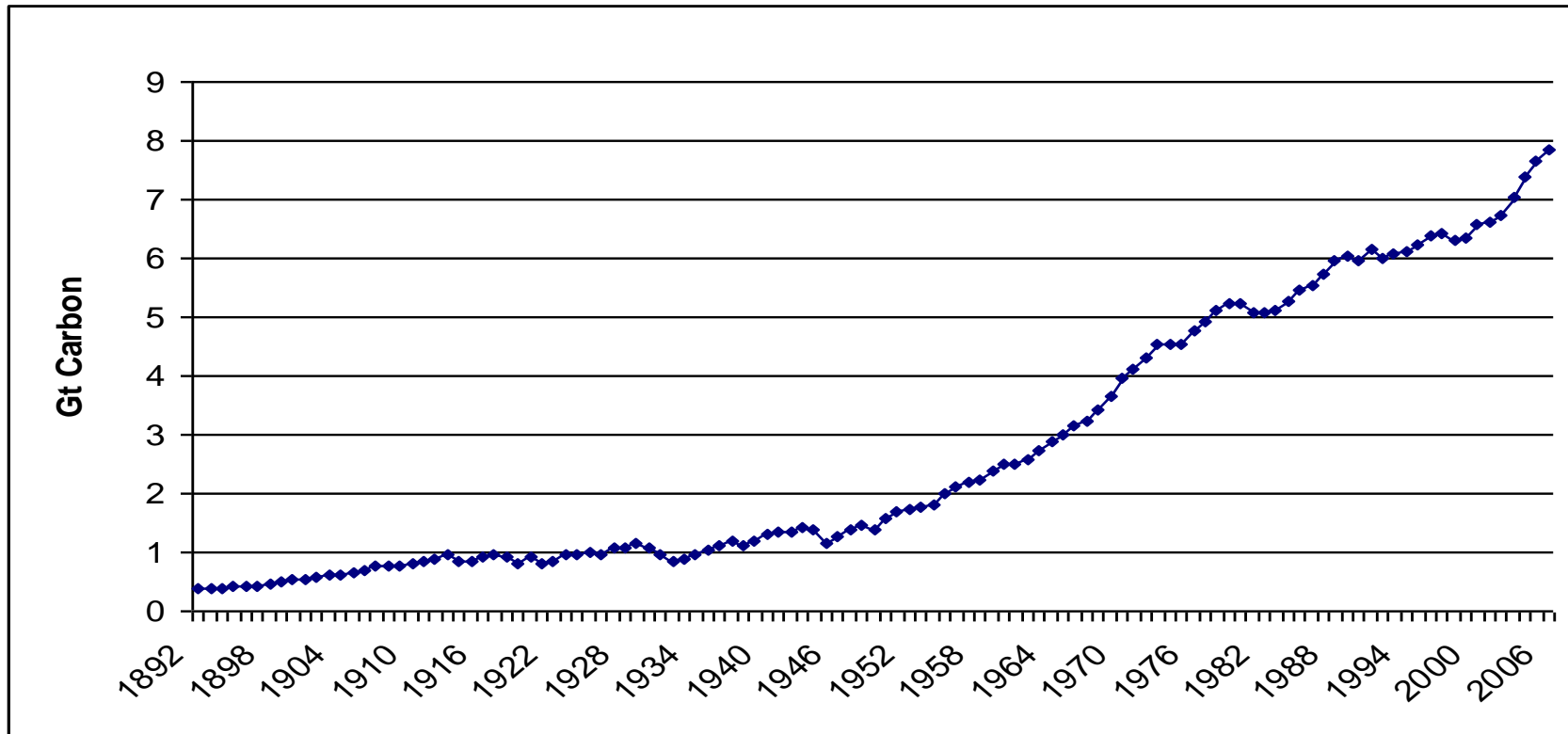


Source: Allen et al. Nature, Vol3, May 2009, p 56

# Tipping elements



# Total CO2 Emissions from fossil fuels burning, gas flaring and cement production (in Gt of Carbon)



Source: Boden, T.A., G. Marland, and R.J. Andres. 2009. Carbon Dioxide Information Analysis Center Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.

# Global inequality CO<sub>2</sub> emissions

- More than 50% of total cumulative emissions since the 1750 are from Europe and the US
- Current emission rate of Europe and the US are about 40%
- 80% of 2000-2004 emission increases are from developing countries (app. 50% from China)
- Still huge differences in per capita emissions:
  - World average: 1.1 (t C/cap\*yr):
  - US: 5.5
  - Europe: 2.5
  - China: 1.1
  - Least developed: 0.06

Source: Raupach et al. PNAS, 2007

# Global resource use: Materials

# The industrial metabolism as condition of the possibility of modern society and cause of climate change

# The limits of an agrarian metabolism

- A biomass based energy system has 2 problems: low energy intensity and marginal revenues when maximum NPP per hectare is approached (in absence of external energy subsidies).
- This sets limits to the mobilization of mineral resources and does not allow for continued economic growth per capita (the economy grows when the population grows but not on a per capita level). The metabolic system is governed by negative feedbacks.

# The key innovations of the industrial metabolism

- Making available large amounts of high density energy = fossil fuels (required a highly unlikely coincidence of technological innovation and availability of resource).
- For the first time the metabolic system develops positive feedbacks, the energetic and material basis of industrial production could be decoupled from bio-productivity large amounts of mineral resources can be mobilized (Wrigley talks about a transition from an organic to a mineral economy).
- This allowed for non-conventional economic growth (i.e. on a per capita basis) and radical change in all parts of society (modernity).

# Historical and contemporary world production of copper

Time	Estimated world copper production per capita [gram/cap*yr]
Pre-Historic (2000 to 700 BCE)	4 – 5
Time of the Roman Empire (350 BCE to 350 CE)	30 – 50
~1000 CE (peak production mostly in China)	60
1993	1700
2004	2500

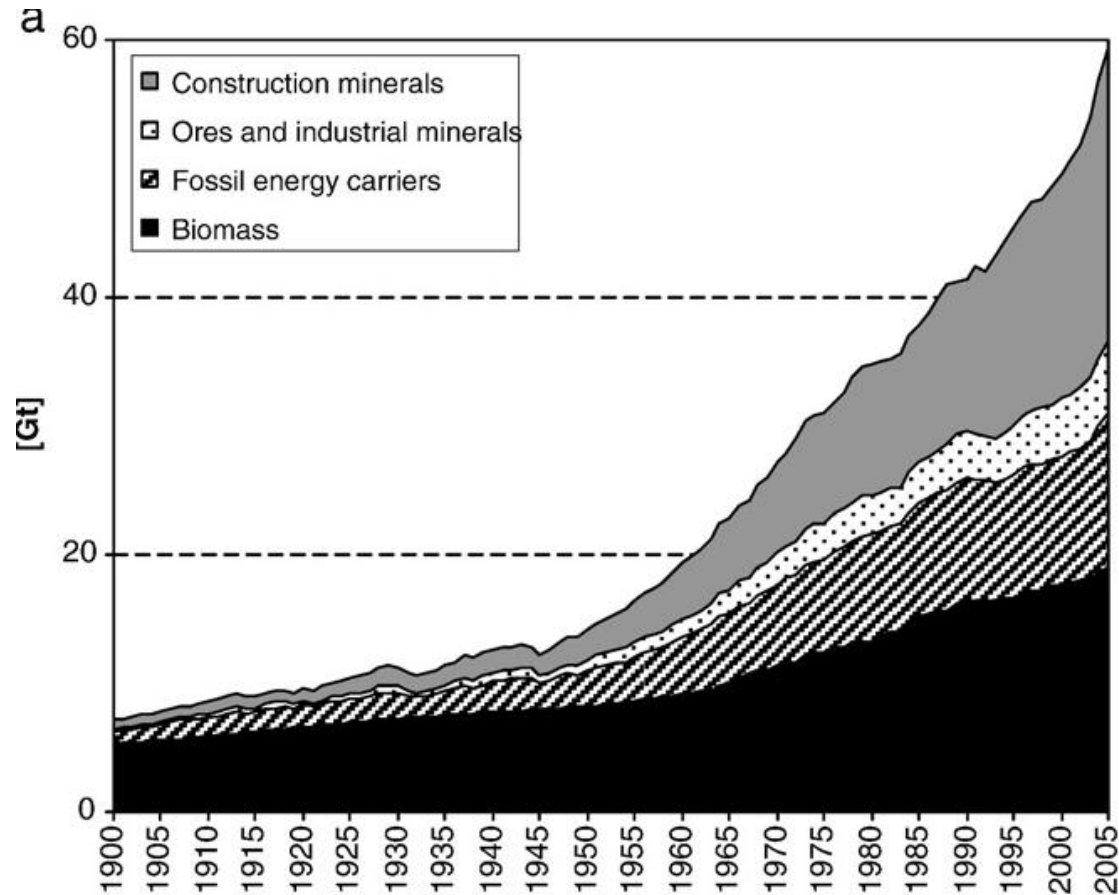
Source: Weisz unpublished based on: Historical cumulative bronze and copper production from Hong et al (1996).

Historical world population (both low and high estimates) from Biraben (2003).

1993 and 2004 world copper production from a data set created by the authors based on USGS.

World population 1993 and 2004 from United Nations.

# Global raw material consumption(= extraction)1900 - 2005



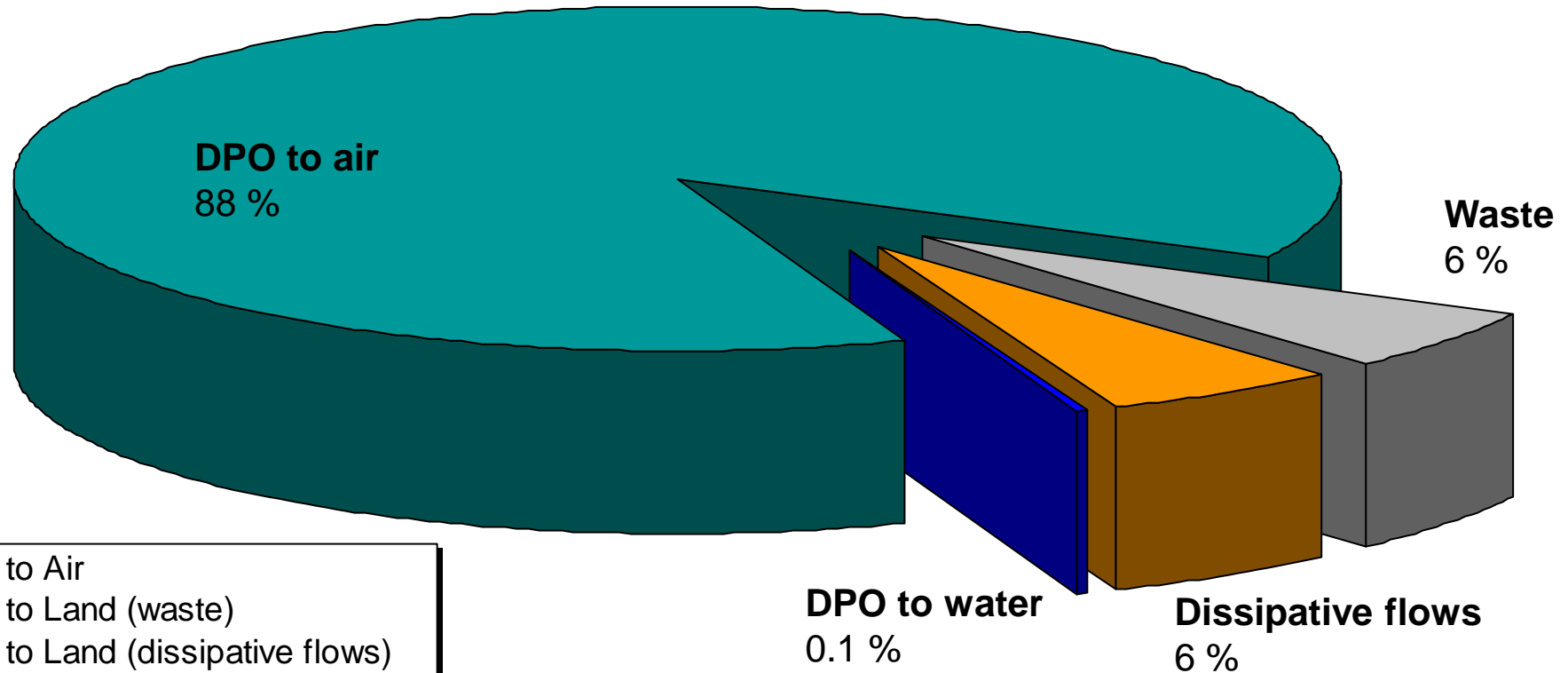
Source: Krausmann et al. 2009, *Ecological Economics* (68), 2696-2705

What happens with all these materials?

# The atmosphere is the most important waste dump for the industrial metabolism

## DPO by gateways 1996

DPO total: 16 tons per capita



- DPO to Air
- DPO to Land (waste)
- DPO to Land (dissipative flows)
- DPO to Water

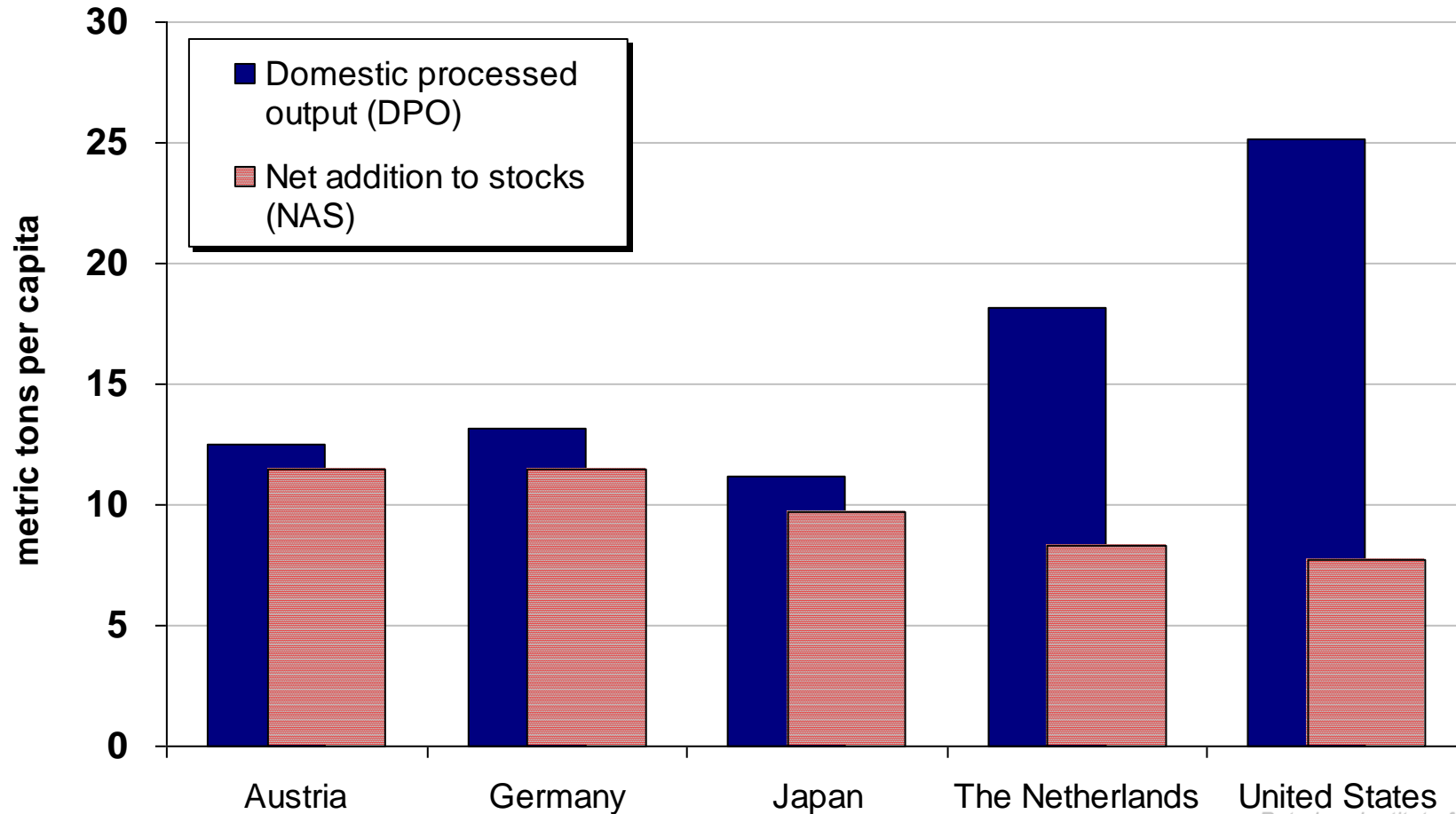
unweighted means of DPO per capita for A, G, J, NL, US; metric tons

Source: own calculations, from Matthews et al. 2000

Potsdam Institute for Climate Impact Research

# Physical stocks are increasing rapidly in industrial economies

## DPO and NAS 1996



# Carbon footprint and metabolic footprint

The key role of fossil fuels as metabolic basis of modern society and major single cause for climate change in combination with huge global inequality in terms of accumulated emissions, current per capita levels and current trends, explains the difficulty of implementing effective climate change policies.

As the availability of high density energy is so vital to industrial development (as we have know it so far) that virtually all climate policy approaches tend to focus on emissions reductions while at the same time securing increasing energy supply – decarbonization

If this is going to be effective the questions arises, what happens with all the energy, and the answer will be: it will blow up global resource consumption in large parts of the world, it will increase the metabolic footprint.

# Global resource use: Water

- A literature search on climate change and sustainable resource management revealed that appr. 90% is about water (rest biomass).
- This is not surprising as climate change is directly effecting the water cycle, consequences are already visible.

# Main findings of the 4th AR (1)

- Climate change affects the world's freshwater resources: freshwater availability, quality, and the destructive potential of water. Overall, the negative impacts of projected climate change on freshwater resources are assessed to outweigh its benefits (Kundzewicz *et al.*, 2007).
- Many sectors and systems (e.g. **water supply and sanitation, agriculture, energy, human health, settlements, infrastructure, industry, transportation, tourism, insurance and financial services**) are dependent on water resources and their availability, so that changes in hydrological regimes and water quality due to climate change will have socio-economic impacts.
- These climate-driven hydrological changes will combine with other pressures on water resources, such as population growth, land-use change (urbanization, deforestation), changes in life styles increasing water demand and environmental pollution, to challenge water management in the 21st century.

# Main findings of the 4th AR (2)

- By mid-century, annual average river runoff and water availability are projected to decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics, while increasing by 10-40% at high latitudes and in some wet tropical areas (Milly et al., 2005), and more pronounced changes are likely by the end of this century.
- - Many of the presently water stressed semi-arid and arid areas are likely to suffer from decreasing water resources availability due to climate change, as both river flows and groundwater recharge decline (Döll & Flörke, 2005).
- - As glaciers retreat due to warming, river flows increase in the short term but decline once the glaciers disappear. More than one billion people (1/6 of the world population) live in river basins supplied by meltwater from mountain ranges, such as Himalaya, Hindukush and Andes (Barnett et al., 2005, Vergara et al., 2007, Magrin et al., 2007), and reduction of low flow in summer and autumn may have large impacts on water resource availability.
- 25% of the global population live in coastal regions that have less than 10% of the global renewable water supply and are undergoing rapid population growth. Saline intrusion due to excessive water withdrawals from aquifers is expected to be exacerbated by the effect of sea-level rise, leading to reduction of freshwater availability in these areas (Kundzewicz *et al.*, 2007).

# Water requirements to feed the world in 2050

- The World Bank defines water-stress threshold with availability of less than 1700 m<sup>3</sup>/capita\*yr.
- The first global study which looked at water and land limitations to feed a 10,2 billion global population in 2050 under climate change assumed that 1300 m<sup>3</sup> water /cap.\* yr are required to produce a healthy diet (3000kcal and 20%meat).
- Their results show that in 2050 under climate change (A2 emissions trajectory):
  - Developed world can meet its demand
  - Developing countries cannot. Improved water management plus subsidies of virtual by trade of agricultural products would still leave app. 5 billion people with insufficient food supply.

# Overall water demand??

- Although AR 4 acknowledged that water availability will affect almost all sectors of the economy no numbers are given on overall water consumption across sectors.
- This may lead to a serious underestimation of the importance of water for an industrial metabolism.
- If we would further include water demands from other sectors, industries, potentially limiting raw materials (phosphorous), and competition between agriculture, bio-fuels, and biodiversity global food supply becomes a multiple constrained system.

# What can we learn from this?

- The climate change problem is concerned with a small fraction of the overall industrial metabolism
- CC is much more advanced in terms of science and policy, a clearer understanding of the cause effect and a greater sense of urgency.
- In climate change the consequences and possible trade offs between mitigation and adaptation strategies and resource use tend to be ignored in particular regarding the use of materials.

# Main links between CC and resource use

- Although there is huge evidence for the urgency of climate change policies there is also the risk that ignorance of the trade-offs between CC and resource use will impose new global challenges:
- **Energy drives the material system.**
- **It is the quality and the quantity of material social metabolism that causes all known environmental effects.**
- **However, the current focuses in CC policy is on carbon emissions and avoids the idea of serious energy use reductions, thus the focus on new low-carbon energy technologies and CCS.**
- In the long run it will not be enough to cut GHG emissions, a stabilization of the metabolic footprint will be needed.
- A catch up of developing countries to industrial energy use levels will multiply the metabolic footprint, as the main purpose for energy use is to mobilize materials and people, whereas a reduction industrial economies will have little impact overall (only 25% of the world population live under an industrial regime).
- However, if industrial countries do not reduce their own resource consumption any international agreement on global resource consumption is highly unlikely.

# Dangers

- Current scientific evidence on climate change suggests that things are more dramatic and more urgent than stated in AR4.
- Policies so far have been unsuccessful, global emissions are raising faster since 2000 than they did in the period 1980 to 1999.
- Securing global a political agreement among national states, given the huge inequality and difference in national interests is enormously challenging.
- Adding a resource perspective makes things even more complicated.

# Hopes

Thank you for your attention