Imperial Centre for Energy Policy and Technology

UK Energy Research Centre

Researching pathways to a low carbon future

Presenting the Future

An assessment of future costs estimation methodologies in the electricity generation sector

Dr Robert Gross, Imperial College and UKERC

What UKERC does….

The UK Energy Research Centre is the focal point for UK research on sustainable energy. It takes an independent, whole-systems approach, drawing on engineering, economics and the physical, environmental and social sciences……

…..the Centre's role is to promote cohesion within the overall UK energy research effort. It acts as a bridge between the UK energy research community and the wider world, including business, policymakers and the international energy research community and is the centrepiece of the Research Councils Energy Programme

UKERC

UKERC Technology and Policy Assessment

- A core function of the UKERC since 2004
- Provide independent, policy-relevant assessments addressing key issues and controversies in energy
- Develop accessible, credible and authoritative reports relevant to policymakers, other stakeholders and wider public debate
- Approach based on a systematic search and appraisal of the evidence base, synthesis, and expert and peer review

UKERC

TPA reports


Investment in electricit
the role of costs, in
Global Oil Depletion
An assessment of the evidence for a near-term peak in global oil production
What policies are effective at
lucing carbon emissions from
surface passenger transport?
A review of interventions to encourage
behavioural and technological change
UKERC
UK Energy Research Centre
A handbook by the Technology and Policy Assessment theme of the UK Energy Research Centre
Energy Materials Availability Handbook
UKERC
The Costs and Impac
of Intermittency:
An assessment of the evidence on the
intermittent generation on the Britis
Energy from biomass:
the size of the global resource
An assessment of the evidence that biomass can make a major contribution to future global energy supply
November 2011
UKERC
UK Energy Research Centre
Great Expectations:
UKERC
The Rebound Effect:
an assessment of the evidence for economy-wide energy savings from improved energy efficiency
October 2007
UKERC

'Presenting the future'
Preliminary questions from scoping note

- How do past estimates and expectations of future costs compare with experience to date?
- Do methodologies differ in terms of their forecasting accuracy?
- Have methodological approaches changed?
- How robust are future costs estimation methodologies?
- How susceptible are the different approaches to exogenous factors?
- What are the strengths and weaknesses of the methodologies?

UKERC

Why estimates matter

- Key input to policy:
  - Successive Energy White Papers
  - Stern Review
  - CCC Renewable Energy Review
  - Energy system models such as MARKAL/TIMES
- Help identify which technologies merit support (and how much)
- Policy can also bear upon costs, which bear upon policy…

UKERC

Approach

- Systematic review of the literature on cost estimation and forecasting methodologies
- Six technology case studies:
  - Nuclear
  - Combined Cycle Gas Turbine (CCGT)
  - Coal and Gas-fired Carbon Capture & Storage (CCS)
  - Solar Photovoltaics (PV)
  - Onshore Wind
  - Offshore Wind

  Available at:
  http://www.ukerc.ac.uk/support/tiki-index.php?page_ref_id=2863
- Synthesis and conclusions

UKERC

Forecasting future costs:
Methods and approaches

- Experience curves – some headlines
  - An evolving literature and discourse….
  - Grounded in empirical observations that learning and cost reductions do happen
  - Can help identify the level of investment and deployment required to drive down costs but…
  - Are susceptible to uncertainties over selection of the correct starting point, learning and deployment rates
  - Concern over the use of proxy values from similar technologies
  - May be more applicable to some technology characteristics than others (modular vs. large-scale)
  - Can be overwhelmed by other factors

UKERC

Experience curve key issues – more detail on issues and problems

- Cost floors and discontinuities
- Deployment assumptions
- Costs, prices, currency and inflation
- System boundaries
- Compound systems
- Modular vs large scale
- Time horizons and 'technology forgetting'
- Other sources of cost reduction –
  - learning by researching, spillovers, autonomous change/time, policy
- Single vs multifactor learning

UKERC

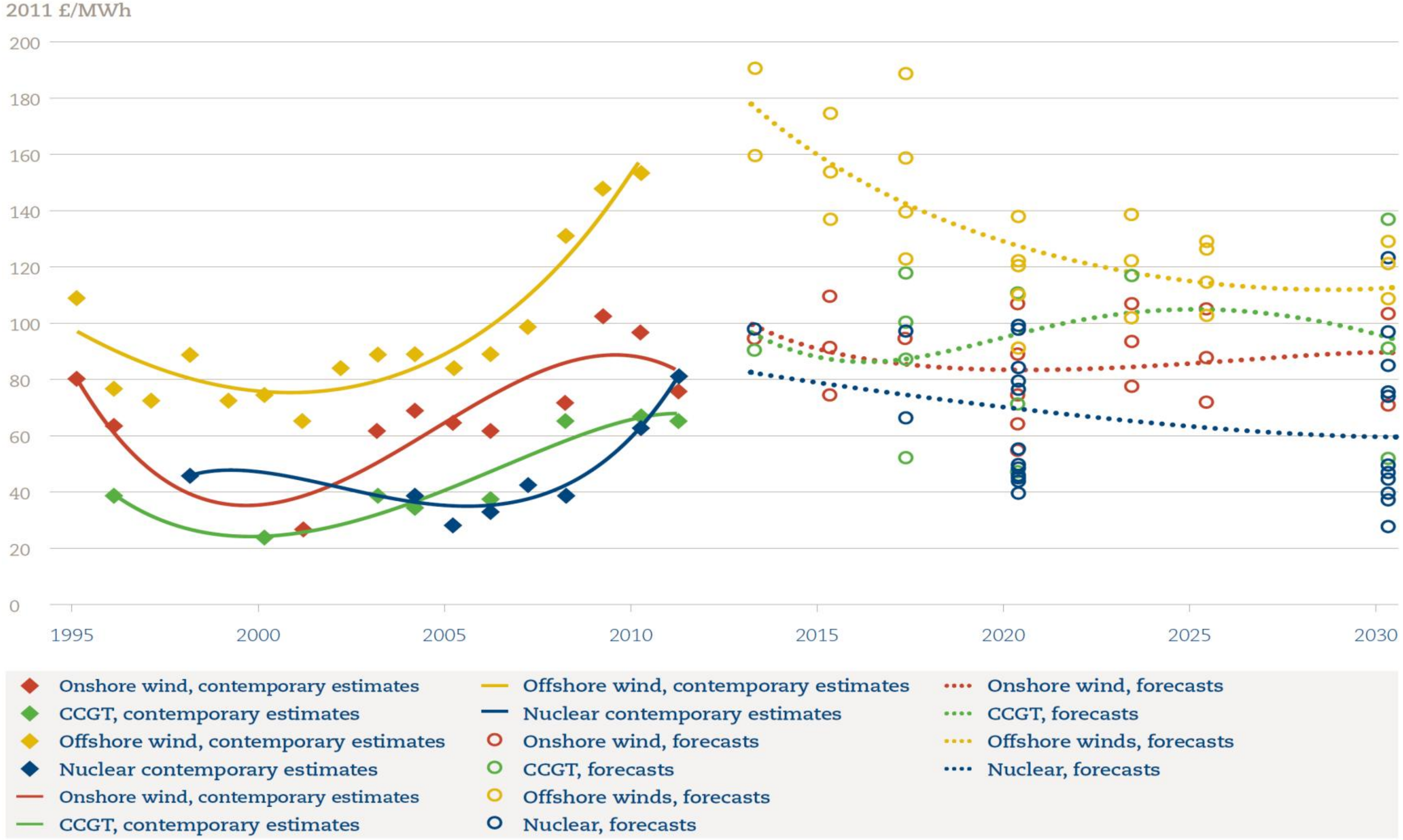
Forecasting future costs: methods and approaches

- Engineering assessment (and expert elicitation, stakeholder workshops, etc.):
  - Can inform detailed parametric models
  - Don't need to rely on previous trends
  - Can allow for discontinuities, but…
  - Expert opinions can differ
  - May suffer manipulation / excessive optimism
  - Still difficult to get right for emerging technologies

UKERC

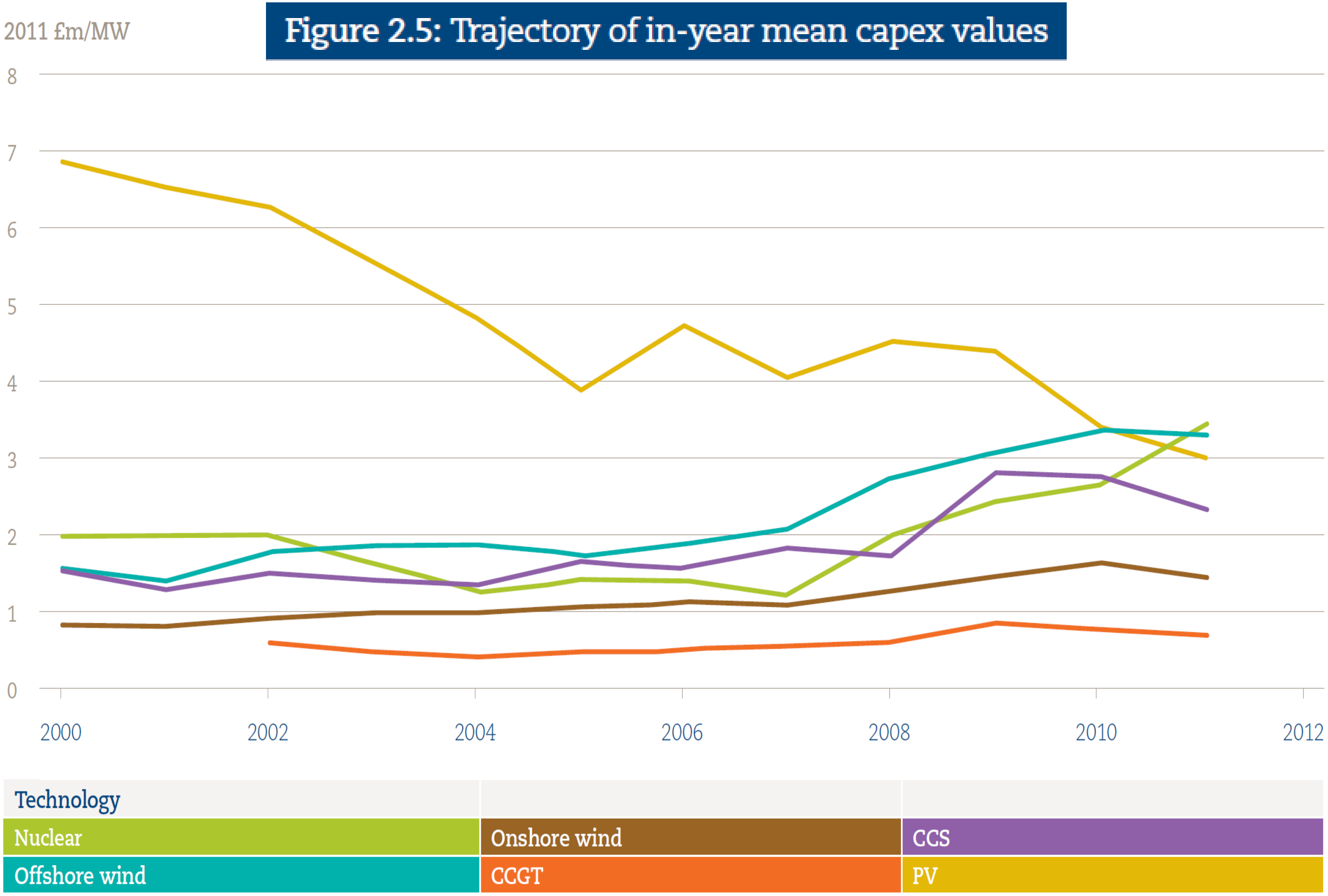
Cost trajectories – LCOE

Figure 2.4: Range of LCOE estimates, in-year mean and UK-specific forecasts



Cost trajectories – capex

Figure 2.5: Trajectory of in-year mean capex values



The case studies

- Nuclear
- Combined Cycle Gas Turbine (CCGT)
- Coal and Gas-fired Carbon Capture & Storage (CCS)
- Onshore Wind
- Offshore Wind
- Solar Photovoltaics (PV)

UKERC

Nuclear

Figure 4.1: In-year means of nuclear forecast capex values worldwide, comparing pre and post 2005 estimates

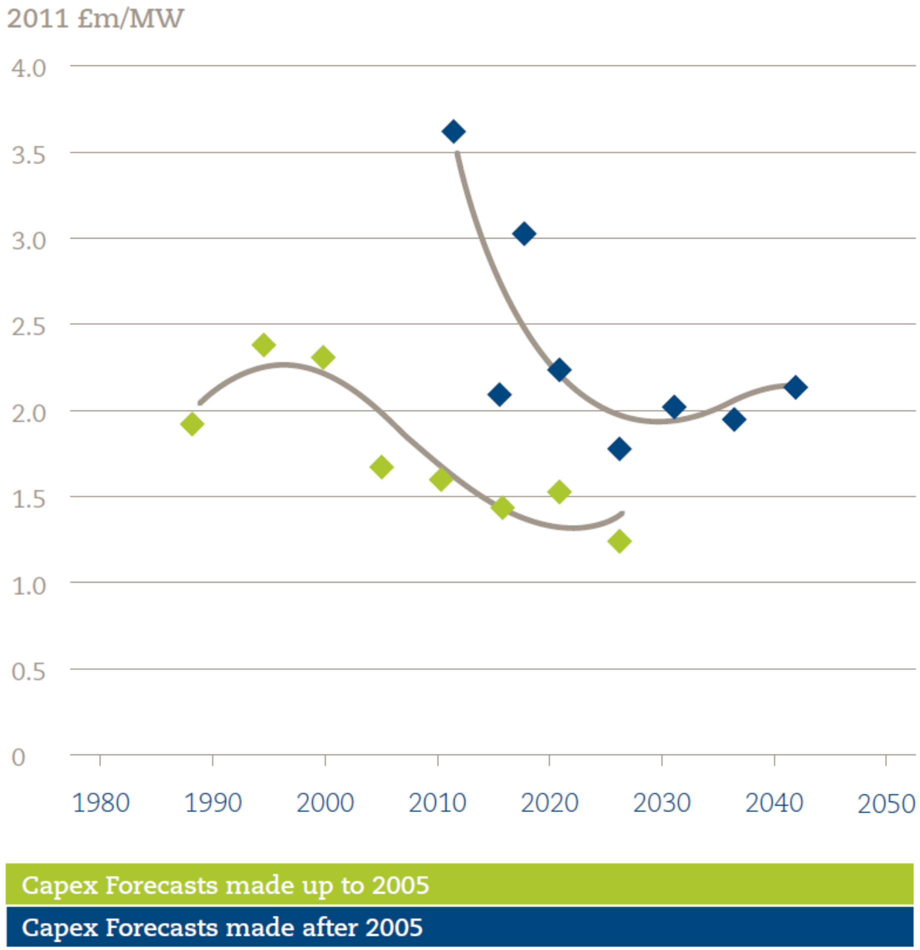
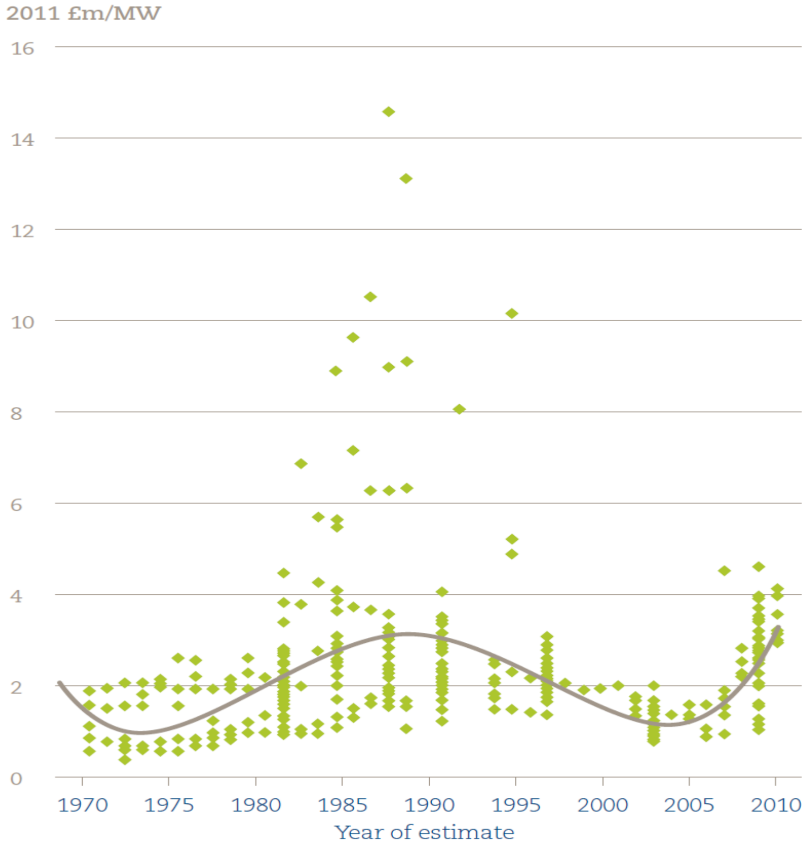


Figure 4.2: Range of estimated nuclear contemporary capital costs worldwide over last four decades



UKERC

CCGT

Figure 4.3: Range of international forecasts of LCOE for CCGT up to and post-2005

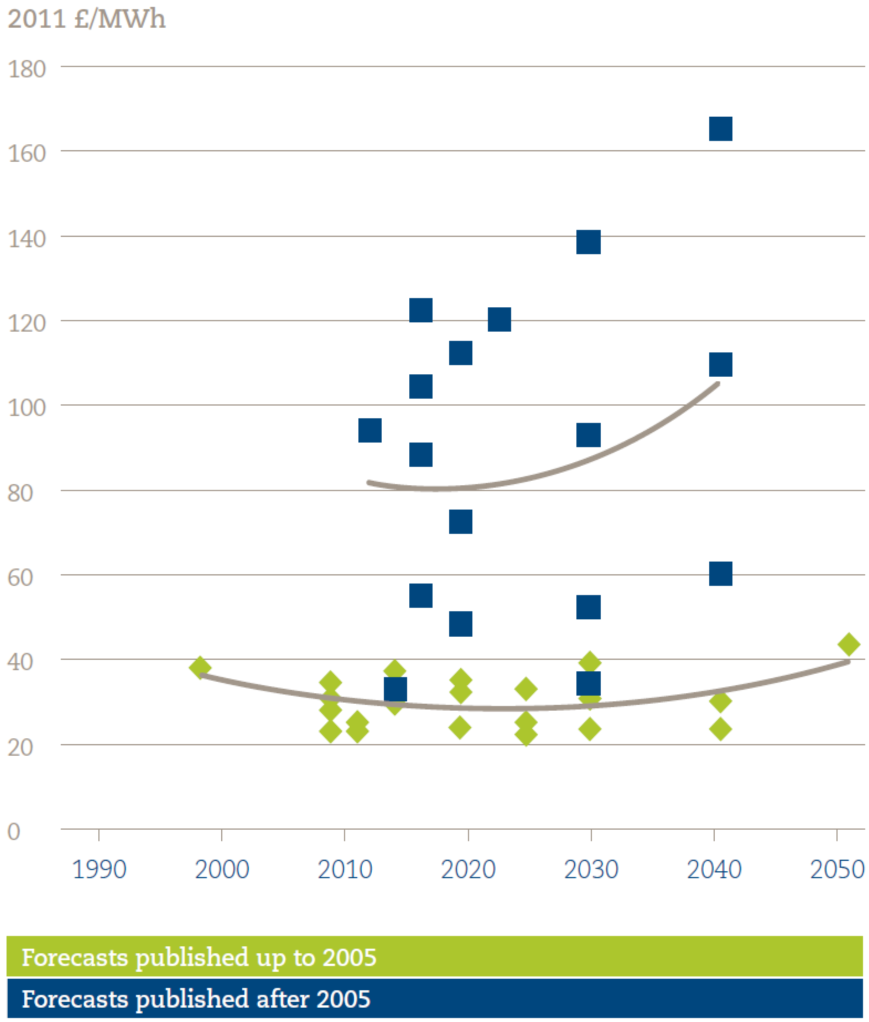
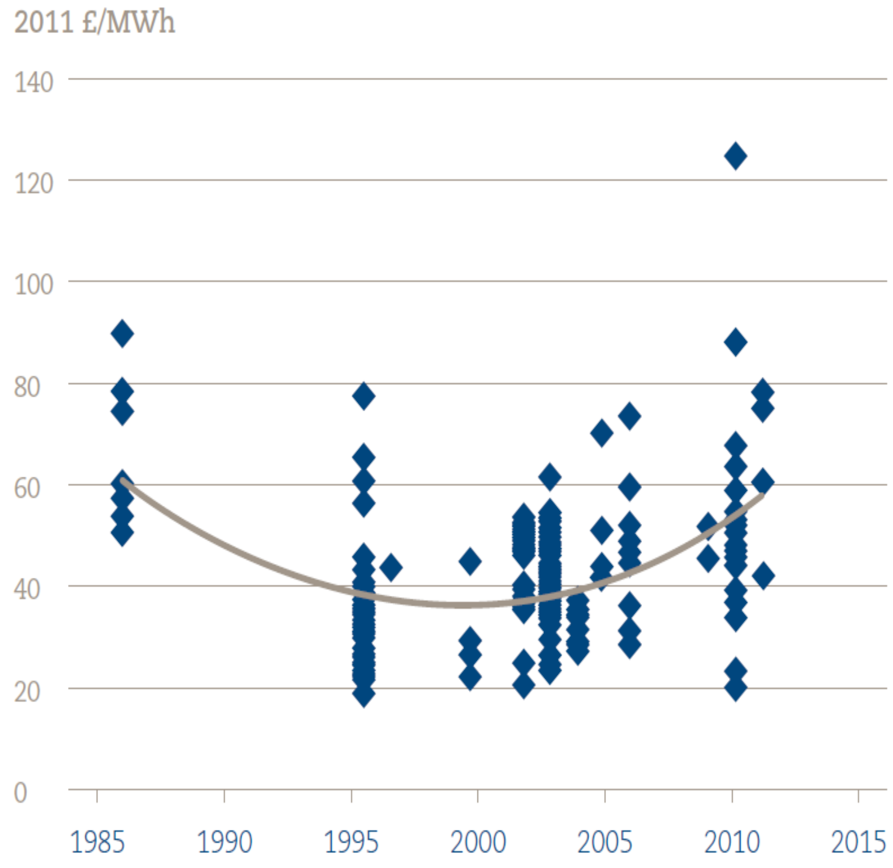


Figure 4.4: Range of worldwide out-turn estimates of LCOE for CCGT



UKERC

CCS

Figure 4.5: Range of forecast estimates of future capital costs of post-combustion gas CCS

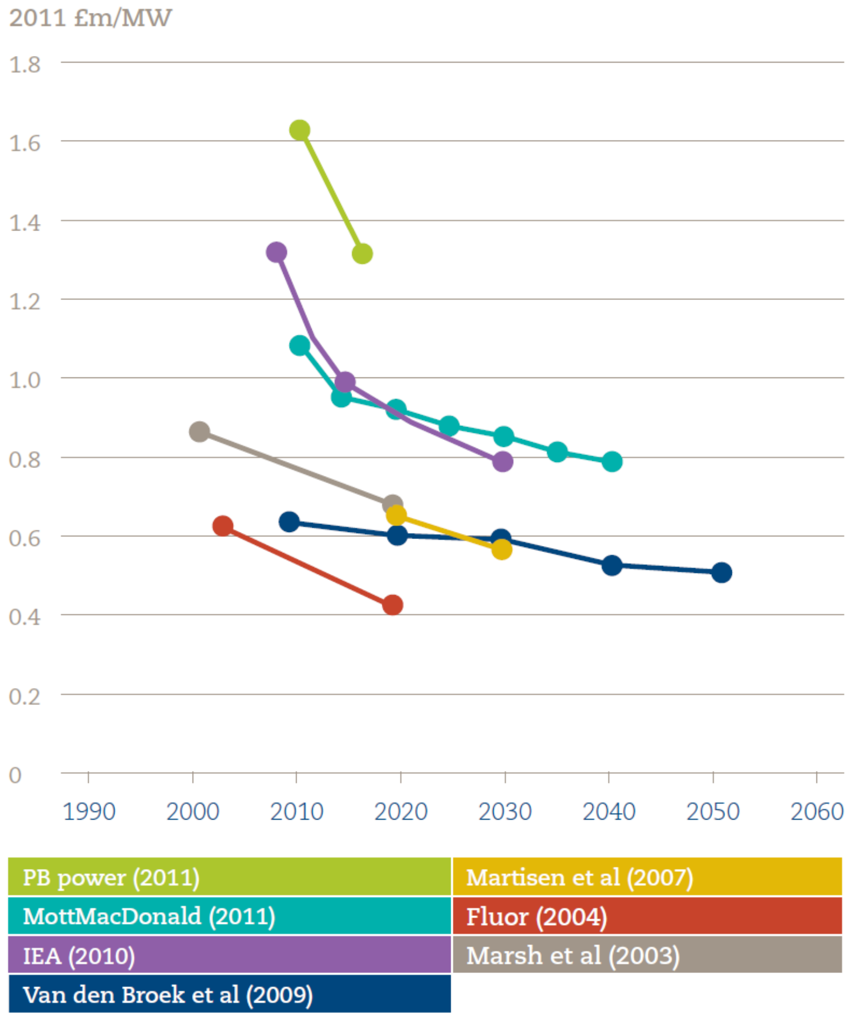
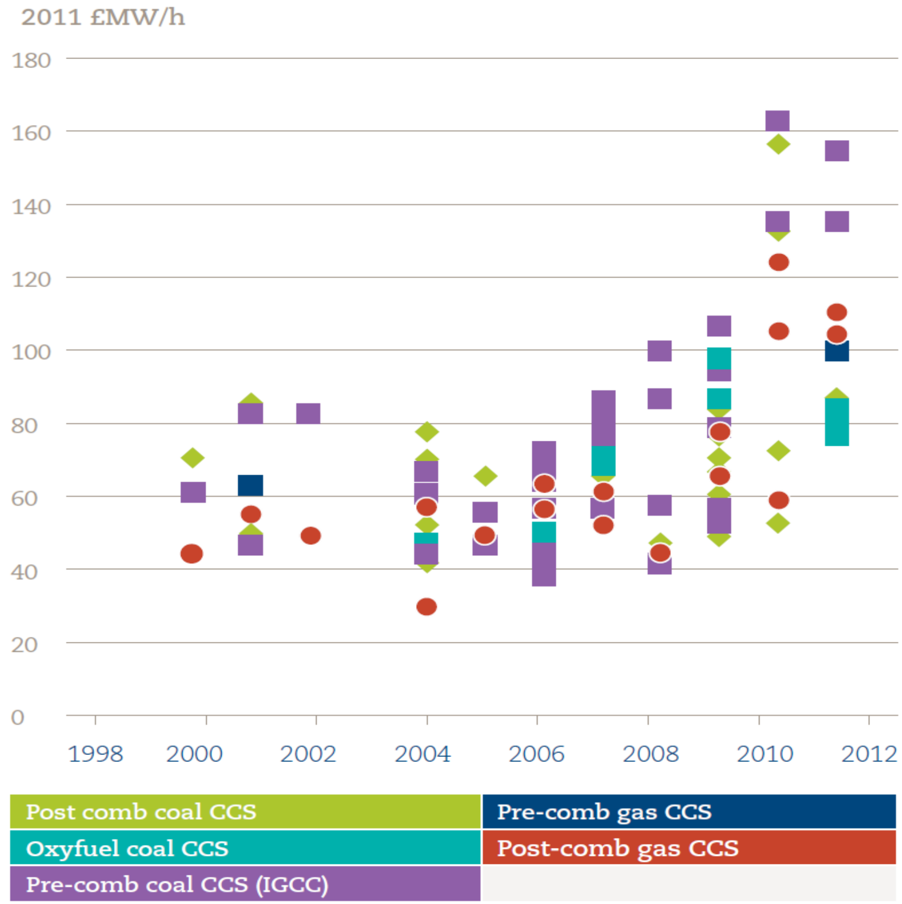


Figure 4.7: Range of contemporary levelised cost estimates of CCS since 2000



Onshore Wind

Figure 4.8: Range of levelised cost expectations for onshore wind

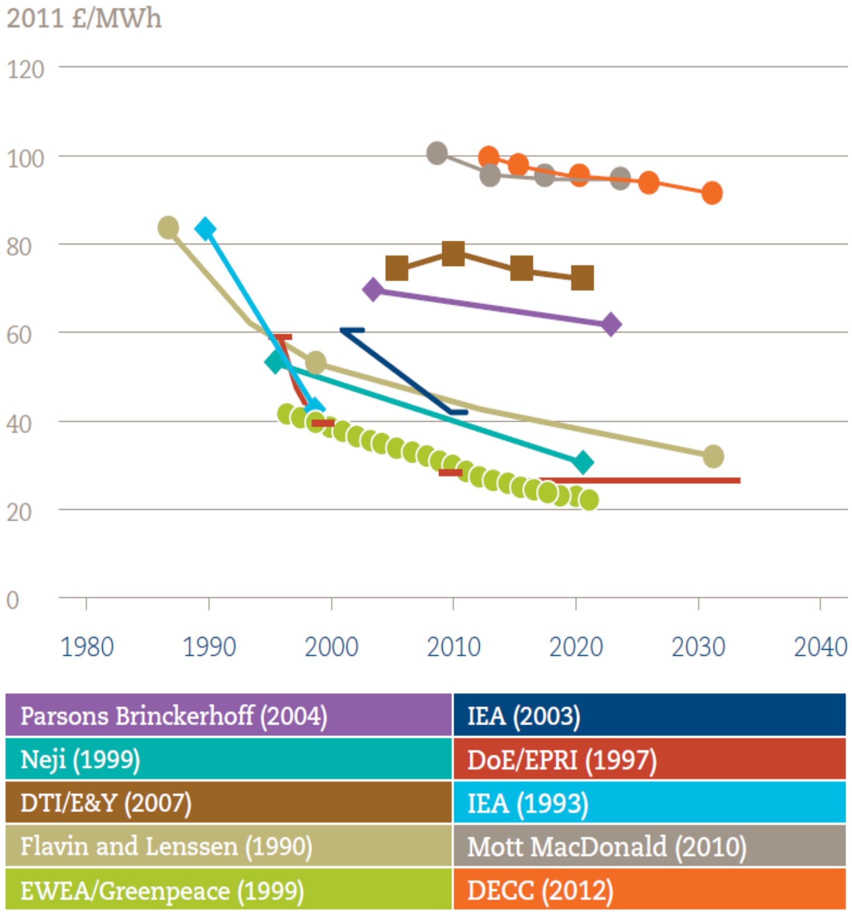
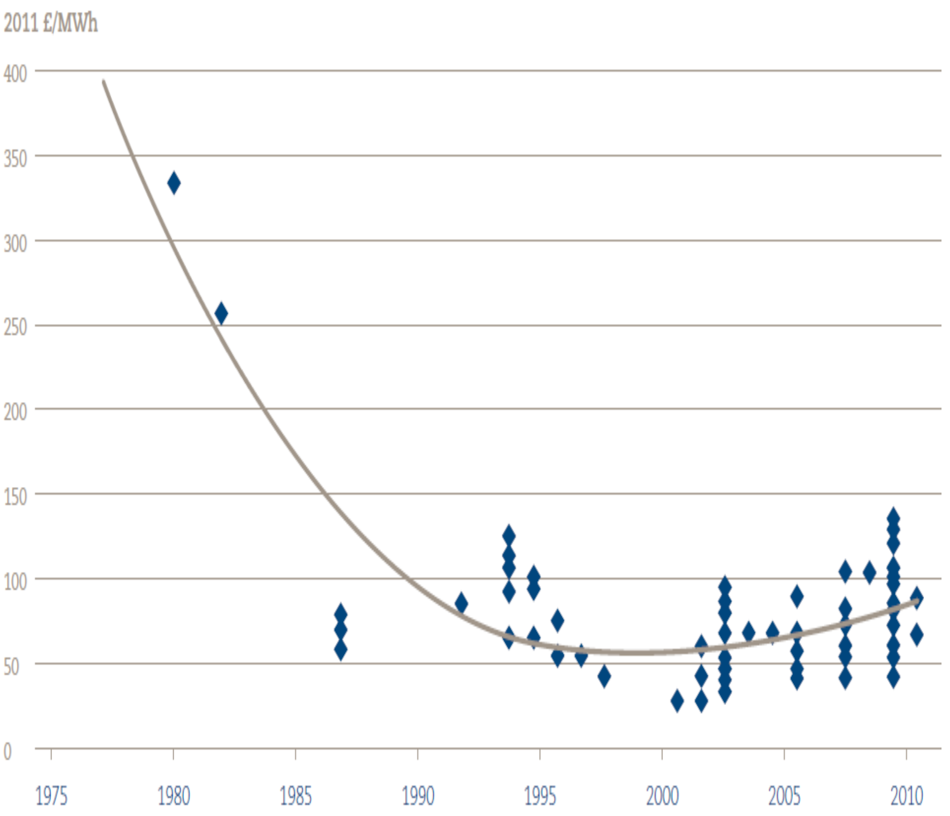


Figure 4.10: Range of levelised costs of onshore wind since 1980



UKERC

Offshore wind

Figure 4.11: In-years means of offshore wind forecast capex, comparing pre and post 2005 estimates

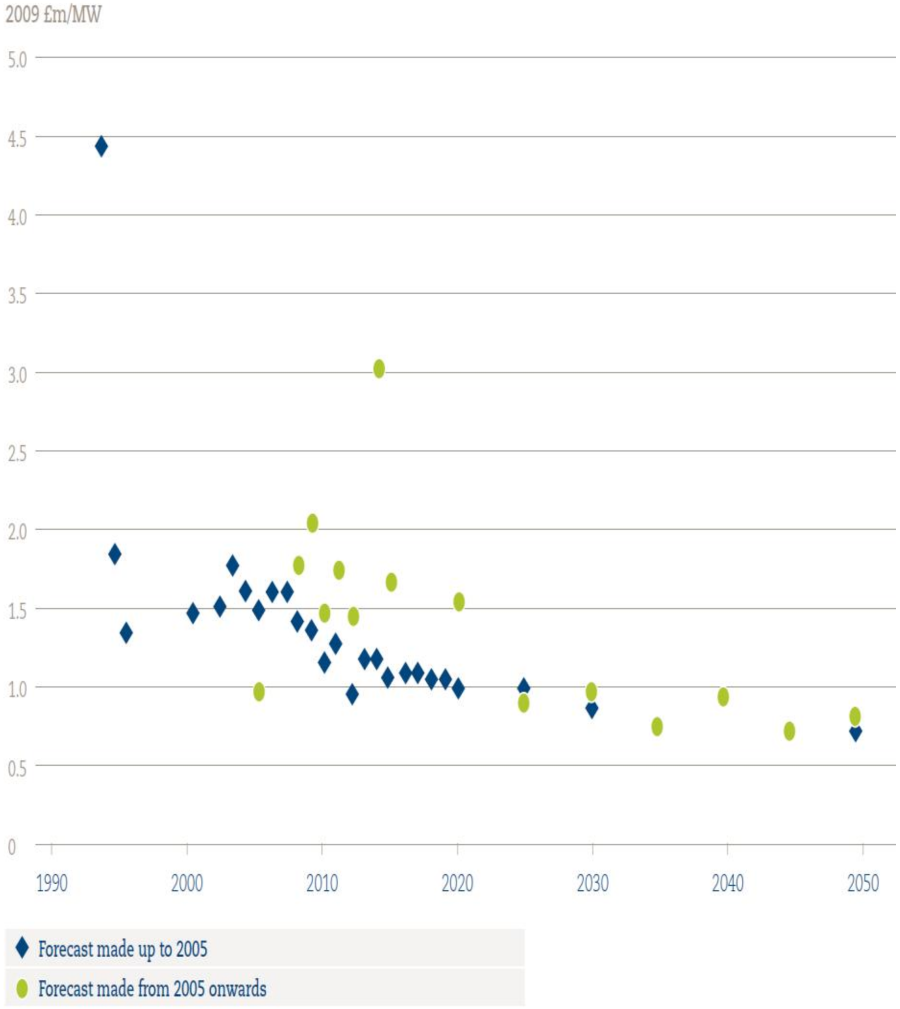
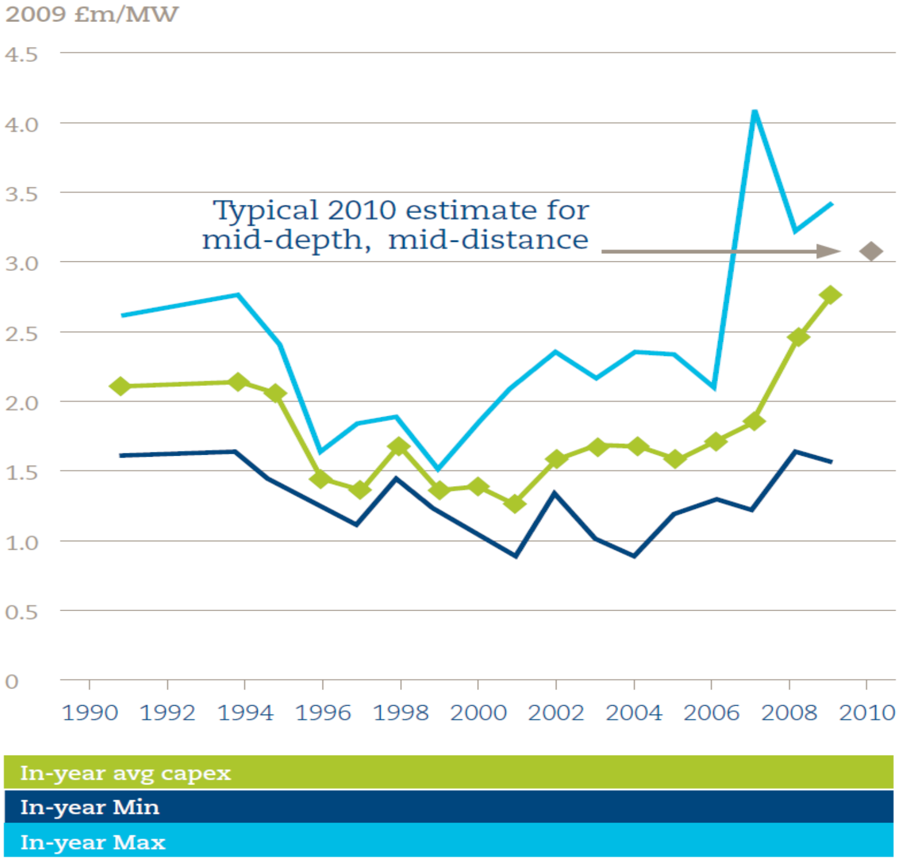


Figure 4.12: Range of offshore wind actual capex, 1990 to 2009



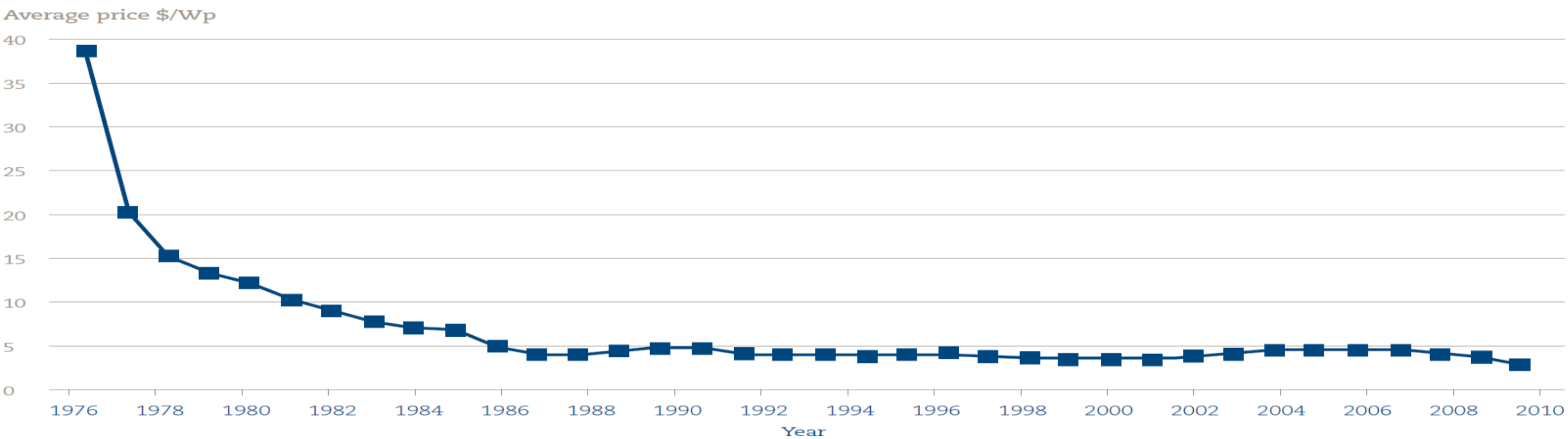
UKERC

PV

Table 4.1: Engineering assessment and experience curve projections of future PV module production costs adapted from (Schaeffer et al. 2004)

Study	Year of study	Year of projection	Engineering assessment ($/Wp)	Experience curve ($/Wp)
JBL86-31 target	1978	1986	1.63	0.86
JBL86-31 Cz	1985	1988	2.17	6.35
JBL86-31 Dentretic	1985	1992	1.02	2.80
EPRI 1986	1986	2000	1.50	0.79
MUSIC FM 1996	1996	2000	1.00	4.07

Figure 4.13: PV module price historical trend



UKERC

General observations

Past experience shows both exogenous ‘sideswipes’ and endogenous factors can override learning effects & economies of scale etc

- Example exogenous factors:
  - Commodity prices increases e.g. steel, copper, silicon
  - Fuel price increases e.g. coal and gas
  - Cost of finance
  - Unfavourable currency movements

- Example endogenous factors:
  - Increased safety, or environmental, requirement e.g. nuclear, or coal FGD
  - Lack of competition re components e.g. OSW turbine market
  - Supply chain constraints e.g. components and support/installation services
  - Greater depth and distance e.g. UK OSW
  - Increased O&M
  - Disappointing reliability = reduced availability = poor load factors

- Experience curve uncertainties & appraisal optimism
- Can be overwhelmed by other factors and exogenous shocks
- Need for reliable and disaggregated data and sufficient volumes and time
- Acknowledge the uncertainties explicitly
- Recognise that it is an inherently stochastic process

UKERC

Conclusions

- Clear empirical evidence that the cost of electricity generation can fall through time and as deployment rises – learning happens. But
  - learning is not inevitable and quality of projection a product of data, assumptions, judgement, etc…
  - learning can be overwhelmed by other factors – temptation to focus on potential for cost reductions risks ignoring prosaic issues such as supply chain constraints
  - Initial roll-out of a technology may result in short-term bottlenecks, 'teething trouble' and other issues –short term costs may rise before they can fall
- Some of the uncertainties revealed by the case studies are exogenous, inherently unpredictable and may exhibit high volatility – what to do about these?
- Some of the endogenous cost drivers are more 'known' and lend themselves more readily to future projection – but this is not always well done
- One size does not fill all – technology specifics are paramount to cost reduction prospects. Small, mass produced and modular = 'better' at learning?
- Communication of uncertainty is key. There is a trend towards improved 'appraisal realism' in recent analyses

UKERC

Final thoughts

- We should not be surprised when (not if) our forecasts are wrong
- Whilst cost reductions from learning can and do happen they can still be overwhelmed by other factors
- Understandable temptation to focus on potential for cost reductions risks ignoring more prosaic issues such as supply chain constraints and regulatory regimes
- Some recognition that costs can rise in the early stages of a technology, but this rarely shows up in the headline numbers
- Fundamental tension between inherent uncertainties and the need to make decisions now
- Not so much about picking winners based on current forecasts – more about the political will required to follow through when costs (almost inevitably) diverge from a smooth downward trajectory

UKERC

UK Energy Research Centre

+44 (0)20 7594 1574

www.ukerc.ac.uk

robert.gross@imperial.ac.uk

philip.heptonstall@imperial.ac.uk

UKERC