Low carbon scenarios for informing longer term decarbonisation strategies in the UK

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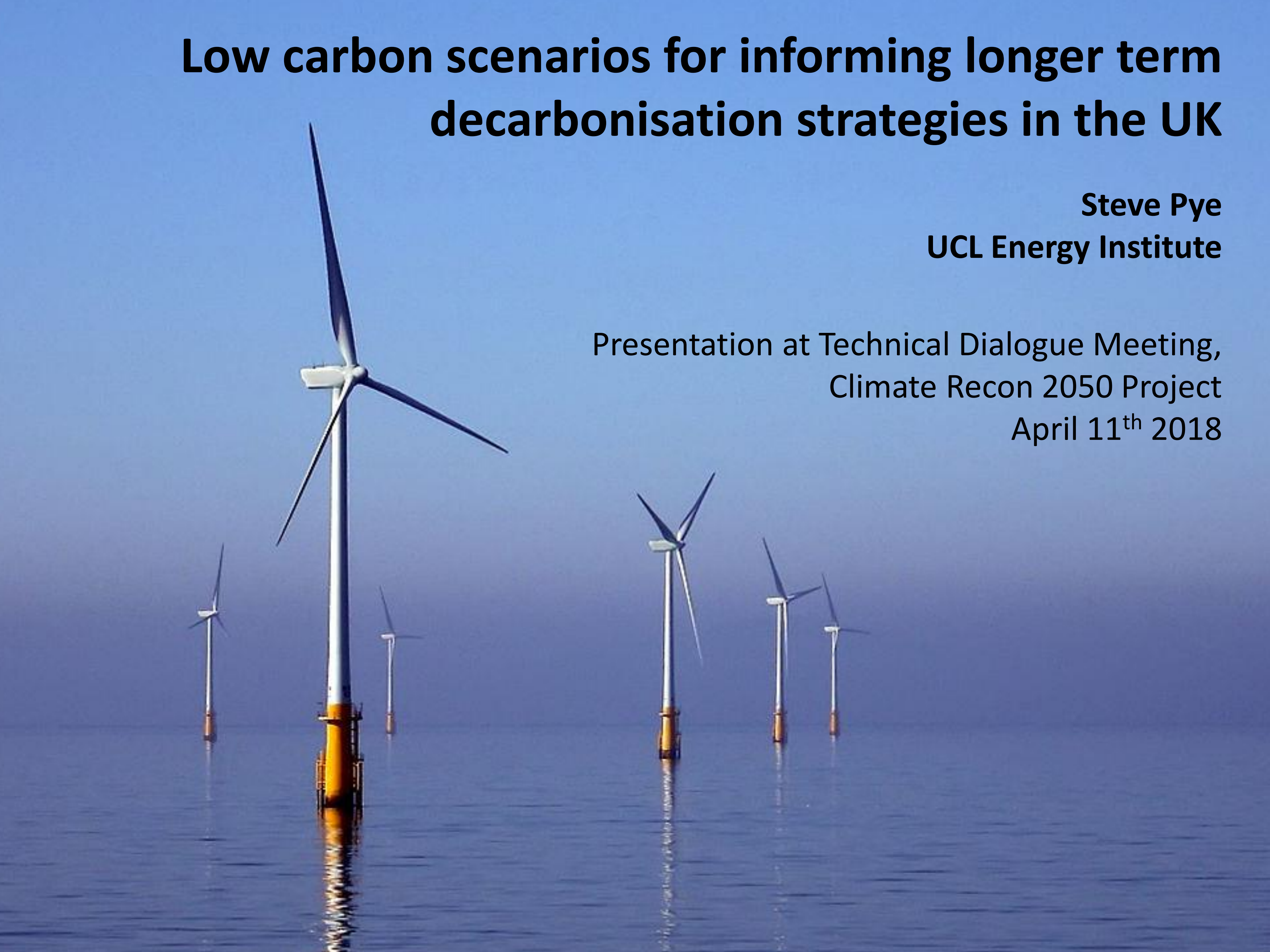
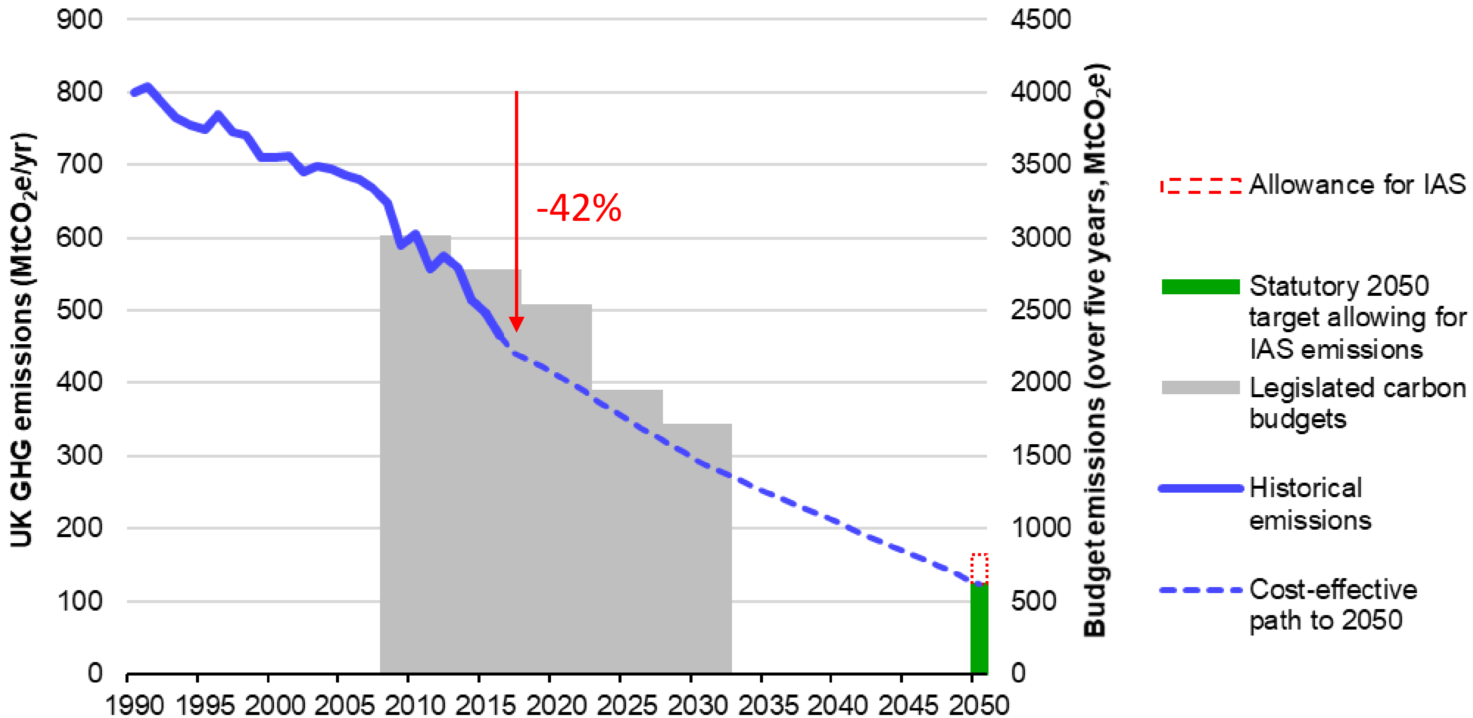


Presentation overview

1. UK context
2. Key modelling insights from low carbon scenarios since 2003
3. Reflecting on scenario analysis & the policy-modelling interface
4. How practice has and can improve

The UK context: where we are now

- One of the most ambitious legislated targets, set in 2008 (10 years ago); (at least) 80% GHG reduction in 2050, relative to 1990
- Interim 5 yr carbon budgets to maintain mitigation effort, whilst providing flexibility

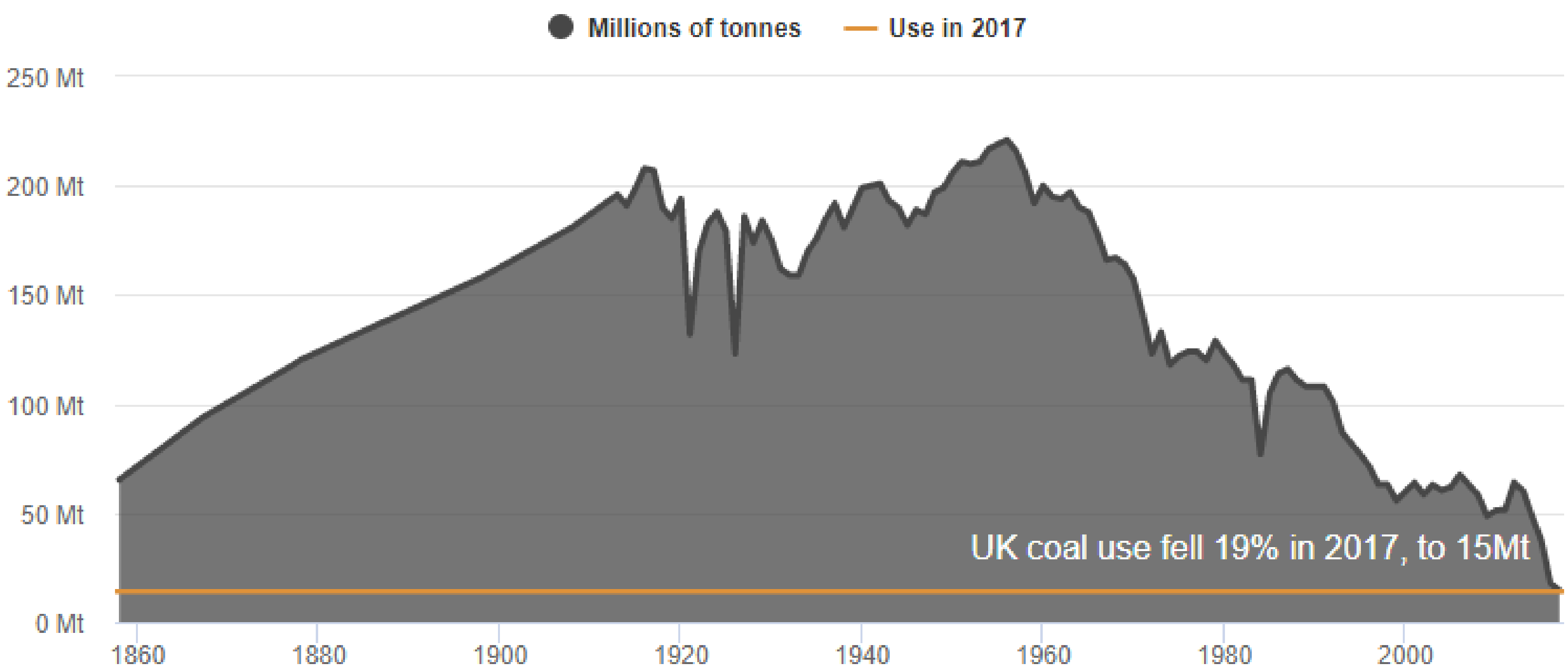


Source: CCC (2018)

The UK context: recent gains from coal phase-out

- CO_2 emissions are now at below 1890 levels, with progress due to carbon floor price in power generation, and 2025 phase out commitment

UK coal use 1858-2017



Source: Carbon Brief

UK low carbon scenarios; informing LT strategy

- Typically use of MARKAL-TIMES type energy system models
  - Technology-detailed, whole system, optimisation-based, national-scale

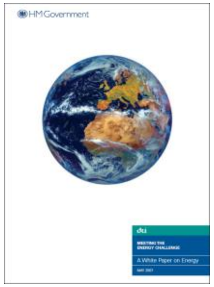
- Model traction due to -
  - Speaking 'language of decision makers' (economics of options)
  - Aided the bringing together of sectoral interests in government
  - Acting as a 'boundary object' for different communities (Taylor et al. 2014)
  - Capacity available – and from ex-Government lab
  - Recognised platform for longer term planning capability (credible)
  - Research funding & incumbency advantage over time

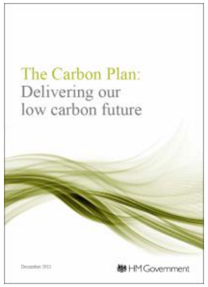
UK energy and climate strategy timeline

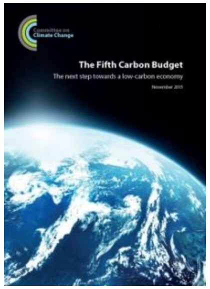
2000 › 2003 › 2004 › 2005 › 2006 › 2007 › 2008 › 2009 › 2010 › 2011 › 2012 › 2013 › 2017

Proposed targets › Building evidence base and political consensus › Developing legislative framework and firming up targets › Developing the implementation framework

Royal Comm. on Environ. Pollution 2000 | Energy White Paper 2003 | Energy Review 2006 | Energy White Paper 2007 | CCC Targets 2008 | CCC 4th Carbon Budget 2010 | DECC Carbon Plan 2011 | CCC 5th Carbon Budget 2015 | Clean Growth Strategy 2017

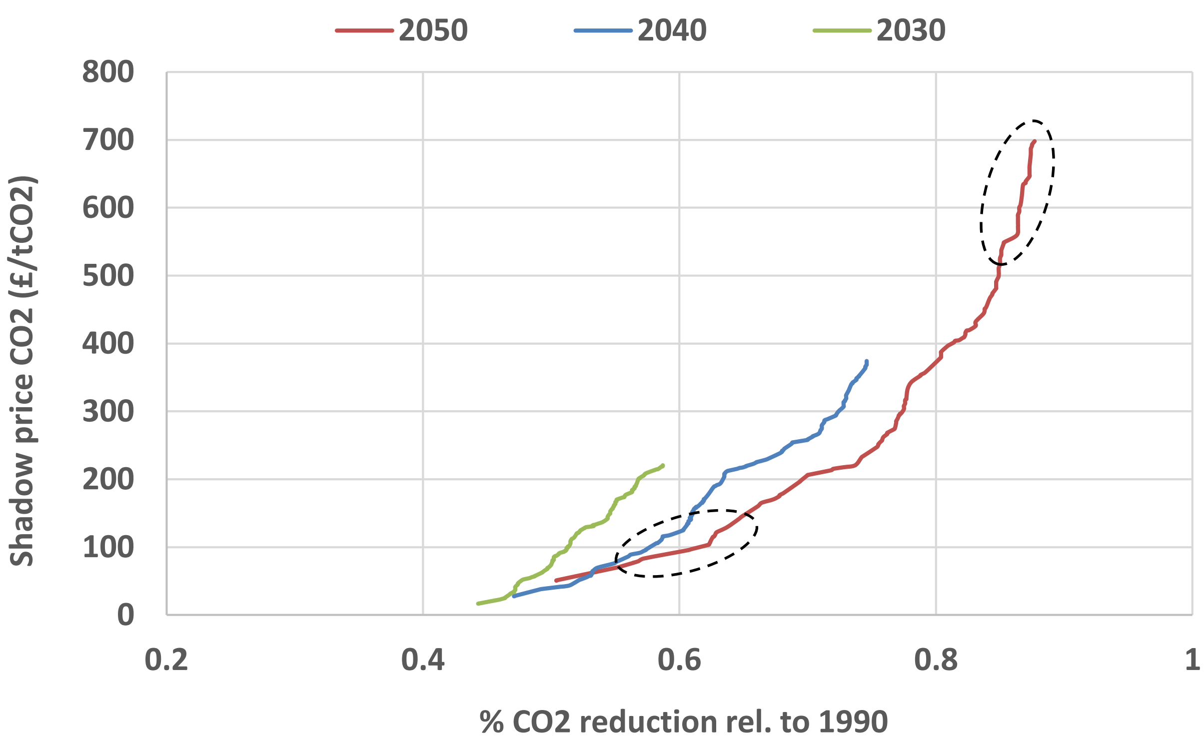




Systems models	UK MARKAL	UK MARKAL-MACRO (Macroeconomic module)	UK MARKAL-MED (Elastic Demand Variant)	UKTM-UCL (Successor to UK-MARKAL)
			TIAM-UCL, ETM-UCL (Global and European Scale Models)	
Model operators	Consultants	Consultants / Academics	Academics	Academics / Government / Industry

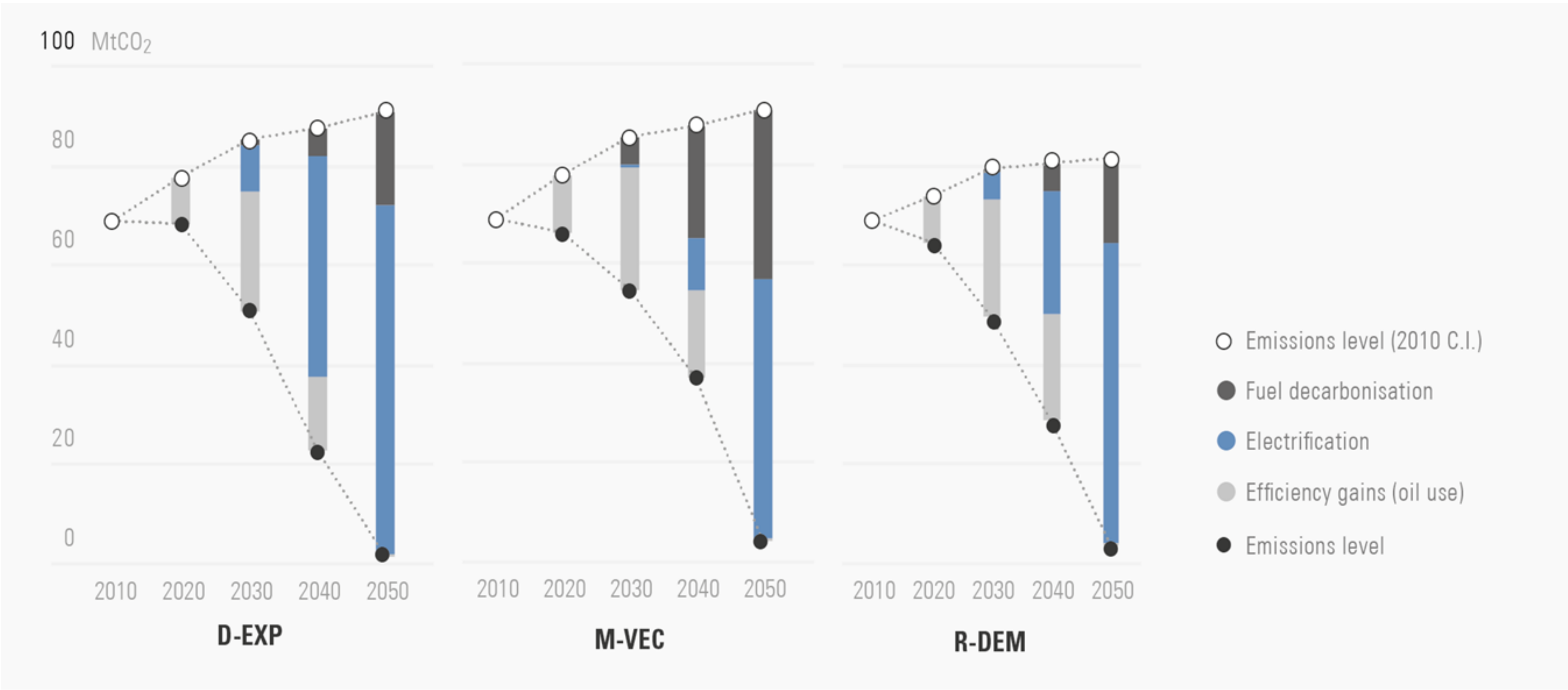
Key insight 1: The transition to a low carbon economy is not cost-prohibitive

- Additional system costs in 2015 of the order of 1-2% 2050 GDP (~40 billion out of a £2.8 trillion economy)
- Other economic analysis that considers impact on wider economy sees a benefit, at least out to 2030 (investment, not costs)
- But cost of mitigation increases steeply as carbon target ratcheted up



CO2 reduction at different carbon prices. Source: Pye (based on ESME analysis)

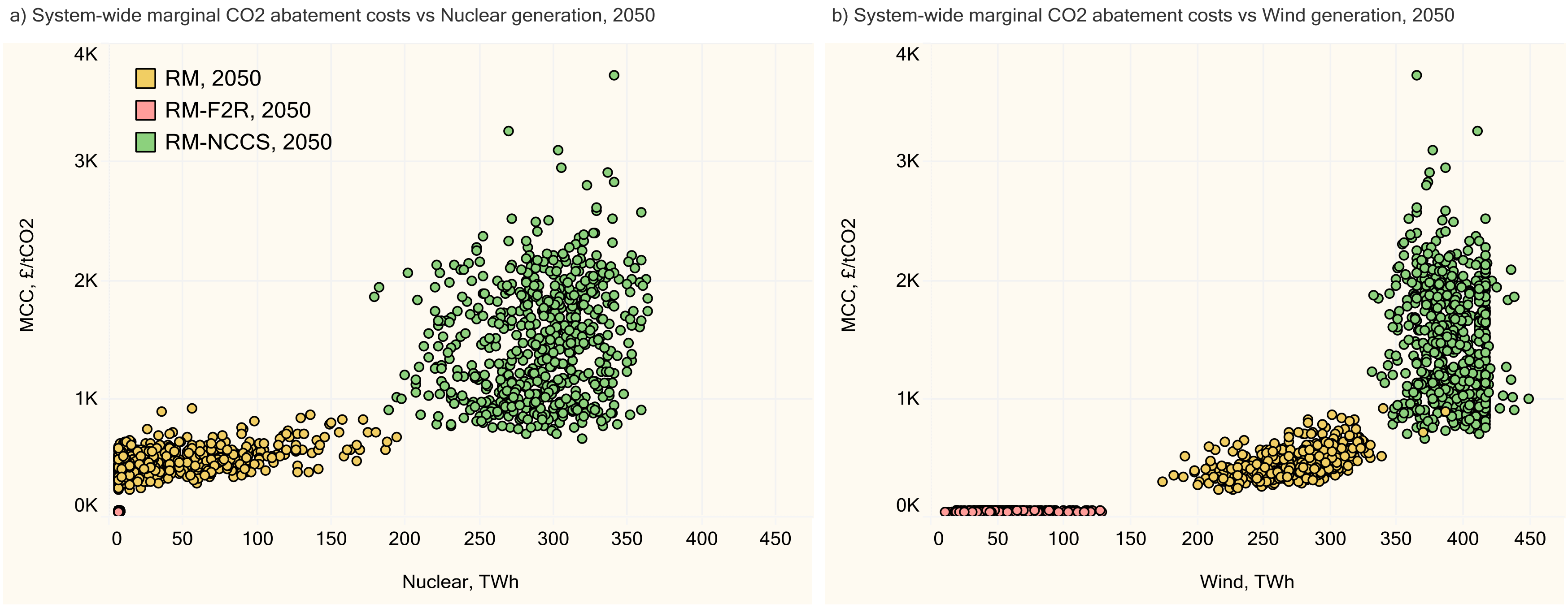
Key insight 2: Deep decarbonisation is technically feasible and there are numerous pathways……….



Decarbonisation of passenger car demand in the UK, 2010-2050.
Source: Pye et al. (2015)

Key insight 2: Deep decarbonisation is technically feasible and there are numerous pathways……….but also some key techs

- CCS (and BECCS) good example of wide system effects – on deployment, sector action and cost
- Need to improve analysis and communication on such effects, and insights (‘push hard’ and / or ‘diversify due to risks’)

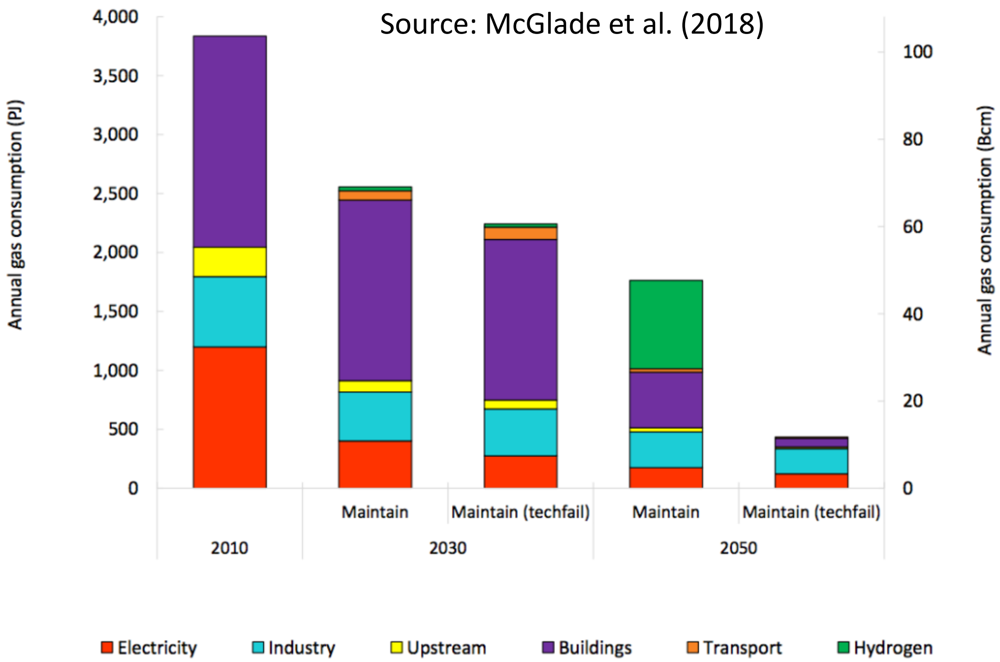


Generation by nuclear (left) and wind (right) in 2050, with CCS (yellow) or without CCS (green).
Source: Pye and Keppo (2018)

Key insight 3: Path dependency issues require that policy decisions undertaken now recognise longer term objectives…..

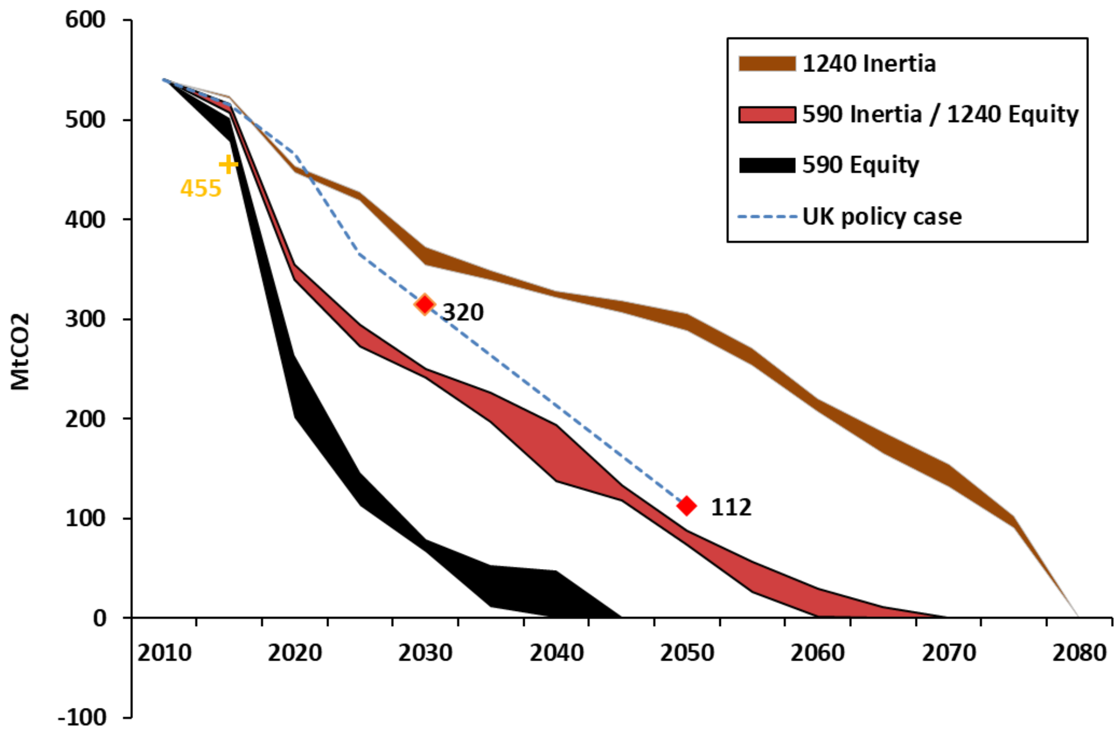
- Strategic decisions can lock-in a specific system due to the long asset lifetime of energy infrastructure e.g. airports, power stations
- Increased costs from a short term orientated investment focus (AEA, 2008)
- Recent focus on the future role of gas (McGlade et al. 2018)

Source: Carbon Brief



Key insight 4: ….and therefore long term target ambition matters

- Post-Paris, argued that a net-zero CO2 target for the 2045-70 range could help better focus longer term strategy, and provide a clearer goal for stakeholders
- Government to establish net-zero target…..but just not yet



Source: Pye et al. (2017)

Key insight 5: Sectoral linkages and interdependencies highlight the danger of silo thinking in policy

- It makes sense to focus on specific sectors first, while capacity is built to address other parts of the system e.g. power sector decarbonisation
- Some sectors require decarbonisation first e.g. to allow for end use sector electrification
- Limited resources will be competed for by different sectors e.g. bioenergy. Insights into optimal use of resources.

Reflecting on scenarios (McDowall et al. 2014)

Review of historical scenarios

- Actual historical developments frequently lie outside the ranges of scenarios – usefulness in mapping uncertainty space?
- Recommendations to ………
  - Focus on use of multiple studies
  - Avoid reliance solely on energy community to imagine the future
  - Recognise that scenarios often reflect current concerns in energy policy domain…but fail to see broader shifts (e.g. in socio-political domain – also see Li and Pye, 2018)
  - Question if scenarios can be more exploratory, not always least cost / normative
  - View scenarios as basis for opening up / facilitating discussion about options

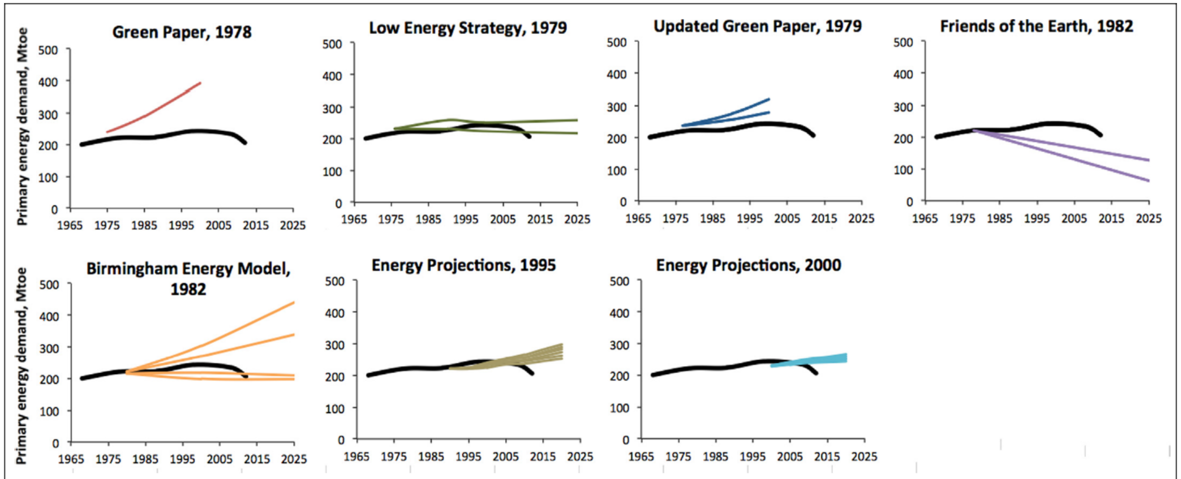


Fig. 2. Comparison of the actual primary demand transition (black line) and selected past UK energy scenarios in terms of primary energy demand, Mtoe.

Source: Trutnevyte et al. 2016

Reflecting on scenarios (McDowall et al. 2014)

Engagement on use and communication of scenarios

- Useful for exploring energy system dynamics, integrating sectors
- Modelling exercises generally useful, although some scenario assessments remain in the academic domain
- Improvements on……..
  - Uncertainty: move from deterministic (core case) to more systematic approaches – that capture wide ranges
  - Transparency: improved publication of assumptions and documentation
  - Communication: caveats on insights without stating what this means for interpretation; not always provision of jargon-free high level summaries

Remaining relevant to decision makers: evolution of approach

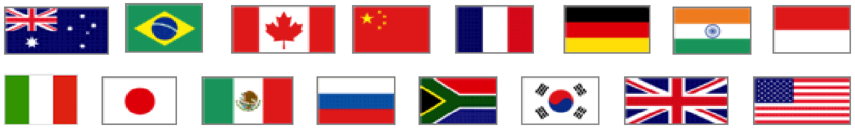
- Moving towards uncertainty assessment methods (Global sensitivity analysis, stochastic programming, modelling to generate alternative, robust decision making etc.)
- Collaborating with other modelling 'tribes'
- Preparing to re-orientate research (LT strategy ------- > NT policy design and implementation)
- Embedding stakeholders in analysis process e.g. UKTM model in UK ministry (BEIS)
- Focussing on demand side options, regional linkages, and opportunity / benefits
- Maintaining core funding to allow for the above!

Table 1 | Key reinvention elements of the energy modelling-policy interface.

Category	Current limitation	Proposed improvement
Enabling	Uneven path-dependent development	Couple to funding and policy cycles
Coordination	Incumbency advantage	Platform-based expert user groups
Review	Modelling silos	Interdisciplinary external stakeholder review
Transparency	Lack of incentives for quality assurance, version control and documentation	Targeted resourcing for these model process tasks

Source: Strachan et al. 2016

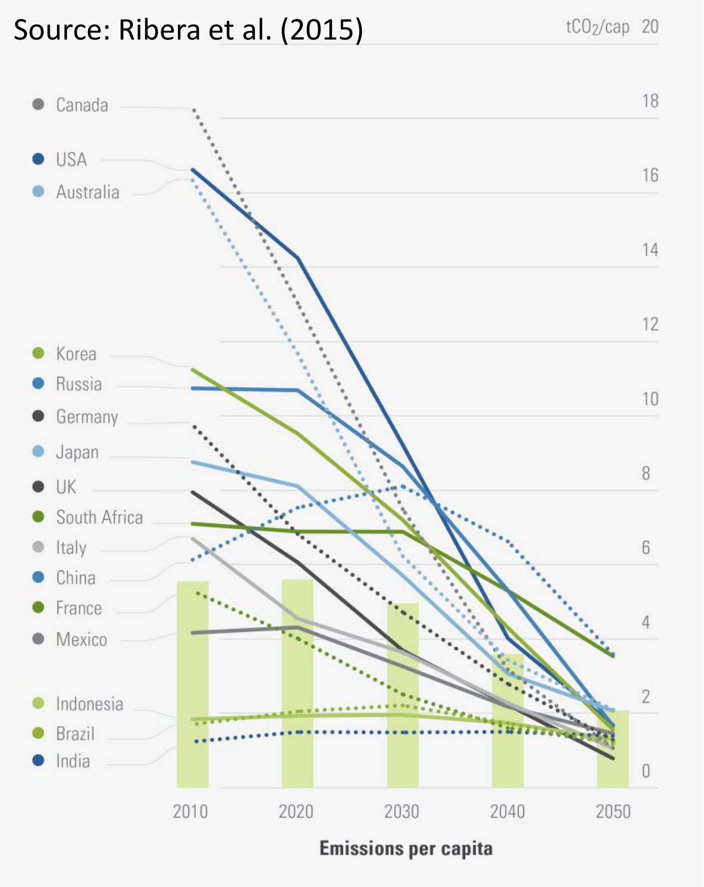
An international perspective: DDPP



DEEP DECARBONIZATION PATHWAYS PROJECT

- Demonstrated that countries can achieve deeply decarbonized energy systems by 2050, commensurate with the transformation required under the internationally agreed 2 °C target whilst pursuing development objectives
- Based on national level modelling analyses by a consortium of the 16 largest emitting countries (>70% of global energy-related CO2 emissions)
- Important technical project to support Article 4.19 of the Paris Agreement

Source: Ribera et al. (2015)



Project reflections

- Many of the same challenges faced in the UK concerning modelling low carbon scenarios – communication, transparency, policy relevance, adequacy of approaches etc. (Pye and Bataille, 2016)

- Huge benefits from network in challenging assumptions, cross-fertilization of ideas, developing regional analysis (Spencer et al. 2017)

- ……..but large capacity gaps in many regions of the world

- Network aims to expand in supporting capacity elsewhere and doing more sector specific analyses. Transport report launched at COP23 (IDDRI 2017), and recent industry paper published (Bataille et al. 2018)

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Thanks for listening.

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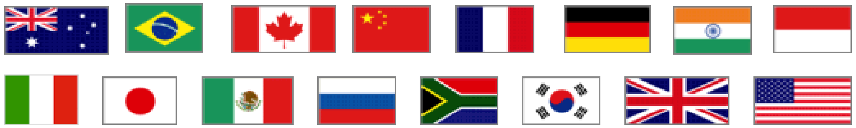
Supplementary slides

DDPP

DEEP DECARBONIZATION PATHWAYS PROJECT

www.deepdecarbonization.org



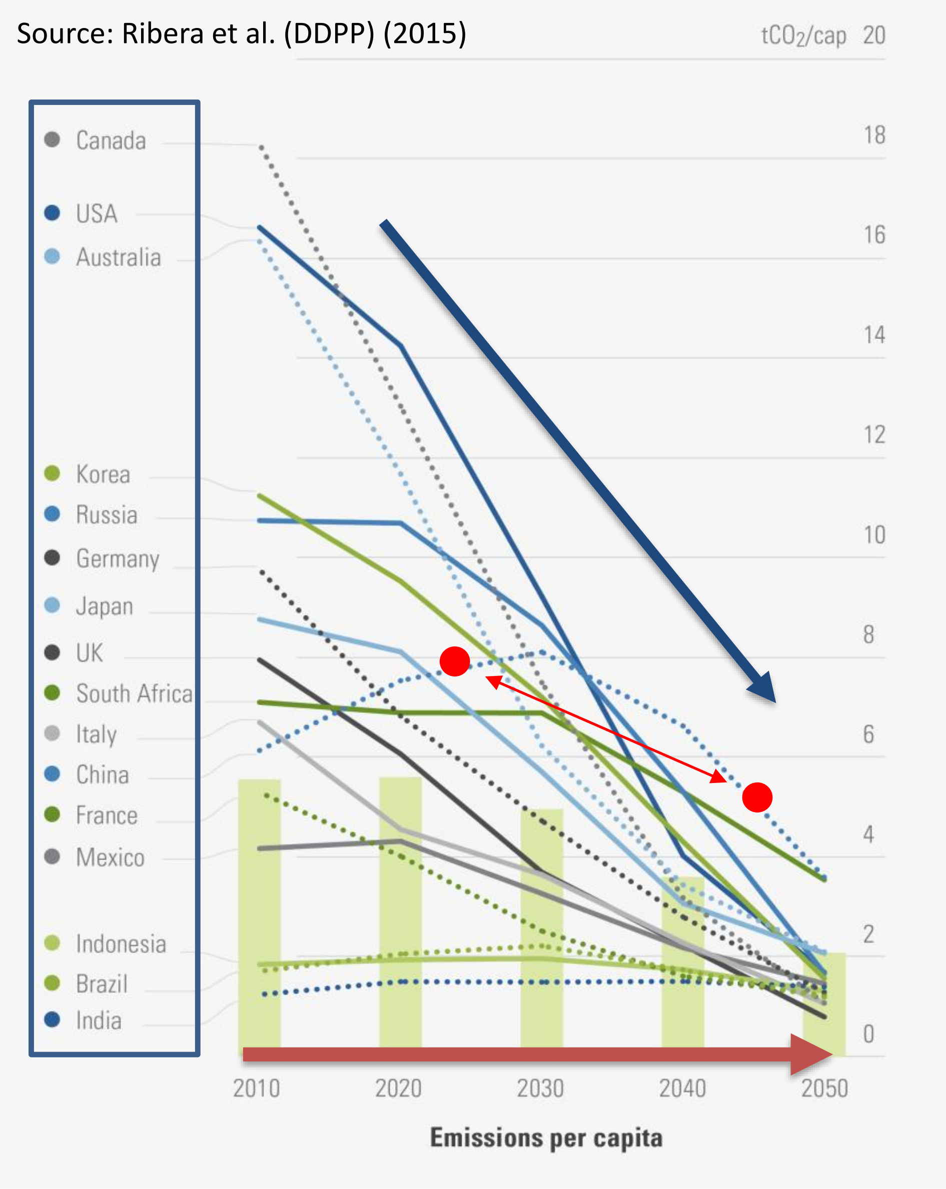
- Objective to demonstrate that countries can achieve deeply decarbonized energy systems by 2050, commensurate with the transformation required under the internationally agreed 2 °C target

- Based on national level modelling analyses by a consortium of the 16 largest emitting countries (>70% of global energy-related CO_2 emissions)

- Complimentary to global Integrated Assessment Models (IAMs) that have dominated the IPCC process

Features of the decarbonisation challenge that models have to capture

- Long term framing (uncertainty)
- Coherence between near and longer term
- Structural (not incremental) change
- Global co-operation
- Multiple objectives – affordability, security, growth
- Multiple actors



Principles of DDPP approach

- **National-scale approach**: account for domestic circumstances and promote synergies with socio-economic priorities (policy traction, whole system)

- **Long-term vision to 2050**: inform short term decisions and the sequence of actions (≠ risks of lock-ins) (normative, not exploratory)

- **Transparency, granularity & diversity**: enable engagement with decision makers and dialogue with different groups of stakeholders

Key outcomes of DDPP

- **Quantitative insights:**
  Transformative scenarios are feasible in all the countries we have studied, and compatible with development objectives

- **Policy impact:**
  Important supporting activity to Paris Agreement, Art. 4.19, and national decision makers

- **Network established:**
  Modelling expertise to support 2050 Platform & Mid Century Strategies, and NDC strengthening

Figure 4. (L) Average carbon intensity of electricity for DDPP countries as a whole, 2010 and 2050. (R) Carbon intensity of electricity in 2050, for individual DDPP countries.

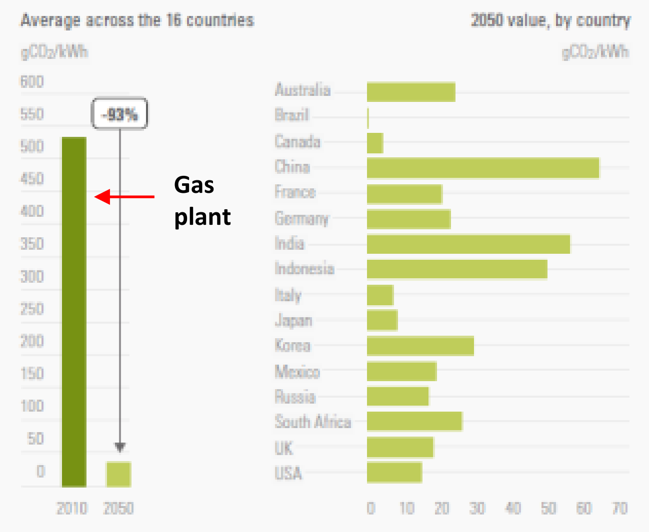
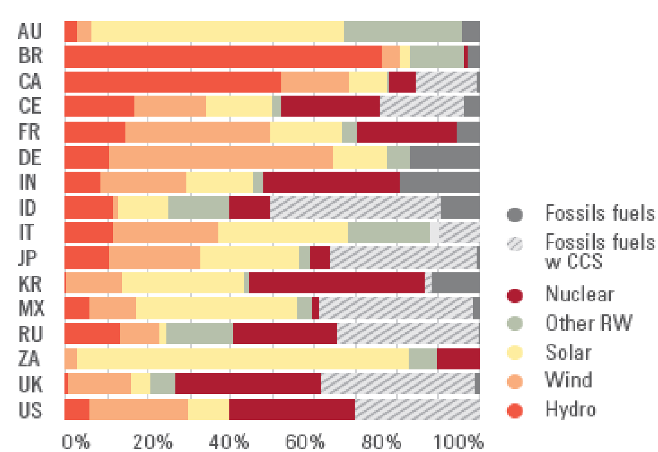


Figure 7. Electricity generation mix in 2050



Source: Ribera et al. (DDPP) (2015)

Necessary features of modelling decarbonisation pathways

Drawing from the Deep Decarbonisation Pathways Project (DDPP):

- **Normative**, not exploratory. Want to understand how we get to where we want (need) to go, not where we are likely to end up.
- **Country-led**. Leverage country expertise and understanding.
- **Policy traction**. Focus on policy priorities, economic insights etc.
- **Long-term time horizon**. Allow for assessment of path dependency issues, due to long life of assets.
- **Options-focused and cross-sectoral.** Explicit consideration of options across the system.
- **Broad stakeholder engagement.** Includes civil society and wider expert groups.

Why use models?

Hotz et al. (2015) highlight benefits -

- Explicit, clear, and systematic – assumptions are written down and subject to questioning
- Allow for inferences of dynamics in complex systems – multiple temporal and spatial scales, objectives etc.
- Allow for systematic experimentation – what if I were to change X?

Net-zero paper

Position on UK targets since Paris…..no change

- Since Paris (March 2016), the Government in Parliament have committed to introducing a net-zero target at some point in the future. Date to be based on advice from the CCC.

- CCC set out recommendations in October 2016.

  - On global ambition, no change. Global ambition underlying current UK target sits within range of 2°C target at 66% probability

  - Recognition that 2050 UK emissions target level premised on large amounts of emission removal e.g. BECCS

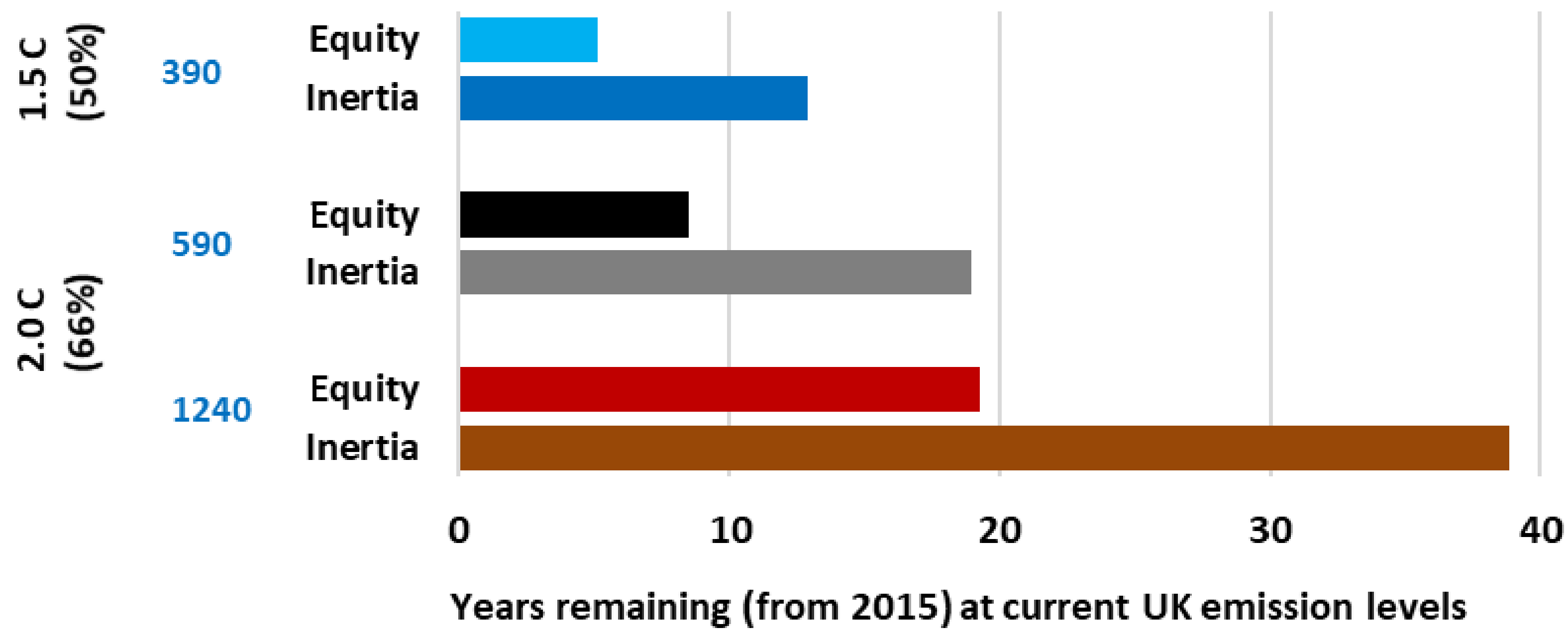
  - On the logic underpinning the existing 2050 UK target, CO_2 should be zero by 2045-65 and net GHGs by 2060-90…….. but not setting legislative target now

Approach to analysis (2)

Select allocation approach

Allocation method to derive UK budget share (Raupach et al., 2014)

- Equity - allocation is on an equal per capita basis (0.8% share)
- Inertia - allocation determined by 2010 share of global emissions (1.5% share)



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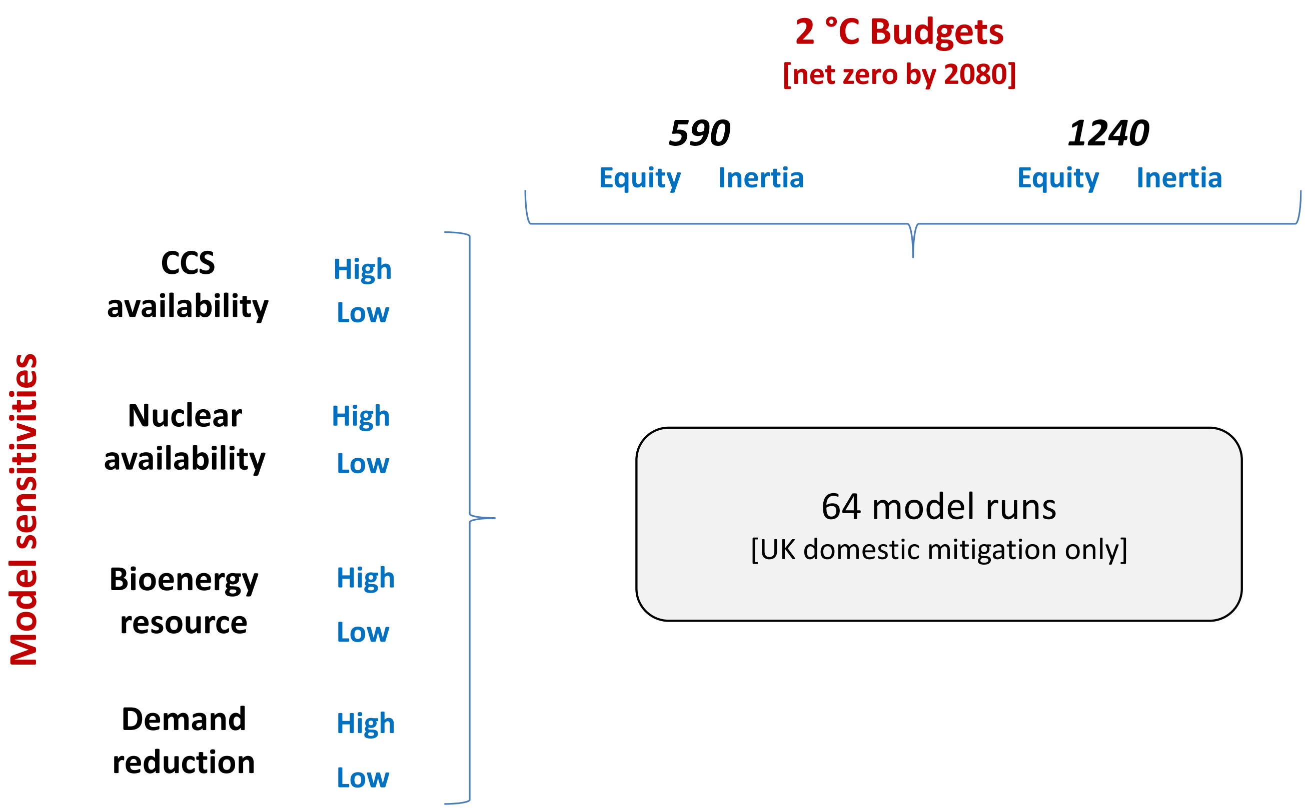
Approach to analysis (3)

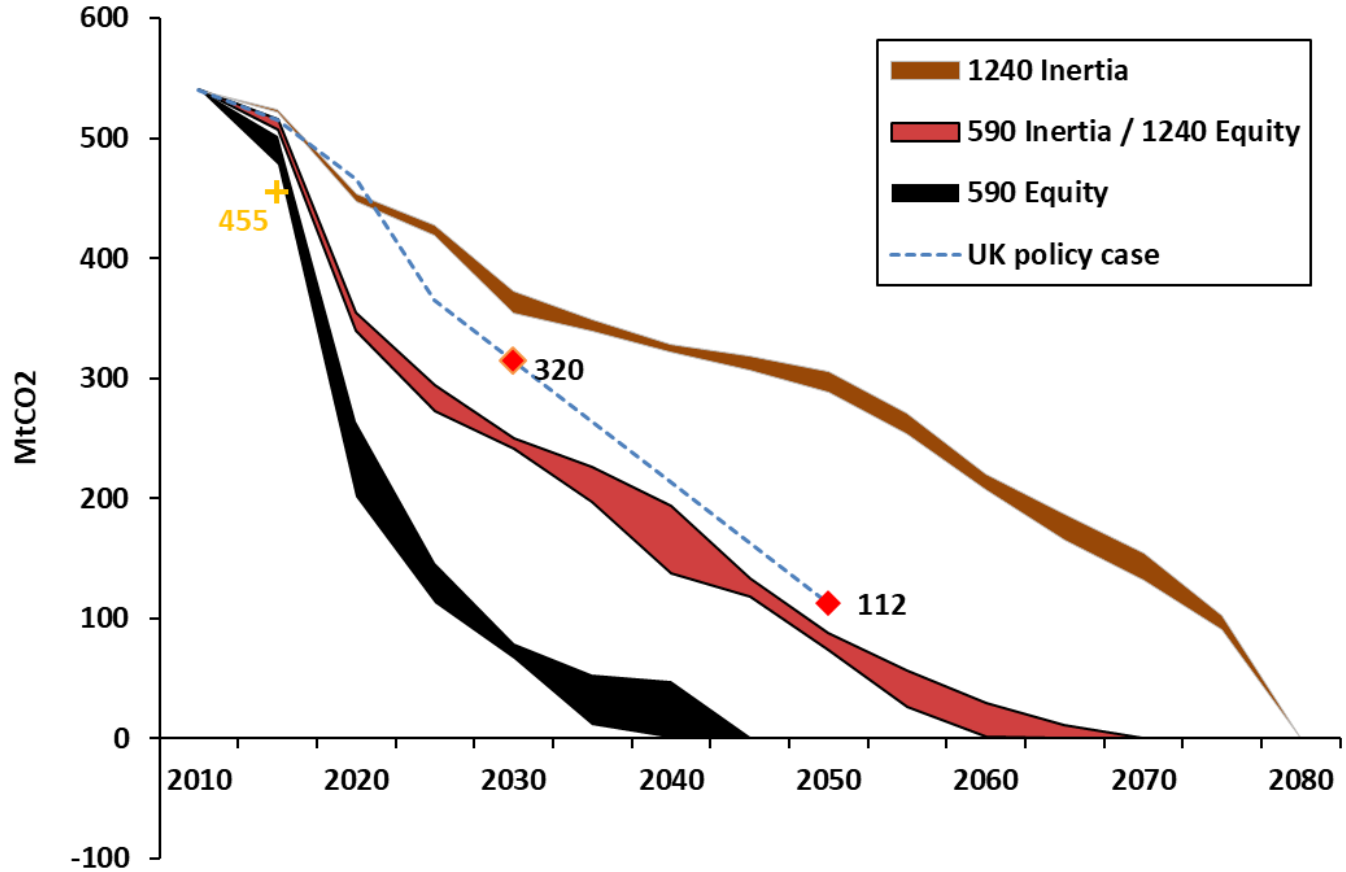
Model budget cases under key energy system uncertainties

From earlier analysis, there are a range of key uncertainties that impact on the low carbon transition, both in terms of technology choice and economics



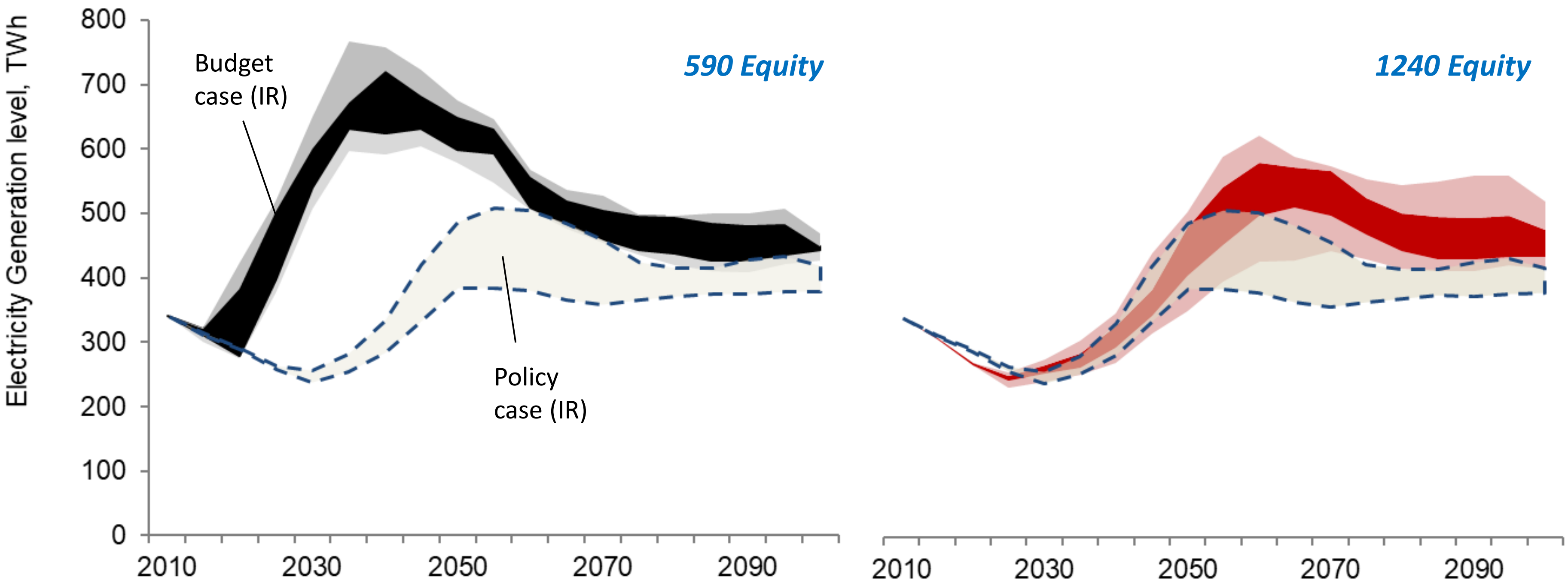
Net CO_2 emissions under the 590 & 1240 Gt budget

	590 Equity (4 Gt)	1240 Equity (9 Gt)	1240 Inertia (19 Gt)
Cum. CO2 to 2050	33%	79%	127%
Ave. mitigation rate / n-z date	9% / 2040-45	4% / 2060-70	2% / 2080
Sensitivities not solved	70%	50%	50%



Power decarbonisation & expansion

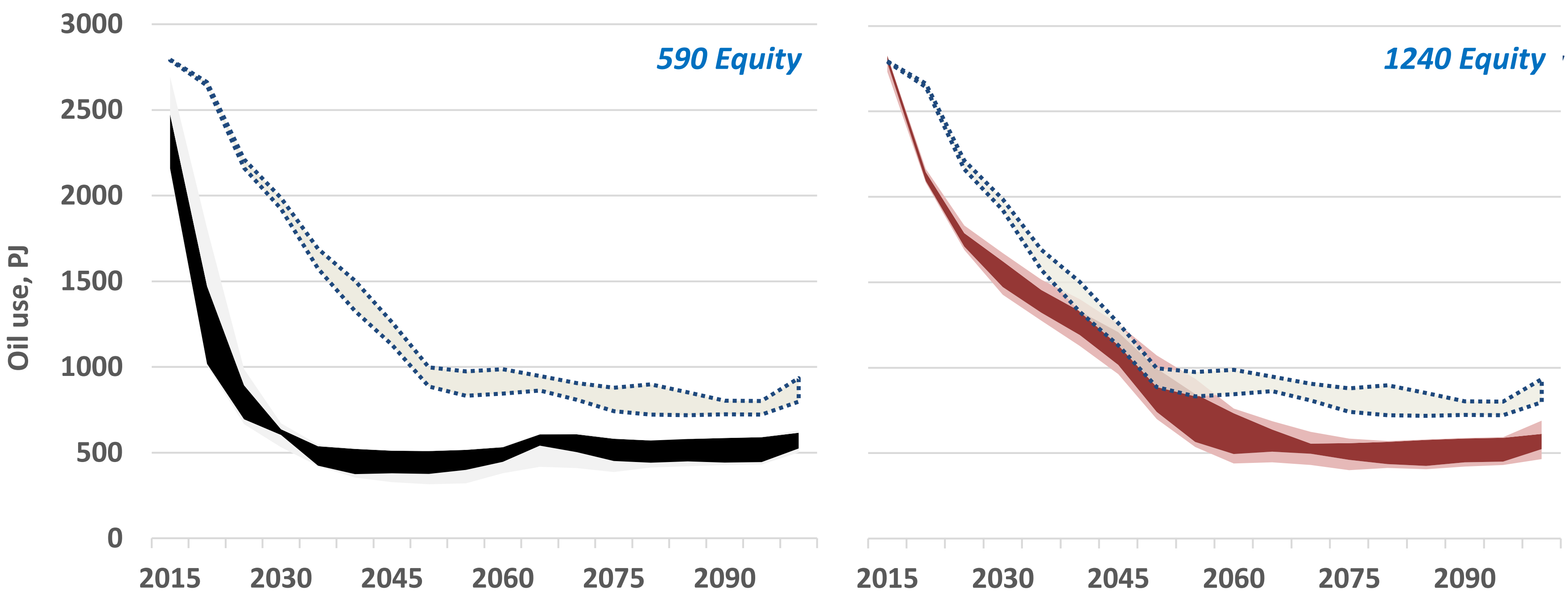
- 590 Equity: immediate and rapid deployment across all LC generation types
  - Post-2050 reductions due to other LC energy carriers (but sunk investment?)
- 1240 Equity: similar pre-2050 decarbonisation, but larger system post-2050



Electricity generation level (TWh), 2010-2100

Shift away from liquid fossil fuels

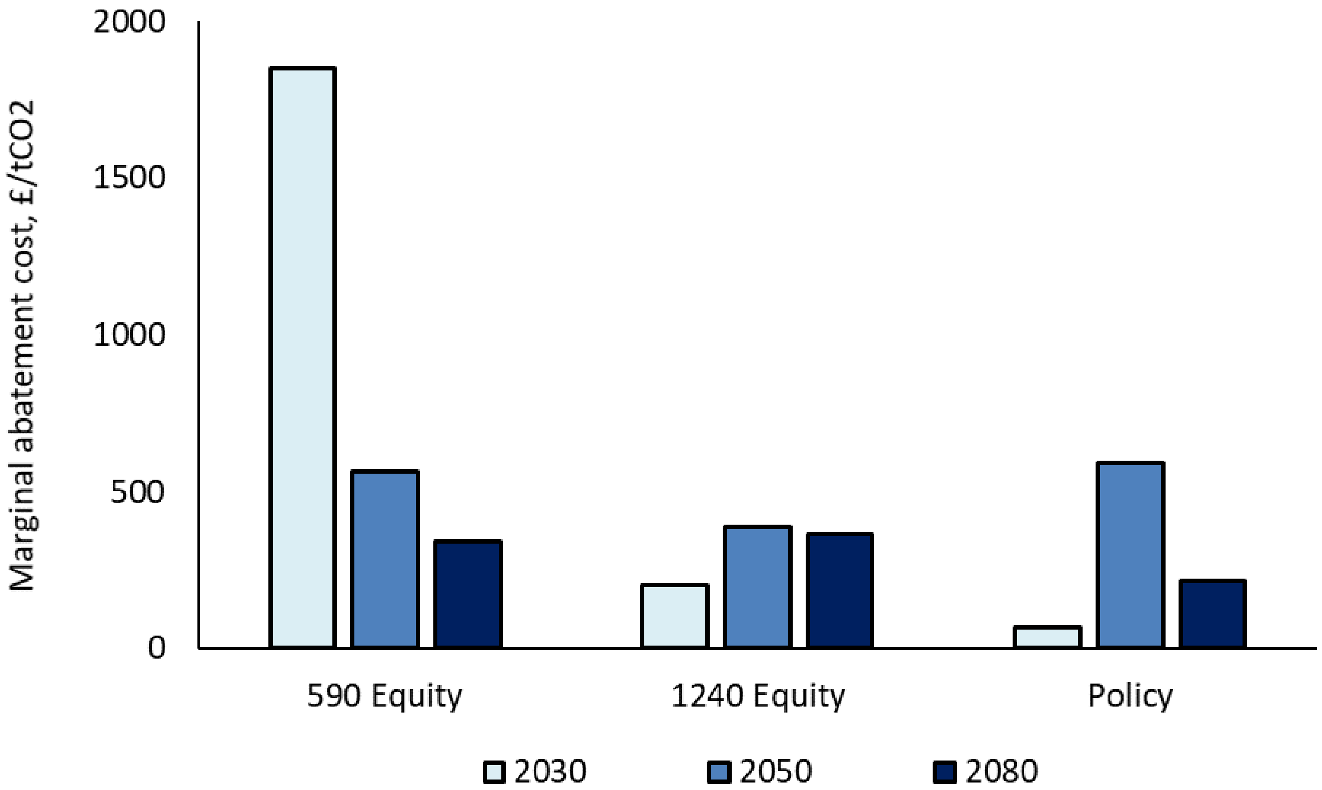
- Both Equity cases see more rapid reductions than policy case, particularly 590 Equity
- Floor level of ~500 PJ driven by international transport; resulting residual emissions drives need for BECCS deployment
- Large uncertainties related to transport demand level



Oil consumption, 2010-2100

System cost implications

- Marginal costs highlight challenge of early & rapid mitigation in 590 Equity
- Annual system costs 20-30% higher pre-2050 (50-100 bn) in 590 Equity, 2-3% in 1240 Equity
- Costs most sensitive to (in order) biomass, CCS, demand response and then nuclear



Marginal abatement costs across budget cases

Model insights

- A longer term perspective, combined with a full horizon budget-based approach, allows for a clearer understanding of eventual ambition – and implications for near term (pre-2050) action; without it, there is a danger we underestimate required action

- Any push towards an equity-based approach suggests stronger ambition, with a particular focus on near term action

- The most ambitious case (*590 Equity*) raises critical questions around how far we can push 'towards 1.5 °C' due to the time constraints, policy & social inertia and economic costs

- From technology perspective, CCS is critical, and in combination with bioenergy, to allow for negative emission technologies. Some sectors cannot be fully decarbonised (at least in this model).