Analytical Audit

Annex on emissions measurement and projections

This paper is based on analysis prepared by the Office of Climate Change to facilitate discussion within government departments – it is not a statement of Government policy.

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Contents

- The process of compiling historical greenhouse gas emissions for the UK
- The process of estimating projected greenhouse gas emissions for the UK
- The consistent story on UK greenhouse gas emissions
- The implications of these findings for the UK's domestic targets

This section tells us how the UK meets its international obligations to report on UK emissions

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The background to emissions measurement

- The emerging consensus on the science of climate change led to the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) in the 1980s
- The UNFCCC placed an obligation on signatory nations to report on emissions
- This in turn led to the establishment of the Kyoto Protocol – establishing targets
- In addition the UK Government has set domestic targets to reduce emissions
- All of this requires an extensive and reliable measurement system

The UK approach to emissions measurement

- This section shows how we report our actual, historical emissions in the UK
- It details the process, methodology and assurance of what's called 'the inventory'
- It provides an example of the complex process of emissions measurement
- It provides clarification of the quality assurance involved

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The UK record of historical greenhouse gas emissions is recorded in an annual inventory compiled according to standard international guidelines

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Annual reporting	The UK is required to submit an annual inventory on greenhouse gas emissions to the UNFCCC and the EU
Two year lag in data availability	There is an unavoidable two-year lag on the data. In January 2007 an inventory with data for the year 2005 will be published.
International guidelines	There are international guidelines and best practice guidance issued by the IPCC which the UK follows. The inventory is peer reviewed every year
Coverage	The inventory covers both UNFCCC and Kyoto requirements
Renowned UK expertise	UK officials, with particular involvement by Defra, have played a leading role in writing inventory guidelines since inception
Defra responsibility	Defra manages the production of the inventory, compiled under contract by AEA Technologies (NetCen)

Emissions are estimated for the inventory using a 'bottom-up' process using data on activities rather than being measured in the atmosphere

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Amount of emissions generating activity in a year

Multiplied by

Emissions per unit of activity

CO_2 | CH_4 | N_2O | PFCs & HFCs | SF_6

Multiplied by

Global Warming Potentials (GWP)

1 | 21 | 310 | 140-11700 | 23900

Equals

Carbon Dioxide Equivalent (CO_2e)

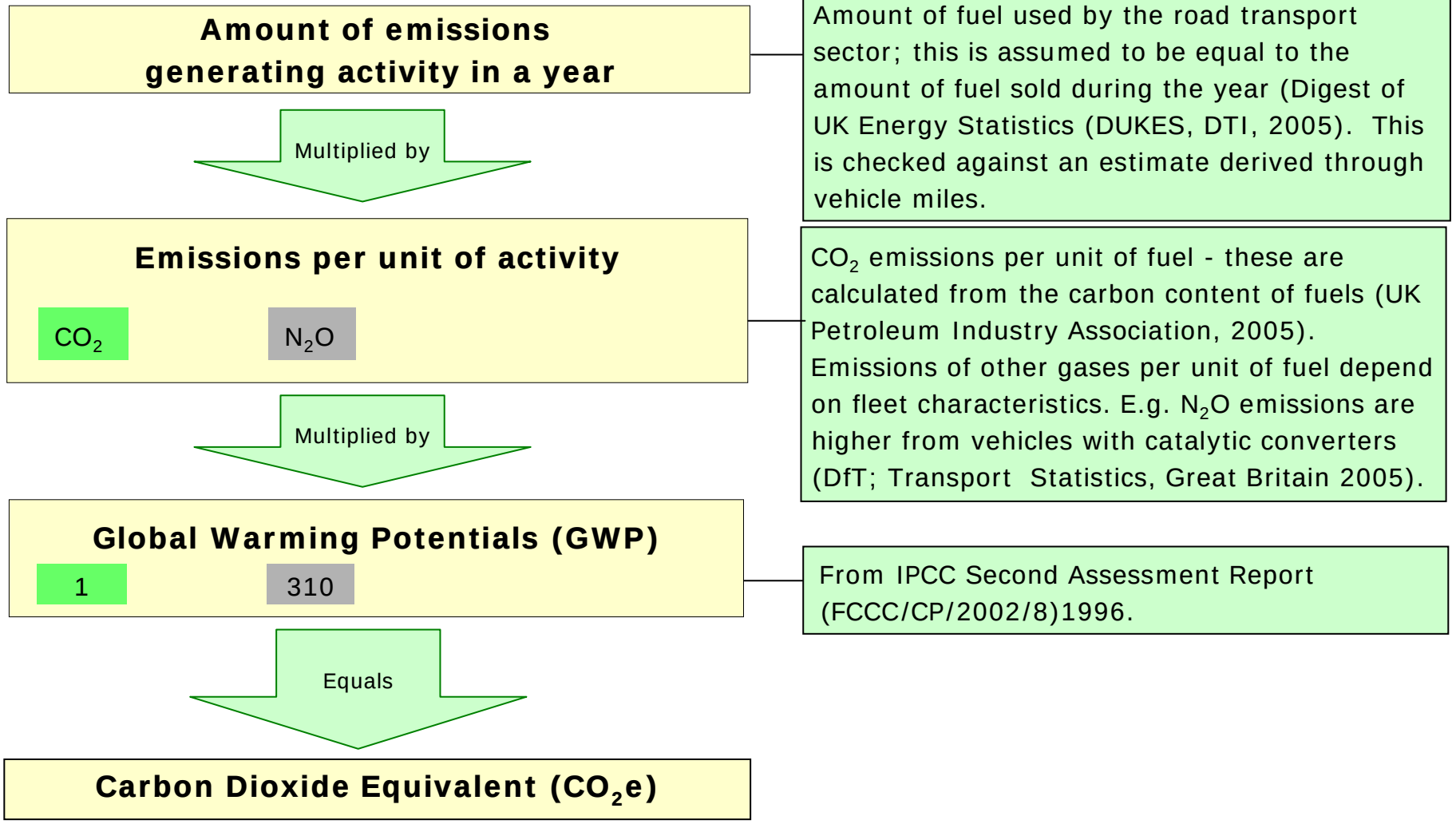
The level of emissions generating activity is taken from National Statistics and is subject to revision.

For carbon dioxide this is usually calculated from the carbon contents of fuels (this information is provided by coal, oil and gas industries). For other gases emissions depend on technologies used. This is subject to revision as more data and better science become available.

GWP figures are agreed internationally at the IPCC. Due to scientific uncertainty these figures are subject to review. The values listed here are those internationally agreed for reporting under the Kyoto Protocol. These will not change in the 1st Kyoto compliance period. The science section of this presentation showed the most recent IPCC GWP figures (IPCC III).

IPCC = Intergovernmental Panel on Climate Change

For example, the transport sector is a good example of how emissions are estimated from data on fuel



This methodology is cross-checked against atmospheric observations to ensure it is robust

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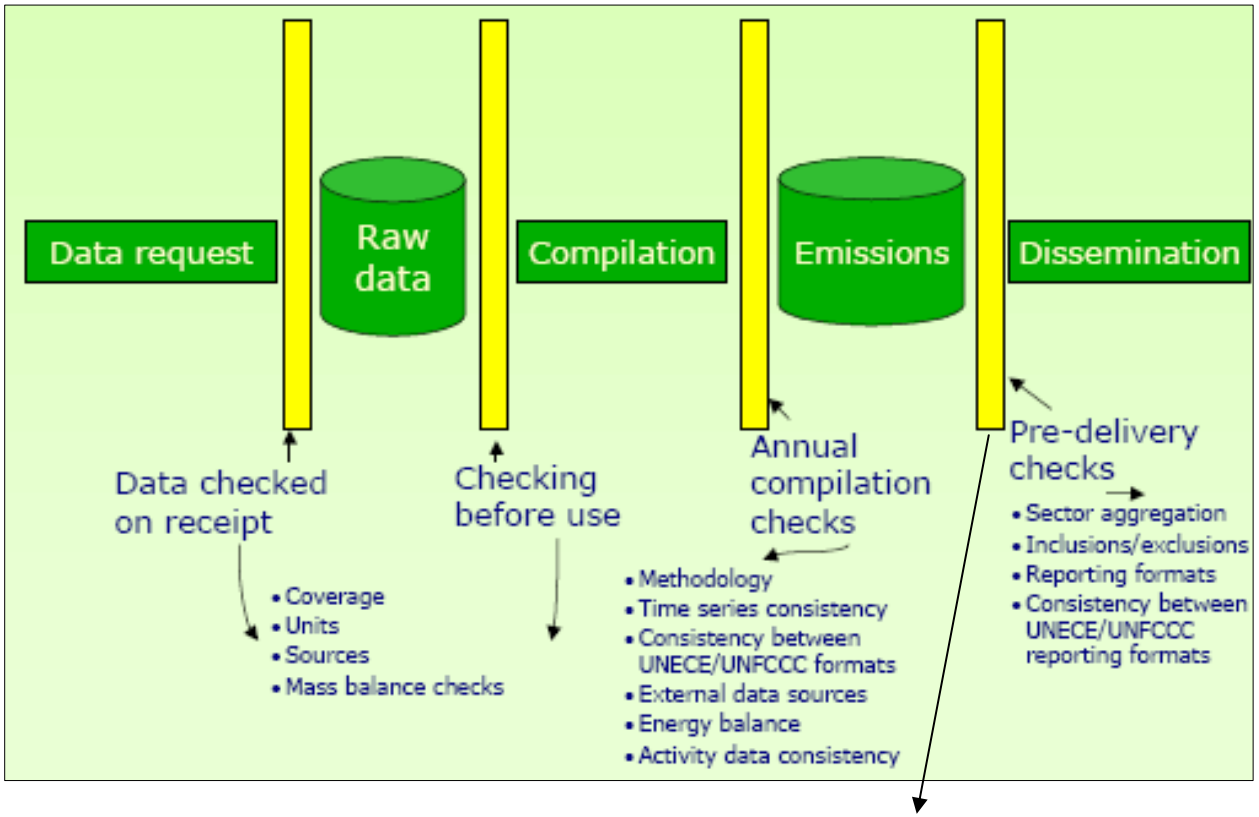
Mace Head: Atmospheric Research Station on the West Coast of Ireland

Continuous measurements of Greenhouse Gases have been made at Mace Head since 1987. The Met Office dispersion model, NAME, can calculate the source of the air observed at Mace Head. Concentrations of GHG which are higher than the 'background' and the air can be attributed to 'polluted' regions in the UK or Europe.

- Through continuous monitoring of the concentration of certain greenhouse gases in the atmosphere, it is possible to identify changes in concentration and therefore emissions
- The Met Office has a model of the dispersion of gases arriving at the Mace Head Station that can attribute the emissions back to their source, which provides an alternative estimate of UK and European emissions
- The two estimates can be cross-checked and significant differences investigated/researched
- This is a new and developing technique and can be applied to all gases which are sufficiently long-lived and whose emissions close to the monitoring site are small

In addition to the atmospheric verification, the inventory process has quality assurance checks built-in at a number of stages



The yellow bars represent 'gates' through which data should not pass until the appropriate checks have been performed. Source data received by the inventory contractors are logged, numbered and are traceable back to their source from anywhere in the inventory system.

UN Expert Review Team reports in recent years all indicate that the UK submissions generally conform to international standards. Any recommendations for improvements are implemented following the annual reviews.

Quality checks conform to IPCC good practice guidance Tier 1 and are being extended to meet Tier 2.

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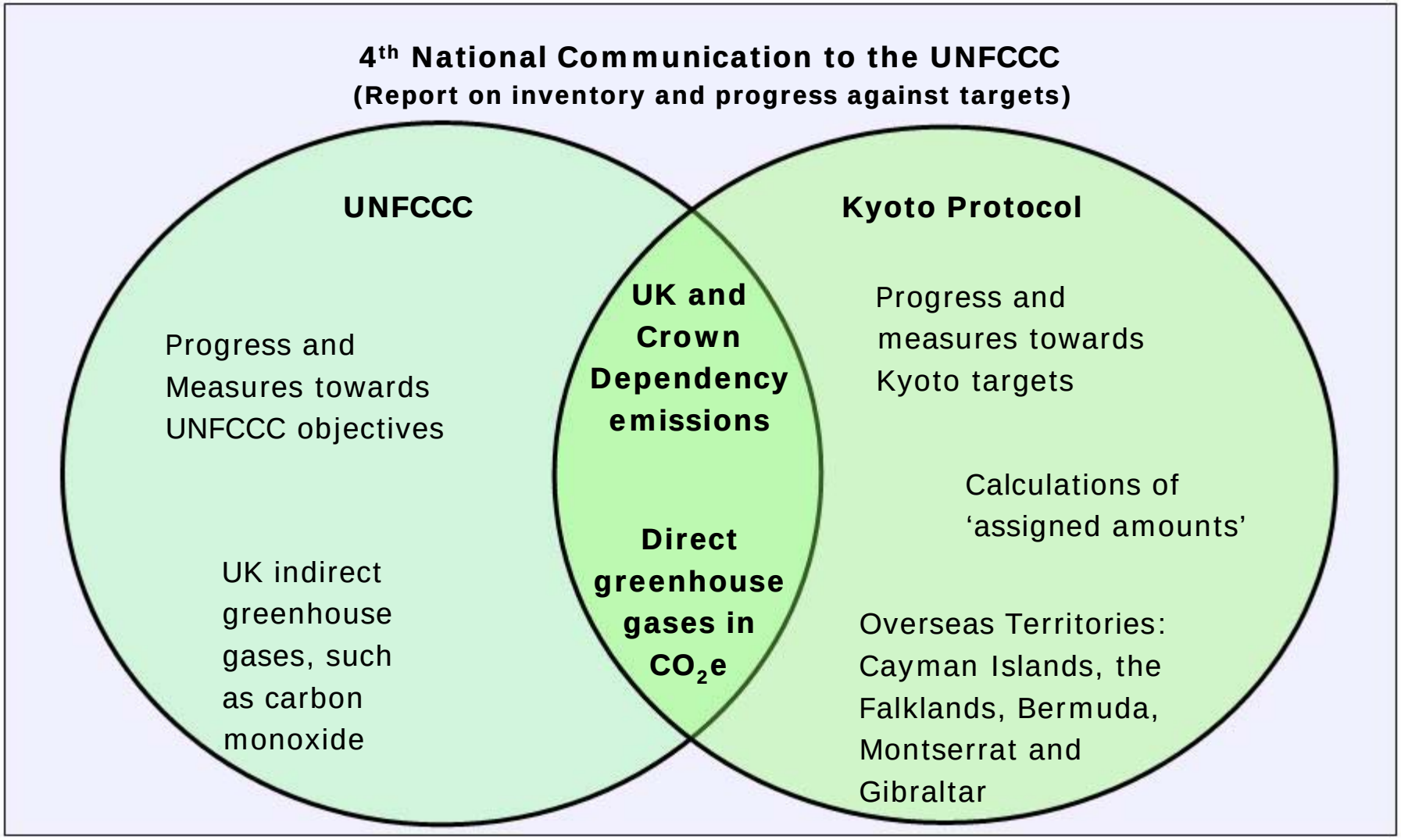
The inventory has to accommodate the different international reporting requirements that have grown up over time



So although there is one consistent database, different figures can be and are presented

There are many different permutations of presenting the same inventory data, partly because of the choices on offer due to the evolution of international reporting requirements…

UK National Atmospheric Emissions Inventory Database

What geographic information to include?

England / Wales / Scotland / Northern Ireland / Crown Dependencies / Overseas-Territories

Whether to include international transport?

Domestic Transport / International Aviation / International Navigation

Whether and to what extent to include land use?

Land Use, Land Use Change and Forestry (LULUCF)

What metric?	Which GWP values?	What sector split?
Carbon	IPCC Guideline II	IPCC
CO_2e	IPCC Guidelines III	Climate Change Programme 2006 (CCP06)
		Fuel-use
		BERR Energy Projections (UEP)

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This section explains how projections of future greenhouse gas emissions are created in the UK and the complexities involved in that process

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Projection of emissions into the future requires estimation models

- Emissions are dependent on a range of activity drivers
- These include things like population growth, and trends in product efficiency
- Such factors interact in a complex manner
- Estimation models are required to model these various drivers
- But ultimately models are only as good as the assumptions that they rely on

The UK approach relies on a series of models in different departments

- Greenhouse gas emissions projections are fed by various models in government
- None of the models provides a complete picture of emissions
- Therefore the various modelling systems need to be complementary
- This is a complex process

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Modelling emissions generating behaviour is key to projecting future emissions with and without policy impacts

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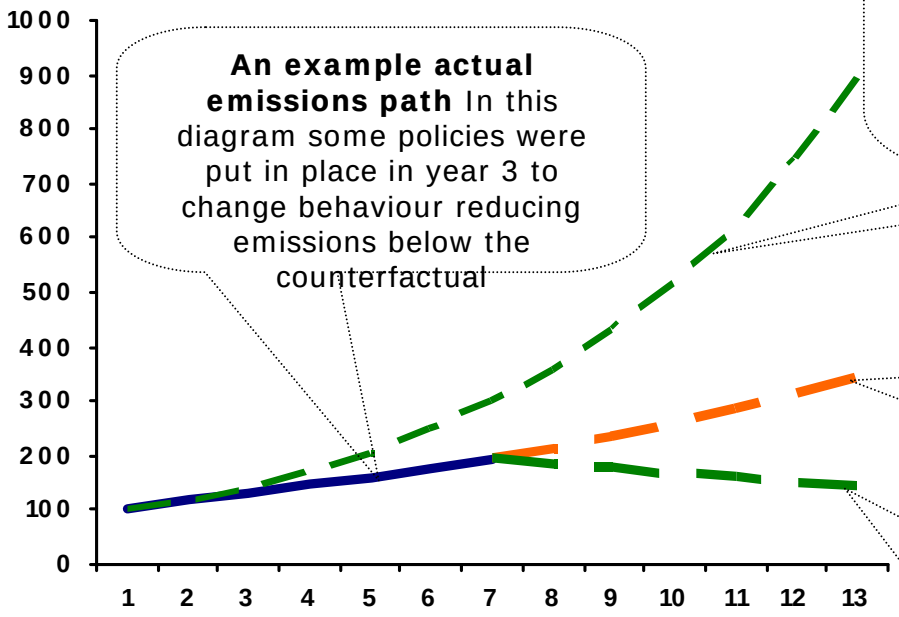
Understanding Emissions Trajectories using Example Data



An example actual emissions path In this diagram some policies were put in place in year 3 to change behaviour reducing emissions below the counterfactual

A counterfactual

What emissions are estimated to be in the absence of <u>any</u> policy measures.

Counterfactuals can be:

- ex-post – what emissions would have been in the past in the absence of policy
- ex-ante – what emissions would have been in the future in the absence of policy

An example projections path

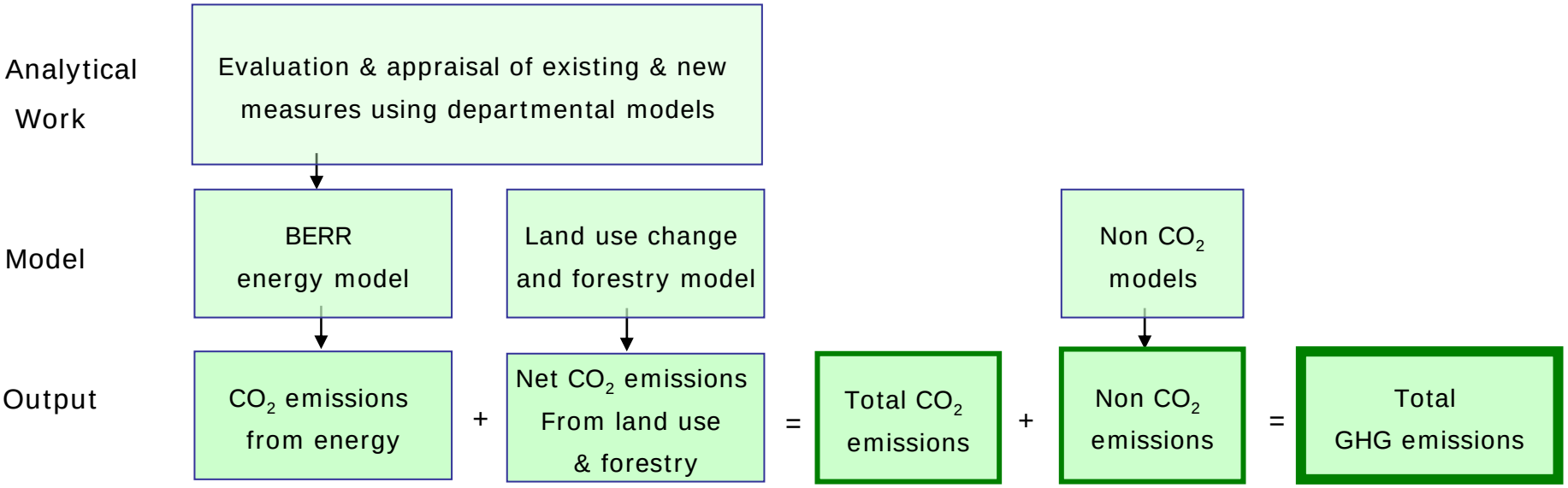
What emissions are estimated to be assuming current policy continues

A new example projections path

What emissions are estimated to be after the implementation of new or additional measures. Note that at this point, the orange line becomes the counterfactual against which these new measures should be judged

None of the data in the above graph represent UK emissions this graph is a presentational aide only

The BERR energy model is the core model used for all sector CO_2 projections, but other models are also required for the full picture



- The BERR energy model is a 'top down' model.
- More detailed bottom-up departmental specific models and analytical work are used to supplement the BERR model on the impacts of specific policies on CO_2 emissions.
- Which models are used on CO_2 will depend on the policy – it is a 'horses for courses' approach (e.g. BERR's model cannot model the impact of road pricing on CO_2 emissions).

BERR = Department for Business, Enterprise and Regulatory Reform

Because a large number of models are involved of necessity, close cross departmental working is essential

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Case study: Climate Change Programme 2006

The Interdepartmental Analysts Group (IAG) and the Projections Advisory group (PAG) were used during the Climate Change Programme Review 2006 (CCPR06) to ensure:

- cross departmental understanding and buy-in
- consistency in assumptions underpinning the various modelling tools
- consistency and quality control of analytical approach through peer review

These aims were achieved

- There are a large number of departments and individuals involved in producing emissions projections
- There are a range of different modelling tools used
- Different modelling tools are needed because no one model can do everything
- Different models are useful because they enable analysis to be cross-checked and give an idea of the range of modelling uncertainty (i.e. the fact that different models give different results tells us something useful)
- The Interdepartmental Analysts Group is where analysis and projections from the different Departments are brought together

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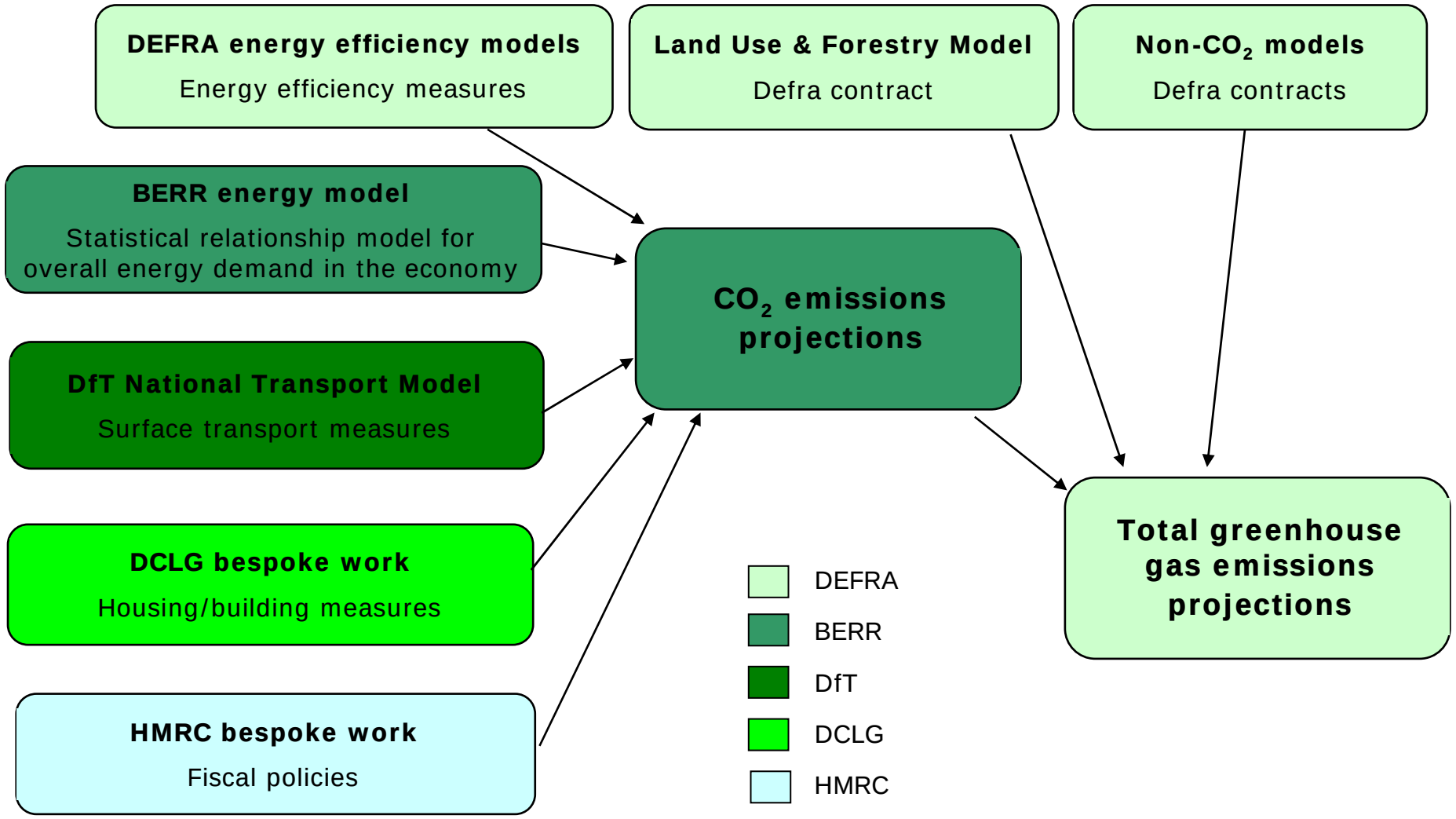
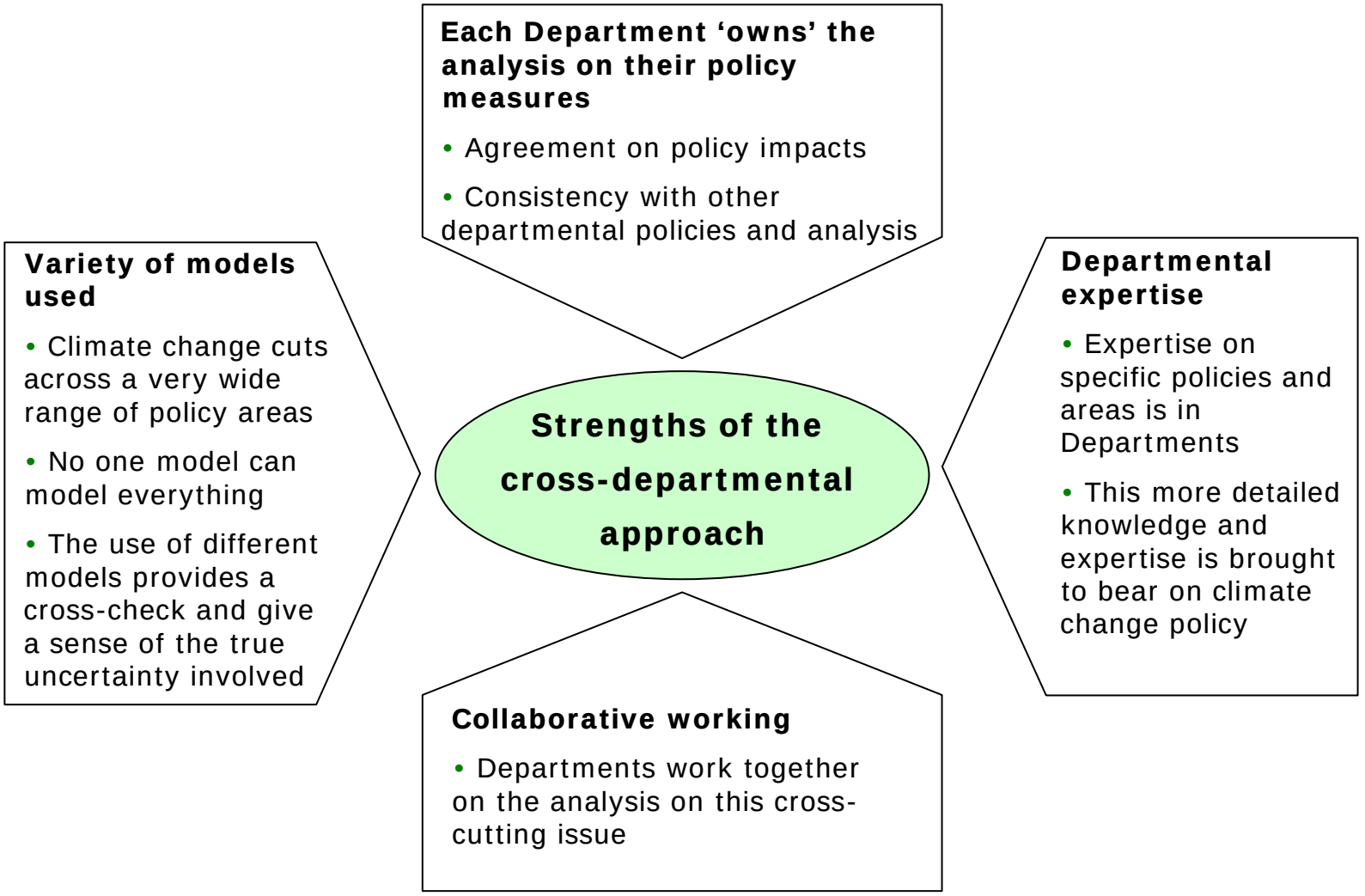
The production of emissions projections is very complex because of the roles of different departments



The cross-departmental approach to producing projections has clear strengths



But it requires a very strong co-ordination and control process to ensure that consistency is not a problem

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There is a significant co-ordination role

- The Interdepartmental Analysts Group (IAG) is the forum for discussions
- A single Dept is usually responsible for physically bringing everything together, this is usually DEFRA or BERR for the big policy events

Peer review of how policy measures are analysed

- Checking consistency of approach
- Checking technical approach is correct
- A major task

Ensuring consistency

Producing a set of numbers involves major programme management

- Lots of different workstreams in different departments
- The sequencing of workstreams and inter-relationships is complex

Need to ensure that the 'counterfactual' used in all the different models is consistent

- Checking assumptions
- Checking model outputs
- A major task

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There is no single accepted way of presenting emissions so we have selected a single format to avoid unnecessary confusion in this presentation

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	Emissions presented here cover	The following are not covered or presented
Geographical Coverage	UK	Overseas territories
Gases	Six Kyoto Gases	Indirect gases
Emission Sources	All Kyoto Sources plus some additional land use sources	Memo items of international aviation and shipping
Metric	CO_2 equivalent	Results in Carbon
Source Definitions	As used in CCPR06	IPCCC, BERR definitions or any other variants
UK effort or activity	UK activity	Impact of trading which increases UK effort

Even with this single format there are still issues around the latest available data and difference between 'activity' and 'effort' to be aware of

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Latest Available Data

- All of the historical data used in this section comes from the 2006 National Inventory which includes data up to 2004
- This has not yet been updated to include data from the 2007 National Inventory (which extends the time-series to 2005) because the CCPR06 source/end-user splits were not available at the time of writing
- All of the projections data in this annex are based on projections carried out in 2006, in particular the CO_2 projections are from Updated Energy Projections 26 (July 2006) except slides 41 and 42 which are taken from the Energy White Paper 2007

Distinction between UK 'effort' and 'activity' on emissions

- Data up to 2004 (as presented here) simply represents emissions from UK activity
- However, from 2005 onwards the purchase of EU ETS permits or CDM credits mean that 'UK effort' and emissions from 'UK activity' are not the same thing
- This raises the issue for the future of how the different types of data will be presented
- The distinction between 'effort' and 'activity' is also an issue for projections

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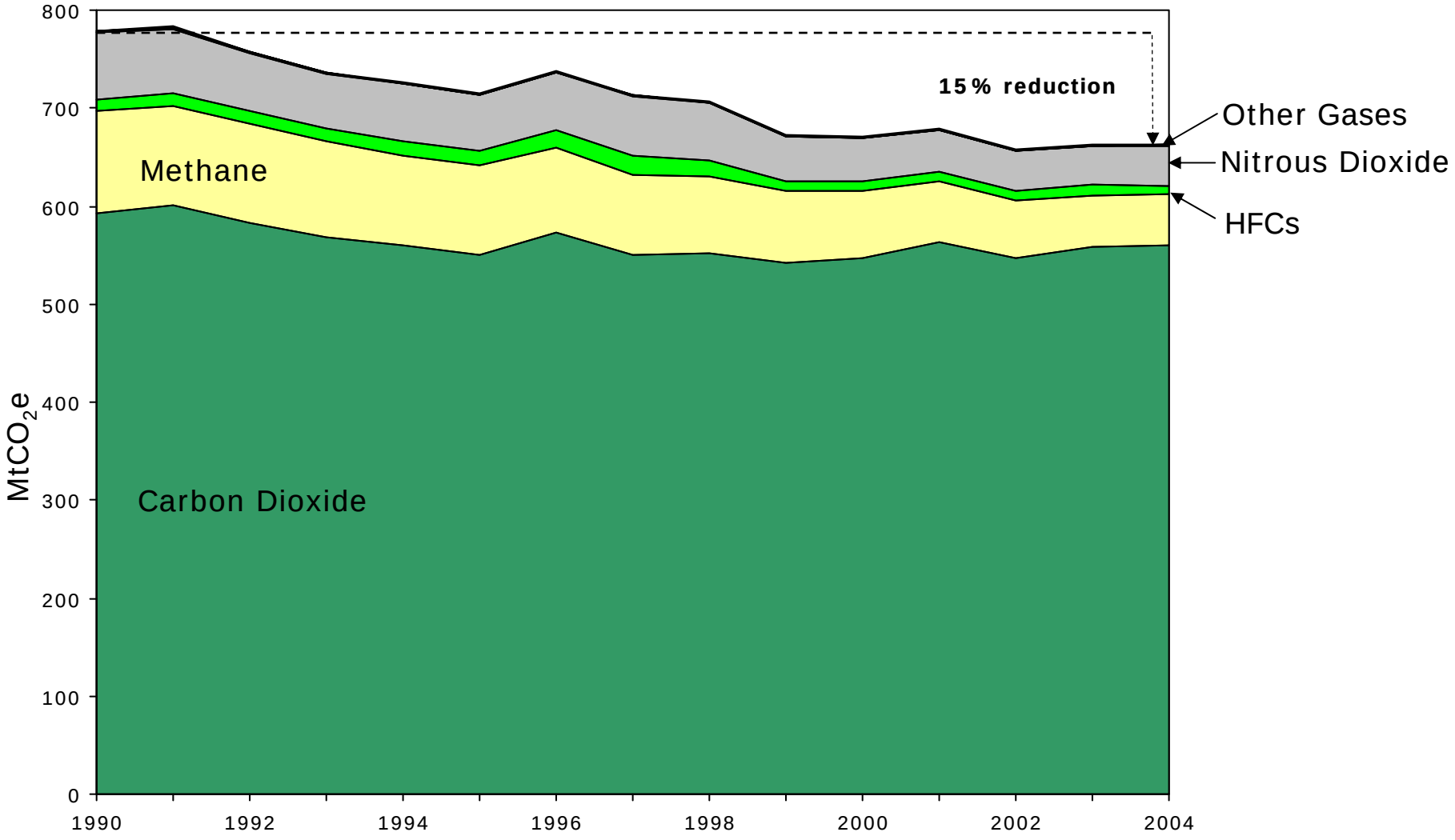
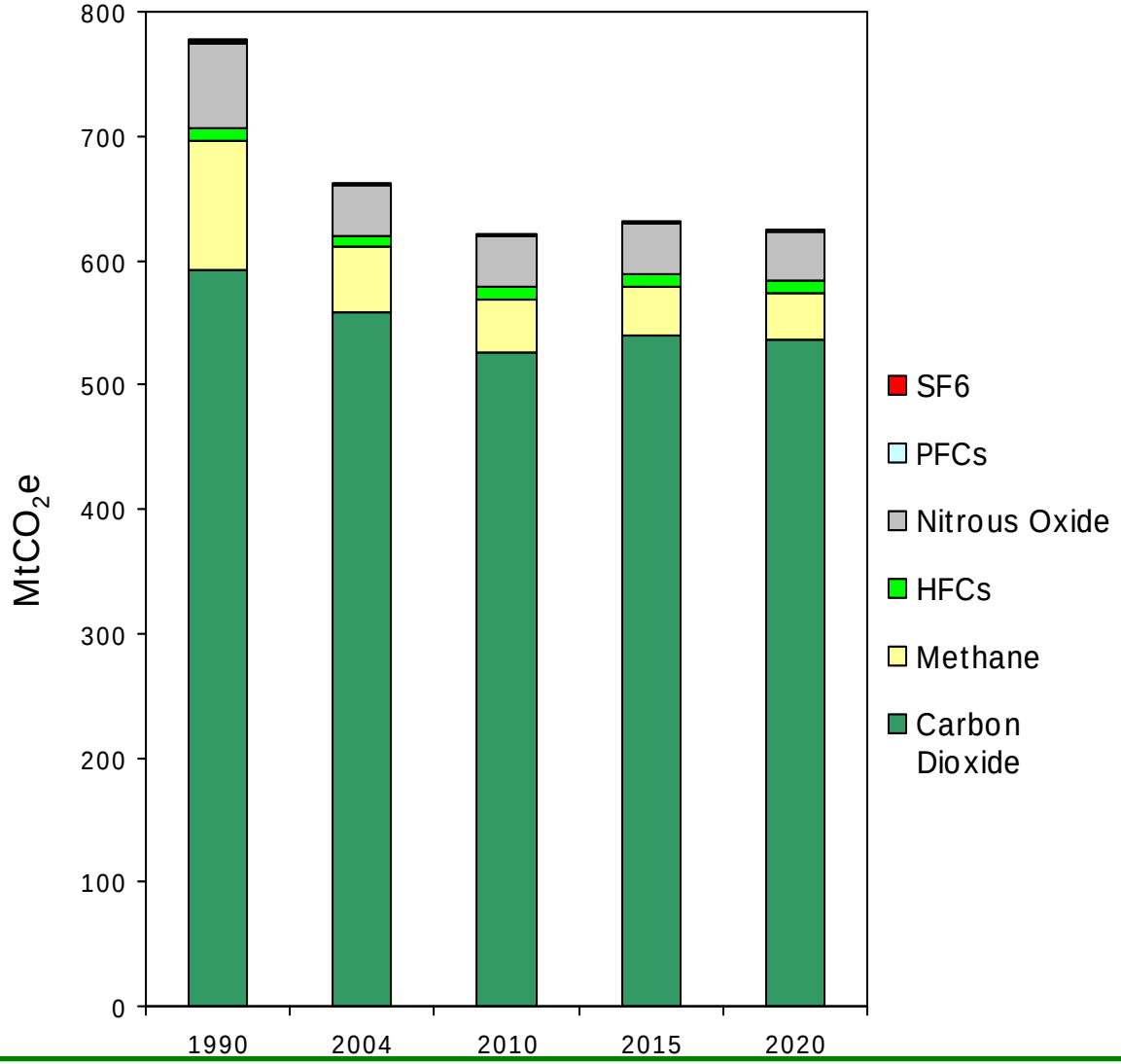
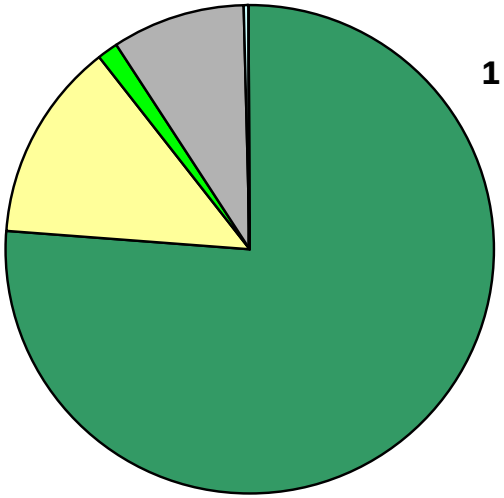
Emissions reduced by 15% between 1990 and 2004 though progress has stalled since 2002

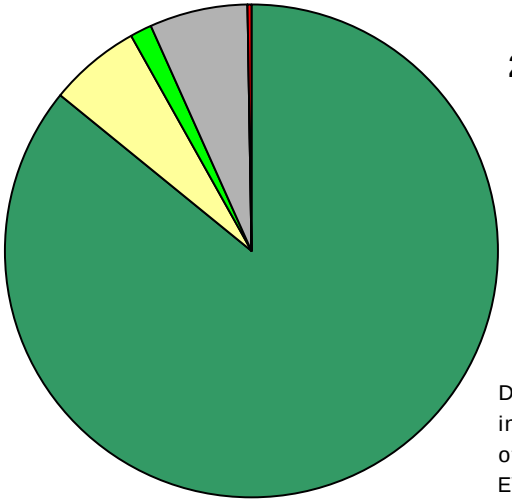


Source: To be consistent with the rest of this annex, this graph is based on the 2006 Inventory Report as gas/sector breakdowns used herein are not available for UK 'effort' (including EU-ETS trading activity) for 2005 data.

Early progress on non-CO_2 gases means that CO_2 will dominate into the future







Does not include impact of EU ETS or EWP measures

Sources: National Inventory Report Issue II, 2006. UK's Fourth National Communication, 2006. Climate Change The UK Programme, 2006. CESA division, DEFRA. Updated Energy Projections 26, 2006.

CO_2 progress has stalled after early gains due to the 'dash for gas' in energy production but significant progress has been maintained on some other gases

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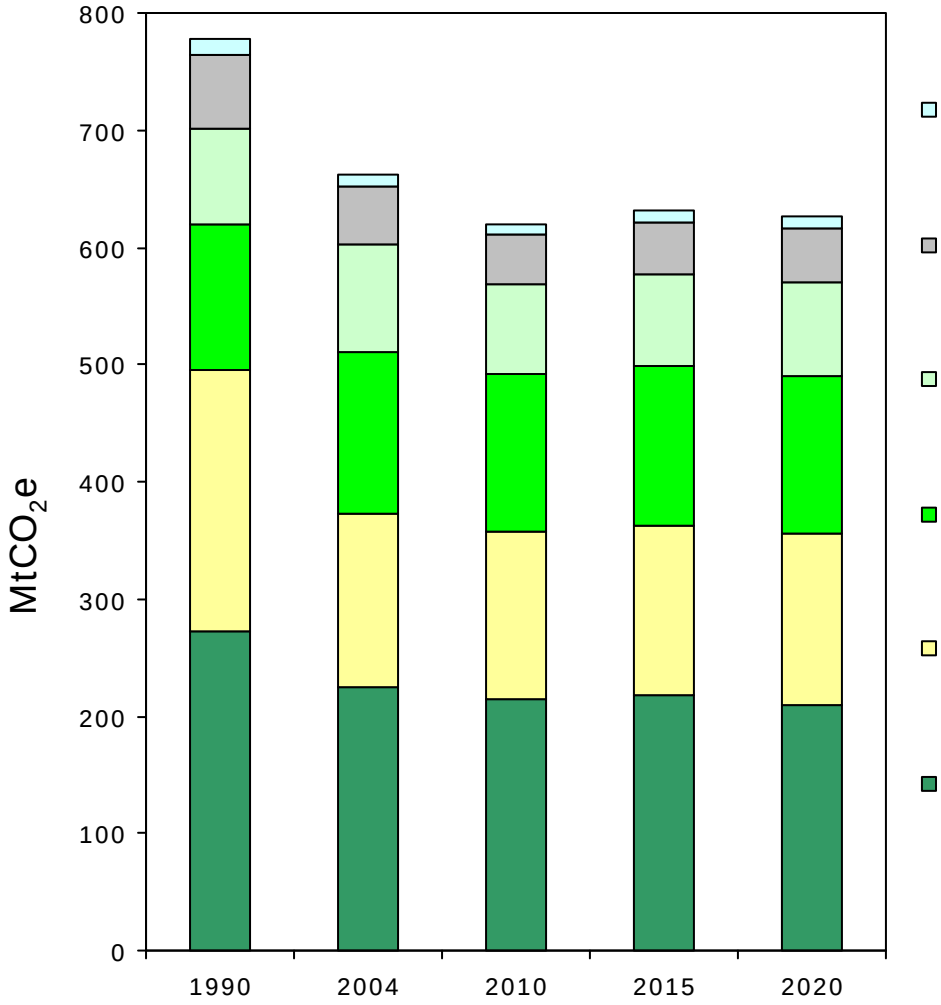
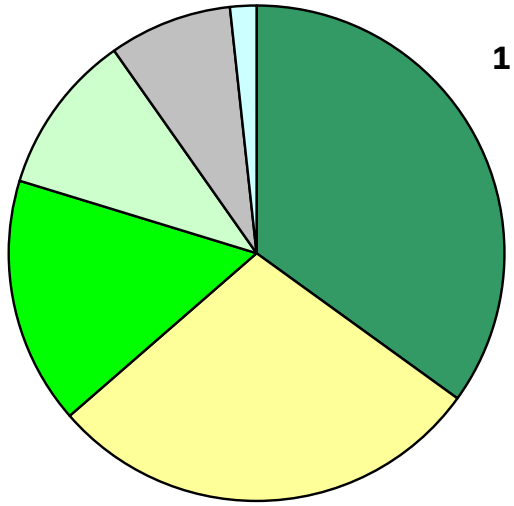
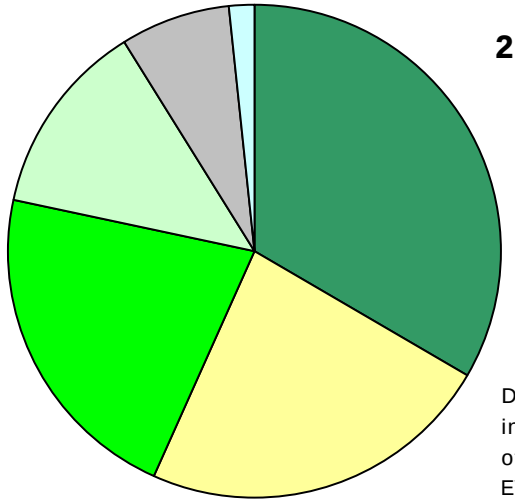
(2004 share)	Progress	Driver
Carbon Dioxide (85%)	5% decrease from 1990 but increasing since 2000	Restructuring of the energy market in early 1990s but increasing electricity and road transport demand
Methane (8%)	50% lower than 1990 levels	Improved waste management at landfills
Nitrous Oxide (6%)	40% lower than 1990 levels	Improved chemical manufacturing process
HFCs and PFCs (<1%)	HFCs and PFCs are 22% and 75% respectively, lower than their 1990 levels	Improved pollution abatement technology
SF_6	9% higher than 1990 levels	Increased use in manufacturing processes

Based on where emissions are created (source shares) business emissions have fallen while domestic and transport emissions have increased







*Agriculture includes Forestry and Land-use emissions and sinks

Does not include impact of EU ETS or EWP measures

Sources: National Inventory Report Issue II, 2006. UK's Fourth National Communication, 2006. Climate Change The UK Programme, 2006. CESA division, DEFRA. Updated Energy Projections 26, 2006.

Emissions reductions due to energy and industrial restructuring has masked a continuous rise in emissions from transport and domestic heating

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(2004 source* share)	Progress	Driver
Energy Supply (34%)	17.5% decrease from 1990	A shift since the early 1990s from coal and oil to gas, reversed in recent years
Business (22%)	33.5% lower than 1990 levels	A shift from manufacturing to service industries, improved industrial processes
Transport (21%)	9.5% higher than 1990 levels	Increased road transport demand has offset gains in vehicle efficiency
Domestic heating (14%)	14% higher than their 1990 levels	Growth in demand for energy services due to smaller households, rising population and rising demand
Agriculture (7%)	22% lower than 1990 levels	Increased forestry area, reduced livestock and fertiliser use
Public (2%)	21.5% lower than 1990 levels	Improved Procurement

* Source share sector splits are based on where emissions are physically created.

Static shares for end-use sectors between 2004 and 2020 are predicted in contrast to earlier changes

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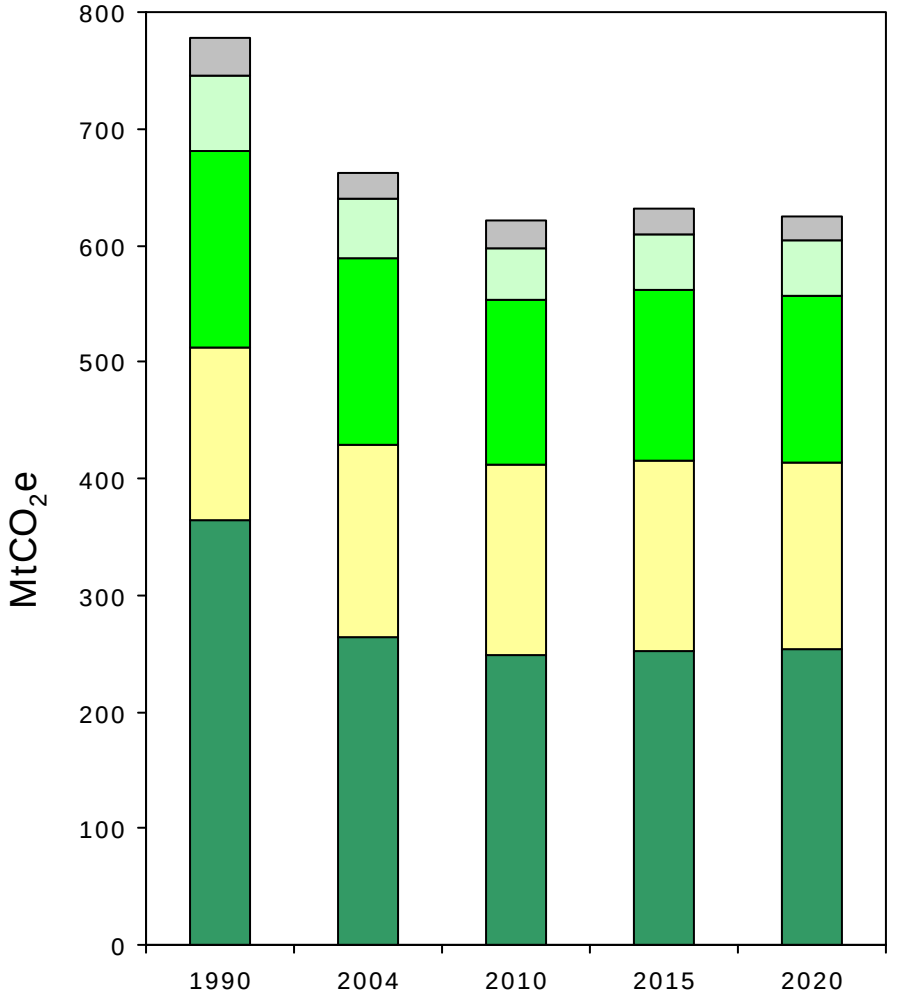

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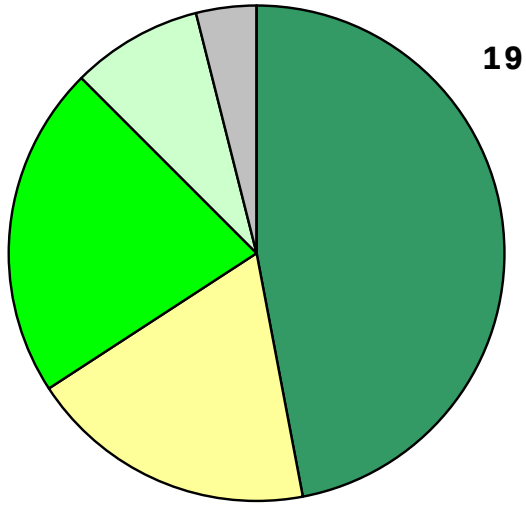

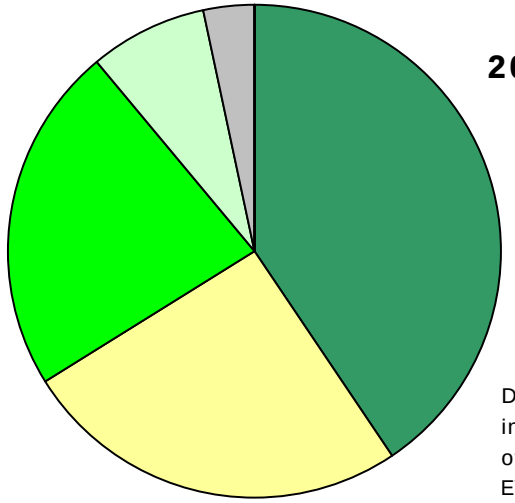

Does not include impact of EU ETS or EWP measures

Sources: National Inventory Report Issue II, 2006. UK's Fourth National Communication, 2006. Climate Change The UK Programme, 2006. CESA division, DEFRA. Updated Energy Projections 26, 2006.

On an end-use basis, emissions from domestic usage of energy in households tells a different story because the 'dash for gas' made electricity less emissions-rich

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(2004 end-use* share)	Progress	Driver
Business (40%)	28% decrease from 1990 levels	A shift from manufacturing to service industries, restructuring of electricity industry
Transport (25%)	12% increase from 1990 levels	Increased road traffic
Domestic (all) (24%)	4.6% lower than 1990 levels but increasing again since 2000	Restructuring of electricity industry but increasing electricity and heating demand
Agriculture (8%)	22% lower than their 1990 levels	Increased forestry area, reduced livestock, reduced fertilizer use
Public (3%)	31% lower than 1990 levels	Improved Procurement

* End-use sector splits are based on the purpose for which the emissions were created.

It is important to acknowledge that the different countries in the UK have not all experienced the same trends in historical emissions

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England

Total emissions of CO2 declined by 6.7% from 1990 to 2004. Emissions from power generation declined by 20%. The generation mix in England contains a much higher proportion of combined cycle gas turbines than elsewhere in the UK.

Wales

Total emissions of CO2 increased by 2.3% from 1990 to 2004. Emissions from power generation actually increased by 15.6% over the same period. Manufacturing, construction and industrial processes are bigger sources for Wales (approx. 25% of CO2 emissions in 2004) than elsewhere in the UK.

Scotland

Total emissions of CO2 fell by 14% between 1990 and 2004. Emissions from power generation increased by 4% over the same period. However a marked decline in emissions from business (a 35% decrease) outweighed this effect.

Northern Ireland

Total emissions of CO2 increased by 3.6% from 1990 to 2004. Emissions from power generation declined marginally while emissions from transport are increasing.

Source: Climate Change The UK Programme, 2006.

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Aviation emissions are underestimated owing to lack of international agreement over how to quantify the full warming impact and allocate to countries

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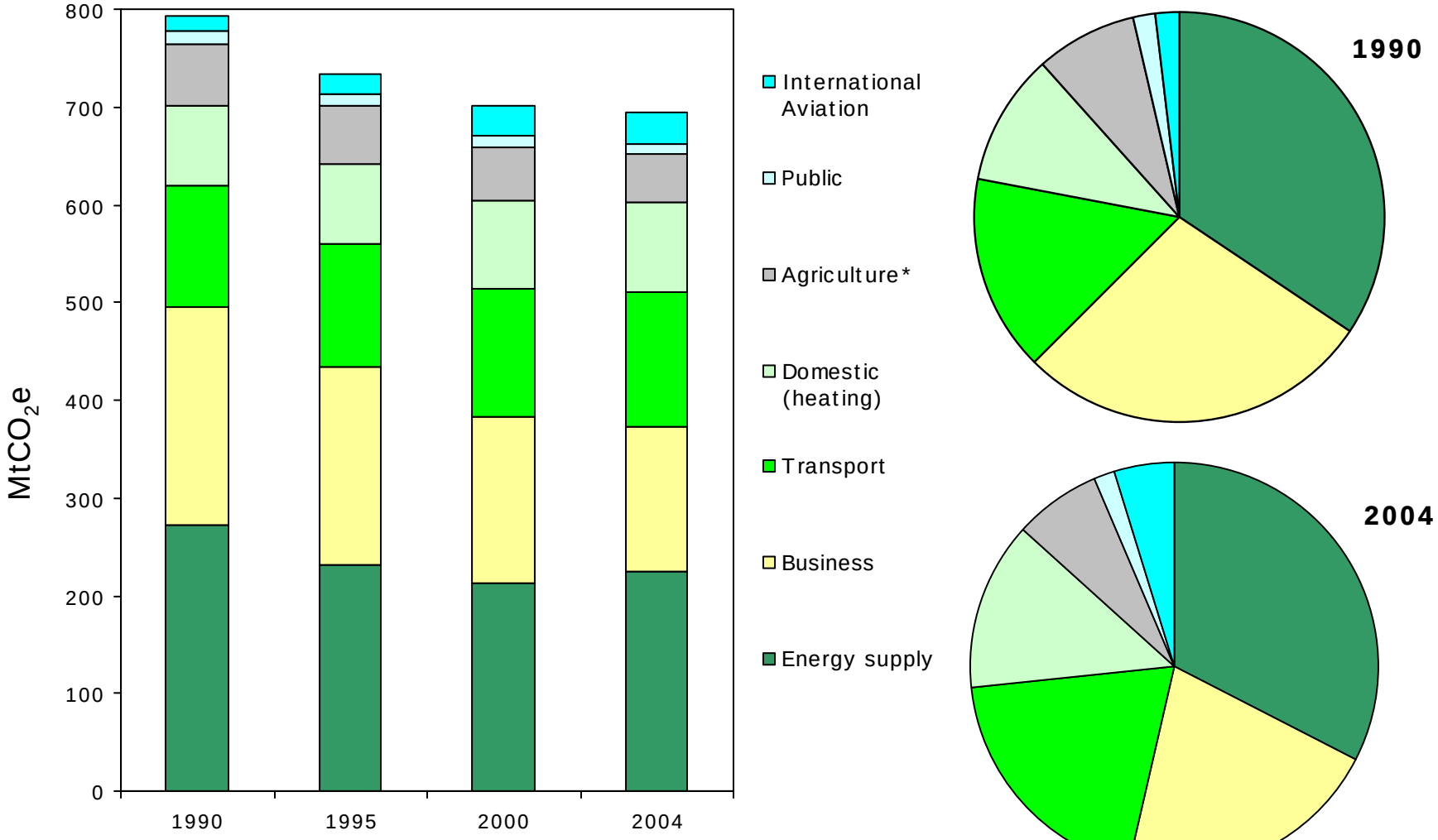
- Aviation emission estimates for the UK underestimate the impact of aviation on global warming for two reasons:
  - The estimates do not take into account the effect of high-altitude emissions because there is great scientific uncertainty over how to measure these impacts. The Global Warming Potential of gases is calculated on the basis of emissions at ground level. However, these impacts can differ substantially when they are emitted higher in the atmosphere, and latest scientific studies suggest that aviation emissions have around twice the warming* effect as its CO_2 emissions alone would suggest.
  - The estimates include emissions from domestic UK flights only, and exclude emissions from any international flights.
- There is data available on both these effects, but lack of international agreement over how to incorporate them in national emission inventories means that aviation emission estimates for the UK and other countries currently exclude them.

* Aviation is not the only source over which there is uncertainty about the radiative forcing (warming) effect; however there are no other sectors where the effect is believed to be as large as it is for aviation emissions. e.g. Emissions from shipping are believed to have a negative radiative forcing effect i.e. they contribute proportionately less to global warming than their CO_2 emission alone would suggest.

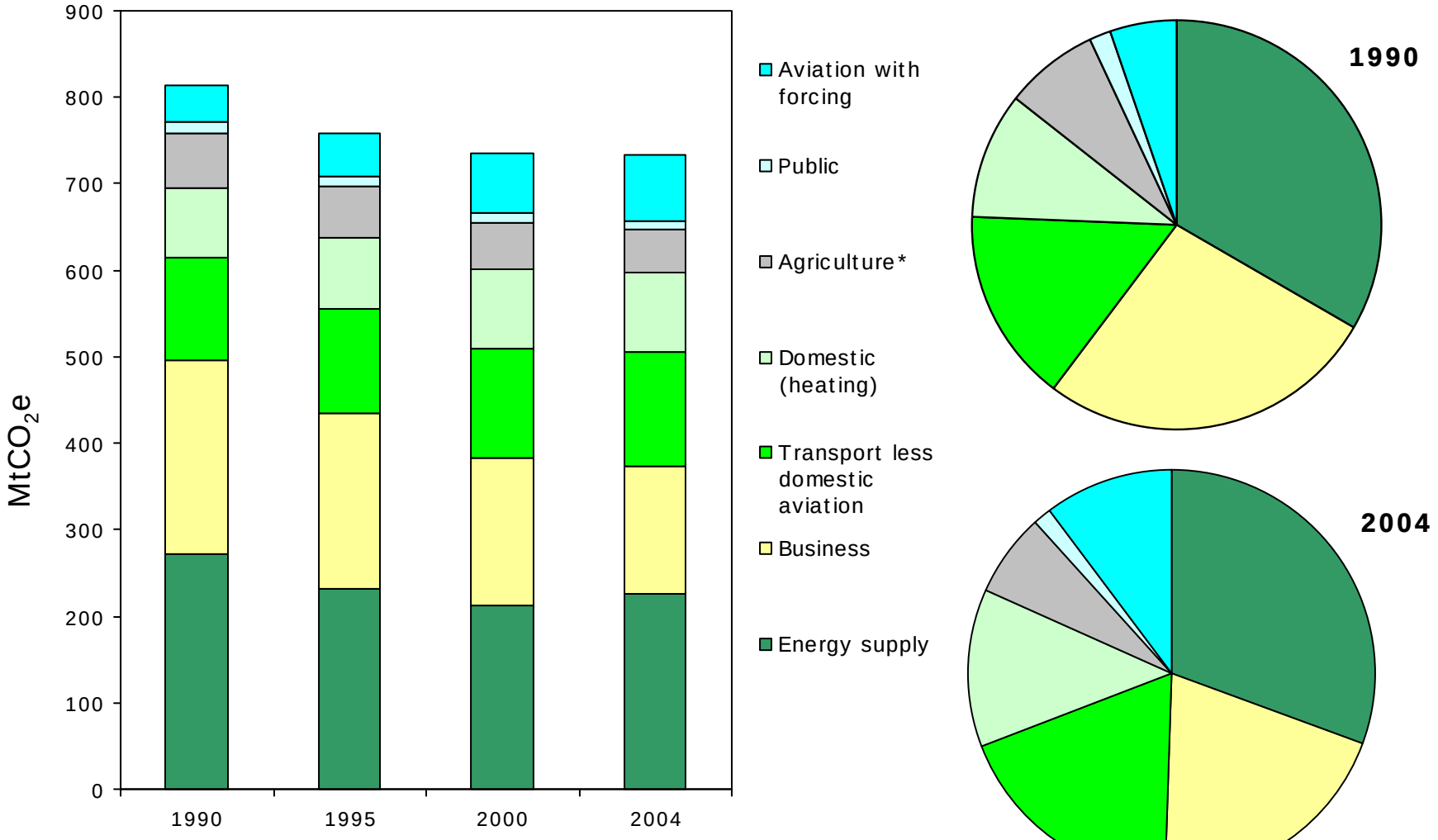
Once included in the totals, it is clear that international aviation is an increasingly important source



*Agriculture includes Forestry and Land-use emissions and sinks

Source: CCP06 and National Inventory Report Issue II, 2006.

Furthermore, uncertainty about the radiative forcing effect of aviation could mean that aviation accounts for as much as 10% of emissions in 2004



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The UK currently has four main targets for greenhouse gas emissions

KYOTO	**Reduce the basket of six greenhouse gases by 12.5% compared to 1990 levels by 2008-2012***
2010 CO_2 TARGET	**Reduce CO_2 emissions by 20% compared to 1990 levels by 2010**
2020 CO_2 TARGET	**Reduce CO_2 emissions by 26-32% compared to 1990 levels by 2020**
2050 CO_2 TARGET	**Reduce CO_2 emissions by 60% compared to 1990 levels by 2050**

* For some gases the reference year is 1995.

Even without the impact of Energy White Paper measures, we are on course to meet our Kyoto target…

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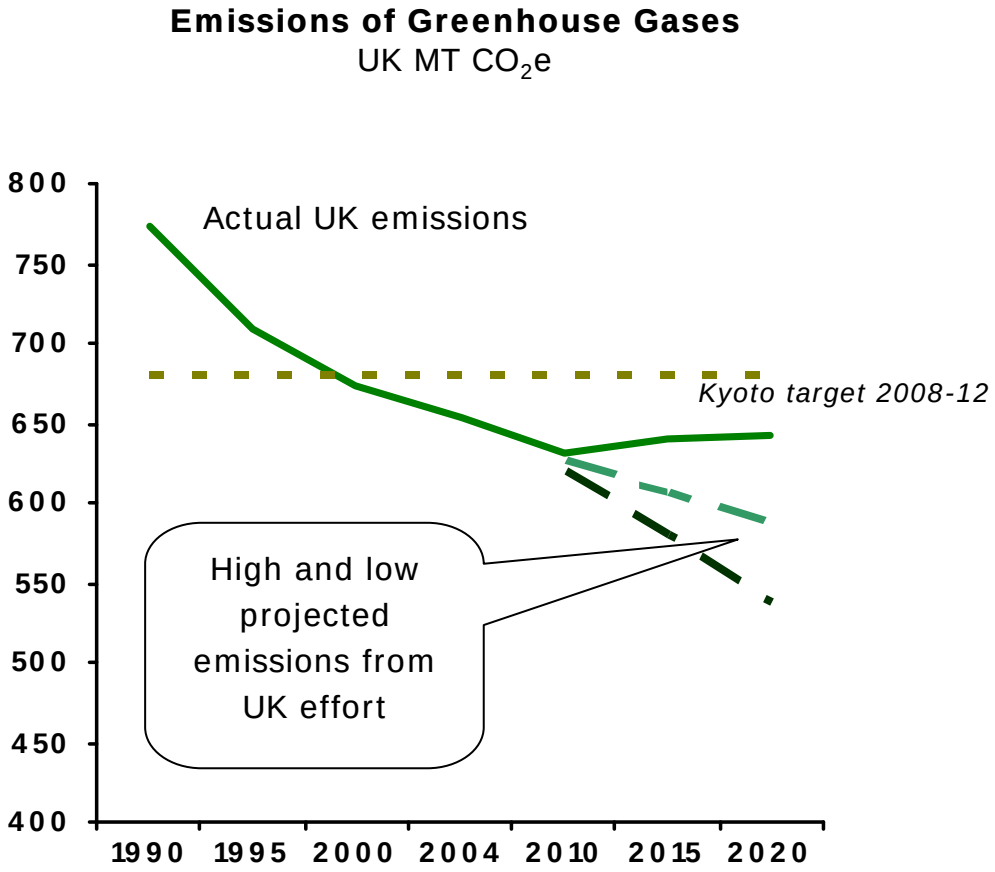
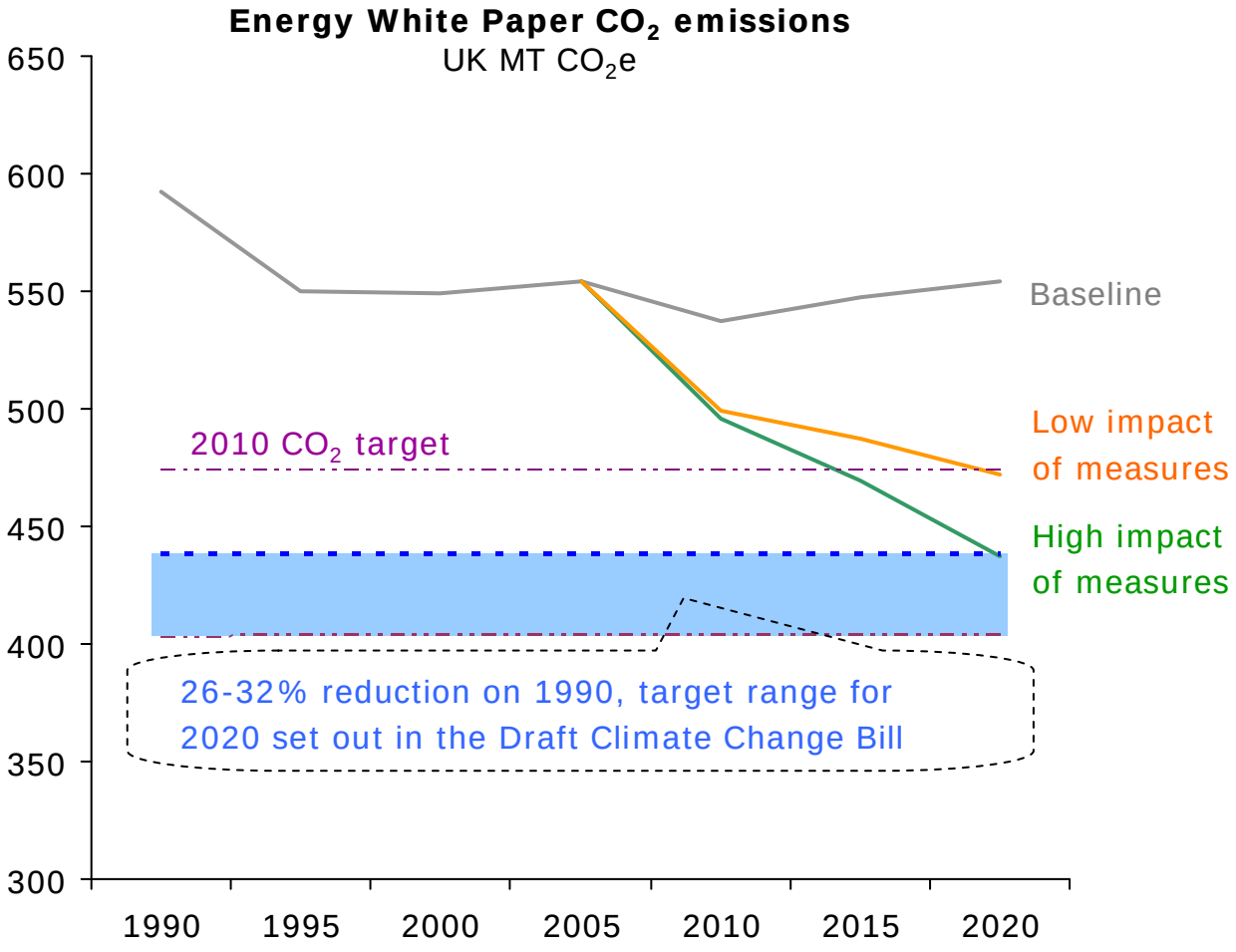


Key points

- We are on course to meet our Kyoto target even without the impact of EU-ETS and Energy White Paper measures.
- Emissions in this graph represent emissions from UK effort including EU-ETS and Energy White Paper projected impacts.

Sources: National Inventory Report Issue II, 2006. UK's Fourth National Communication, 2006. CCPR06, 2006. CESA division, DEFRA. Updated Energy Projections 26, 2006. IAG synthesis of appraisals and evaluations, 2006.

...but the scale of challenge to meet the Government's CO_2 targets remains significant



Key points

- These projections include effort of EU-ETS compliance.
- Energy White Paper measures are projected to put the UK just within the 2020 target range of 26-32% reduction on 1990 CO2 levels set out in the draft Climate Change Bill.

Source: DTI (2007) Energy White Paper. EU-ETS = European Union Emissions Trading Scheme.