



**CARBON ABATEMENT:
Background and Pointers for the
UK**

By

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British Flame Technical Meeting

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- The IPCC thesis is that CO₂ emissions and thus combustion of fossil fuels should be constrained in order to limit climate change.
- That premise is a key element in the Government's White Paper on Energy (cm 5761, Feb 2003). Aim is 60% reduction of CO₂ from current levels by 2050.



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Energy balance
on planet, Wm^{-2}

INCIDENT RADIATION

		345 Wm^{-2}	
Absorbed in Stratosphere		10	3%
Absorbed in Lower Atmosphere		69	20%
Reflected		104	30%
Absorbed by Earth		162	47%

EARTH EMITS

		393	
Escaping into Space		24	6%
Trapped in Atmosphere		369	94%

ATMOSPHERE RECEIVES

By Radiation	$10 + 69 + 369 =$	448	
From Clouds and Precipitation		90	
From Surface Convection		17	
Total		555	

ATMOSPHERE RADIATES

To Space		217	
Back to Earth	$555 - 217 =$	338	

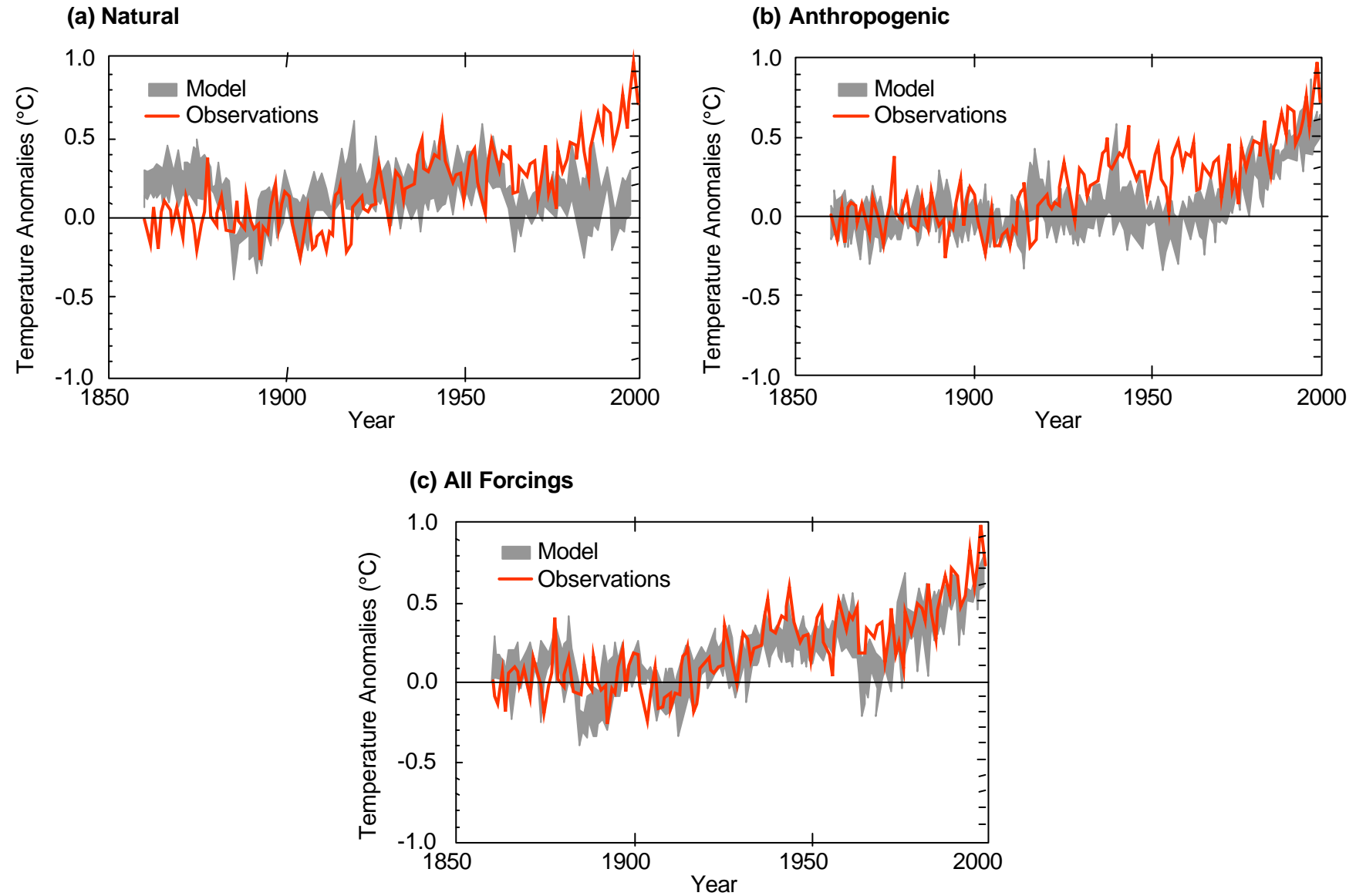
ATMOSPHERIC HEATING FROM EARTH

Evaporation (Clouds and Precipitation)		90	65.2%
Radiative	$369 - 338 =$	31	22.5%
Convection		17	12.3%

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Simulated Annual Global Mean Surface Temperatures



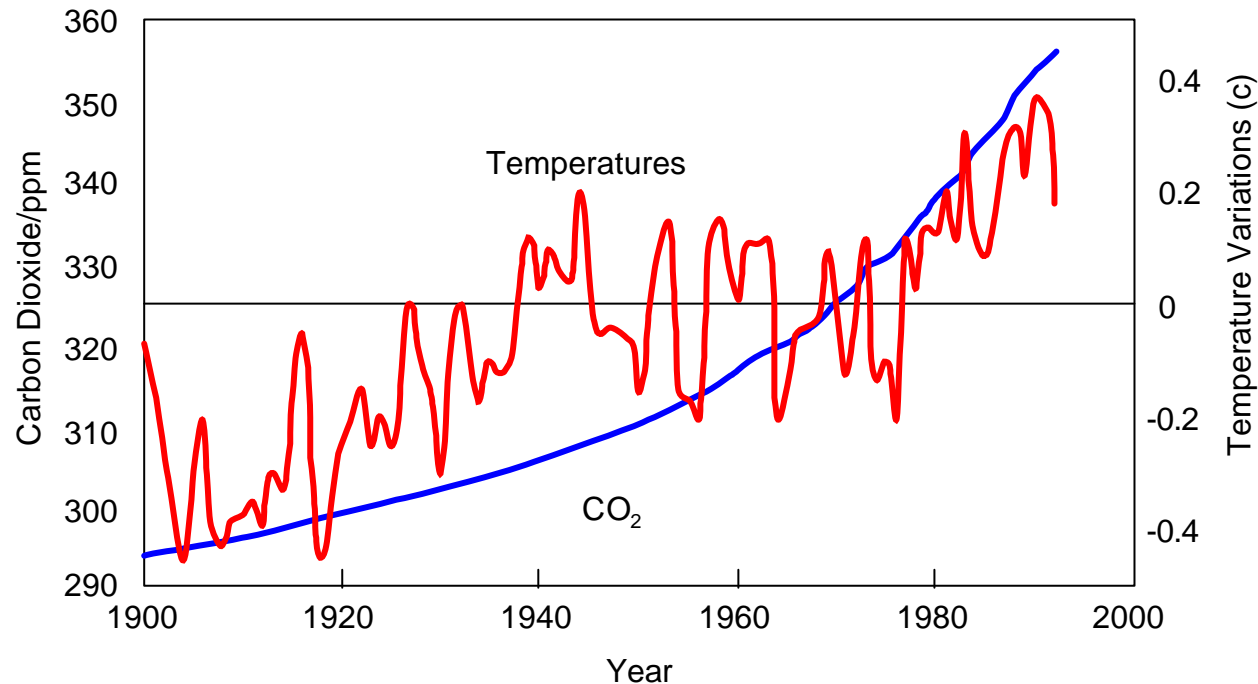


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Criticisms of Climate Models

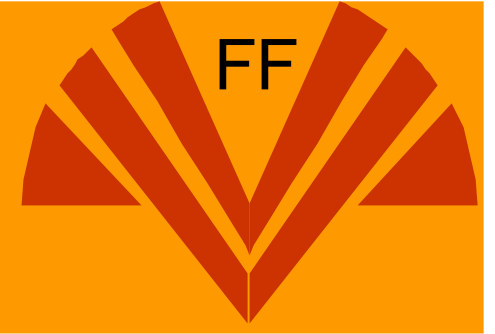
- The science of 'global warming' is not fully understood and cannot be formulated
- The models are so large and complicated that simplification and approximation is needed to make them tractable
- As more factors and mechanisms are incorporated the greater the uncertainty in the predictions from them
- Natural variability not dealt with
- Water vapour and clouds inadequately treated

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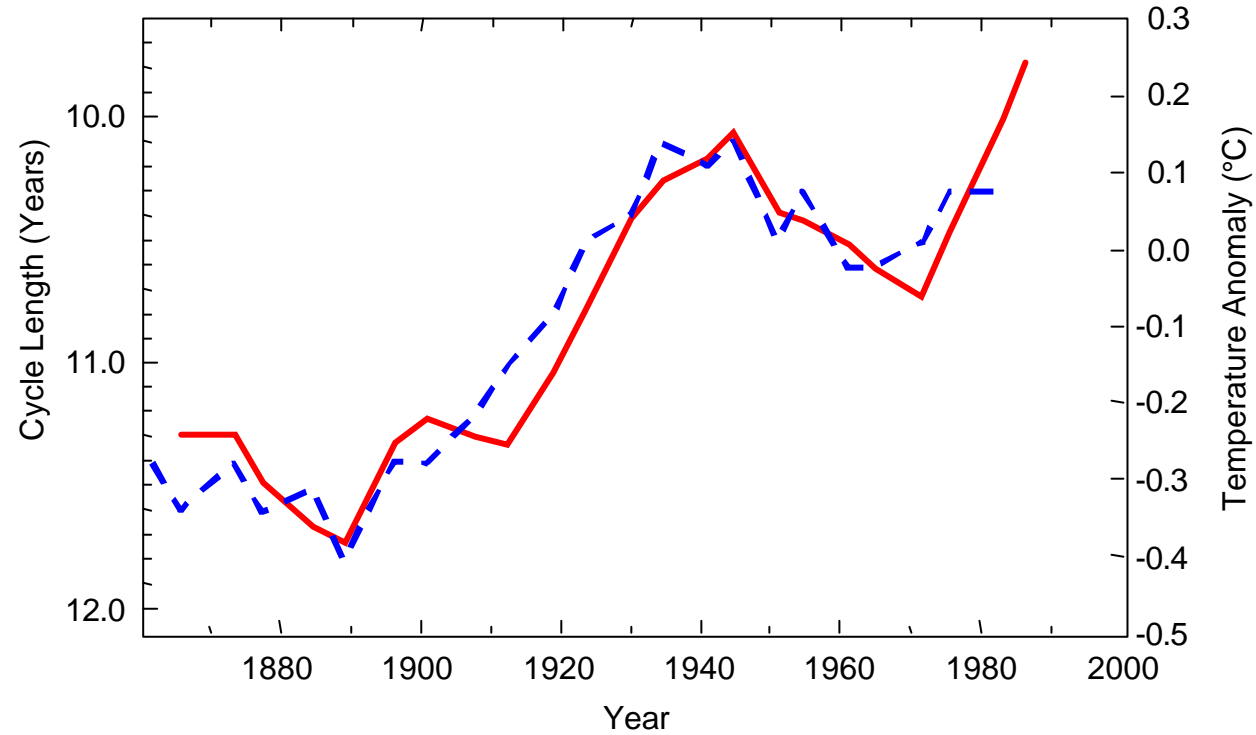


Mean sea and surface temperature changes and atmospheric carbon dioxide concentrations (parts per million) for the years 1900-1992. Northern hemisphere. The zero for the temperature changes is the mean value from 1950 to 1980.

After Barrett



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The variation of the sunspot cycle length since 1860, (—) superimposed on the variation in the mean air temperature for the northern hemisphere (- - -) (from Friis-Christensen, 1991)



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IPCC Climate Prediction

- Calibrate climate model using historical data
- Predict patterns of future CO₂ levels from future world scenarios
- Use predicted CO₂ patterns in climate model to calculate temperature changes
- From the range of models and scenarios, temperature increases from now until 2100 range from 1.4 °C to 5.8 °C
- Measured change since middle of last century 0.6 °C ±0.2 °C



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Criticisms of Future World Scenarios

- Depend critically on assumptions of future population levels, lifestyles and technologies
- World in 2100 likely to be as different from today as today is from 1900
- Volume of anthropogenic CO₂ small compared with that produced geologically and biologically
- Oceans and photosynthesis remove large quantities from atmosphere
- Lifetime of CO₂ in atmosphere disputed



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Surface Temperature Measurement

- Past measurements unreliable and incomplete.
- Measurements only over a very short period of earth's existence and a small proportion of its surface.
- Number of land based stations limited:-
 - 1880s – hundreds
 - 1960s – 8,000
 - today – 3,000 max
- Very few sea based stations.
- Data from land based stations may need 'urbanisation' correction as high as 20% of measured values. Some believe correction still too small and 'warming' spurious.
- Whilst weather stations show 'warming', data from proxy methods, weather balloons and satellites show none or very much reduced values.



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Atmospheric Temperature Measurement

- For the greenhouse theory to hold temperatures in the lower atmosphere should warm at least as quickly as at the surface: the 'fingerprint'
- Satellite and radio-sonde measurements agree perfectly and show less warming than surface measurements
- In May 2004 satellite measurements said to show fingerprint when corrected for cooling effect of the upper atmosphere (University of Washington)
- Washington study said to be methodologically flawed (University of Alabama: May 2004)
- From 1978-2003 northern latitudes warmed by 0.19 °C; little or no such warming in the tropics and southern latitudes (University of Alabama: February 2004)



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The Kyoto Protocol 1997

- Industrialised countries will reduce their combined greenhouse gas emissions by at least 5% compared to 1990 levels by the period 2008-2012
- The protocol was opened for signature on 16th March 1998
- It became binding on Feb 16th 2005, 90 days after it had been ratified by at least 55 parties to the convention, including developed countries accounting for at least 55% of the total 1990 CO₂ emissions from this industrialised group



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CO₂ Reduction Targets

- Kyoto: Reduce CO₂ emissions by 5% below 1990 levels by 2012
- UK1: Reduce CO₂ emissions by 20% by 2010
- UK2: Reduce CO₂ emissions by some 60% by about 2050 with real progress by 2020
- UK industry at a disadvantage compared with the industry in countries accepting basic Kyoto reduction, or free of restriction



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Emissions Trading Scheme

- Operational 1st January 2005
- Covers only 46% of EU carbon emissions as air and land transport excluded
- Companies' emissions 'capped' and breach of cap incurs penalties
- Emission Permits can be traded
- Joint Implementation Schemes and Clean Development Mechanisms



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- POLITICAL ASPECTS
- US the biggest emitter has not ratified Kyoto and neither has Australia
- China, India, Nigeria, Mexico and Brazil are exempt from restrictions as they are developing countries.
- China plans 40m new cars by 2020 and up to 30 large coal fired power stations. In fifteen years it will be emitting more CO₂ than the USA
- How and when does Kyoto embrace these nations



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- Emissions savings currently agreed will have only a tiny effect on climate
- Energy prices have risen sharply driven by Chinese and US demand. Further significant increases expected as a result of Kyoto initiatives
- Manufacturing profitability will be reduced
- UK industry disadvantaged compared with US and developing countries
- Business may be driven off-shore
- Former communist countries have advantage of excess emissions permits



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Estimated Costs of Implementing Kyoto Protocol Europe

- Loss in GDP
5% UK, Germany, Spain; 3.8% Netherlands
- Unemployed
1.8M Germany; 1M UK, Spain; 240,000 Netherlands

From Wall St. Journal Europe, 22nd April 2002



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Estimated Costs of Implementing Kyoto Protocol United States

- From MIT 2000
\$45 bn - \$58 bn (1995 \$US) in 2010 depending
on extent of emissions trading
- From US Department of Energy 1998
Annual GDP lowered by \$56 bn (1992 \$US) in
2010, equals 11% GDP



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Hydrogen Production and CO₂ Removal Before Combustion

- Catalytic Reforming; $\text{CH}_4 = \text{CO} + 2\text{H}_2$ followed by
- A Shift Reaction; $\text{CO} + \text{H}_2\text{O} = \text{H}_2 + \text{CO}_2$
- CO₂ Removed for Sequestration and perhaps enhanced oil recovery
- Hydrogen for power production in combined cycle plant or for transport fuel



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- **Growing interest in gasification of wastes**
- **Some processes cannot operate without solid carbon and use in combination with pure oxygen is not feasible e.g. the iron blast furnace**
- **In the short term industry generally must improve the efficiency of its processes in terms of maximising prime yields and the proportion of product sold to specification per unit of energy consumed**
- **Greater industrial symbiosis is desirable.**



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Conclusions For Pessimists

- **Climate models are flawed**
- **Future world scenarios very uncertain**
- **Scientific basis of Kyoto unproven**
- **Cost of its implementation enormous**
- **Foreseeable benefit minimal**
- **Penalises UK industry**
- **Some industries may be forced offshore**