A nuclear future? UK Government policy and the role of the market

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The Beesley Lectures on Regulation

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http://www.electricitypolicy.org.uk
Outline

• UK energy policy evolves
  – CCC Reports and targets for electricity
• The case for nuclear power
• Investment risks and the *Renewables Directive*
• Consequences of large wind share
• Suitable market design
  – Congestion management, plant operation
  – Location/type of generation and nodal pricing
  – Treatment of existing assets
• Support policies for RD&D and fuel poverty
UK Energy policy

‘securing cheap, reliable, and sustainable sources of energy supply has long been a major concern for governments’ (The PIU Energy Review 2002 Introduction, Tony Blair)

choose any two of the three?
UK Energy policy

‘securing cheap, reliable, and sustainable sources of energy supply has long been a major concern for governments’ (The PIU Energy Review 2002 Introduction, Tony Blair)

choose any two of the three?

‘ensure our energy is secure, affordable and efficient’ and ‘bring about a transition to a low-carbon Britain’ (DECC web site, 2009)
Why low-C electricity?

• 80% GHG reduction by 2050:
  – Easier to decarbonise electricity than fuel
  – switch much heating, transport to electricity

• Wide range of low-C electricity
  – constrained by resource base
  – and cost => need for RD&D to lower cost

But government energy policies are target driven, lack economic rationality
How to decarbonise UK

MacKay’s estimates indicate the large role of low-C electricity in any future low-C UK-sized Economy: figures per head per day

http://www.withouthotair.com/
2006 UK generation and emissions

Total generation supplied to customers (net of losses):
- Nuclear: 20%
- Coal: 39%
- Gas: 35%
- Renewables
- Other: 100% = 328 TWh

Emissions:
- Coal: 70%
- Gas: 28%
- Renewables
- Other: 100% = 183 MtCO₂

CO₂ per kWh:
- Average: 560 g/kWh
- Gas: 450 g/kWh
- Coal: 1000 g/kWh

Source: CCC ’09
2020 UK’s carbon targets are challenging

Figure 5  CO₂ intensity per kWh of electricity generated, 2006-2050

183 Mt

100 Mt = 55% 2006

Almost decarbonised
Anything built now still operates
New build must be low-C

Source: CCC
CCC 2008 report

• De-carbonising electricity is key
• What is economically justified?
  – RES *could* make a significant contribution
    • wind: proven, costs have fallen; maybe 30% by 2020?
  – Severn Barrage: needs v low discount rate
  – CCS: needed globally, demos needed urgently
  – Nuclear: cost competitive; economic case strong
    “once a significant C price is in place” or high fuel prices
    but constrained by supply (companies, engineers, finance)
Assumes C price set by coal vs gas-fired generation
Most generation investment is gas and renewables

Central case €50/EUA by 2020

CCC ’08 forecasts instead of 20% under Renewables Directive
EUA price 25 October 2004-7 August 2009

- Futures Dec 2007
- OTC Index
- Second period Dec 2008
- Second period Dec 2009
- CER 09

Start of ETS
Second period
Changes in 2020 CO$_2$ price forecast

- CCC ’08 forecast central case €50/EUA 2020
- CCC ’09 now forecasts €20/EUA (recession)
  - too low for required low-C investment
- requires action to raise minimum price
  - ETS cap tightened, or stabilised around rising trend
  - failing which UK issues CfDs on C price, or C-tax

*Underlines uncertainty in C price*
CCC 2009 Report

- 2003-7 GHG emissions fall < 1% p.a.
- need to fall 2-3% p.a. (depending on target)
- recession is masking poor performance and undermining ETS Carbon price
- “significant chance” C price too low to incentivize low-C investment
  - need to underwrite price or provide support
- need to review electricity market arrangements
  - and renewables support
Emissions intensity in 2030

- Fully efficient market
- Market subject to uncertainty and myopia
Delivering low-C electricity

- Hydro: limited UK resources
- **Nuclear**: France post oil shock demonstrates success
- Wind: costs falling, but other challenges
- Wave/tidal: too costly
- Biomass: more efficient for heat raising?
- CCS: moderately mature but expensive
- Solar PV: too expensive? Could become cheaper?
- Solar Concentrated Power in N Africa - eventually?
5 plans “that add up” for 50kWh/d/p electricity

- **plan D (diversity)**: Clean coal: 16 kWh/d, Nuclear: 16 kWh/d, Tide: 3.7, Wave: 2, Hydro: 0.2, Waste: 1.1, Wood: 5 kWh/d, PV: 3 kWh/d, Wind: 8 kWh/d
- **plan N (Nimby)**: Solar in deserts: 20 kWh/d, Clean coal: 16 kWh/d, Tide: 3.7, Wave: 2, Hydro: 0.2, Waste: 1.1, Wood: 5 kWh/d, Solar HW: 1 kWh/d, Biofuels: 2, PV: 3
- **plan L (LibDem)**: Solar in deserts: 16 kWh/d, Clean coal: 16 kWh/d, Tide: 3.7, Wave: 3, Hydro: 0.2, Waste: 1.1, Pumped heat: 12 kWh/d, Wood: 5 kWh/d, Biofuels: 2, PV: 3
- **plan G (Green)**: Solar in deserts: 7, Tide: 3.7, Wave: 3, Hydro: 0.2, Pumped heat: 12 kWh/d, Wood: 5 kWh/d, Biofuels: 2, PV: 3, Wind: 32
- **plan E (Economic?)**: Nuclear: 44 kWh/d, Tide: 0.7, Hydro: 0.2, Waste: 1.1, Pumped heat: 12 kWh/d, Wood: 5 kWh/d, Solar HW: 1 kWh/d, Biofuels: 2, PV: 3, Wind: 4

http://www.withouthotair.com/
“A plan that adds up”

Composite of 5 plans with 35 GW onshore and 29 GW offshore wind
48 GW PV
50 GW CSP in Africa
45 GW nuclear
Cap cost €1,020 bn = €17,000/hd

http://www.withouthotair.com/
Case for nuclear power

• Can deliver bulk zero-C electricity
• Very little land take
  – in contrast to renewables
  – existing sites ready and willing
• Costs have risen since 2005
  – But so have all other capital intensive projects
• Least costly large scale zero-C option
  – Particularly at low discount risks

*What are the risks facing investors?*
CCC ’09 Nuclear investment

- New nuclear stations in 2018, 2020, 2022
- Risks:
  - IPC may not deliver
  - waste problem may not be resolved
  - new regulatory framework may be subject to judicial review
  - inadequate supply chain
  - insufficient trained personnel
  - problems financing with uncertain C price
Table 7.6 Lifetime levelised costs of plant added by 2020 (£/MWh)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Conventional</th>
<th>2020 Renewable Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>New coal</td>
<td>56.4</td>
<td>57.4</td>
</tr>
<tr>
<td>New CCGT</td>
<td>56.5</td>
<td>58.5</td>
</tr>
<tr>
<td>Nuclear</td>
<td>37.9</td>
<td>37.9</td>
</tr>
<tr>
<td>Onshore wind*</td>
<td>65.7</td>
<td>60.4</td>
</tr>
<tr>
<td>Offshore wind*</td>
<td>87.8</td>
<td>86.4</td>
</tr>
<tr>
<td>Biomass*</td>
<td>95.6</td>
<td>95.7</td>
</tr>
</tbody>
</table>

*Before any ROC subsidy, currently around £40-45/MWh

Table 7.2 2020 Price assumptions

<table>
<thead>
<tr>
<th>Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas (p/therm)</td>
<td>55</td>
</tr>
<tr>
<td>Coal ($/te)</td>
<td>110</td>
</tr>
<tr>
<td>Oil ($/barrel)</td>
<td>85</td>
</tr>
<tr>
<td>Biomass fuel (£/GJ)</td>
<td>3.6</td>
</tr>
<tr>
<td>Carbon permit (€/te CO2)</td>
<td>30</td>
</tr>
</tbody>
</table>

Source: SKM
BERR URN 08/1021

- but costs have risen since then
Levelised cost at 3.5% discount rate

CCC '09

No learning benefits

Large barrage (Cardiff-Weston, 8.6GW)  Small barrage (Shoots 1.1GW)  Offshore wind  Coal CCS  Onshore wind  Nuclear
CO2 emissions per kWh 1971-2000

- **USA**
- **Italy**
- **UK**
- **Europe**
- **France**
Average annual increment to nuclear capacity

France delivers 50 GW nuclear 1975-90

UK always modest
French nuclear investment 9 times high as German wind for 15 years
Electricity market risks

• Huge oil price volatility: $145-40/bbl
  – contract price of gas linked to and lags oil
  – UK gas prices 20p/th-110p, now 45-55p/th
  – coal prices $50-200/t; now $80-100/t
  – 2nd period EUA prices € 12-30/t, now € 15/t

• Forward clean spark spread £6-9/MWh
• Forward dark green spread £10-15/MWh

*Electricity prices mirror gas prices*
*coal and gas costs move together*
UK price movements: 2007 to 2009 in €

Correlation of coal+EUA on gas+EUA high at 96%
Does nuclear power hedge risk?

- In 2004 gas had higher expected return
- Ignoring correlations of gas and electricity price, nuclear reduces downside risk of portfolio of power plants
  - nuclear reduces company/portfolio risk
- If gas and electricity prices correlated nuclear no longer reduces risk

*Seek hedging value elsewhere*
Impact of Gas and Electricity Price Correlation

Electricity and gas cost correlated
⇒ stable profit stream

Electricity price volatile,
Low-C costs stable ⇒ risky profit stream
Figure 4.26 Relative importance of uncertainties faced by nuclear investors

- **Gas price**
  - 30p/therm: €33/tonne
  - 50p/therm: €98/tonne
  - 70p/therm: €132/tonne

- **Average carbon price**
  - 30p/therm: 62%
  - 50p/therm: 77%
  - 70p/therm: 87%

- **Capacity factor**
  - 30p/therm: Top 77% of price
  - 50p/therm: Average price
  - 70p/therm: Bottom 77% of price

- **Price capture**
  - 30p/therm: £1,500/kW
  - 50p/therm: £2,500/kW
  - 70p/therm: £3,000/kW

- **Construction costs**
  - 30p/therm: 7%
  - 50p/therm: 8%
  - 70p/therm: 9%

- **Cost of capital**
  - 30p/therm: 30
  - 50p/therm: 40
  - 70p/therm: 50

- **Plant life**
  - 30p/therm: -1,500
  - 50p/therm: -1,000
  - 70p/therm: -500

- **Construction and planning time**
  - 30p/therm: 10
  - 50p/therm: 9
  - 70p/therm: 8

**Impact on NPV (£/kW)**

Source: Ofgem Project Discovery 10/09
Development of GB generating capacity

SKM’s mid-scenario projection

Source: Digest of UK Energy Statistics/DECC
UK’s 2020 renewables target

= 40% renewable ELECTRICITY (SKM mid scenario)

= 150 TWh; wind = 38GW; total 110 GW

– 56 GW conventional @ 31% fossil fuel load factor
– investment cost of renewables = €70 bn + €15 bn grid
– of non-renewables = £12 b, (£coal=3.9b; nuclear = £3.9b)

= €95/t CO₂ c.f. €14/t current EUA

• 38 GW> demand for many hours

=> volatile supplies, prices, congestion, ....

• Offshore wind dependent on electricity price

– now looks unfavourable even with banded ROCs
– and challenges to jack-up barge availability

**CCC’09 scales back ambitions**
CCC ’09 scenarios: less wind

Capacity
- 27 GW wind
- 7 GW other RES

Generation
Possible evolution of wind power (CCC’09)

We monitor progress of all stages of project cycle (e.g. planning, grid access, construction) in deploying up to 23 GW of new wind by 2020 (27 GW in total)

2 vessels available, 12 needed by 2020
Average increments to Wind capacity previous five years

UK 2011 target

2014 target

MW


Denmark  Germany  Spain  UK  UK built over year (BWEA)
CCC’09 UK 2020 target is 27,000 MW

Installed wind capacity

UK’s target looks feasible at DE roll-out rate
Implications of substantial wind

- Much greater price volatility
  - mitigated by nodal pricing in import zones
  - requires CfDs and nodal reference spot price
- Reserves (much larger) require remuneration
  - \( \text{VOLL} \times \text{LOLP} \) capacity payment?
  - or contracted ahead by SO?
  - Or will spot price volatility induce contracts that cover availability costs?
Simulation – more volatility, harms baseload (nuclear)

Illustrative Price duration schedule
Flexible generating capacity

Source: Ofgem Project Discovery p42
Will T investment be timely? Will it be efficiently used?

Strong case stage 1

Strong case stage 2

Source: Ofgem
Project Discovery
Current GB transmission access

• Connect for firm access
  – delay until reinforcements in place
=> excessive T capacity for wind
  – excessive delays in connecting wind

• TSO uses contracts and Balancing Mechanism to manage congestion
  – weak incentives on G to manage output
  – costly to deal with Scottish congestion
Balancing - problems and requirements

• efficient dispatch: schedule ahead of time
  – to allow for warm-up, ramping, etc
• wind forecasts increasingly accurate at -4hrs
• day-ahead market bad for wind contracting
• managing cross-border balancing requires more co-operation (and area-wide dispatch?)
The argument for change

• A flawed system can be improved
  => potentially everyone can be made better off

• The challenge:
  – identify the efficient long-run solution
  – that can co-exist with an evolving regime for incumbents
  – apply new regime to all new generation
  – which compensates incumbents for any change
  – while encouraging them to migrate
Spatial and temporal optimisation

=> nodal pricing + central dispatch

• Nodal price reflects congestion & marginal losses
  – lower prices in export-constrained region
  – efficient investment location, guides grid expansion

• Central dispatch for efficient scheduling, balancing

• Market power monitoring – benchmark possible

• PJM demonstrates that it can work
  – Repeated in NY, New England, California (planned)
GB objections to nodal pricing

• Disadvantages Scottish generators
  – but would benefit voting Scots consumers!
=> Large revenue shifts for small gains
• All earlier attempts thwarted by courts
=> need to compensate losers

Need to make change *before* large investments made (wind + transmission)
Transition for existing plant

- Existing G receives long-term transmission contracts but pays grid TEC charges
- for output above TEC, sell at LMP
  ⇒ G significantly better off than at present
  ⇒ No T rights left for intermittent generation

Challenge: devise contracts without excess rents and facilitate wind entry
Politics and constraints

• **Aim:** Security, Sustainability, Affordability

• **Need:**
  – Investment uncertainty reduced
  – Adequate credible and durable C-price
  – Charge R&D to general budget

• **Currently costs all levied on consumers**
  – and excessive because of ROCs etc

  *Creates additional policy uncertainty and lacks credibility*
CCC ’09 recommendations

• Climate Change Levy exemption for all low-C generation (make a genuine CC not elec levy!)
• Underpin C price for credibility
• To reduce investment uncertainty
  – feed-in tariffs for new low-C generation
  – Tender auctions for low-C capacity?
  – low-C obligation on suppliers?

*What does this mean for market design?*
Criteria for market design

- Foster competition and entry => efficiency
- Incentives for timely, efficient (location and type) and adequate investment in G and T – reflecting comparative advantage
- Reflect social cost of carbon
- allow RD&D support without distortion
- deliver efficient dispatch

=> affordable cost to final consumers
Is nuclear viable in liberalised markets?

- Credit supply drying up
  - low risk free rate (indexed bonds)
  - but high cost of capital to most companies
- Low debt-equity needed for construction
- Electricity price-cost margin very volatile
  - issue electricity indexed bonds?
  - or require long-term carbon price guarantee?

*Is any electricity investment viable without an off-take contract?*
Towards a Single Buyer?

• The cost of off-shore is huge
  – unsustainable in current conditions?
  – Precipitate move to long-term contracting?
  – Spot market too risky to support investment?
  – Balancing market works overtime with wind

• Any investment without a long-term contract?
  – But then need a Single Buyer?
  – With short-fall in spot market revenue via capacity payment charged through grid?

*How long before a viable market design?*
Market solutions

• Nodal pricing plus central dispatch
• SO incentivised to balance over 4 years
• Change ROC and FIT
  – Capacity payment for availability + energy payment if dispatched
  – Leave nodal spot prices to determine dispatch
  – Avoids negative wind bidding
• RD&D element financed from C-tax and/or full rate VAT on energy
Costs of renewables (Ofgem ’08)

• 150 TWh renewables by 2020?
• 2006/7 14.6 TWh = £10/year/HH (household)
  HH 29% total =£250 m; total £870m
• BERR predicts £32-53/HH/yr
  – HH = £0.8-1.32 b/yr; total = £2.8-4.6b/yr
• SKM’s estimate = £60-90/HH =>£5.2-7.8b/yr

Even the low estimate is a 6-fold increase

Ofgem revises estimates Oct ’09
Scenario Analysis: Key Results (Ofgem Project Discovery)

Source: Ofgem Project Discovery
British fuel poverty

Annual average domestic standard electricity bill

- Pre-payment
- Standard credit
- Fuel poor England
- Fuel poor UK

- 4 million taken out of fuel poverty by £100 fall
- 500,000 more for a £20 rise
Support for RD&D

• Renewables subsidy above C price justified by learning benefits => commercialise to save the planet

• Why charge electricity consumers for that?
  – Make VAT on energy standard rate
  – C-tax on non-tradable non-ETS sectors

Solution - fund from general taxation or EUA auction revenues (as with CCS)
Conclusions-1

• Low-C electricity requires proper C price
• Renewables target justified by learning benefits
  – requires *and currently lacks*
    • efficient transmission access regime
    • efficient market design for dispatch and balancing
• Wind incompatible with current market design - require Single Buyer or nodal pricing + enhanced SO
• both require transition arrangements/contracts
  – for new/old generation
• Sustainable decarbonisation requires nuclear power
Conclusions-2

• Renewables and other targets undermine liberalised market

=> threatens *all* generation investment

• Current UK support for RES risky and costly

=> required shift to long-term contracting marks end of liberalised market?

Nuclear power needs an attractive offering to compete politically with renewables:

*attractive real return with sensible C price*
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