Transport and Climate change

Jonas Åkerman

Mail: jonas.akerman@abe.kth.se

Contents in brief

(Other) Global challenges

- Ecosystem services
- Oil scarcity

Climate change

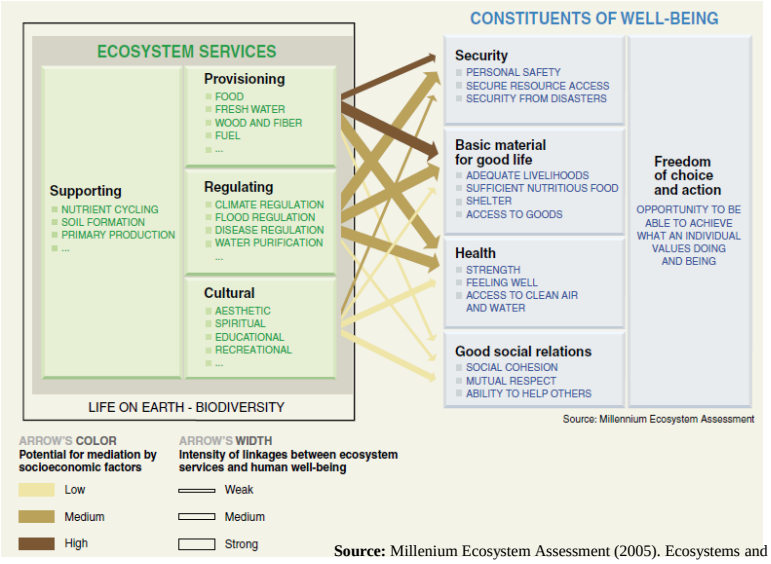
- Greenhouse gas emissions
- Observed climate changes
- Drivers of climate change
- Projected consequences of climate change
- What emission redcuctions would be needed to keep global warming below 2 degrees
- Intro to Energy futures

Three global challenges that concern transport

- Mitigation of **Climate change**
- Preserving **Ecosystem services** (Food production, clean air and water etc)
- Growing **scarcity of oil** (Peak-oil debate)

These are connected to each other.

Ecosystem services



Source: Millenium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Synthesis

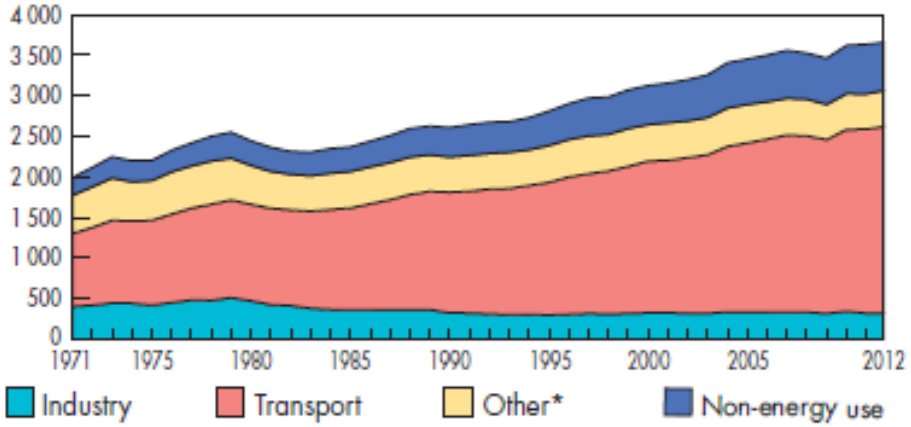
It seems like preserving Ecosystem services is a necessary condition for also achieving social and economic sustainability.

Ecosystem services that have been degraded during the past 50 years.

- Capture fisheries
- Water supply and purification
- Waste treatment and detoxification
- Regulation of air quality
- Regulation of erosion
- etc

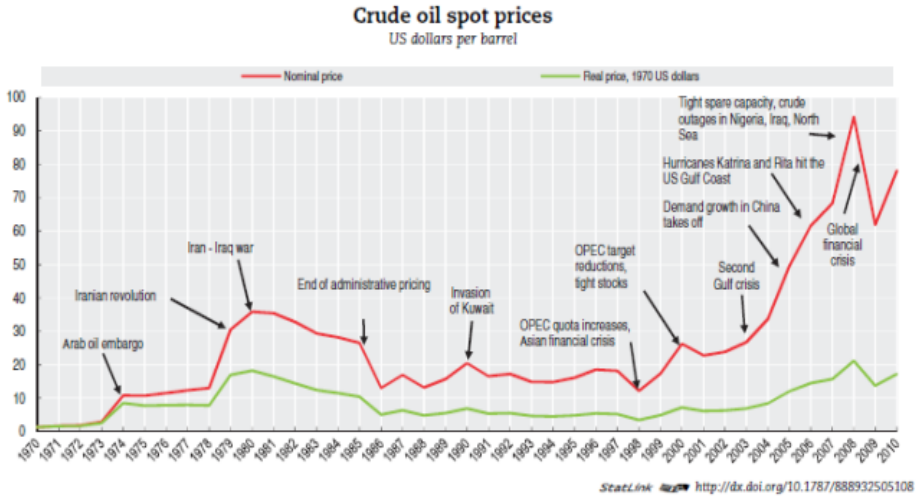
Scarcity of oil?

Oil - Total final consumption by sector 1971-2012

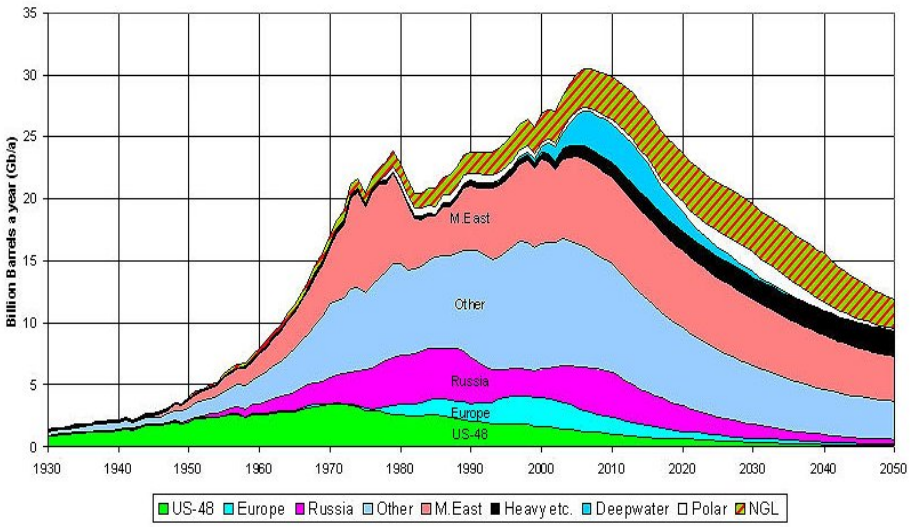


Source: IEA (2014) "Key world energy statistics"

Oil price development



Peak (conventional) oil



Unconventional oil

Types:

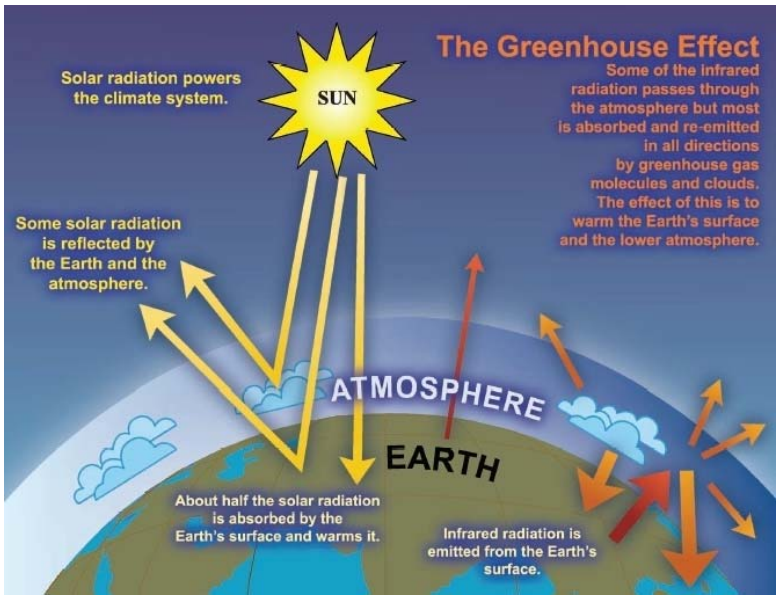
- Bitumen and tar sands
- Oil shales
- Gas to liquid
- Coal to liquid

Typical cost: 40-120 $/barrel

High investment cost:

Considerably higher CO2-emissions than conventional oil (roughly 40-100% higher)

Climate change



Some key concepts

Radiative forcing *(W/m²)*

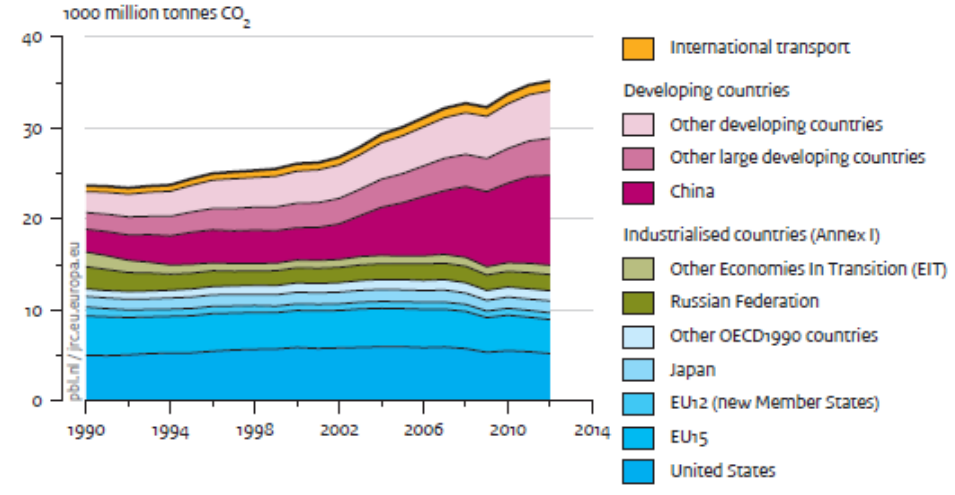
Radiative forcing is a measure of how the energy balance of the Earth-atmosphere system is influenced by different factors. It measures the balance between incoming solar radiation and outgoing infrared radiation.

GWP (Global Warming Potential)

Measures the integrated radiative forcing, caused by an emission, during a time period (typically 20, 50 or 100 years)

The global warming potential (GWP) of a certain GHG is measured as the amount of CO2 that has the same GWP. The measure is called CO2-equivalents or CO2-eq.

Global CO2 emissions per region from fossil fuel use and cement production



Source: EDGAR 4.2FT2010 (JRC/PBL, 2012); BP, 2013; NBS China, 2013; USGS, 2013; WSA, 2013; NOAA, 2012

Globally the transport sector stands for about 23% of energy related GHG emissions

Transport energy projection 2000-2050
If no measures are taken...

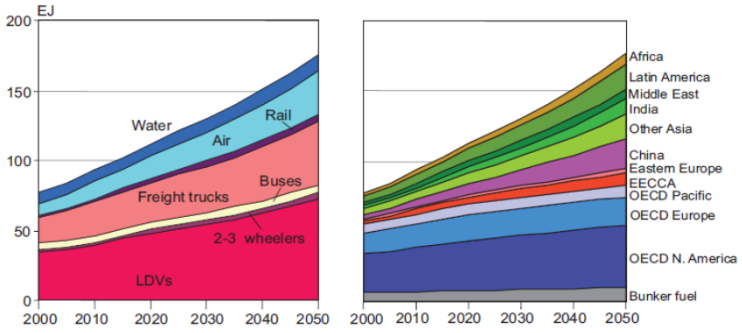
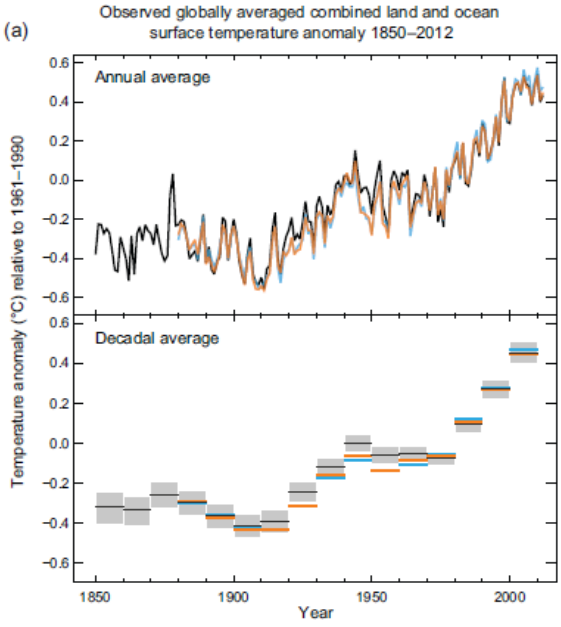


Figure 5.3: *Projection of transport energy consumption by region and mode*
Source: WBCSD, 2004a.

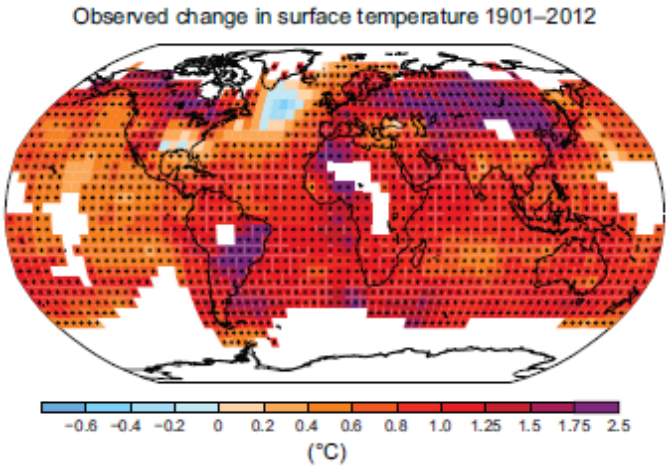
- Forecasts assume that oil supply will be sufficient…..and that no measures to limit climate change are introduced.
- EJ = Exajoule = 10^{18} J = 1 quintillion Joules
- LDV = light-duty vehicles (e.g. cars, small vans)

Global average temperature 1850-2012

(Increase of 0.8 degrees)



Observed surface temeperature change 1901-2012



Arctic ice sheet extent – Modelled and measured

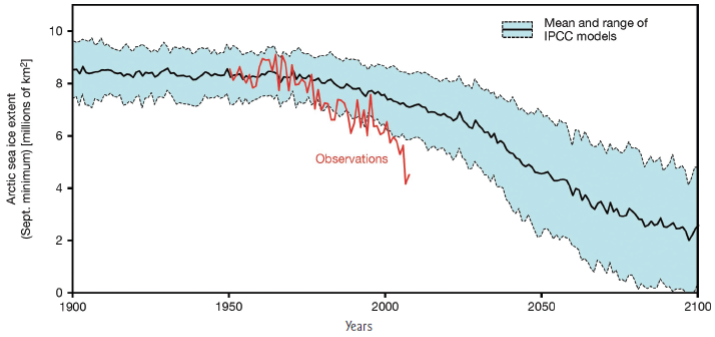
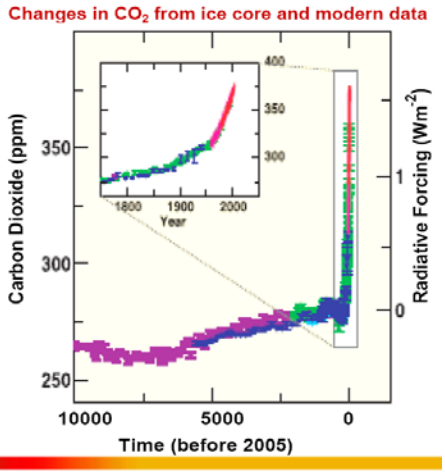


Figure 13. Observed (red line) and modeled September Arctic sea ice extent in millions of square kilometers. The solid black line gives the ensemble mean of the 13 IPCC AR4 models while the dashed black lines represent their range. From Stroeve et al. (2007) updated to include data for 2008. The 2009 minimum has recently been calculated at 5.10 million km², the third lowest year on record, and still well below the IPCC worst case scenario.

Human contribution to climate change

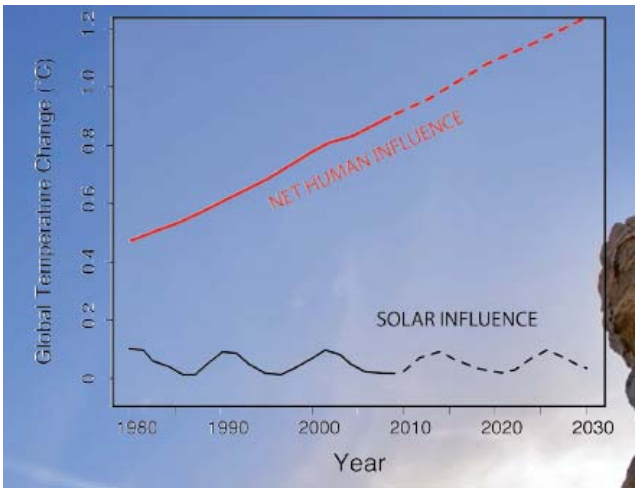
Global atmospheric concentrations of greenhouse gases **increased markedly as result of human activities**

In 2005 concentration of CO_2 **exceeded by far the natural range** over the last 650,000 years



But, is it not natural causes behind global warming?
Like variations in solar radiation?

Net human influence vs solar influence



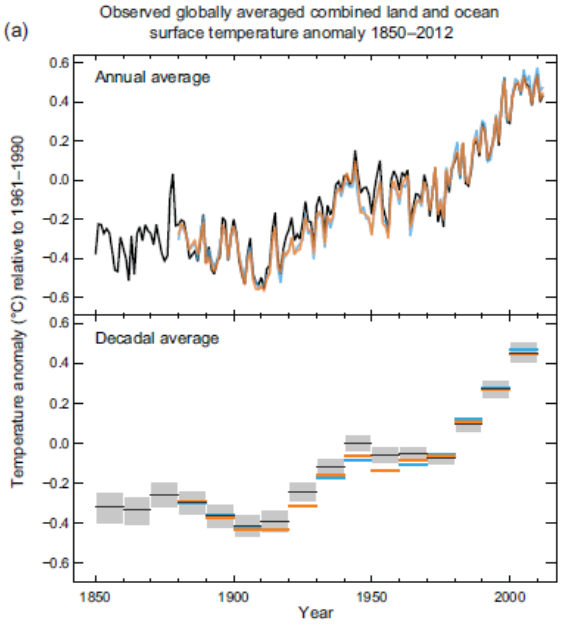
Source: The Copenhagen diagnosis, 2009: Up-dating the World on the Latest Climate Science. Allisson et al.

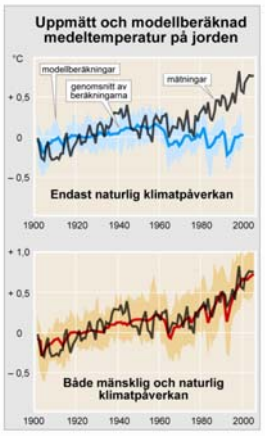
The Southern Oscillation (La Nina/El Nino)

- The Southern Oscillation affects winds and currents in the Pacific Ocean.
- Two extreme states:
  - La Nina
  - El Nino
- In the El Nino state the surface water of the Pacific Ocean is warmer than in the La Nina state. Cold deepwater is hindered from getting to the surface outside South America.
- El Nino occurs on average every 4th to 7th year.
- The Southern Oscillation may change <u>global</u> temperature by up to 0.2 degrees C.

Global average temperature 1850-2012

(Increase of 0.8 degrees)

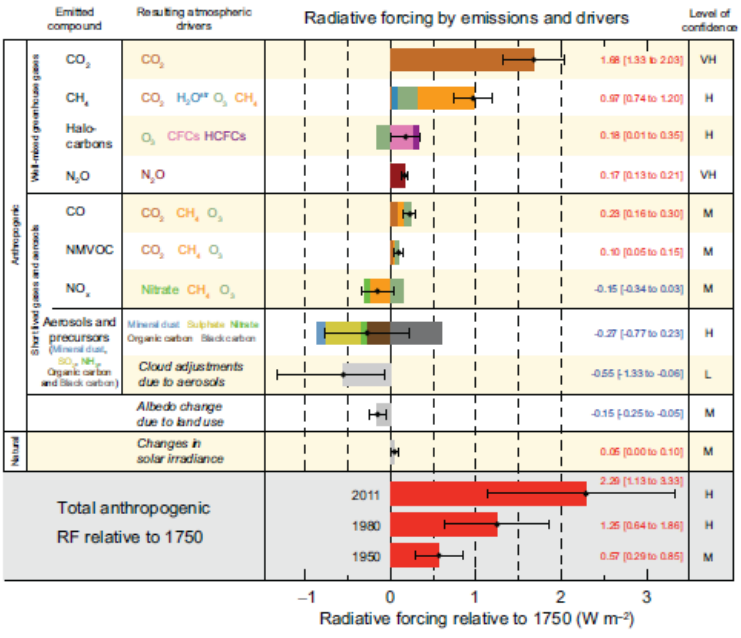




Från IPCC (2007) och *En ännu varmare värld* (Monitor 20). Naturvårdsverket

Drivers of climate change

Source: IPCC Fifth Assessment Report (2013)



How would global temperature develop if all fossil emissions ended tomorrow?

Global distribution of emissions

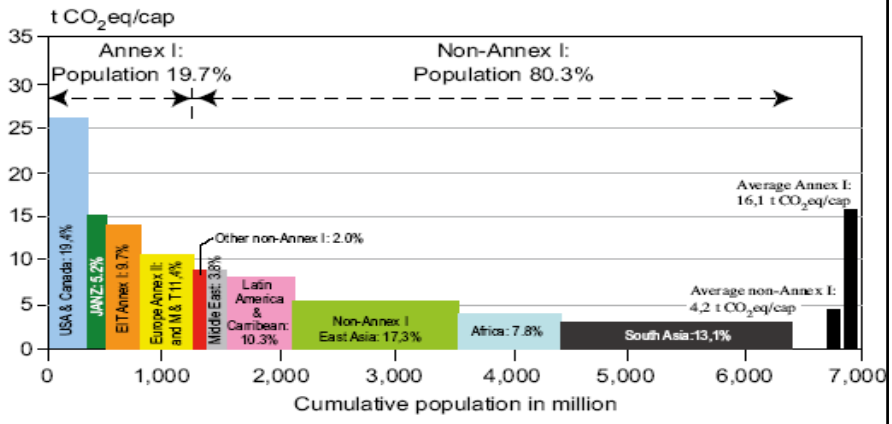


Figure TS.4a: *Distribution of regional per capita GHG emissions (all Kyoto gases including those from land-use) over the population of different country groupings in 2004. The percentages in the bars indicate a region's share in global GHG emissions [Figure 1.4a].*

Consequences of climate change

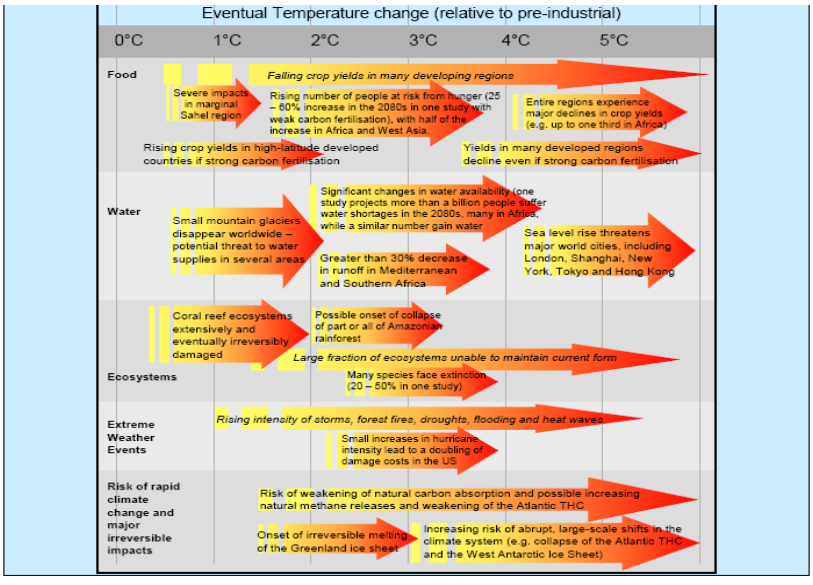
- Is a higher global temperature so bad?

Heavier precipitation, more intense and longer droughts….

More important are secondary consequences
- Impact areas of global change

- Water supply
- Food supply
- Health effects (malnutrition, deseases etc)
- Sea level rise, threatening big cities (London, New York, Shanghai etc) and agricultural land (like Bangladesh)
- Catastrophic weather events
  - *Floodings*
  - *Draughts*
  - *Storms (e.g. Hurricane Katrina in New Orleans)*

Estimated consequences from from global temperature increases



Global warming

↓

Drafts more frequent/Flooding of coastal areas

↓

More people starving

↓

Social unrest/Migration flows increases

↓

Higher risk for conflicts/wars

Costs are difficult to estimate, but:

Estimated costs for stabilizing at 450 ppm CO2-e:
<5% of global annual GDP.

Welfare loss without emission reductions:
Corresponding to 5-20% of global annual GDP.

” the appropriate estimate is likely to be in the upper part of this range.” (Stern, 2006, p x)

Still, worst case scenarios are not included in this analysis!

Källor: Stern, Nicholas (2006), STERN REVIEW: The Economics of Climate Change; EEA (2005), Climate change and a European low-carbon system; IPCC (2007), IPCC Fourth Assessment Report, Working Group III, Summary for Policymakers (07-05-04).

Possible feedback mechanisms that may accelerate global warming out of human control

- Warmer climate➔ Decreasing snow and ice cover ➔ More solar radiation is absorbed ➔ Even warmer climate
- Warmer climate➔ Permanently frozen ground in Siberia is melting in the summer time ➔ Methane is released from the ground (methane is a strong greenhouse gas) ➔ Even warmer climate

According to best available scientific knowledge there is 80-90% probability that human emissions are the cause of climate change

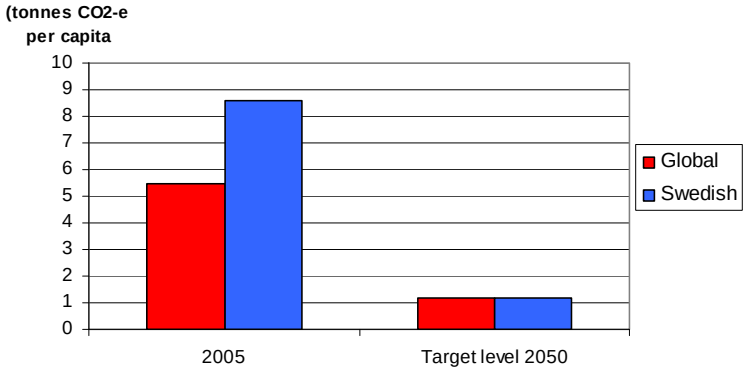
- But what if the probability only was 50% or even 20%?
- What conclusions on action would we draw then?

The EU among others have adopted the ”2-degree target”

Global temperature increase should be kept below 2 degrees in order to avoid the worst consequences of climate change.

Target levels for emissions 2050 in order to keep global warming below two degrees

(-80% per capita globally, -87% for Swedes)



Sources: Stern, Nicholas (2006), STERN REVIEW: The Economics of Climate Change; EEA (2005), Climate change and a European low-carbon system.

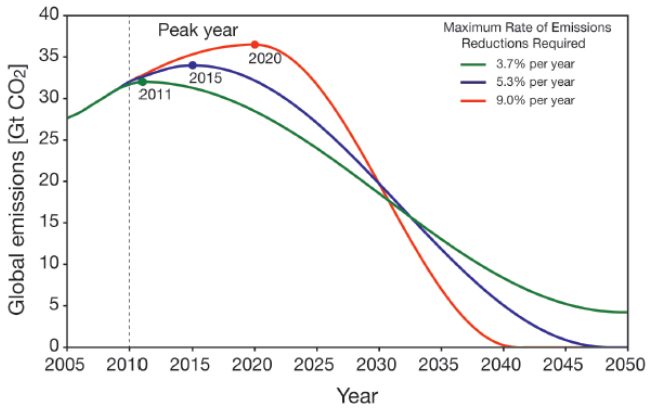


Figure 22. Examples of global emission pathways where cumulative CO_2 emissions equal 750 Gt during the time period 2010-2050 (1 Gt CO_2 = 3.67 Gt C). At this level, there is a 67% probability of limiting global warming to a maximum of 2°C. The graph shows that the later the peak in emissions is reached, the steeper their subsequent reduction has to be. The figure shows variants of a global emissions scenario with different peak years: 2011 (green), 2015 (blue) and 2020 (red). In order to achieve compliance with these curves, maximum annual reduction rates of 3.7 % (green), 5.3 % (blue) or 9.0 % (red) would be required (relative to 2008). (Source: German Advisory Council on Global Change; WBGU 2009).

Three global challenges that concern transport

- Mitigation of **Climate change**
- Growing **scarcity of oil** (Peak-oil debate)
- Preserving **Ecosystem services** (Food production, clean air and water etc)

Energy futures are connected to all three!

Energy futures…

…will be shaped by:

- Climate change
- Growing scarcity of oil
- Rising global population increasing the demand for food and resources

How to reduce emissions of carbon dioxide fossil fuels

(1) Less carbon intensive energy supply

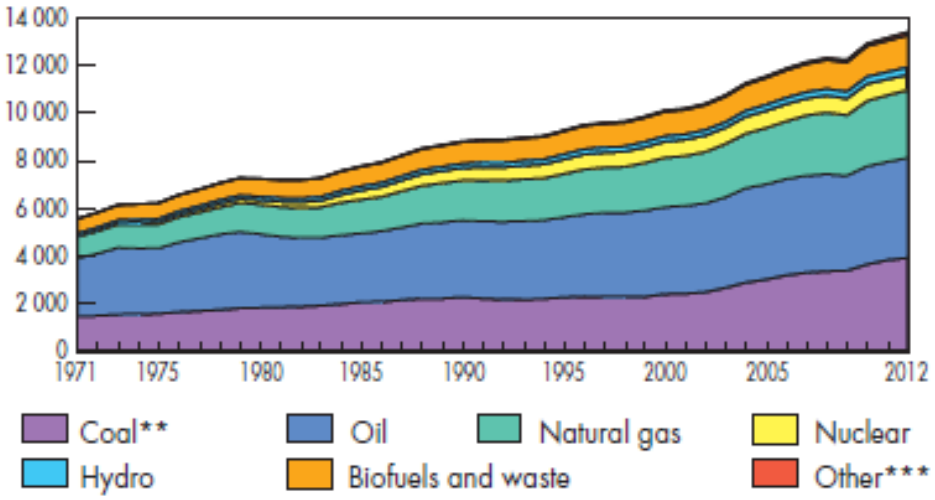
(2) Improved end-use technology (more energy efficient cars, aircraft etc)

(3) Decrease need for transport activities (e.g. by urban planning measures)

Emissions= Activity * Energy efficiency * Carbon intensity* Population

Example: (passenger-km) (kWh/p-km) (kg CO2/kWh)

World primary energy supply 1971-2012



Energy sources that might be used to reduce greenhouse gas emissions

- Bioenergy
- Renewable electricity; wind, solar, hydro, wave etc
- Renewable heat; solar heat, geothermal heat etc
- Fossil fuels with carbon capture and storage
- Nuclear power
- Natural gas (25% reduction compared to oil if there is no leakage…)

More about Energy futures