Climate Change

The Scale & Urgency of the Challenge

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(water vapour) carbon dioxide, methane,... Fourier (1827), Tyndall (1861)

Causes of the current imbalance in the energy budget IPCC 2007



Radiative forcing of climate between 1750 and 2005

IPCC 2007 Fourth Assessment Report: "Global Warming is unequivocal"

Since 1970, rise in:

- Global surface temperatures
- Tropospheric temperatures
- Global ocean temperatures
- ✤ Global sea level
- Water vapour
- Rainfall intensity
- Precipitation in extratropics
- Drought
- Extreme high temperatures
- Summer Greenland ice sheet melt

Decrease in:

NH Snow extent Arctic sea ice Glaciers Cold temperature extremes 20th Century Continental Temperatures: Observed & Modelled with & without anthropogenic forcings



Projections of globally averaged surface warming

IPCC 2007



Surface Temperature & Precipitation Projections Dec-Feb and June-Aug: 2090s relative to 1980-99



IPCC Projections of Sea Level Rise at 2100



Acidification of the oceans



Mechanisms for extreme changes?

- •Large dynamical ice sheet loss: Greenland & West Antarctic
- •Reduced carbon absorption/emission: soil, vegetation, ocean
- •Methane emission from melting tundra, peat, hydrates
- Rapid change in the circulation of the atmosphere/ocean: reduction in the Atlantic northward heat transport frequency or nature of ENSO Asian monsoon circulation summer European blocking nature or location of winter storm-track nature or location of tropical cyclones
 Complex dynamical system behaviour

6 Global warming above present temperature (°C) Year 2100 (IPCC 2007) 5 Atlantic meridional overturning circulation Sahara/Sahel and West African monsoon El Niño southern oscillation amplitude 4 3 West Antarctic ice sheet Arctic summer sea ice Greenland ice sheet Amazon rainforest 2. Boreal forest 0

Burning Embers

range

Potential policy-relevant tipping elements that could be triggered by global warming this century, with shading indicating their uncertain thresholds. For each threshold, the transition from white to yellow indicates a lower bound on its proximity, and the transition from yellow to red, an upper bound. The degree of uncertainty is represented by the spread of the colour transition.

T. M. Lenton & H.J. Schellnhuber (Nature Reports Climate Change, 2007)

Updated Reasons for Concern



TAR (2001) Reasons For Concern

Proposed AR4 (2007) Reasons For Concern

(Smith et al. 2009 PNAS)

First Report of the UK Climate Change Committee Dec 2008: Building a Low-Carbon Economy – The UK's Contribution to Tackling Climate Change

Recent observed trends in CO₂ emissions & concentrations



Trend in global carbon dioxide emissions from fossil fuel burning and other industrial processes (source: CDIAC)

Observed trend in global atmospheric CO₂ concentration (source: NOAA/ESRL)

Kyoto GHG emissions trajectories designed by the CCC

•Peak in emissions around 2028 or 2016.

•Subsequent reductions in CO_2 emissions range from 1.5% to 4% per year.

•Other Kyoto gas emissions are reduced at consistent rates, with consideration of the ultimate emissions 'floor' that might be reasonably reached.



Peak 2028 CO_2 emissions reducing at 1.5% or 4%. Peak 2016 CO₂ emissions reducing at 1.5%, 3% or 4%. 2016:3% and 2016:4% were given lower emissions floors

Some projected CO₂e concentrations

CCC 2008



Examples of projected global mean temperatures CCC 2008



Probability distributions of global mean temperature increase by 2100 CCC 2008



Preferred trajectories: emissions target for 2050 CCC 2008

| Emissions | Kyoto gas emissions (GtCO ₂ e) | | | 2050 emissions cut, from | |
|------------|---|------|------|--------------------------|------|
| trajectory | 1990 | 2007 | 2050 | 1990 | 2007 |
| 2016:3% | 36.1 | 48.1 | 23.9 | 34% | 50% |
| 2016:4% | 36.1 | 48.1 | 19.6 | 46% | 59% |

Broadly in line with the G8 commitment to halve emissions by 2050.



Cumulative emissions perspective

| 6:3%low | | | |
|----------|-----------|----------------------|-----------|
| 6:3%high | Years | Gt CO ₂ e | Tt Ce |
| 6:1.5% | 1990-2008 | 800 | 0.22 |
| | 1990-2050 | 2420-2540 | 0.66-0.69 |
| | 1990-2100 | 3000-3200 | 0.82-0.87 |

Year

CCC proposed UK CO₂e emission targets



Appropriate UK contribution : the scale of the challenge

CCC 2008



* bunker fuels basis