Cost Projections and Investment in Electricity Generation Infrastructure in the UK: A study of cost uncertainty

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Overview

- UK Government (DECC) levelised cost (LCOE) estimates – *as they are presented* – lack context and the ability to track variation over time

- Two analyses are performed to:
  - Address the lack of context
  - Quantify uncertainty by tracking variability

- The degree of *variation* in estimation is an indicator as to the degree of *uncertainty* implicitly presented in a portfolio of estimates

- A number of observations are gleaned from the analyses:
  - Uncertainty presented as decreasing when the estimate horizon increases
  - Timing of deployment for offshore wind
  - Credibility of nuclear estimates given experience of overspends/over-runs

Recapping LCOE

- 'Levelised' costs enable the comparison of different methods of delivering a given final service, by comparing the 'lifetime' costs and revenues

- Costs incurred over the lifetime of an installation summed: CAPEX, OPEX, decommissioning etc. (GBP)

- Divided by the energy generated over the lifetime of the installation (MWh_e)

- Costs are discounted. Energy units are not. Result is: £/MWh

- All costs presented in this study are in 2012 prices, discounted at a rate of 10%, unless otherwise stated

Limitations to LCOE

- Good criticisms:
  - System costs often omitted
  - As are other 'externalities'
  - Discount rate needs to be consistent to enable comparison; the rate chosen may therefore fail to reflect technology-specific financing conditions

- Less good criticisms:
  - Unfairly penalises CAPEX-heavy technologies *(this is realistic in project financing terms)*
  - MWh today vs. MWh tomorrow? Energy undiscounted *(if energy is delivered inconsistently then valid)*

- This study **is not** a critique of the LCOE methodology employed by DECC, or elsewhere

- **It is** an assessment of the cost uncertainty presented by DECC and the implications that stem from it

Uncertainty in estimation

- DECC LCOE estimates: High and low sensitivities presented alongside central estimates

- In earlier reports just the CAPEX portion of the LCOE adjusted; in later reports a number of other variations are presented
  - *We want to assess estimate variation rather than methodological variation*

- Shortcomings of DECC presentation of uncertainty: lacking context and a measure of how estimates vary over time

- 'State of the art' in this area is probably the BofE MPC's fan charts
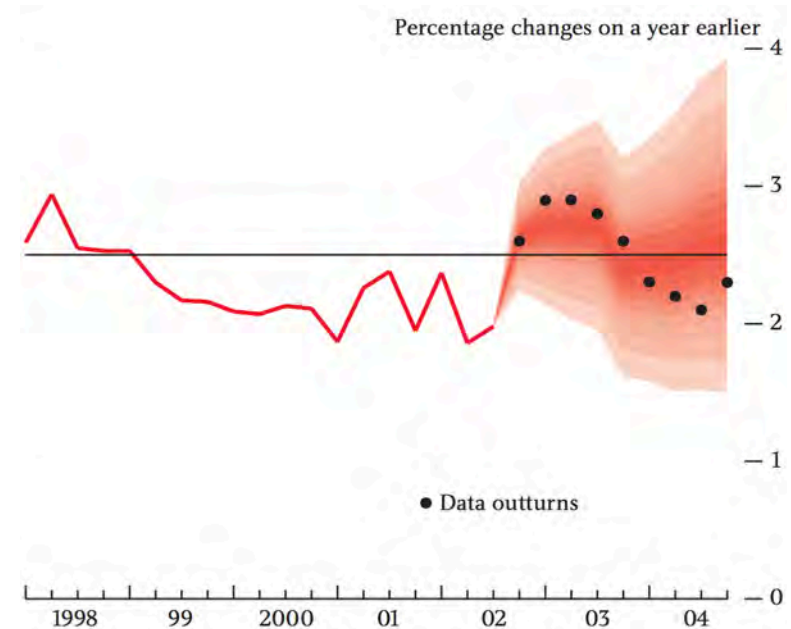
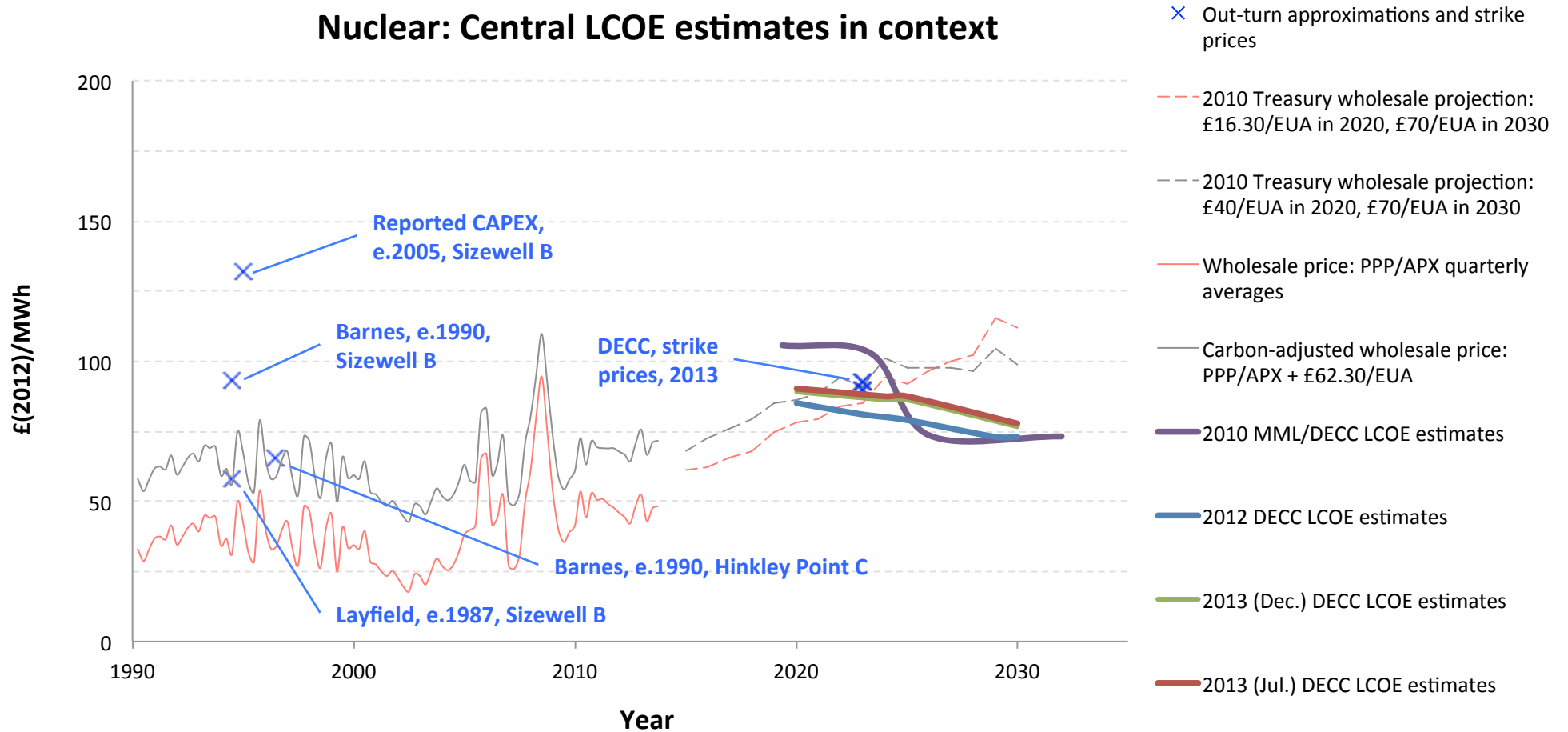BofE MPC's fan charts (Elder, R. et al., 2005)

Other relevant literature

- *UKERC – Presenting the Future: Electricity Generation Cost Estimation Methodologies* (Gross et al., 2013) Comprehensive look at cost methodologies

- *Update on the Cost of Nuclear Power* (Du & Parsons, 2009) & *Cost estimates for nuclear power in the UK* (Harris et al., 2013) Tracking nuclear costs

- *The cost of offshore wind: Understanding the past and projecting the future* (Heptonstall et al. 2012) & *Cost reductions for offshore wind power: Exploring the balance between scaling, learning and R&D* (Van der Zwaan et al. 2012) Tracking offshore wind costs

- (Jamasb, 2007), (Moselle, 2011), (Berthélemy & Escobar Rangel, 2015), (Dismukes & Upton, 2015) & (Verdollini et al. 2015) Learning and expert elicitation

Analyses

- Scope:
  - DECC LCOE estimate reports 2010-2013 (consistent methodology)
  - Nuclear, Offshore Wind (R2/R3) & Coal with CCS (ASC/IGCC) (consistent estimate data)
  - High, low and central estimates for each technology

- *First analysis*: 'Contextual cost landscapes' showing estimate trajectories alongside historic and projected wholesale cost data, and out-turn approximations

- *Second analysis*: 'Temporal estimate uncertainty' quantifying variability between various years' estimate trajectories in the decade 2020-2030

- Note: 'Trajectories' are formed from cost estimates plotted against their projected commissioning data; variable amounts of data in each
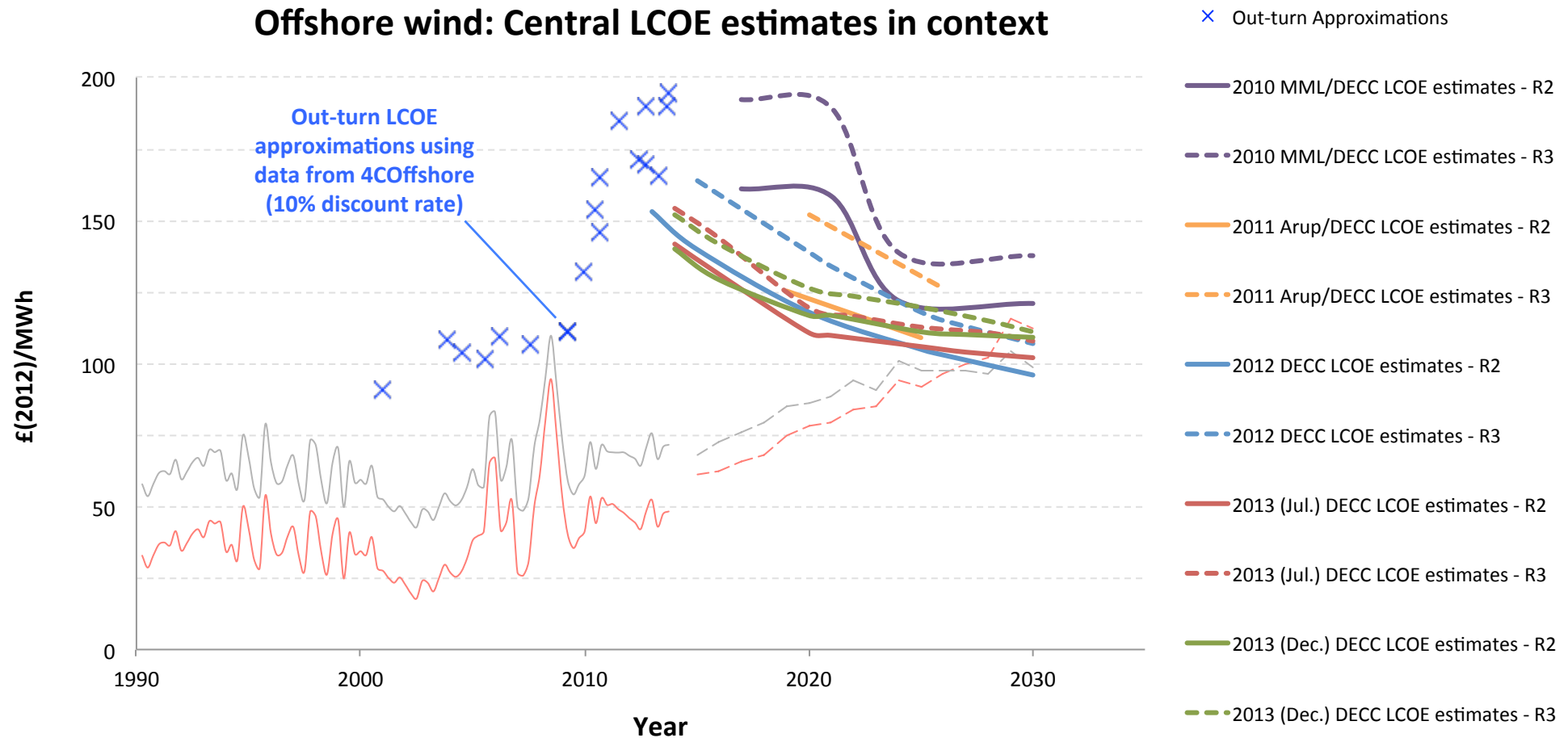
First analysis: Providing context

Nuclear: Central LCOE estimates in context

Legend:
- × Out-turn approximations and strike prices
- 2010 Treasury wholesale projection: £16.30/EUA in 2020, £70/EUA in 2030
- 2010 Treasury wholesale projection: £40/EUA in 2020, £70/EUA in 2030
- Wholesale price: PPP/APX quarterly averages
- Carbon-adjusted wholesale price: PPP/APX + £62.30/EUA
- 2010 MML/DECC LCOE estimates
- 2012 DECC LCOE estimates
- 2013 (Dec.) DECC LCOE estimates
- 2013 (Jul.) DECC LCOE estimates

Chart annotations:
- Reported CAPEX, e.2005, Sizewell B
- Barnes, e.1990, Sizewell B
- DECC, strike prices, 2013
- Barnes, e.1990, Hinkley Point C
- Layfield, e.1987, Sizewell B

Y-axis: £(2012)/MWh
X-axis: Year

First analysis: Providing context

Offshore wind: Central LCOE estimates in context

× Out-turn Approximations

— 2010 MML/DECC LCOE estimates - R2

--- 2010 MML/DECC LCOE estimates - R3

— 2011 Arup/DECC LCOE estimates - R2

--- 2011 Arup/DECC LCOE estimates - R3

— 2012 DECC LCOE estimates - R2

--- 2012 DECC LCOE estimates - R3

— 2013 (Jul.) DECC LCOE estimates - R2

--- 2013 (Jul.) DECC LCOE estimates - R3

— 2013 (Dec.) DECC LCOE estimates - R2

--- 2013 (Dec.) DECC LCOE estimates - R3

Out-turn LCOE approximations using data from 4COffshore (10% discount rate)

£(2012)/MWh

Year

First analysis: Providing context

Coal with CCS: Central LCOE estimates in context

2013 CRTF LCOE estimates; Post comb. & IGCC

Legend:
- 2010 MML/DECC LCOE estimates - ASC
- 2010 MML/DECC LCOE estimates - IGCC
- 2012 DECC LCOE estimates - ASC
- 2012 DECC LCOE estimates - IGCC
- 2013 (Dec.) DECC LCOE estimates - ASC
- 2013 (Dec.) DECC LCOE estimates - IGCC
- 2013 (Jul.) DECC LCOE estimates - ASC
- 2013 (Jul.) DECC LCOE estimates - IGCC
- × 2013 CRTF LCOE estimates - Post Comb.
- × 2013 CRTF LCOE estimates - IGCC

Y-axis: £(2012)/MWh
X-axis: Year
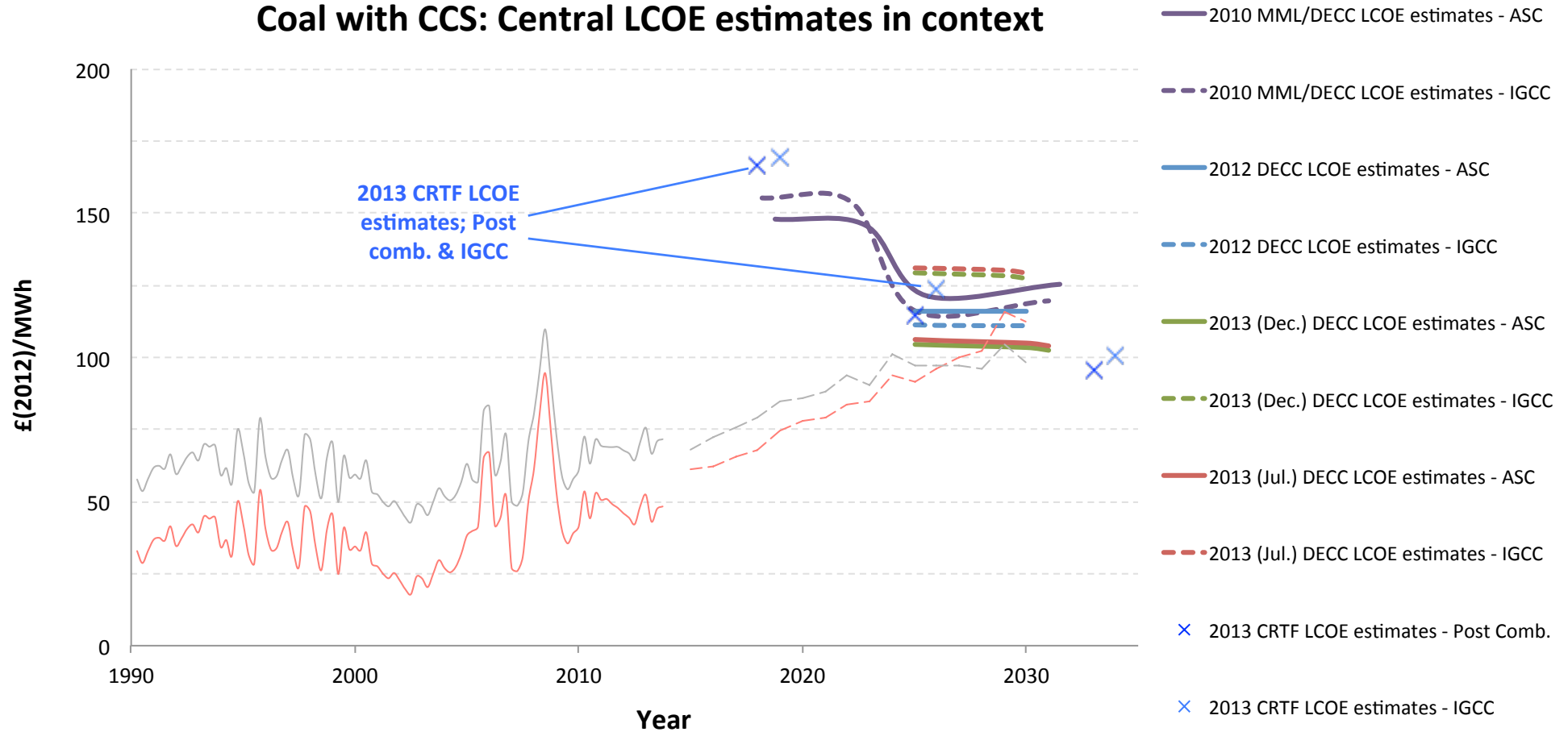
Second analysis: Quantifying uncertainty

Brief explanation of method...

- Enclosed boundary formed around the four years' estimate trajectories (red, blue, grey-dashed lines)

- Simple integral to calculate area enclosed (shaded in yellow)

- Result divided by the time period 2020-2030 (in hours) to normalise and produce '£/MWh'

- Example shown for R3 offshore wind on RHS: Same process for central, high and low trajectories for each technology

**Nuclear: Low, central and high estimates 2010-13**

Legend:
- Temporal estimate uncertainty
- Upper bound function
- Lower bound function

Low estimates	= £19/MWh
Central estimates	= £26/MWh
High estimates	= £33/MWh

Results for nuclear

Low estimates: 96, 73, 71, 56
Central estimates: 118, 83, 79, 63
High estimates: 133, 93, 93, 67

Y-axis: £(2012)/MWh — 0, 25, 50, 75, 100, 125, 150, 175, 200

X-axis: 2020, 2030 (repeated)

Year (fixed 10-year analysis period)
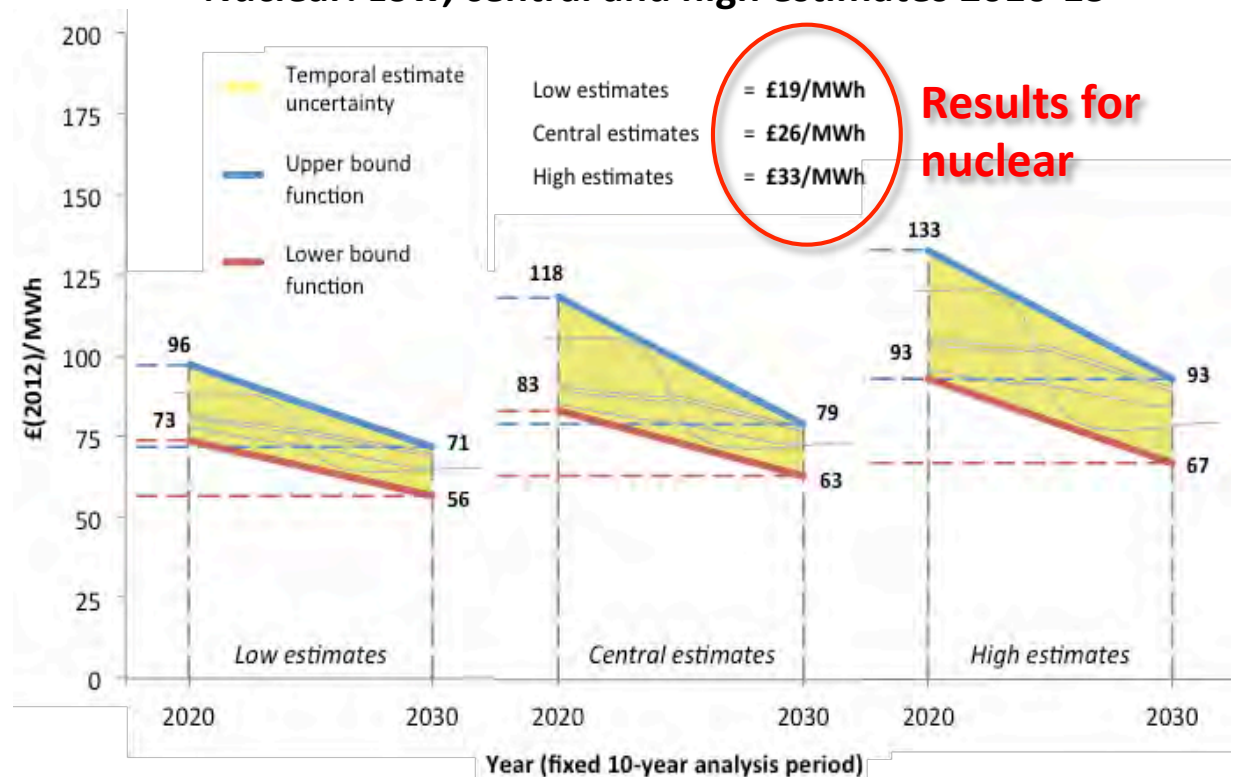
Second analysis: Quantifying uncertainty

Uncertainty results: All technologies; low, central and high estimates
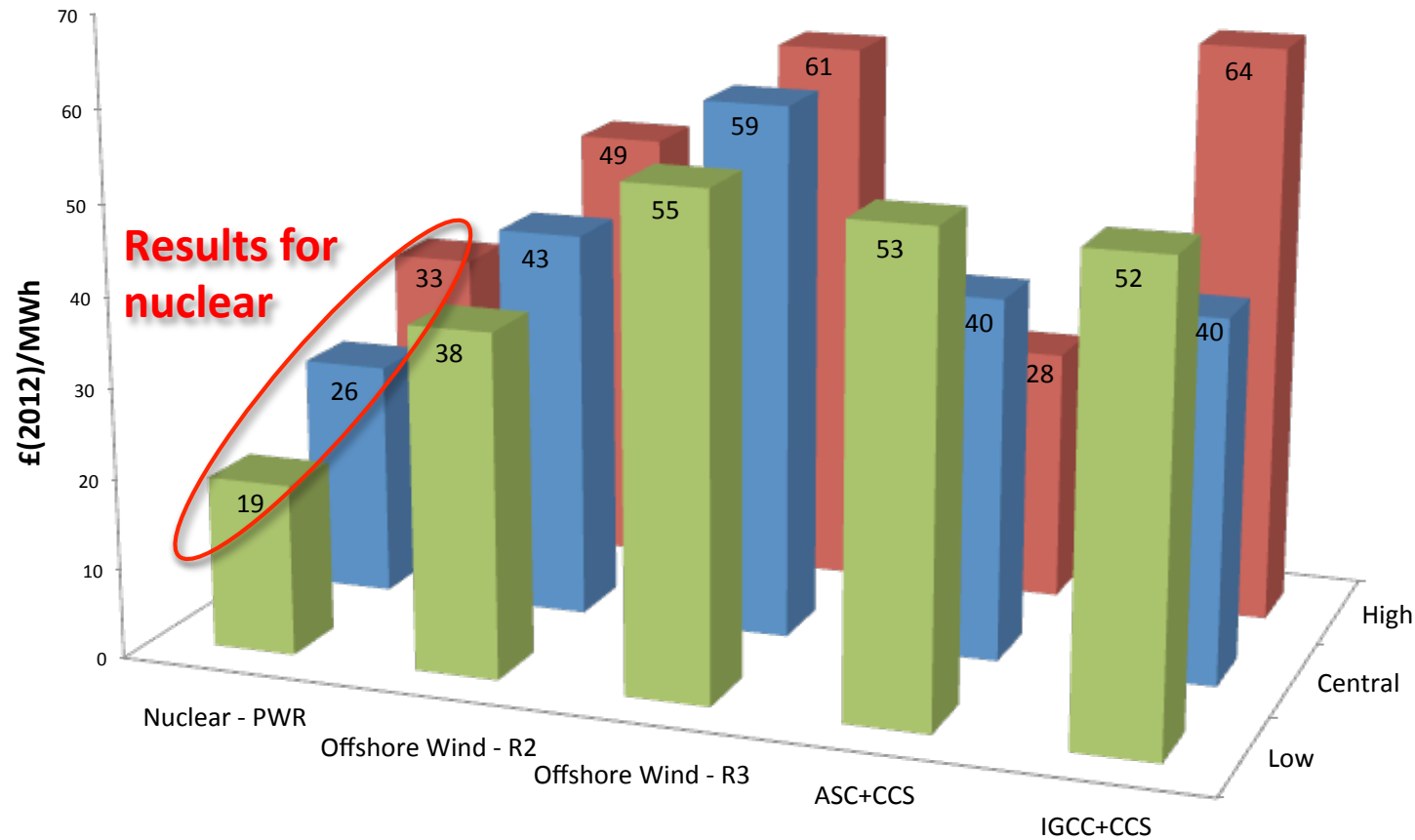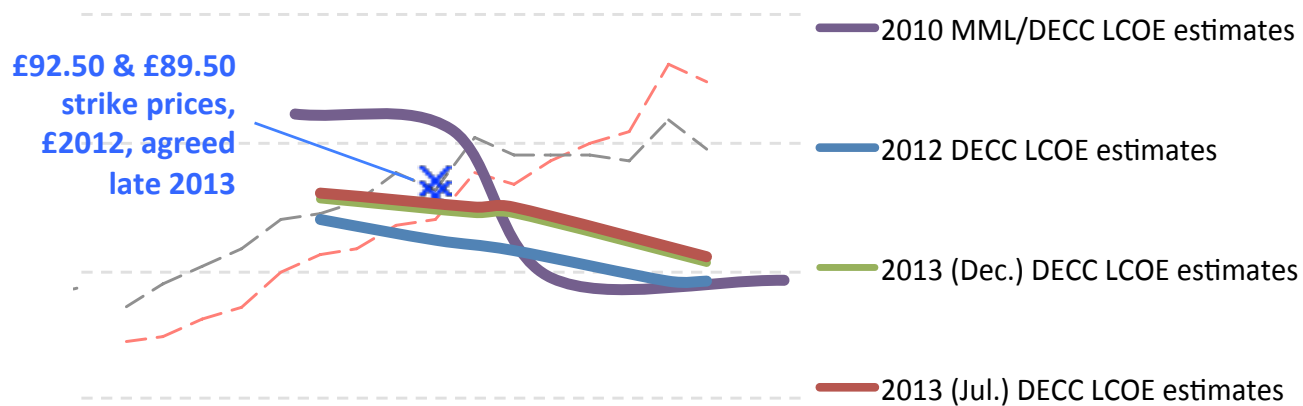
Observations: General

- Shaded area enclosing estimate trajectories in almost all cases taller on LHS (A) than RHS (B)

- Decreasing uncertainty with increasing estimate horizon: Unintuitive/unrealistic

- In other words, estimates for further flung commissioning dates have greater levels of consistency – lower uncertainty

- *Why?* Perhaps little information on which to base adjustments to a relatively poorly informed quantity – strange presentation nonetheless
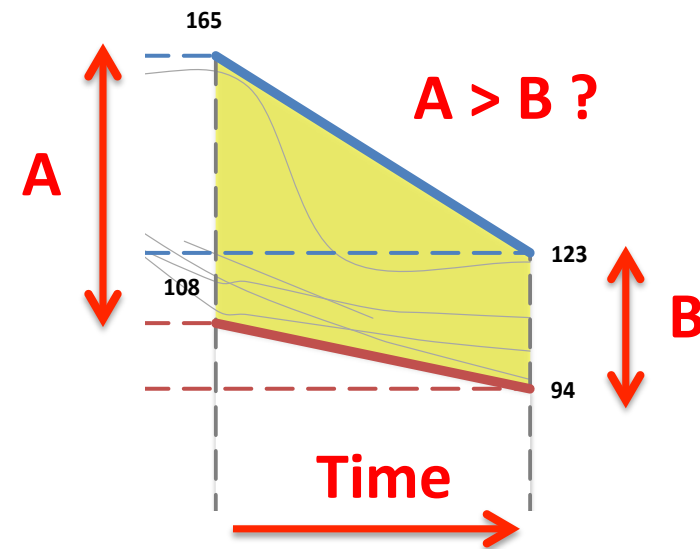
Offshore wind (R2) central estimates uncertainty analysis (excerpt)
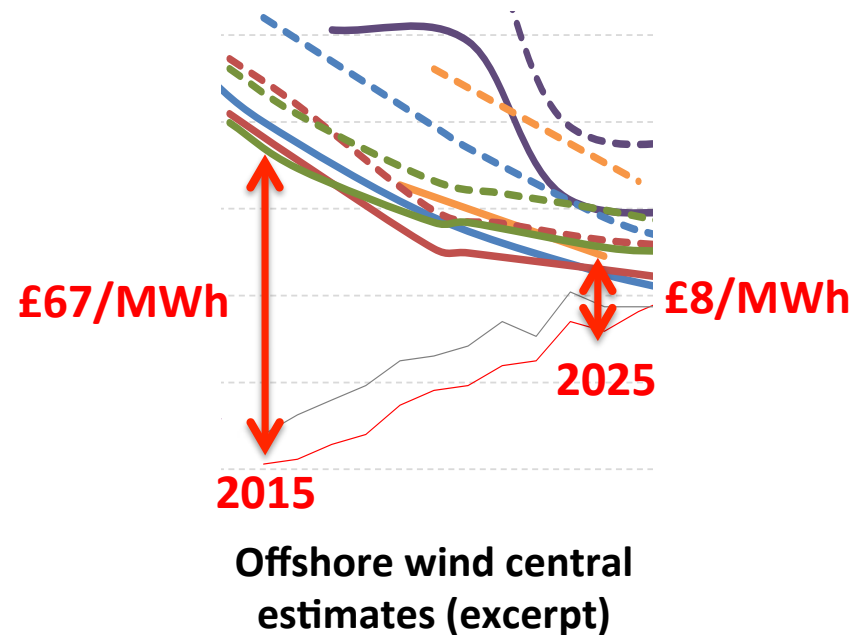
Observations: Nuclear

- Cheapest and lowest uncertainty measure results of the three: From DECC's presentation seemingly the best bet for new large supply

- LCOE is highly sensitive to CAPEX. Given experience of overspends (Harris et al. 2013); are the narrow uncertainty bounds justified?

- Chronology of estimates tracks very consistently with strike price agreements

£92.50 & £89.50 strike prices, £2012, agreed late 2013

2010 MML/DECC LCOE estimates

2012 DECC LCOE estimates

2013 (Dec.) DECC LCOE estimates

2013 (Jul.) DECC LCOE estimates

Nuclear central estimates (excerpt)

Observations: Offshore wind (R2/R3)

- Significant cost premiums over wholesale and considerable variation in estimation: Bleak picture of costs presented in portfolio of estimates

- Difference in premium above wholesale 2015/2025 = £59/MWh (for conservative R2!): £2.07bn/GW extra (assuming 40% LF) installed at 2015 as opposed to 2025 LCOE prices

- The cost of hastened deployment is considerable: Apply the above premium to the 'Gone Green' scenario of National Grid's projections (21GW added by 2025) and the cost of waiting is roughly £43.4bn

£67/MWh

£8/MWh

2025

2015

Offshore wind central estimates (excerpt)

Observations: Coal with CCS (ASC/IGCC)

- High variability in estimation fits with conceptual stage of technology development – an *unknown-unknown* characterisation

- Can coal with CCS compete with nuclear for base-load capacity in the short/medium term? Looks unlikely based on results

- But it remains a promising option for the long term, given coal remains the most abundant fossil fuel (BP, 2013), much of which must be *left in the ground* if only unabated technologies are available

- It is being appropriately funded as an R&D demonstration (White Rose, Drax etc.) but perhaps not appropriately presented – alongside proven technologies in LCOE estimates
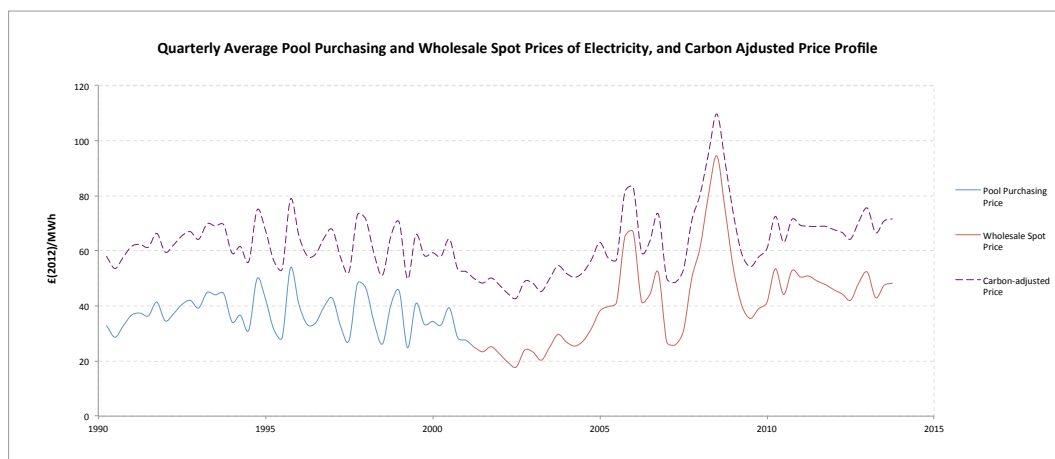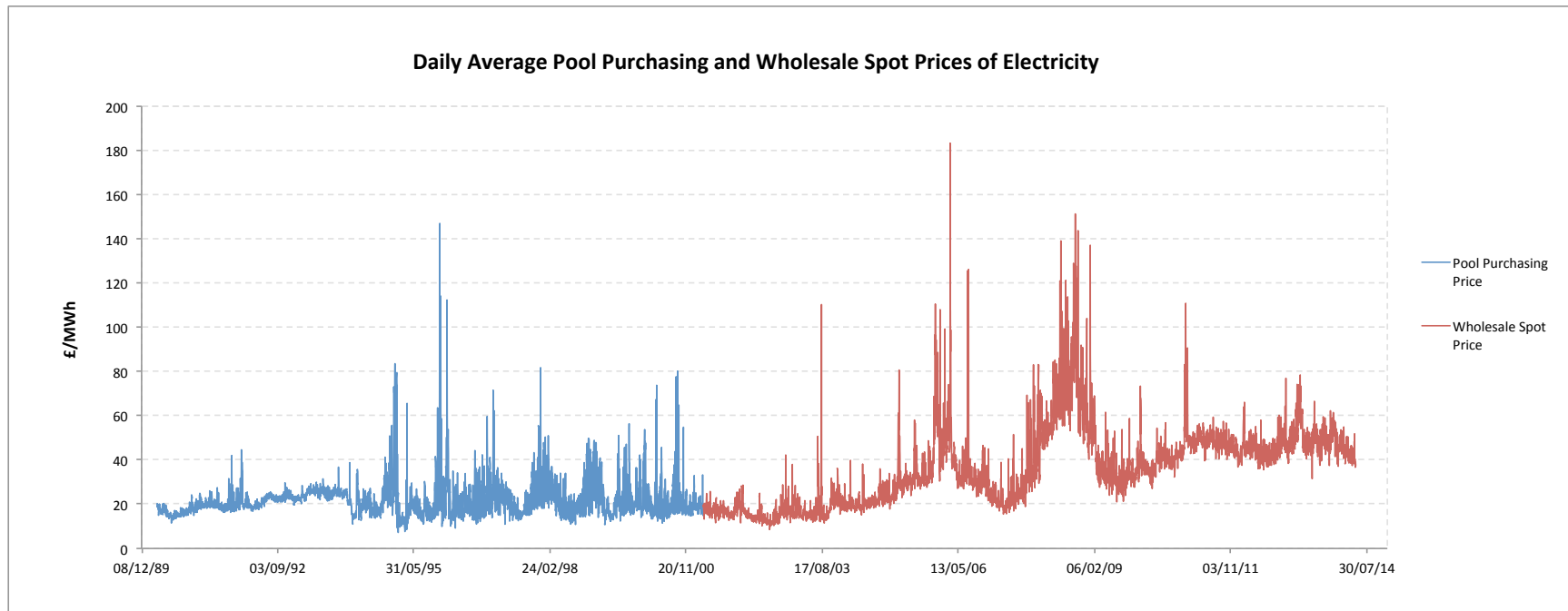
To conclude

- A richer picture of uncertainty can be gleaned if current estimation is tracked against what has been estimated previously

- A number of irregularities highlighted that are not readily exposed in the current temporally isolated approach to presenting uncertainty

- A number of ways this analysis could be improved; more estimate data generated (original model would need to be made available)

- Ideally the presentation of uncertainty in LCOE would move towards the *gold standard* set by the BofE MPC – *perhaps naïvely ambitious!*

Works cited

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Historic wholesale cost (PPP/APX)

Daily Average Pool Purchasing and Wholesale Spot Prices of Electricity

Quarterly Average Pool Purchasing and Wholesale Spot Prices of Electricity, and Carbon Ajdusted Price Profile

HM Treasury CPF Report Projections

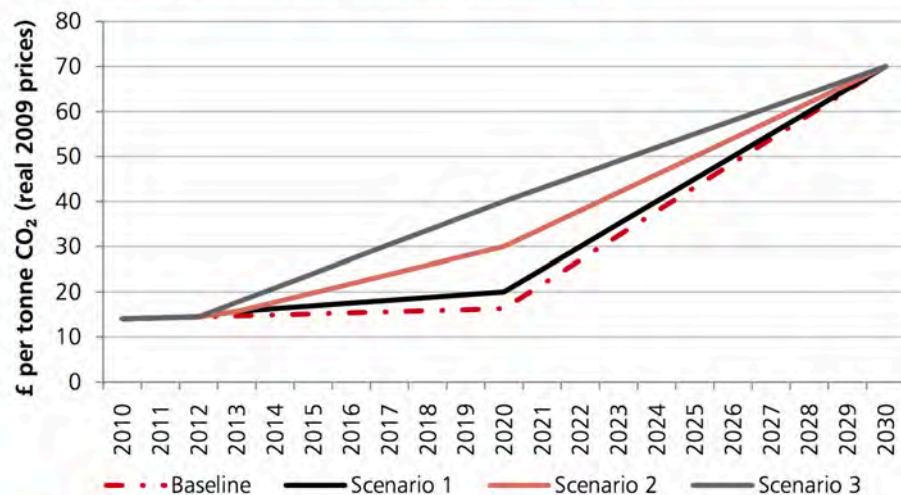Chart 5.A: Indicative carbon price support scenarios and baseline

Chart 5.E: Time weighted baseload electricity prices (£/MWh, real 2009 prices)