



The Future and UK Energy

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An engineering achievement



World energy demand



2006

10 000 000 MW



2050

20 000 000 MW

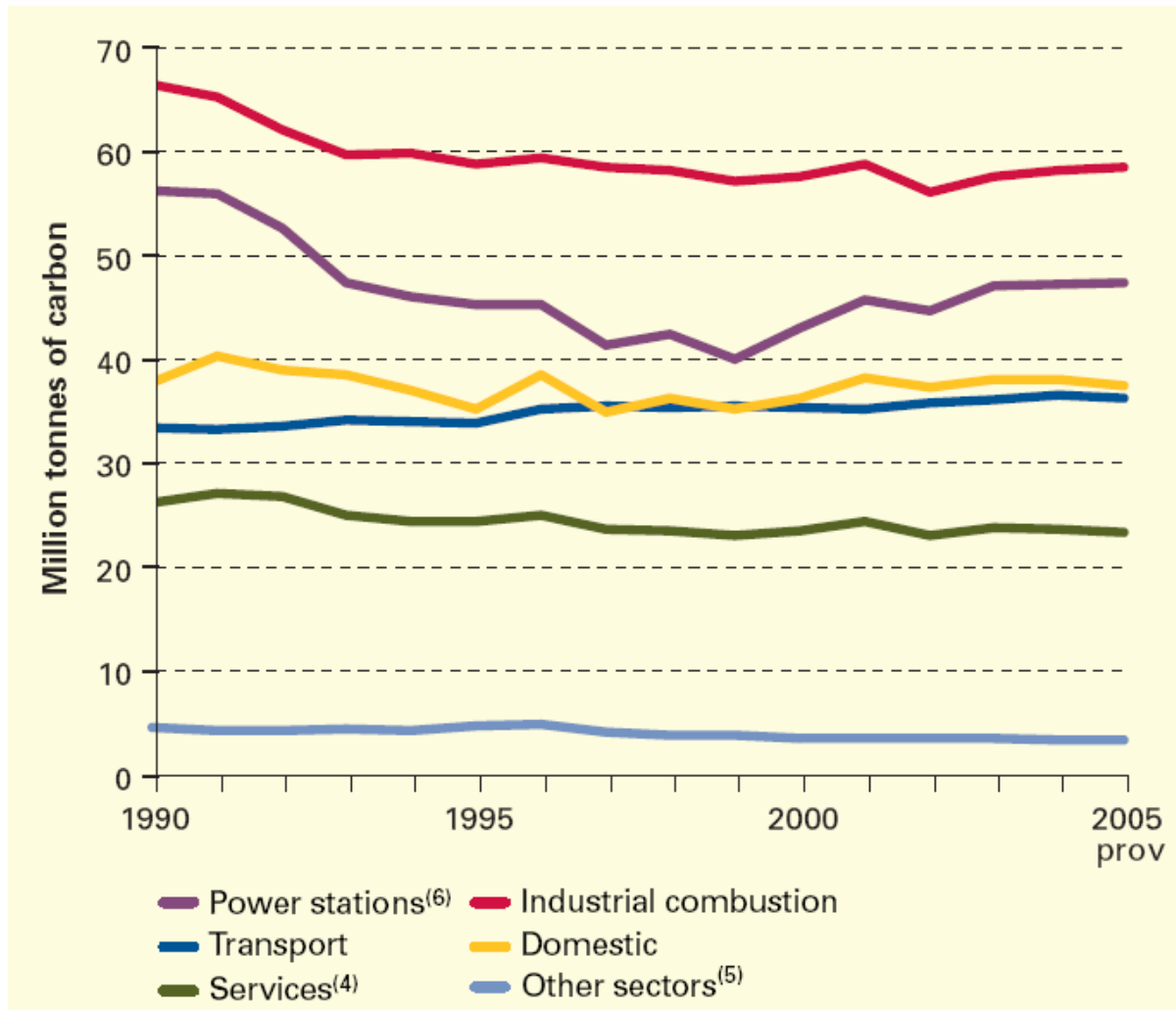
Sun

100 000 000 000 MW

Wind

100 000 000 MW

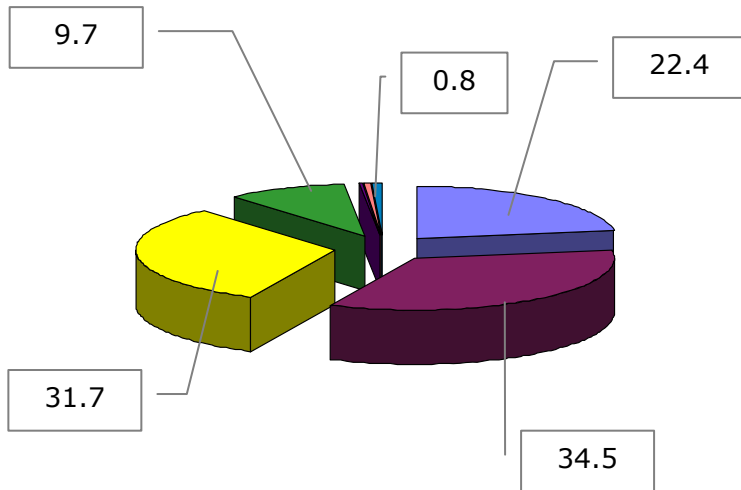
UK energy use by sector



UK energy sources

1995

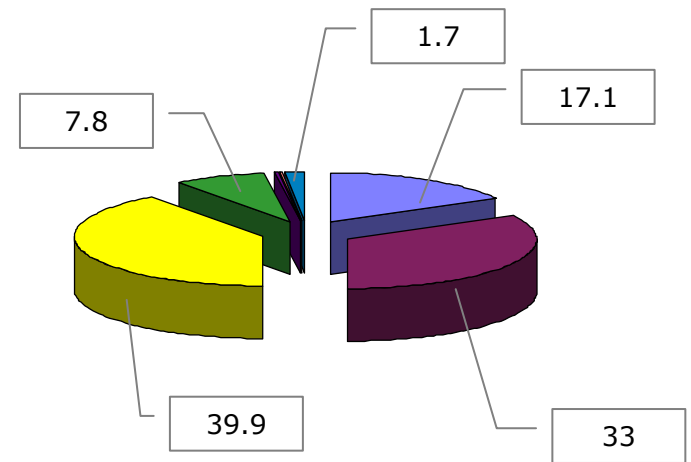
Total: 218.4 mtoe



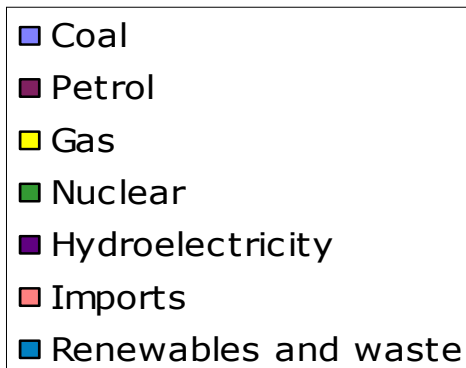
%

2005

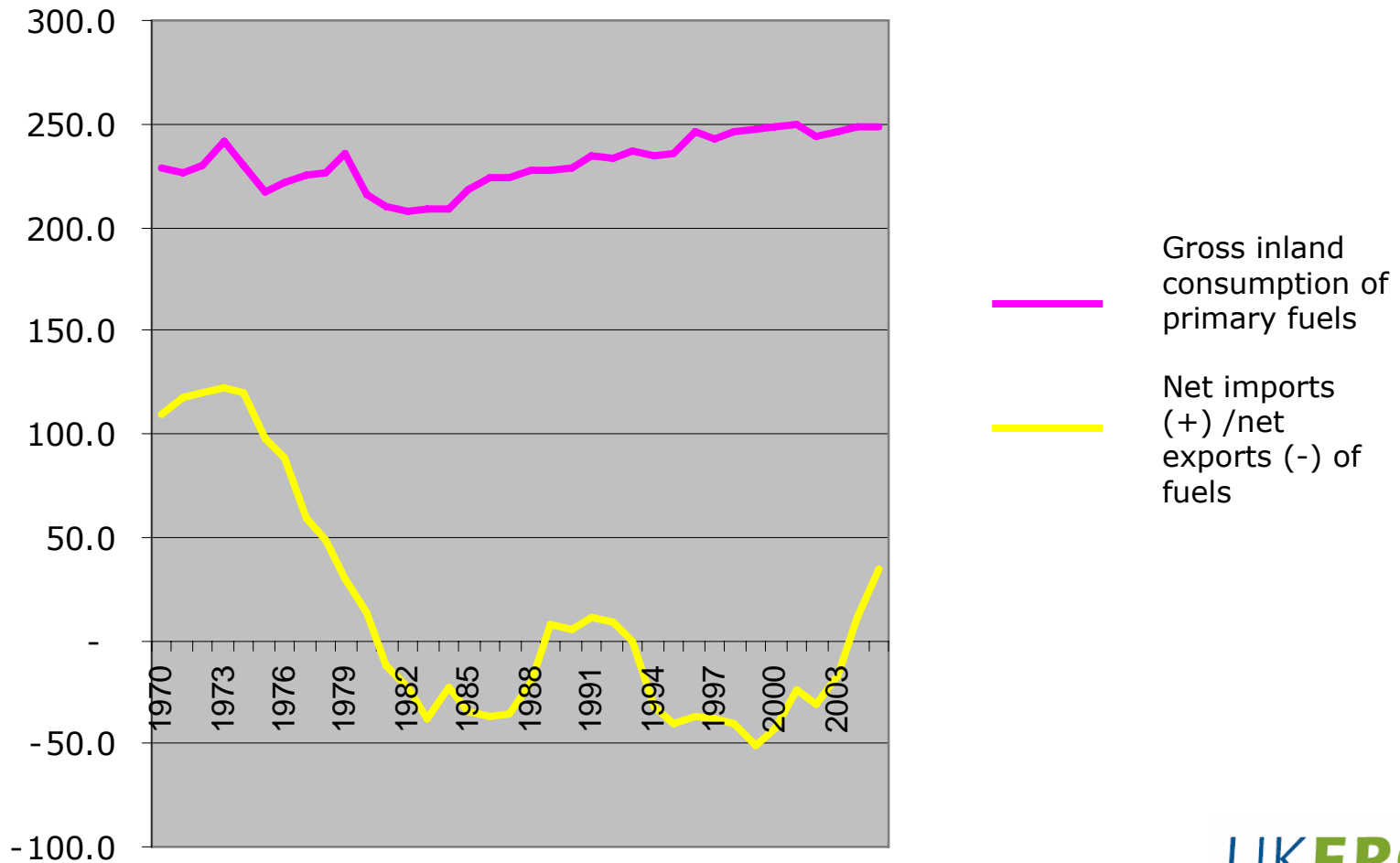
Total: 234.3 mtoe



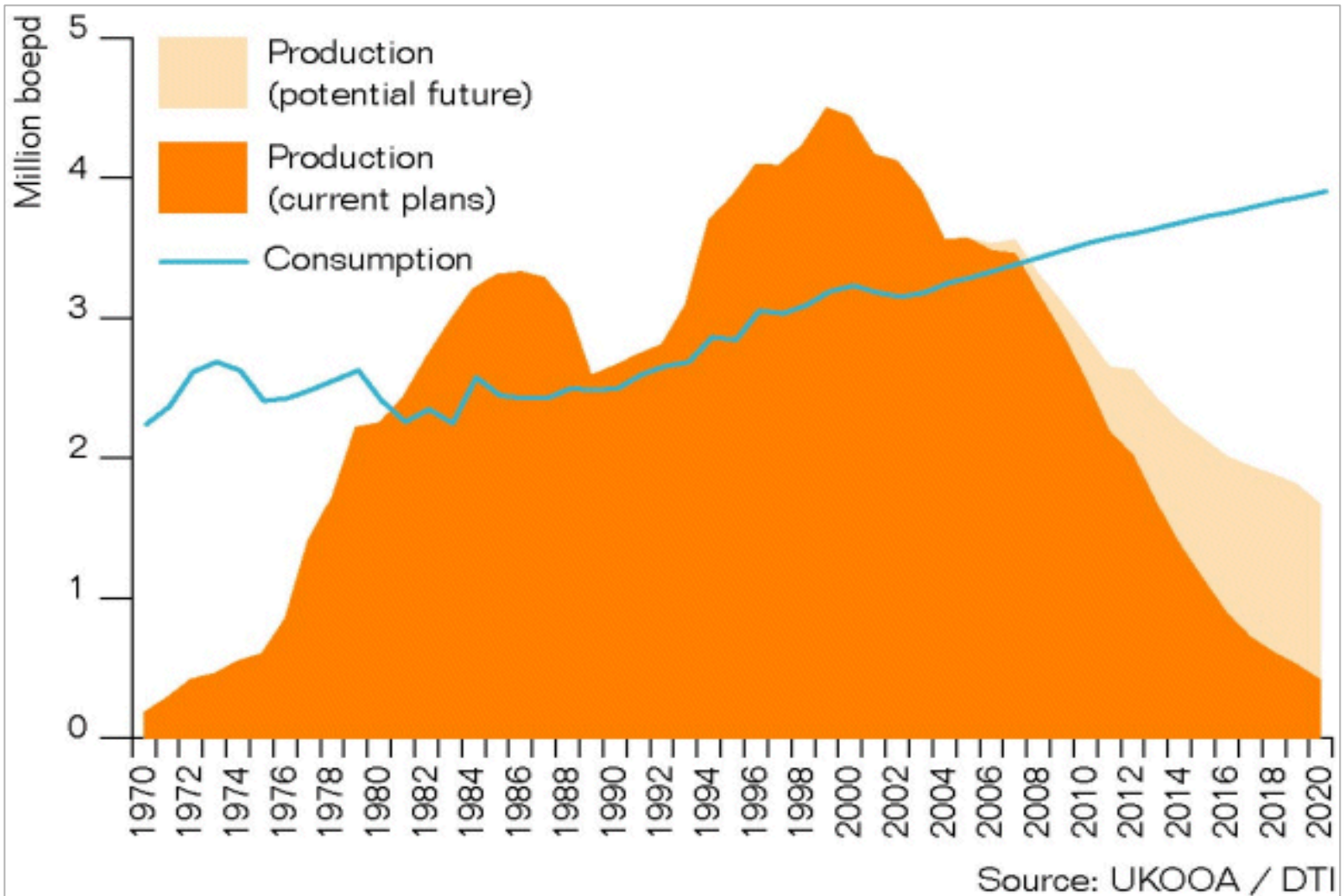
%



UK fuel consumption



North Sea Oil and Gas Production



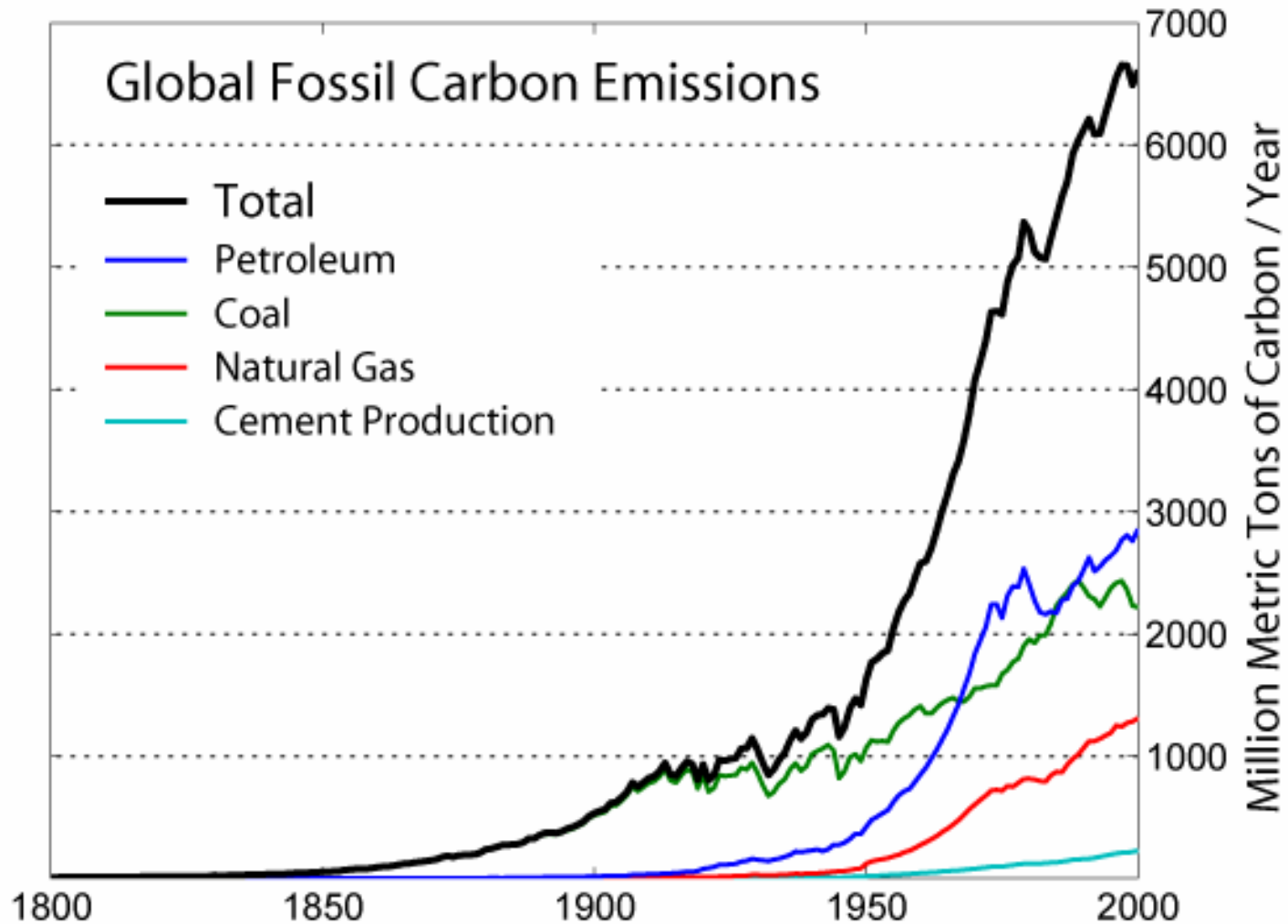
"Proven" reserves of energy



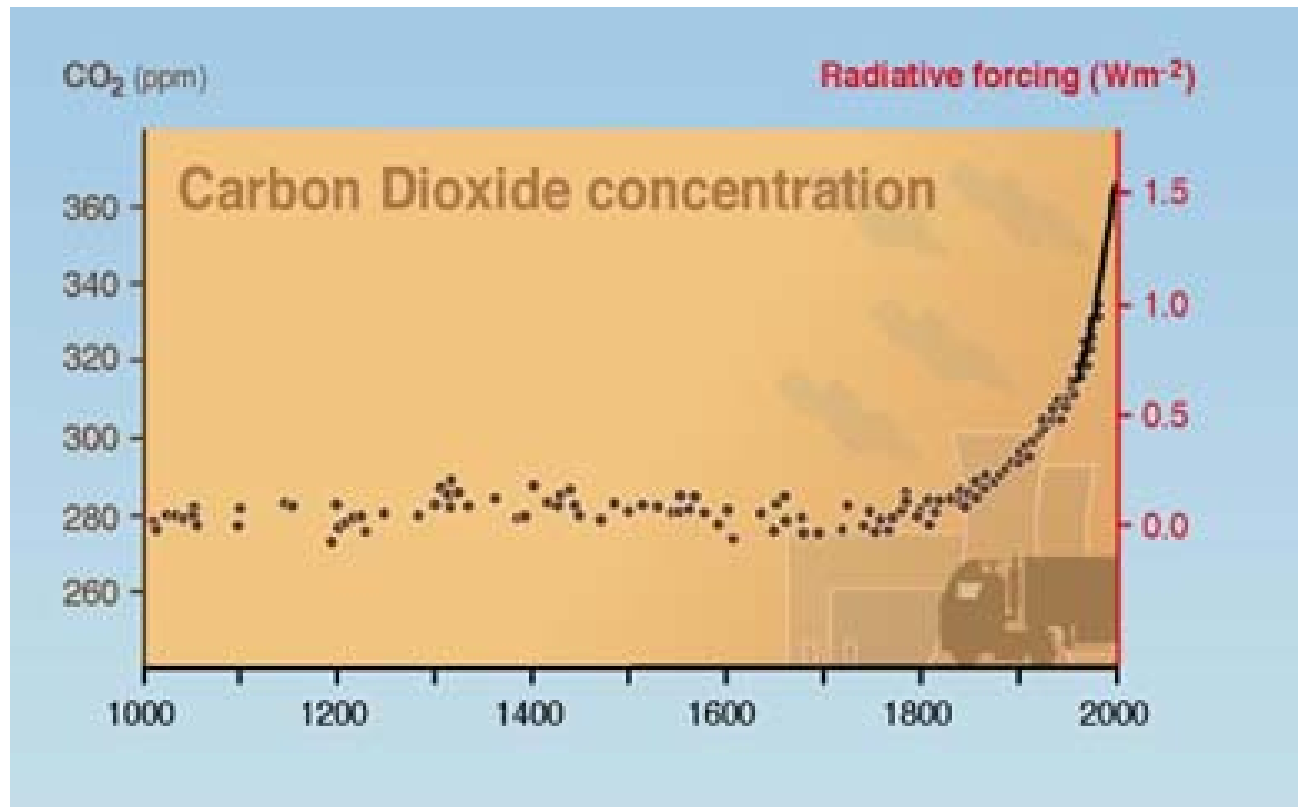
- Oil 41 years
- Natural Gas 67 years
- Coal 165 years

Based on current prices at today's rates of extraction and consumption

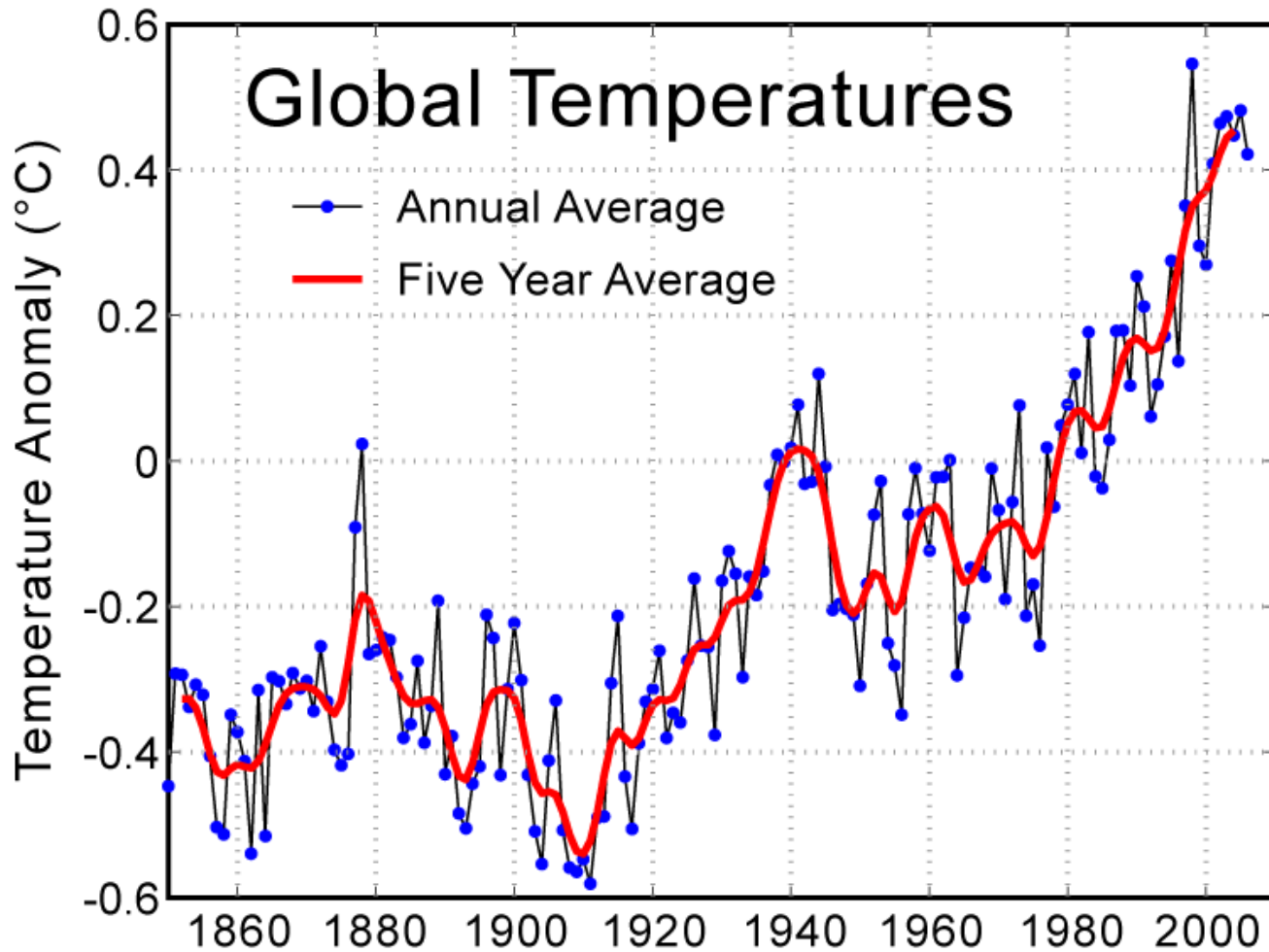
World emissions of fossil carbon



CO₂ levels over 1000 years

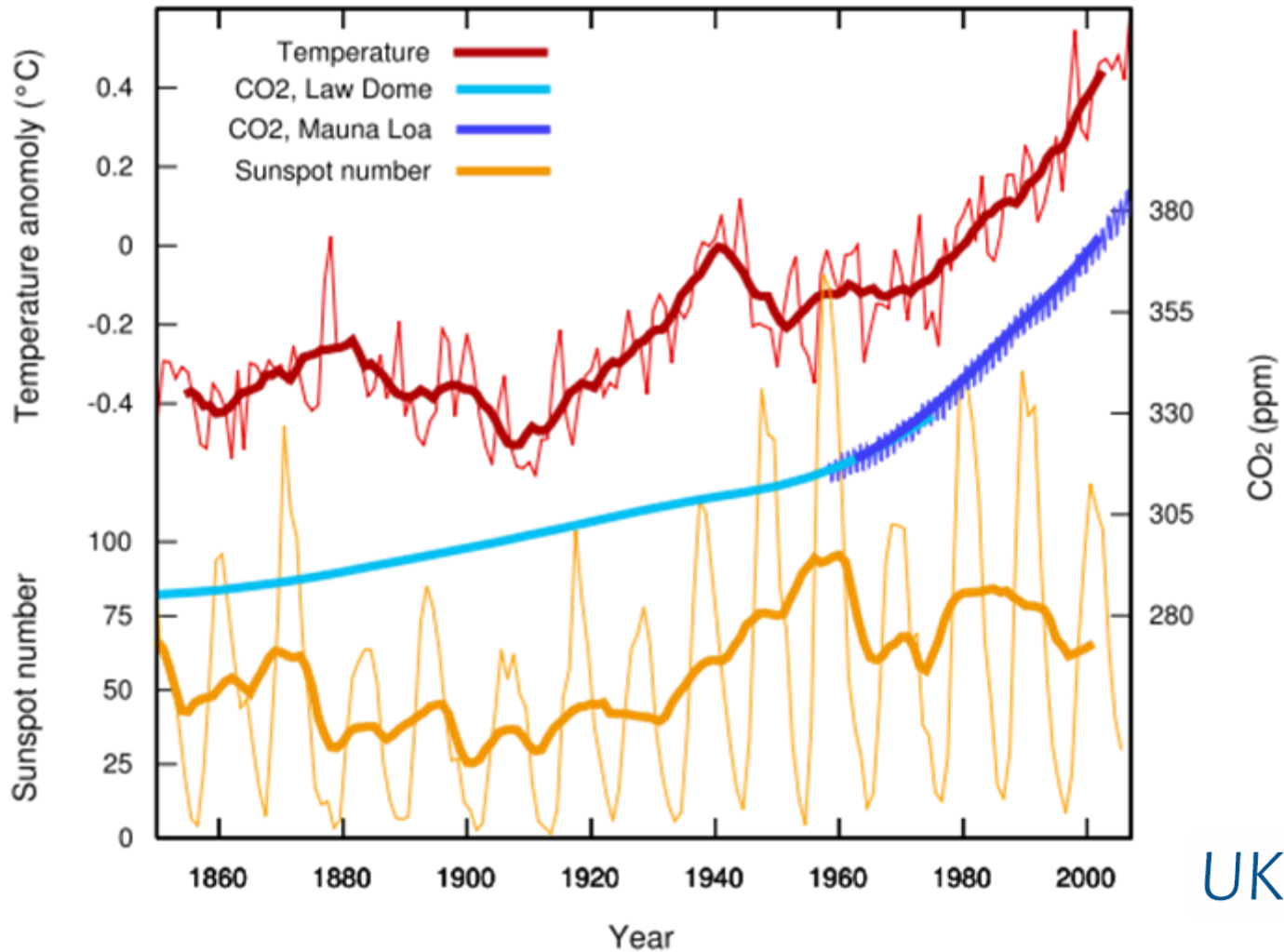


Historical temperatures

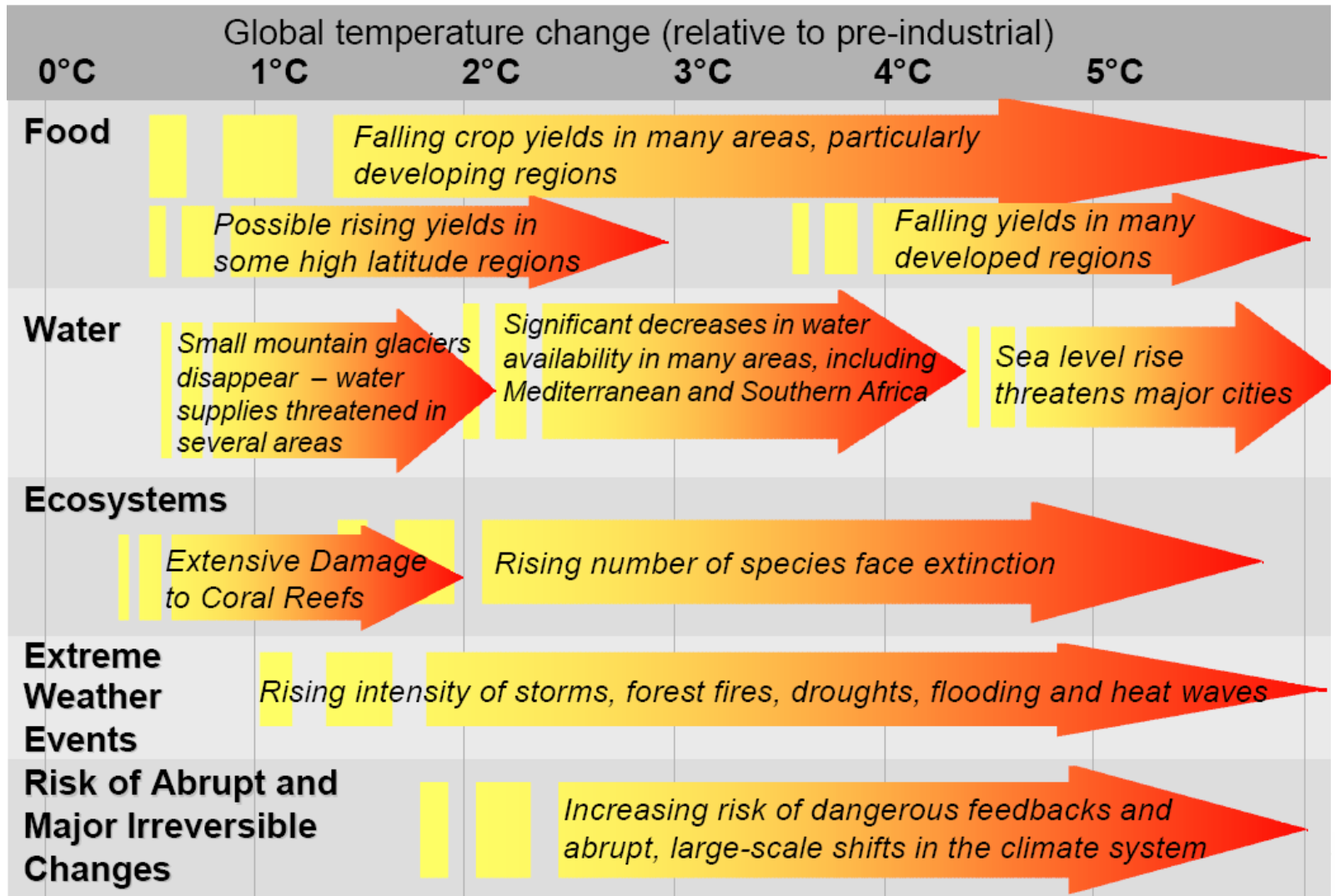


Another view

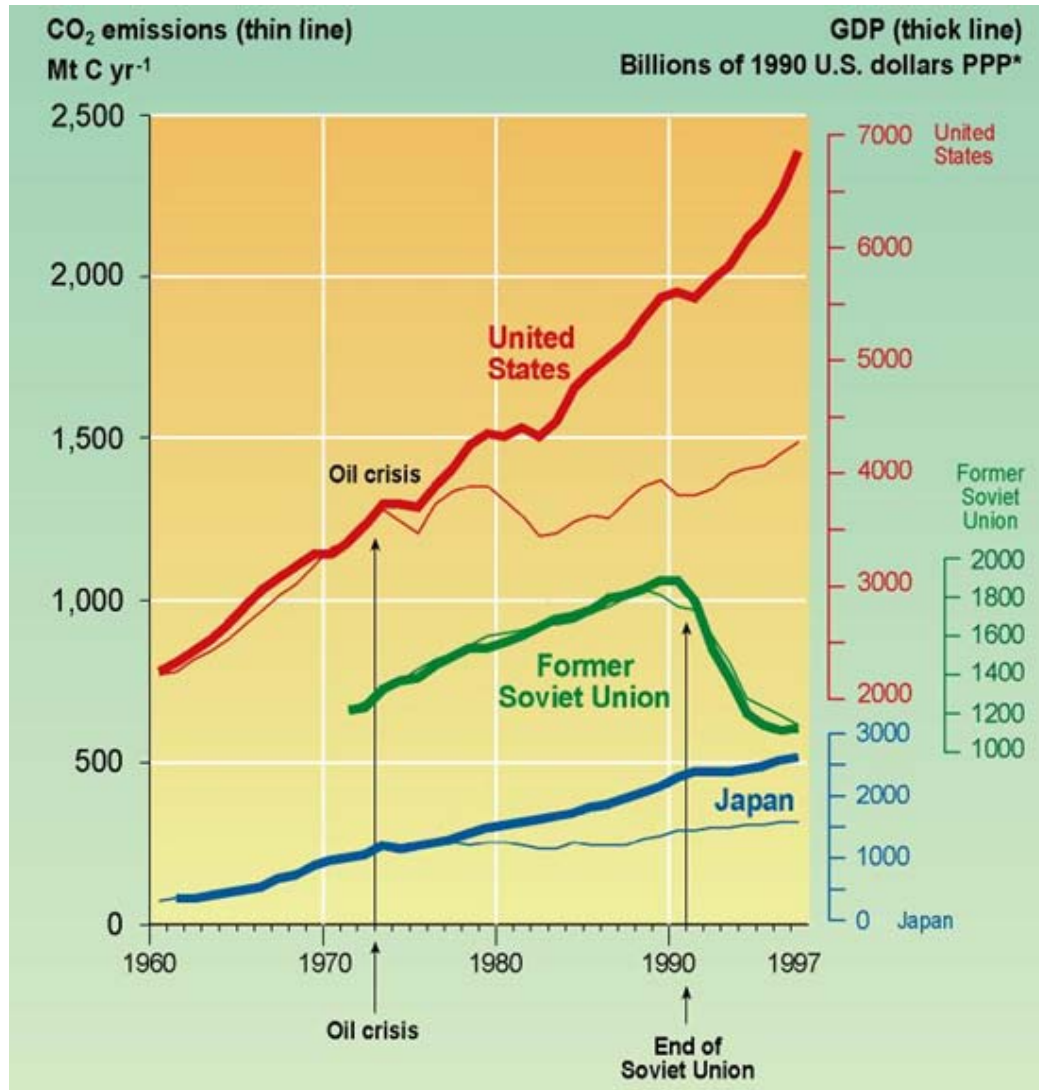
Temperature, CO₂, and Sunspots



Projected impacts of climate change



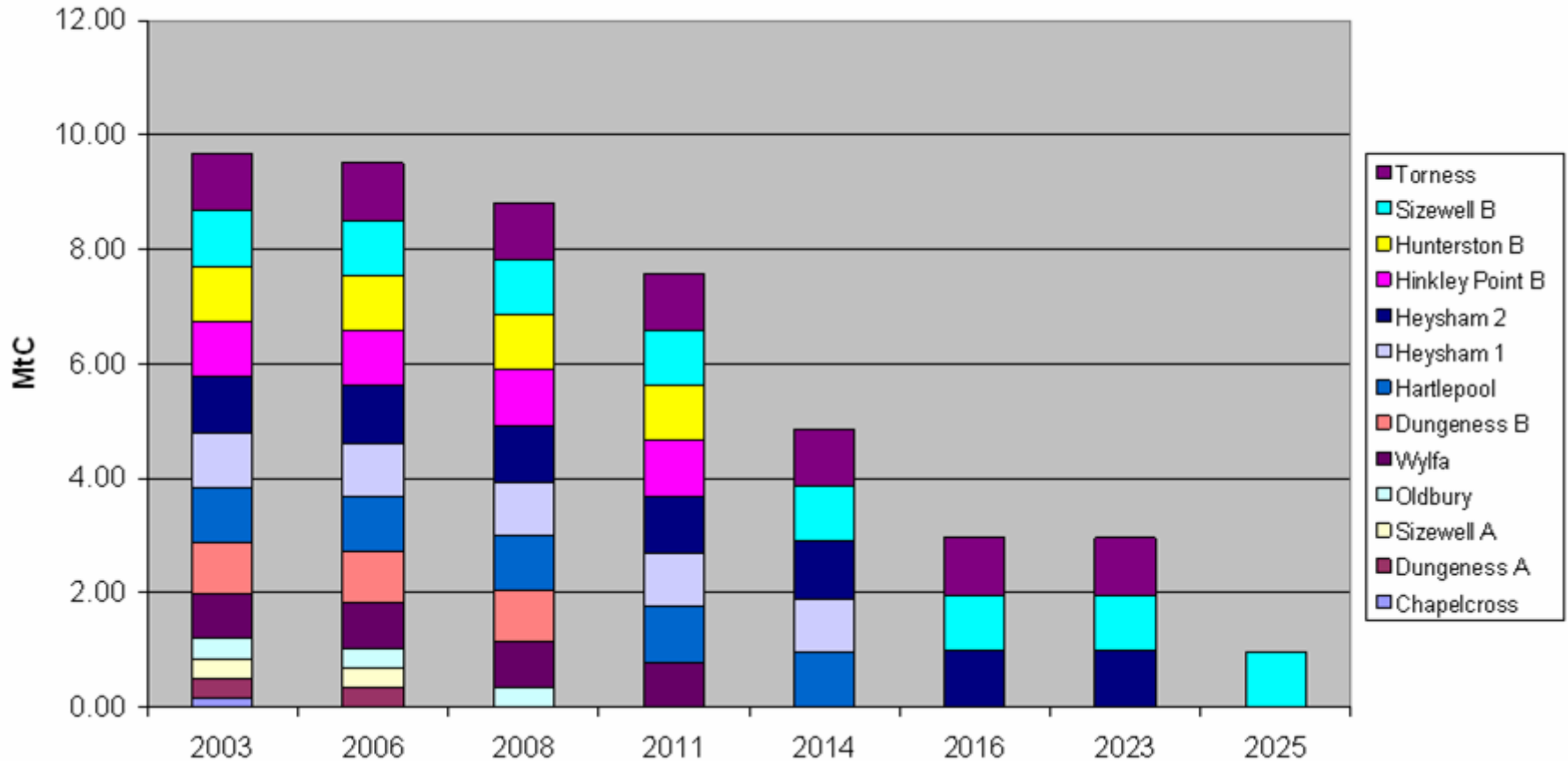
GDP and CO2 Emissions



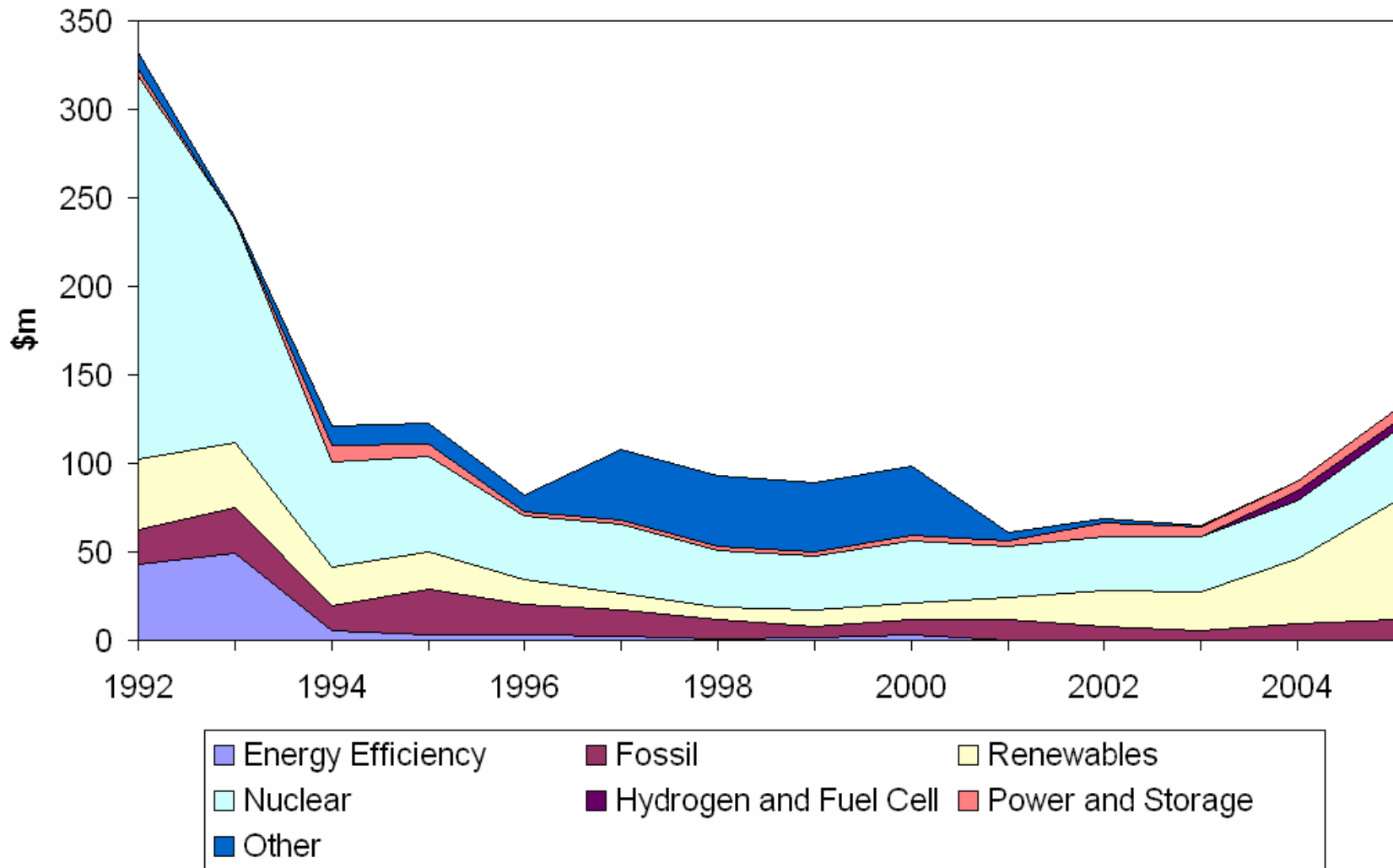
Source: IPCC

Future 'Carbon saving' from nuclear energy

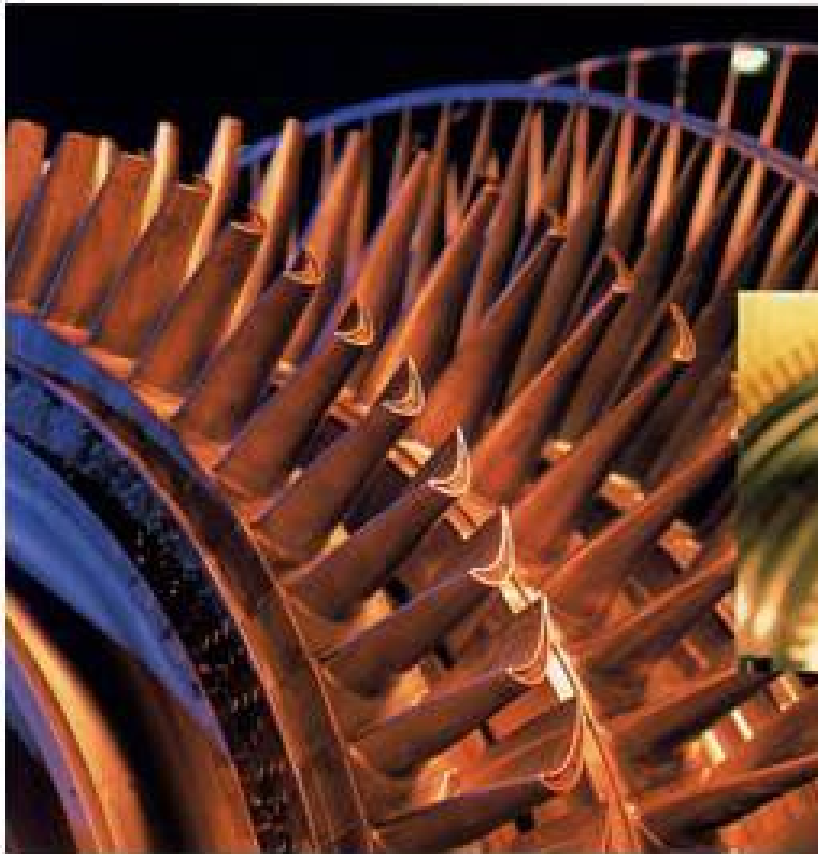
2003-2025



UK energy R&D



Advanced turbines – battling for 1%



Technologies – “clean” fossil

The background of the slide features a stylized illustration. On the left, several high-voltage power line towers are shown with power lines stretching across the sky. In the middle ground, there are green bushes and trees. On the right side, a power plant is visible with several tall smokestacks emitting a light blue mist or steam into the sky. The overall scene is set against a light blue sky and a brownish ground plane.

Advanced steam turbine cycles

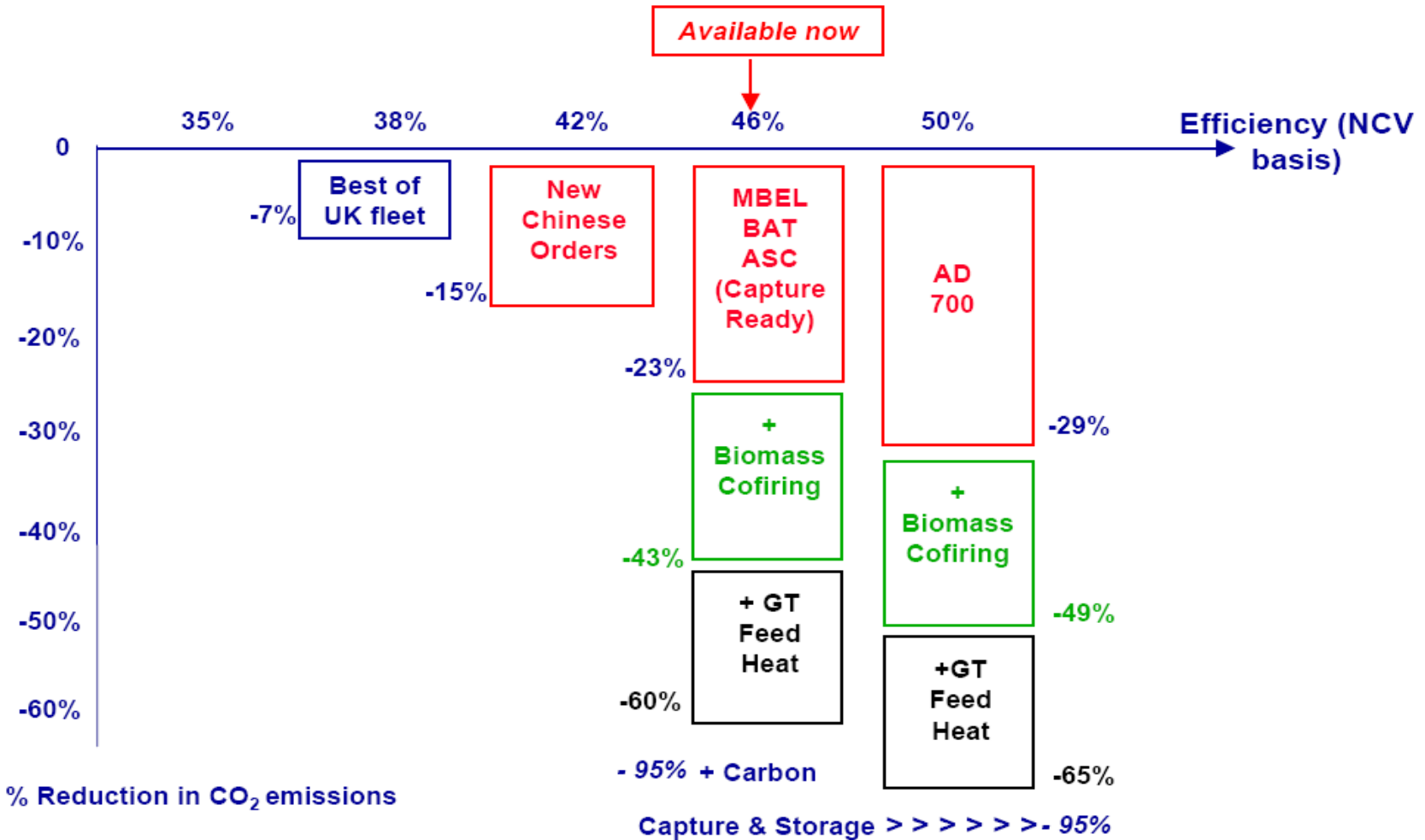
- Higher temperature coal combustion
- Associated HT steam turbines

IGCC - Integrated Gasification Combined Cycle

CCS – Carbon Capture & Storage

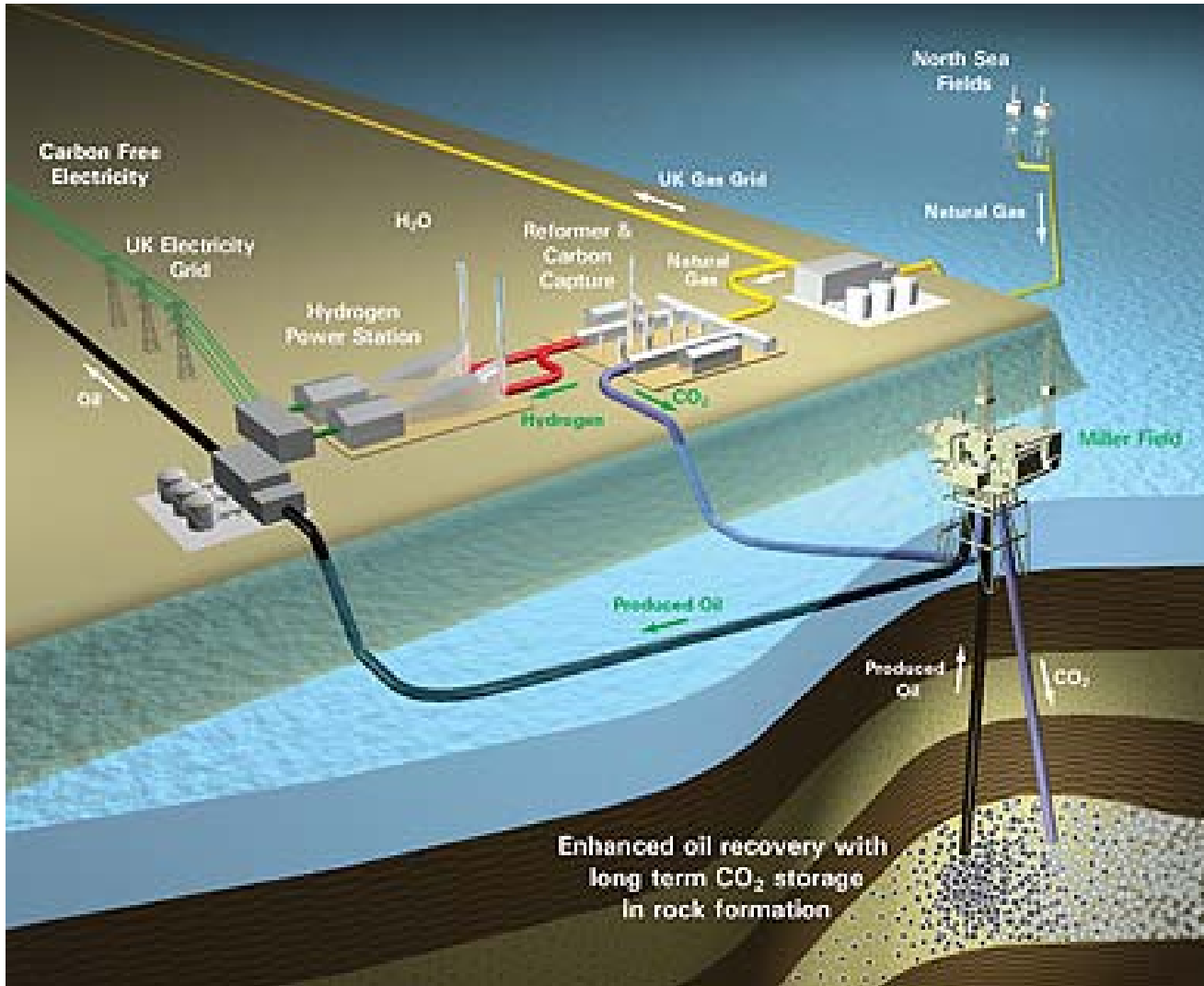
- Peterhead project (gas fired)
- Sequestration studies

CO2 Abatement by Efficiency Improvement



Source: Doosan Babcock

CCS in Scotland



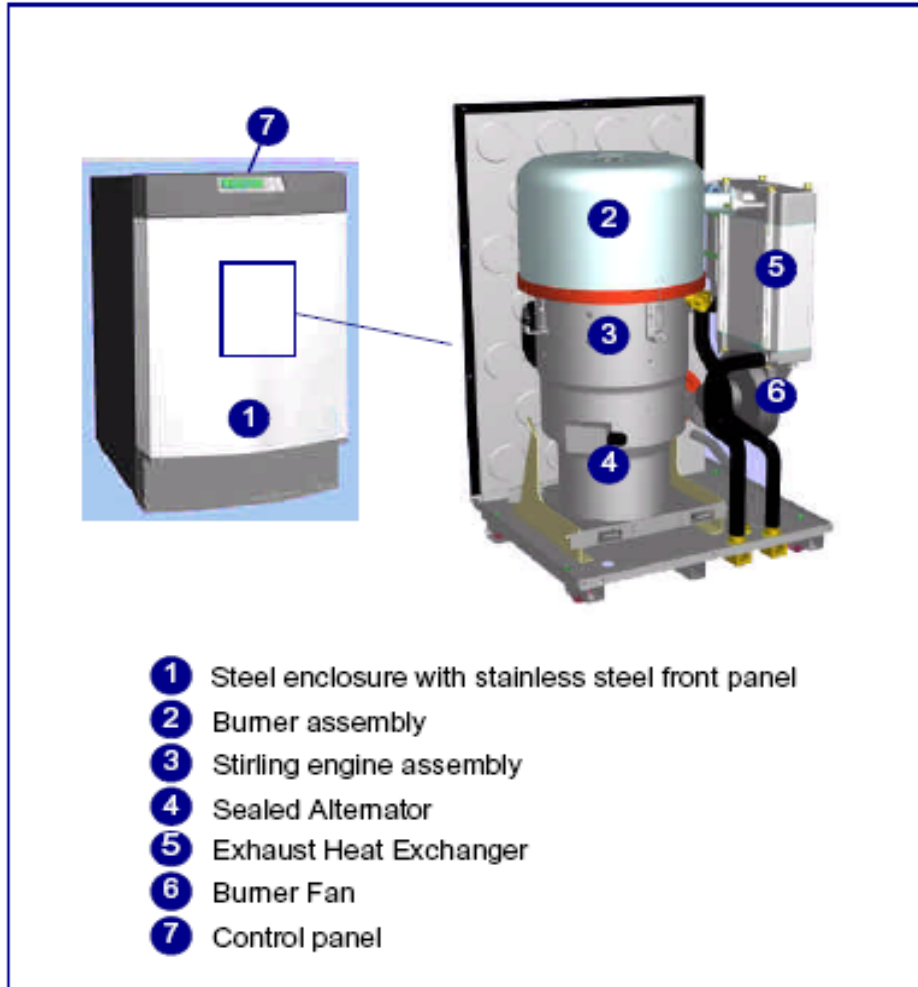
Peterhead power station, Scotland

CO2 Leakage?



CO2 borehole leakage, Colorado © S Haszeldine

Stirling Engine CHP



- Domestic installation
- $1-3\text{kW}_e$
- $7-16\text{kW}_{th}$
- $\eta \sim 90\%$
- CO_2 saving 2 tonnes/year
- 3000 in UK - trial

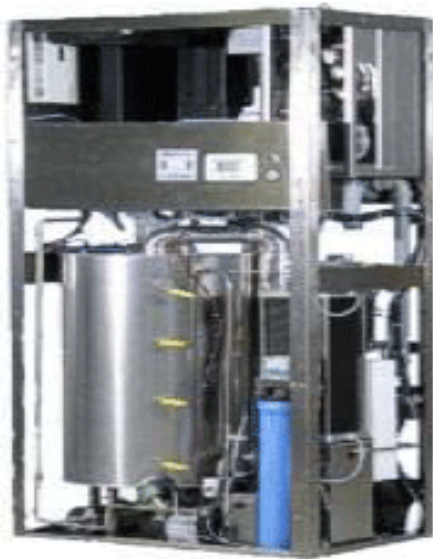
BG Microgen micro CHP unit



Fuel Cell CHP

Table 2.3-2: Targets and quality criteria for different mileposts along the R&D road
BOL: beginning of life

	Early field tests	Demonstration	Lighthouse and deployment
Stationary applications 1 –10 kW (residential)			
Timeframe	2006 – 2008	2007 – 2010	2009 – 2012
Electrical efficiency @ BOL, including DC/AC conversion [-]	30 %	32 %	34 %
Total fuel efficiency BOL; @ best point [-]	> 70 %	75 %	80 %
System cost [EUR/kW]	20,000	10,000	4,000
Stack durability (90 % BOL performance) [h]	3,000	5,000	> 10,000
Number of low-temperature start-ups from 15 °C [1/a]	20	35	50



Home Energy Centre micro-CHP unit

On-shore wind

- **114** UK onshore wind farms
- **1,124 MW** of power
- **27** under construction
- **67** consented wind farm projects
- **160** projects in planning stage
- Current predictions: c. **8GW** of wind capacity by 2010, made up of 50% onshore and 50% offshore (Sustainable Development Commission)



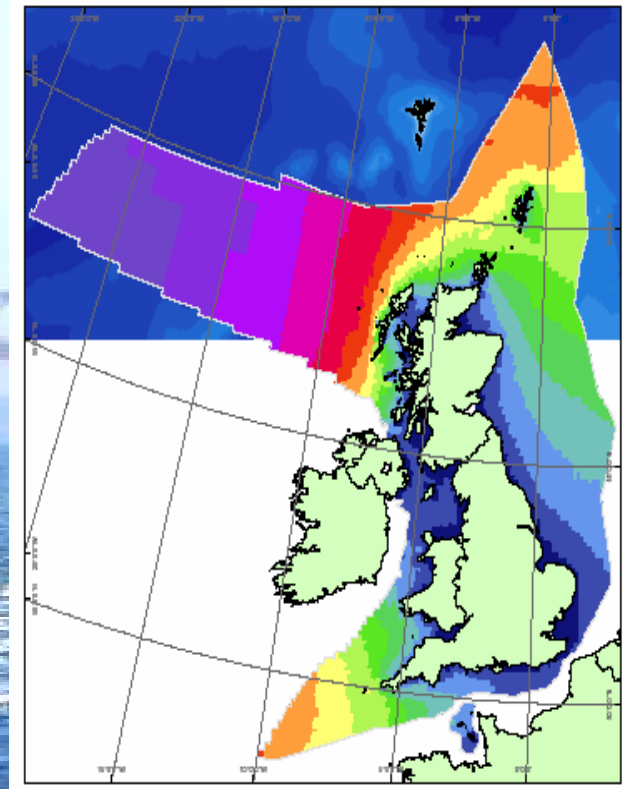
Offshore wind

- 214MW operational
- 90MW under construction
- 855MW schemes approved
- 4880MW sites awarded



Wave Energy

- Atlantic Ocean collects some of the best wave resources in the world
- Not resource limited
- In Scotland alone 3-6 GW feasible when technology matures and manufacture is economic

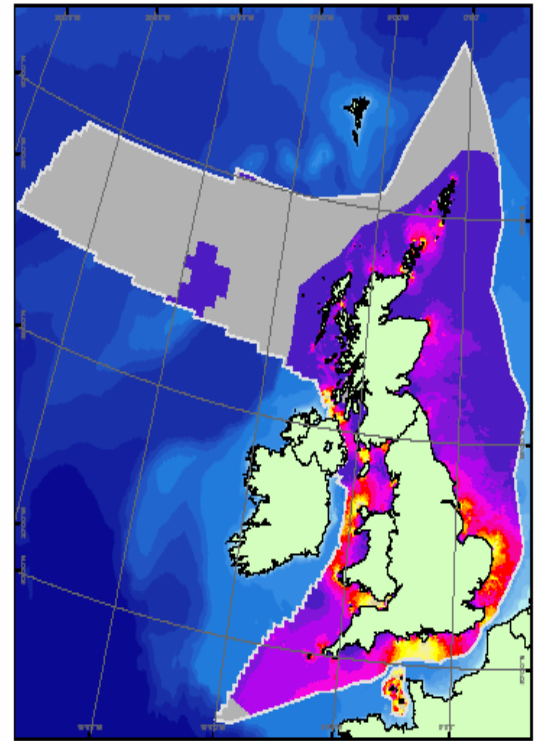


Source: DTI

First generation Pelamis (750 kW) device at sea. Ocean Power Delivery developing UK, Portugal and SA markets

Tidal-Current Resource

- Some of the most energetic sites in the world
- Not resource limited
- In Scotland alone 1-2 GW easily achievable when mature



Seaflow (300 kW) by Marine Current Turbines Ltd now in service for 3 years. Twin propeller system deployed later this year

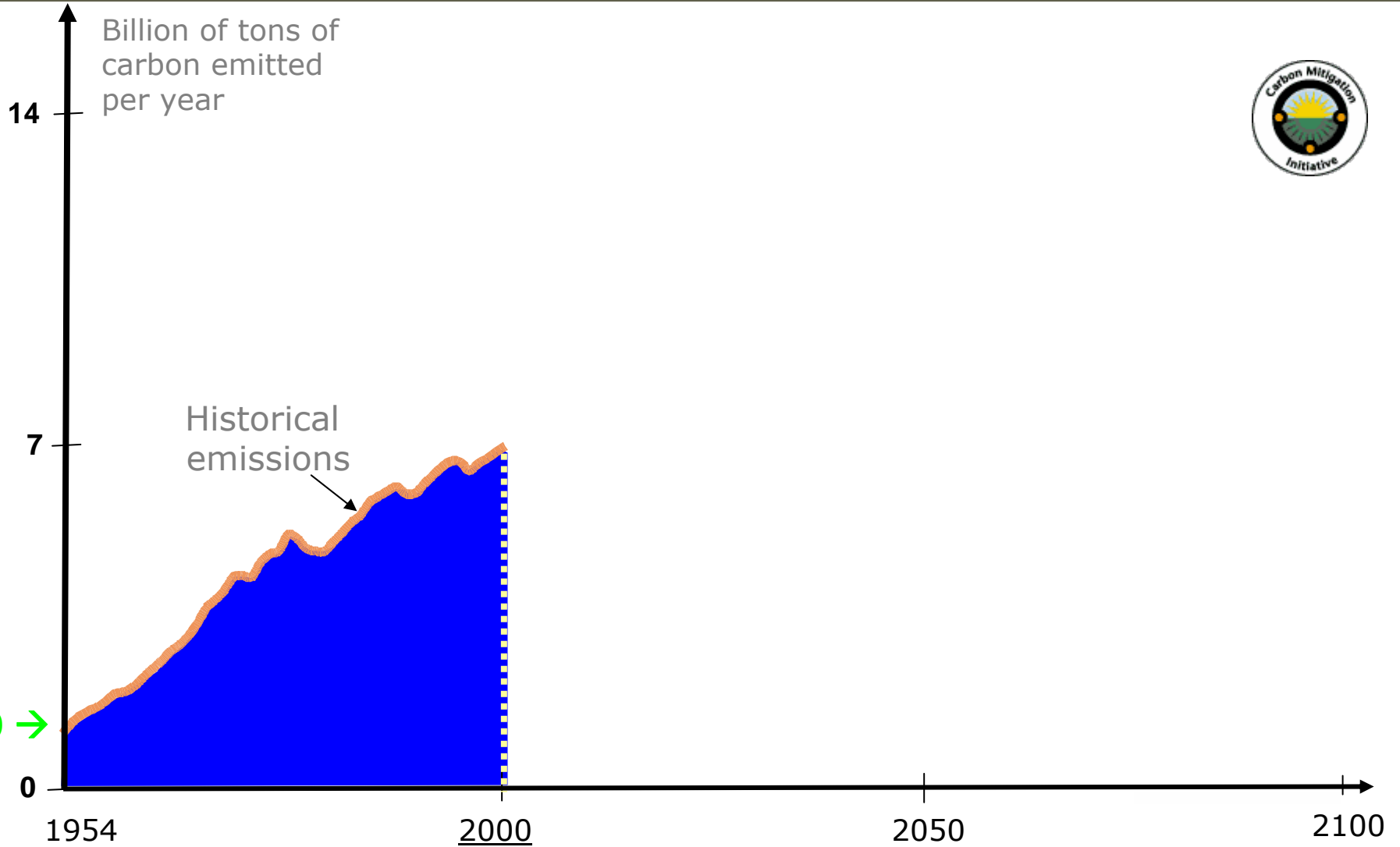
Solar PV



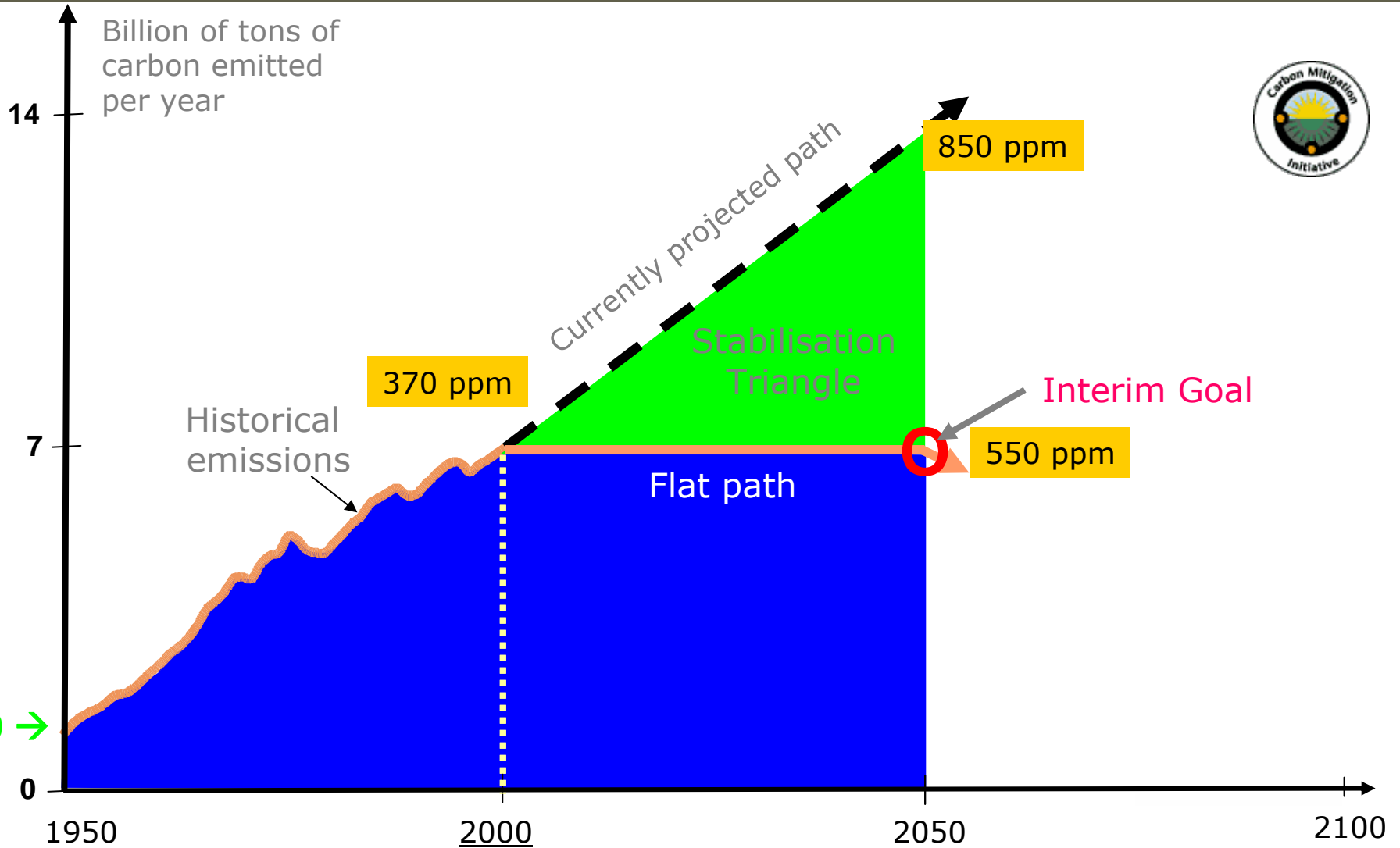
- Over **100,000** systems in place today
- **10,000** solar PV systems installed in the UK p/a
- 8.2 MWe installed capacity in 2004, generating 4GWh of power
- Current installation is max. 2MW p/a (expected to rise to 8MW p/a end 2006; 10 MW by 2010)
- Estimated to become cost-competitive by 2020–30 (DTI's Renewables Innovation Review)
- R&D effort on 3rd generation PV technologies including organic-based systems

Past Emissions

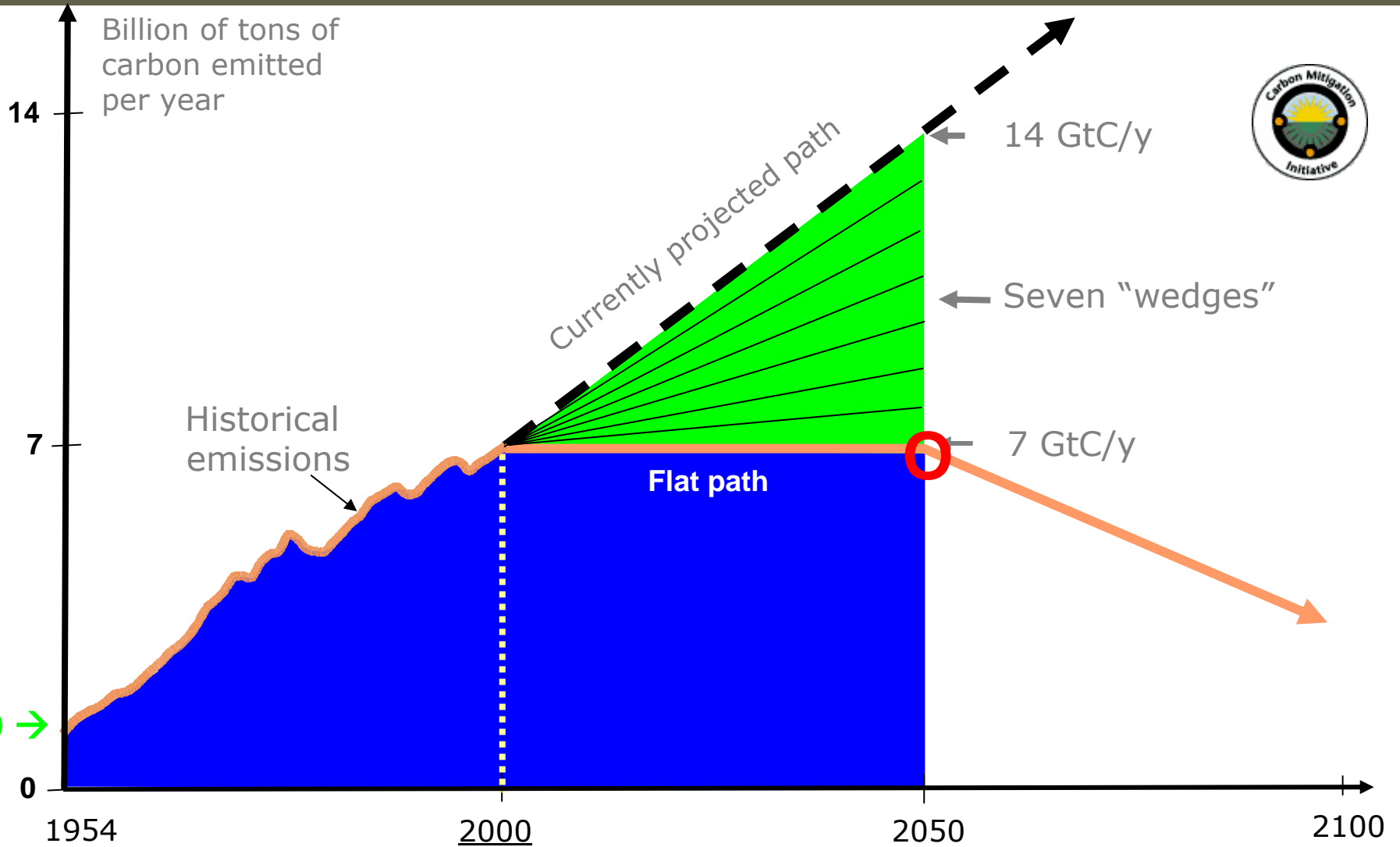
Billion of tons of carbon emitted per year



The Stabilisation Triangle

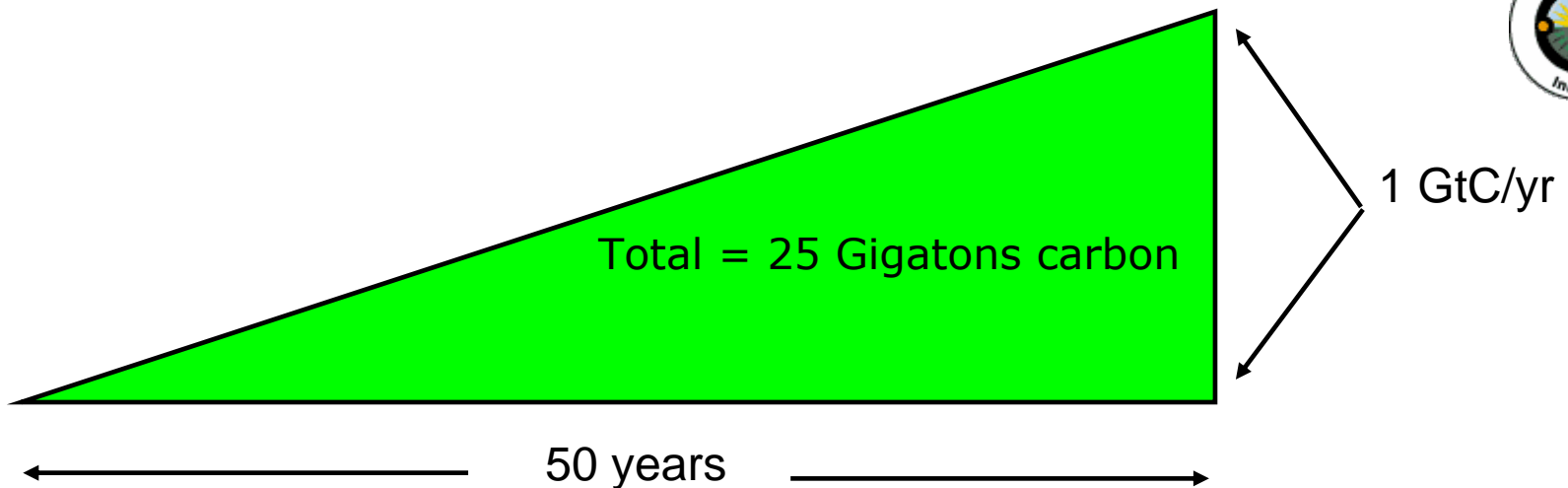


Wedges



What is a "Wedge"?

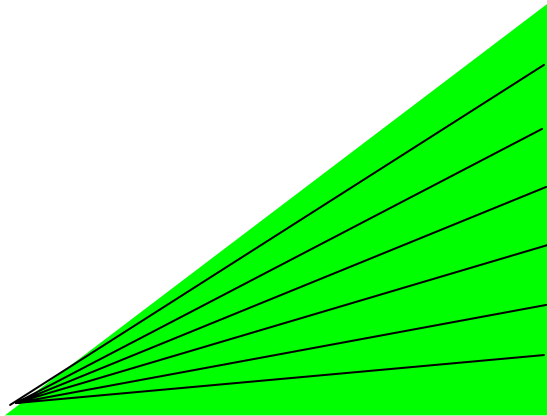
A wedge is a strategy to reduce carbon emissions that grows in 50 years from zero to 1.0 GtC/yr



Cumulatively, a wedge redirects the flow of 25 Gt(C) in its first 50 years. This is 2.5 trillion dollars at \$100/t(C)

A "solution" to the Greenhouse problem should have the potential to provide at least one wedge

Effort needed by 2054 for 1 wedge: Nuclear

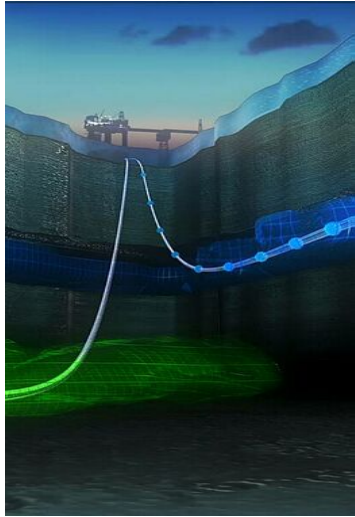
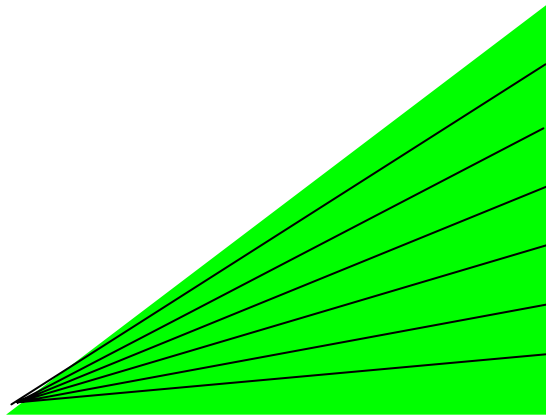


Nuclear

700 GW (twice current world capacity) displacing coal power

Phase out of nuclear power creates the need for another half wedge

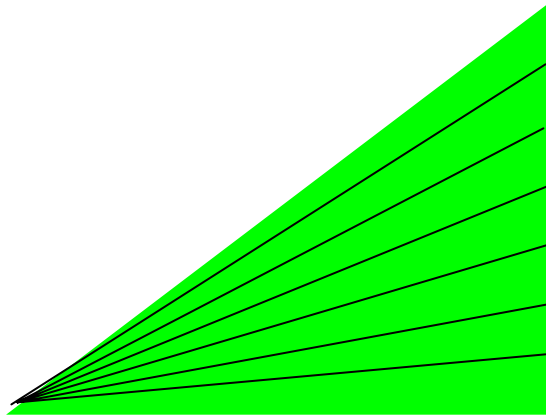
Effort needed by 2054 for 1 wedge: CCS



CCS

- 3500 Sleipners @1 MtCO₂/yr
- 100 x U.S. CO₂ injection rate for EOR
- A flow of CO₂ into the Earth equal to the flow of oil out of the Earth today

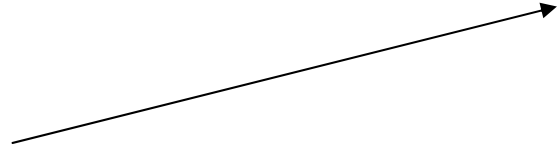
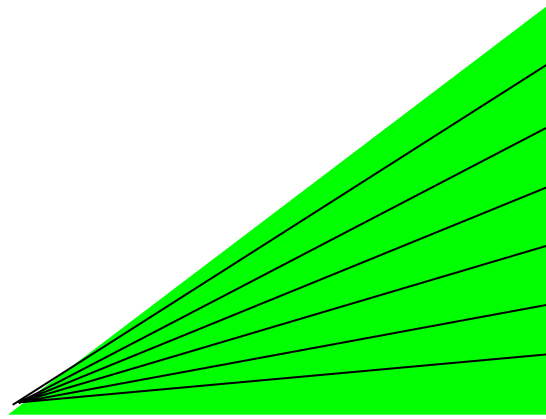
Effort needed by 2054 for 1 wedge: Wind hydrogen



Wind hydrogen

- H₂ instead of gasoline or diesel in 2bn vehicles
- 4m 1 MW windmills
- Twice as many windmills as for a wedge of wind electricity
- Today: 40,000 MW (1%)
- Assumes the H₂ fuels 100-mpg cars

Effort needed by 2054 for 1 wedge: Offshore wind

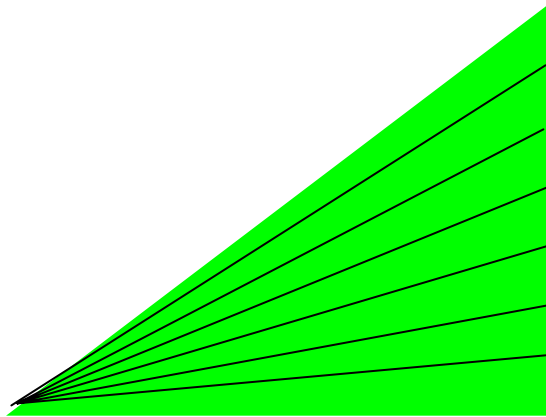


Offshore Wind

Effort needed by 2050 for 1 wedge:

2 000 000 MW

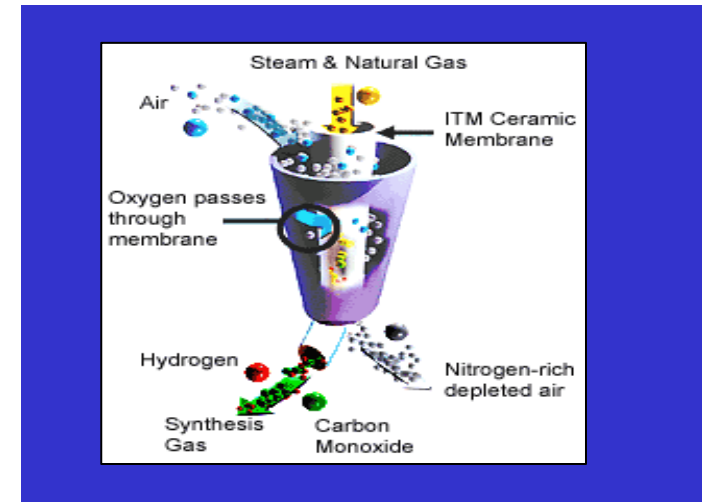
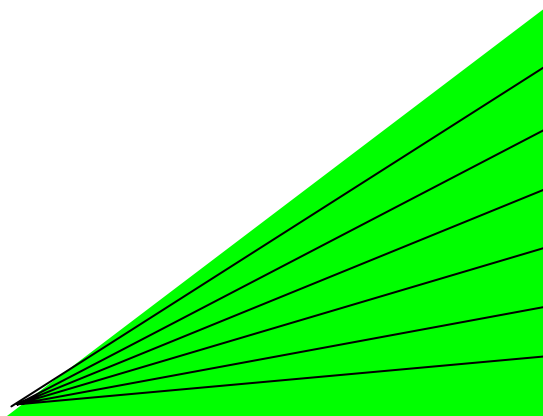
Effort needed by 2054 for 1 wedge: Biomass



Biomass

Two billion 60 mpg cars running on biofuels
250 million hectares of high-yield crops (one sixth of world cropland)

Effort needed by 2054 for 1 wedge: Fossil-fuel-based H₂ with CCS



Fossil-fuel-based H₂ with CCS

Use: H₂ instead of gasoline or diesel in 2 billion vehicles

Production: Capture and store, instead of venting, the CO₂ byproduct of 250 Mth₂/year produced from coal

Today: 40 Mth₂/year is produced from all sources

Solar Collection Contribution



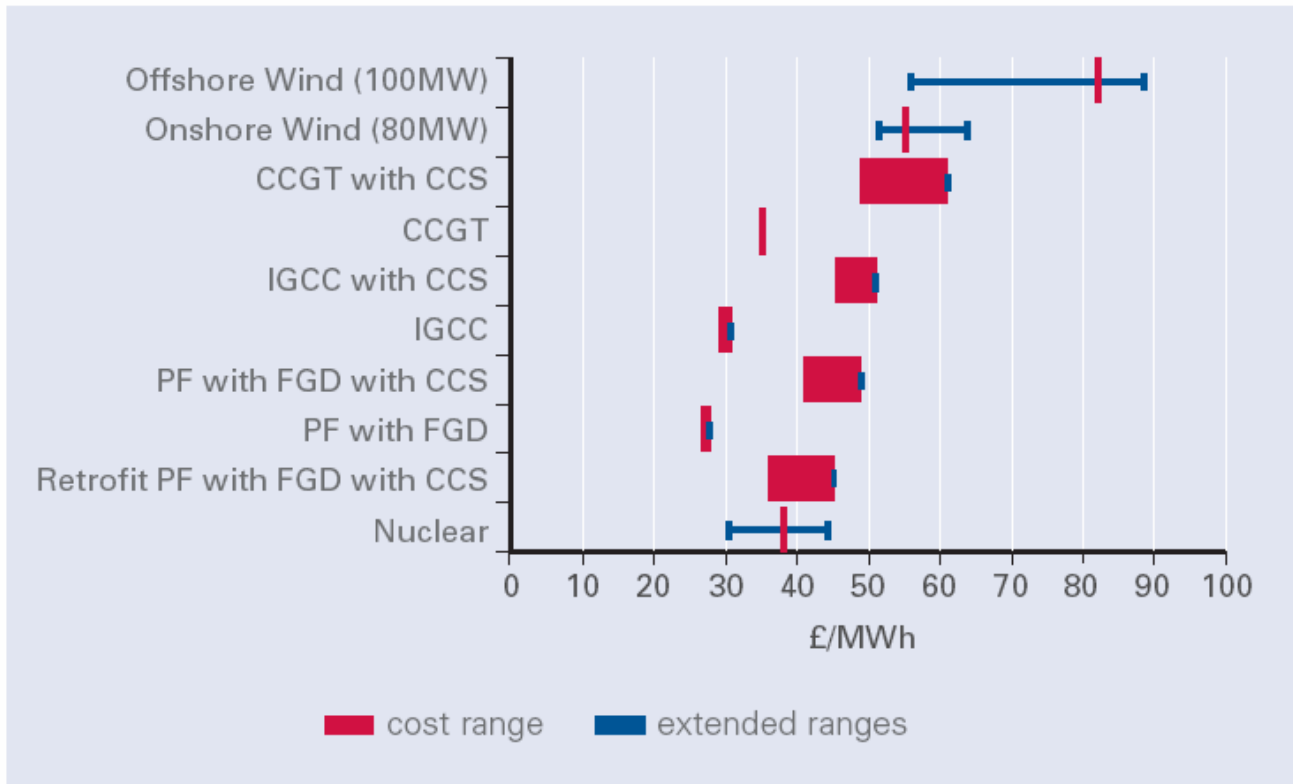
- 1 wedge = 1 400 000 MW
or 12 000 000 000 MWh/yr
- Solar irradiance = 3-6kWh/m²/day or 1-2MWh/m²/yr
- So 1 wedge = 6-12 000 000 000 m² of collector
- Over 50 years we need to install
120-240 000 000 m² each year

Total today of 1500MW PV + 100 000 MW Th is approximately

215 000 000 m²

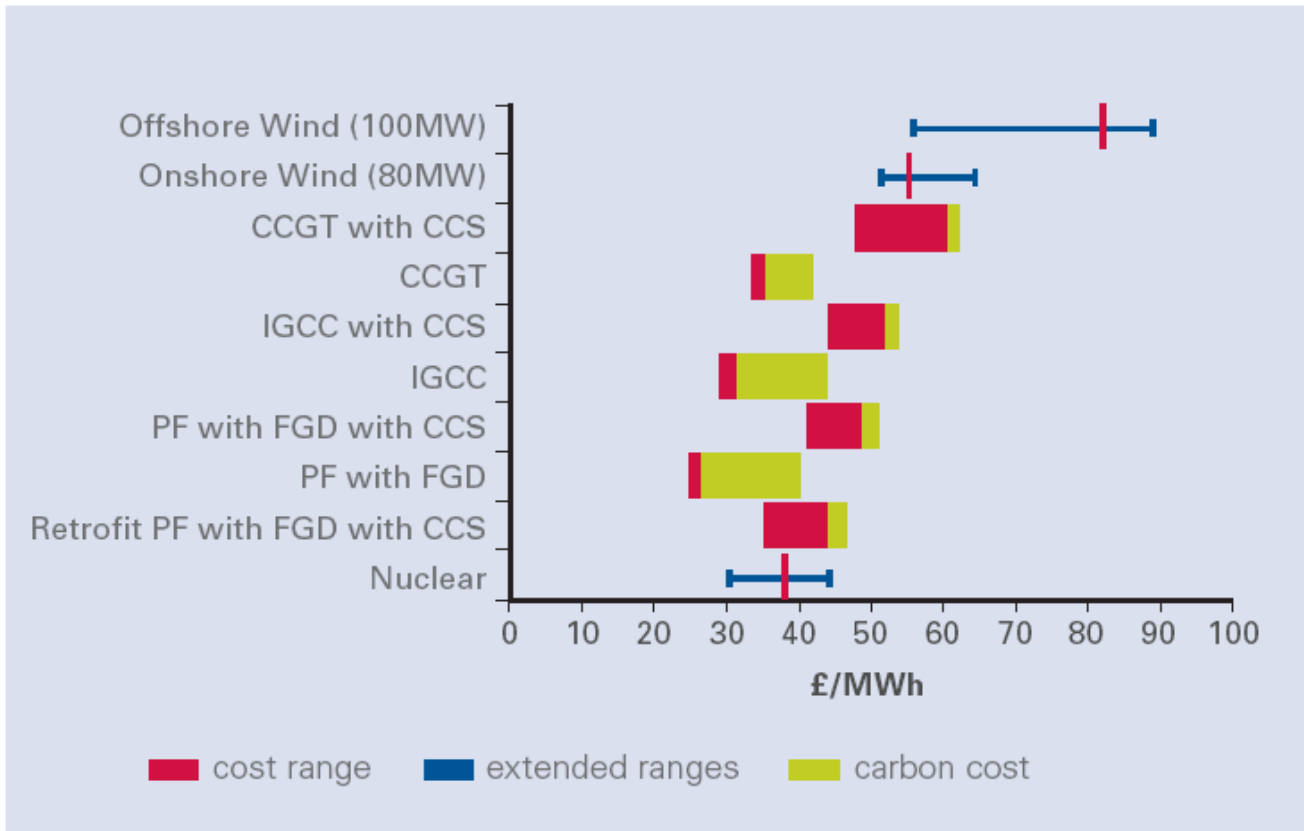
Electricity Costs BAU

CHART B1: BASE CASE (CENTRAL GAS PRICE AND NO CARBON PRICE INCLUDED)



Electricity costs with carbon pricing

CHART B2: BASE CASE COSTS WITH CENTRAL GAS PRICE AND CARBON PRICE OF €25/tCO₂



Interim Conclusions



- Meeting future needs through renewables will be challenging
- Fossil fuels will remain the UK's major energy source for the foreseeable future

Energy hierarchy



The Energy Hierarchy

Sustainable



Energy conservation – changing behaviour to reduce demand

• **Energy efficiency** – using technology to reduce demand

• **Renewable, sustainable energy sources** – setting a course to replace fossil fuels

• **Conventional energy sources** – using low/no-carbon technologies

Exploitation of conventional energy sources as we do now

A projection to 2050

The background of the slide features a stylized illustration of a landscape. In the foreground, there are several green trees of varying sizes. In the middle ground, a series of high-voltage power lines with lattice towers stretch across the scene. In the background, a large industrial facility with several tall chimneys is visible under a light blue sky.

- Renewables provide an increasing amount of energy but do not meet our ambitions
- Integrating renewables will require **new approaches to energy infrastructures**
- Fossil fuels remain dominant and available but at a price
- Coal becomes increasingly important
- Improved technologies for fossil use and carbon management are critical
- Developing economies are key both as users and as developers of energy technology
- Nuclear renaissance
- **Demand reduction becomes key theme**

So we might see ...



- Advanced HC recovery systems
- Renewables, notably solar and marine
- Bio-processes for capture and conversion
- **Energy vectors: hydrogen, HC–product, energy storage**
- **Evolution of energy infrastructures, especially electrical distribution networks**
- Clean coal, CCS
- Sociological aspects of **demand reduction**
- Energy efficiency
- Socio-economic means of **demand modification**

- Skills, skills, skills



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