



Modelling stringent UK CO2 reduction targets:  
The UK Government and Climate Change Committee scenarios

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## Work Programme

### Client

- Climate Change Committee ([www.theccc.org.uk](http://www.theccc.org.uk))

### Project

- Assess the techno-economic impacts of longer term climate mitigation goals on the energy system, with a particular emphasis on the relationship between shorter term (2020) and longer term (2050) targets.

## Work Programme



### Report

- Support evidence in the **Building a low-carbon economy - the UK's contribution to tackling climate change**
- The report contains the CCC's recommendations on the 2050 emissions reduction target and advises on the levels of the UK's first three legally binding carbon budgets for 2008-2022.



## Model Structure



### UK Model

- As part of ongoing work under UKERC, KCL have been leading on the development and improvement of the UK model, supported by AEA and PSI.

### MED version

- UKERC research programme from KCL

## Model Structure



### CCC Requirements

- Change in hurdle rates in the transport sector.
- Global discount rate
- Update fuel price and scenarios
- Inclusion of Biomethane
- Biomass constraint and domestic production
- Tidal barrier amendments
- Domestic/services energy conservation measures

## Structure of UK model



Regions	Single
Timescale	2000-2070 (5 yr periods)
Sectors	5 end-use sectors, upstream, energy processes, electricity supply industry
Demand drivers	Energy service demands by sector / mode (mainly central govt)
Future technology characteristics	Exogenous input – technology vintages / learning rates
Supply curves	Fossil resources (incl. Imports) and renewables
Infrastructure	Electricity grids, CCS transport / storage
Base constraints	Primarily between 2010-2020
Emissions tracking	CO <sub>2</sub>

## Key UK model assumptions



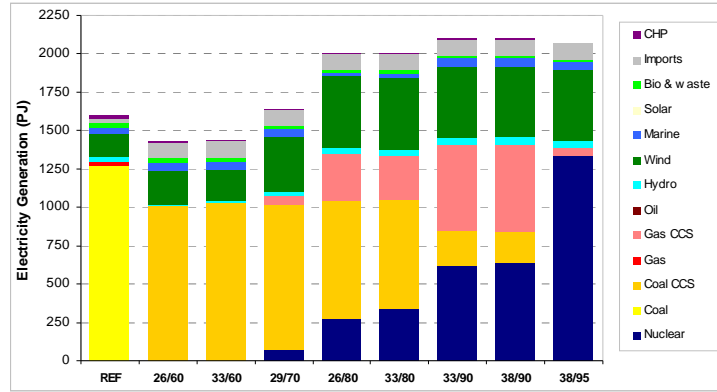
Discount rate	3.5% (10% in past)
Hurdle rates / Costs of capital	Transport modes and building EE / Large infrastructure
Electricity system reserve	Typically 30%
Load profile	Based on 6 time periods
Fuel prices	Central Govt publication
Key policies	Energy efficiency uptake, biofuel obligation, renewable generation
Taxes	Climate Change Levy, Road fuel duties

## Runs



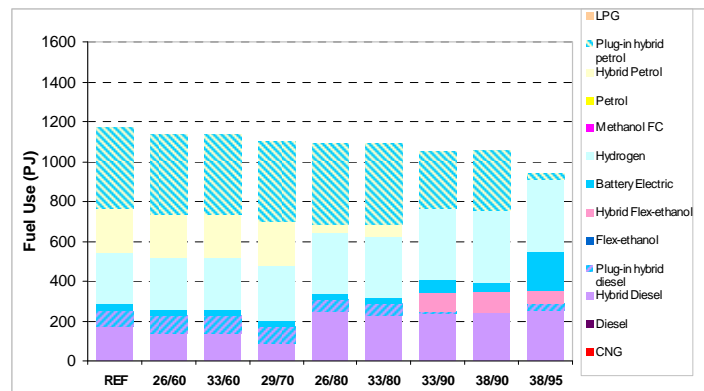
- Trajectories (against 1990 levels)
- 2020 and 2050 targets (26/60 upwards to 38/95)
  - Cumulative targets (2040)
- Carbon Credits
- Myopic / 2 stage
- Limit Role of Low Carbon Technologies
- 40% Renewable Electricity Generation
- Additional Transport Constraints
- Higher Fossil Fuel Prices
- International Aviation
- Over 60 different runs

## Trajectory analysis



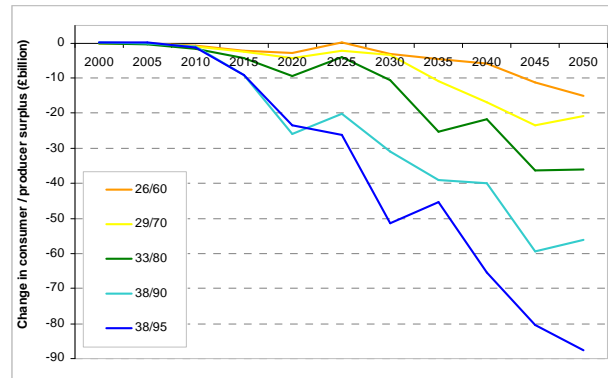
Electricity generation (PJ) in 2050 for range of target trajectories

## Trajectory analysis



Transport fuel use (PJ) in 2050 for range of target trajectories

## Welfare Costs



Change in undiscounted welfare loss

## Trajectory analysis



### Marginal abatement cost (£/tCO<sub>2</sub>) for range of target trajectories

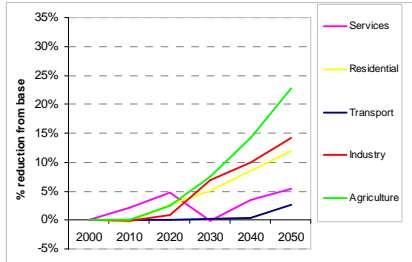
Scenario	2010	2020	2030	2040	2050	2050 (Euro/tCO <sub>2</sub> )
26/60	0.0	6.0	14.6	46.3	86.0	315.1
33/60	0.0	29.1	14.6	45.1	85.8	314.7
29/70	0.0	11.8	14.8	75.0	152.9	560.6
26/80	0.0	0.0	40.6	139.0	206.9	758.7
33/80	0.0	27.0	50.8	136.5	197.1	722.8
33/90	0.0	25.1	134.0	243.5	493.1	1,808.0
38/90	0.0	75.5	151.9	252.4	480.9	1,763.3
38/95	0.0	78.3	229.9	365.8	988.1	3,623.1

## Demand Response

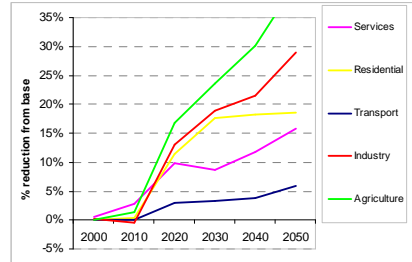


### % reduction in energy service demands under different CO2 constraint levels

33/80



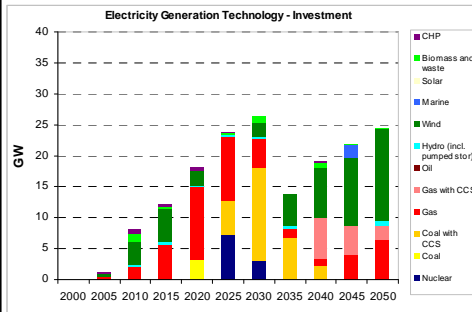
33/90



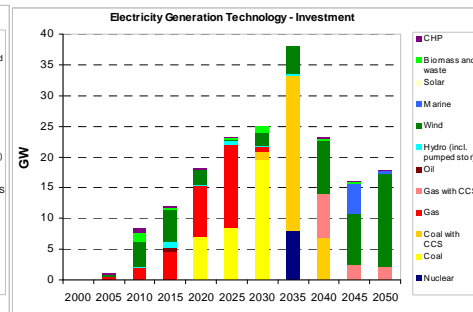
## Constraining foresight



26/80

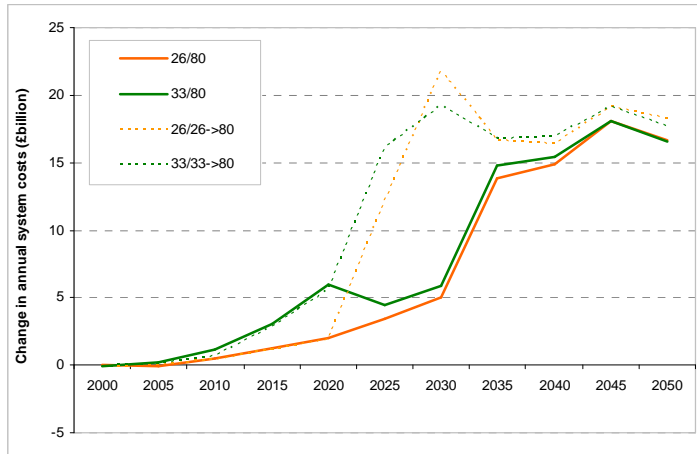


26/26→80



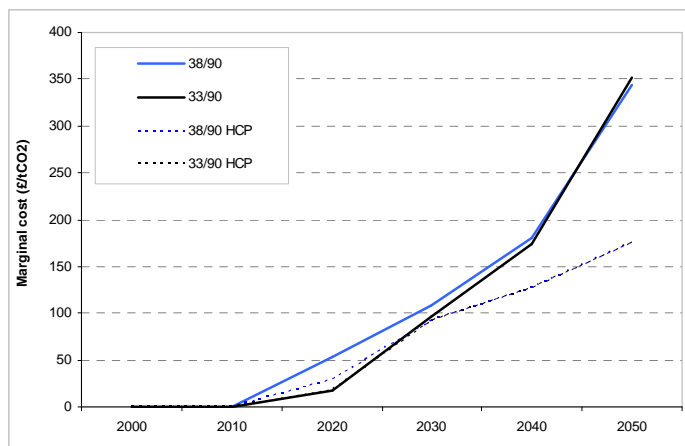
ESI investment profile (GW) for 26/80 case and equivalent constrained foresight case

## Constraining foresight



Comparison of change in annual system costs (£ billion) for constrained foresight cases

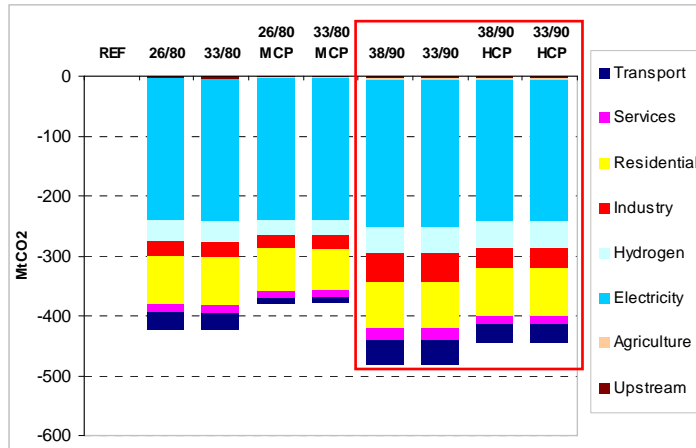
## Domestic vs. International action



Impact of C credits on marginal costs of abatement for 33/90 and 38/90 cases

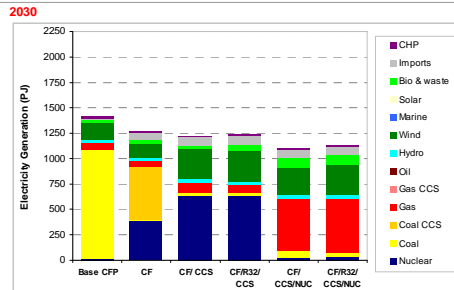


## Domestic vs. International action

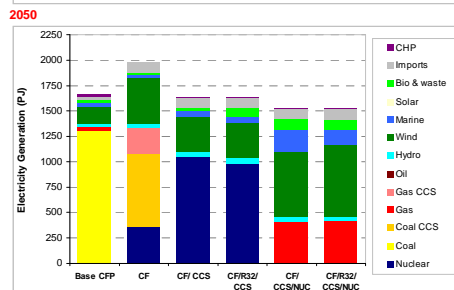


Impact of C credits on sector contribution to abatement for 33/90 and 38/90 cases

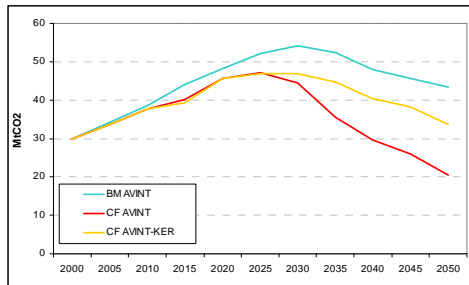
## Low carbon technology sensitivities



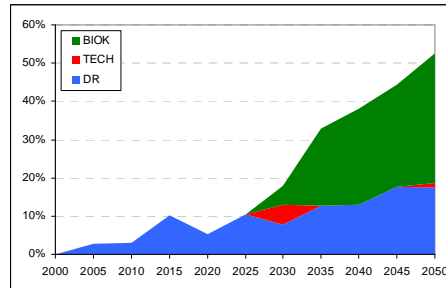
Electricity generation (PJ) in 2030 and 2050 for no CCS / no CCS-nuclear cases



## Sectoral coverage – International aviation

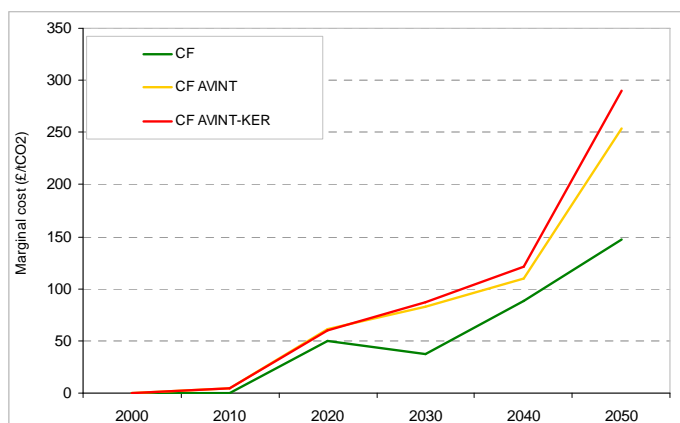


Emissions (MtCO<sub>2</sub>) from international aviation sector



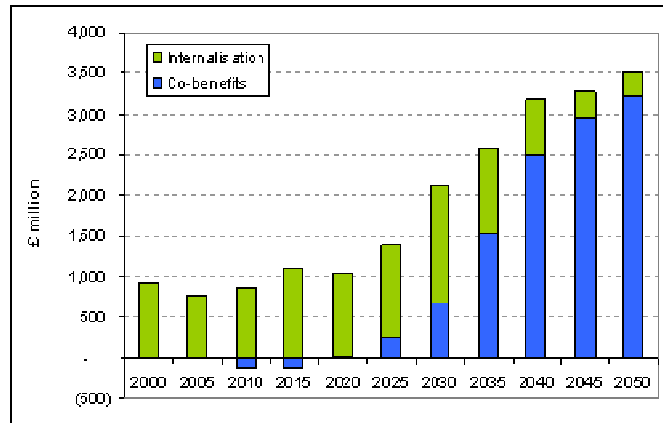
Sector-based mitigation in constrained (CF AVINT) case

## Sectoral coverage – International aviation



Impact of international aviation sector inclusion on marginal costs of abatement

## Co Benefits – Air Quality impacts



Co-benefits of climate policy (under 33/80 trajectory) on AQ pollutant emissions (NOx, PM10, SO2) with and without damage costs internalised (annual undiscounted, £ million) under 33/80 trajectory

## Results



### Summary of Results

- Stringent carbon constraints in the long term, the energy system evolves significantly, with lower overall energy use.
- The electricity sector is key to overall carbon reductions required due to the cost-effective potential available. More work needed on the uncertainties of plants e.g. CCS, grid operation.
- In 2050, reduction in undiscounted economic surplus (con/prod surplus) ranges from £12 billion under a 60% case, and £30 billion under an 80% case, to £50 billion under a 90% reduction target. Accounting for this additional loss of welfare significantly increases overall economic impacts.
- Issue of baseline that is selected and specifically within the transport sector with the use of hurdle rates/ maximum uptake

## Results



Continued...

- It is clear that role of international carbon credits have a significant role to play alongside domestic abatement efforts, but do not prevent the system moving to low carbon technologies.
- A renewable generation target of 40% by 2020 is considered achievable in the framework of the UK model, primarily as a result of increased wind and biomass generation.
- It is recognised that there a range of key low carbon technologies that could be critical to the move towards a low carbon energy system, including CCS, nuclear, renewable energy and hydrogen.
- Under the two stage runs the availability of carbon credits allow the costs of short sightedness to be reduced somewhat.

## Results



Continued...

- Under the two stage runs the availability of carbon credits allow the costs of short sightedness to be reduced, but not completely
- When international aviation is included in the reduction targets it results in additional action from other sectors, pushing non-aviation targets in 2050 to between 84% to 87% fro 80% . Mitigation costs also increase from over £150 /tCO2 to £250-300 /tCO2

Thanks



Thanks to KCL for their support and  
continued cooperation

Thanks for Listening

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