Delivering the Energy Transition

In theory and practice..

Michael Grubb
Prof. International Energy and Climate Change Policy, UCL
Chair, UK government Panel of Technical Experts on Energy Market Reform
Editor-in-Chief, Climate Policy journal

Covering materials presented in Australia, December 2016

Part 2: Electricity technology trends and UK experience of Energy Market Reform

Part 1: The Triads of Energy Policy
Part 2: Electricity technology trends and UK experience
• UK Pillar I & III policies – sketch
• Technology trends – renewables and systems
• UK Energy Market Reform
Part 3: Policy integration, valuing and conclusions
• **Labelling and standards** (mostly driven from EU): effective in appliances, major improvements in vehicles, significant in buildings but implementation challenges

• **Series of Supplier obligations** ("white certificates") ...

• ... **CERT programme (2008-12)** delivered (from domestic sector) 1-2% reduction in national electricity & gas demand
  – tension between ‘cheap’ vs ‘deep’
  – pressure to switch focus to ‘vulnerable’

• **‘Green Deal’** – loans for energy efficiency on households – failed: *Pillar II instruments won’t solve a First Domain problem*
**Pillar 1: Energy Efficiency - business**

- **Carbon Trust** (initially set up as part of deal around climate change levy on business energy use)
  - Efficiency services increasingly tailored to different business segments
  - Consistently identified good potentials with less-than-expected take-up
  - Emphasis upon multiple push’pull drivers
  - Programme savings estimated >> £1m/day

- ‘CRC’ (originally Carbon Reduction Commitment) efficiency scheme:
  - Designed to align financial with CSR corporate drivers
  - **Public sector and Company** (not site)-level purchase of emission (inc elec) allowances with public reporting – over 13,000 organisations
  - .. but over-reach with “league tables” made overly complex and unpopular

- Evaluation with econometrics & interviews vis-à-vis comparators:
  - reduced **electricity** consumption by an annual average of 3-5% between 2010 and 2012
  - Organisations with **highest gas** use, big reductions (estimated at 30%)
  - reduced CO2 emissions by an annual average of 6-8% (c 3 times original estimate)

Technologies have to traverse a long, expensive and risky chain of innovation to get from idea to market.

**UK Pillar III: Innovation**

- **“Invention”**
- **“Innovation”**
- **“Diffusion”**

**POLICY ENVIRONMENT**
- tax incentives, subsidies, emissions pricing, regulations

**Framework Conditions** – Macroeconomic Stability, Education & Skills, IP Protection Etc.

**PE Fig.9.5 The Innovation Chain (derived from Carbon Trust and Grubb (2004))**
Bridging the innovation chain requires a mix of instruments, *Carbon Trust support for innovation through the pipeline*

**CT Examples:**
- Innovation awards & launch of CERES fuel cells
- Offshore wind accelerator
- Seed / niche markets
- Venture capital
- Technology Accelerators
- Incubators
- Applied R&D
- Demonstration

UK Regulator Ofgem created £500m Low Carbon Networks Innovation Fund, evolved into Networks Innovation Competition – cultural/business model change as important as technology
Strategic investment can be very costly but the returns can be huge, particularly when integrated with ‘scarcity pricing’

North-Sea oil investments in the 1970s cost UK c.£10bn/yr; full direct costs initially >> $100/bbl

Transforming *electricity systems*

- Balancing Mechanism and Capacity Auctions starting to reveal wholly untapped sources of potential reserve
- Storage options – including electric vehicles developing rapidly
- Interconnectors serve to increase overall regional efficiency of the system
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Huge fall in PV and battery costs

**Driven mainly by public policy (internationally)**

PV: New record installed power prices
- Chile = $30/MWh
- Masdar = $25/MWh
- Abu Dhabi = $24/MWh

Module costs: -29% in 2016 to $0.39/Watt

[Diagram showing cost for lithium-ion battery packs]

- Actual
- Estimated range

Module costs: -29% ytd

-15%/y
-40%/y
-31%/y
+6.4%/y
-11%/y
-10%/y

[Graph showing cost trends]

Electricity revolution, Pt.1 – distributed services

Source: Prof Jun Dong, North China University of Electric Power
Price trends of the big renewables, 2010-16

*Sharp fall but ranges also show the centrality of policy risk*

Recent trends in international costs and contracted prices for wind and solar (source: UCL Submission)
UK – Becoming a rapidly more interconnected island following adoption of cap-and-floor returns regulatory regime

**Lower wholesale prices** on continent (2015 average annual prices, €/kWh)

- Carbon price
- Underlying wholesale price

**Interconnectors amongst most reliable sources of supply** (2015/16 Avg availability, %)

* France to also introduce carbon price floor in 2017*
Electricity revolution, Pt. 2 ‘system as platform’

Distributed Service Providers

Combined with

Big generation developments, such as North Sea

Source: Prof Jun Dong, North China University of Electric Power

TenneT CEO Mel Koron commented: ‘In Germany and more recently in the Netherlands, TenneT has the role of developer and operator of the offshore grid. From this responsibility we have taken the initiative to establish a realistic and achievable plan for further development of the North Sea. The success of the energy transition depends largely on the extent to which we mount a coordinated joint effort in Europe. Cooperation between national governments, regulators, the offshore wind industry, national grid administrators and nature and environmental organisations is a precondition for achieving Europe’s environmental targets. The vision we have presented shows the relevance of cooperation in the North Sea.’

North Sea Infrastructure: the vision

Solar and wind energy will be necessary on a large scale because attainment of Europe’s targets for reducing CO₂ emissions depends largely on the production of renewable electricity. Moreover, wind and solar energy are

Source: TenneT
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Emission reductions to the mid 2000s largely comprised reductions in industry, power (1990s “dash-for-gas”) and waste – mostly driven by other trends & policies.
Electricity supplied by major UK generators by fuel, 1990-2014

Figure 1 The dash for gas, the decline of coal, a competitive market & Elec Market Reform

Source (data): Digest of UK Energy Statistics, various years
Major changes to UK electricity market, implemented during 2011-15
Energy price topped up (or reimbursed) to a “strike price”

- Initial contracts awarded by government; moving to
- Competitive auction held by National Grid, sophisticated design

CfDs to lower the cost of capital
Yielding big cost savings

... when combined with competitive auctions

- Administered prices, May 2014 followed by competitive auction, Jan 2015
- Over £315m/yr new contracts offered to five renewable technology classes
- Over 2GW of new capacity with saving £110m/yr cf administered price in 2014
- Estimate cost of capital reduction by 3 percentage points – saving £bns.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Capacity</th>
<th>Admin Strike price 2014 (£/MWh)</th>
<th>Lowest auction clearing price Jan 2015</th>
<th>Maximum % saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>72</td>
<td>120</td>
<td>79</td>
<td>34%</td>
</tr>
<tr>
<td>Onshore Wind</td>
<td>1162</td>
<td>95</td>
<td>79</td>
<td>17%</td>
</tr>
<tr>
<td>Energy from Waste CHP</td>
<td>95</td>
<td>80</td>
<td>80</td>
<td>0%</td>
</tr>
<tr>
<td>Offshore Wind</td>
<td>750</td>
<td>140</td>
<td>114</td>
<td>18%</td>
</tr>
<tr>
<td>Advanced Conversion Technologies</td>
<td>62</td>
<td>140</td>
<td>114</td>
<td>18%</td>
</tr>
</tbody>
</table>

- Other European auctions in 2016 with further cost reductions
- Next UK auction announced, expected even offshore wind << £100/MWh
- Now well within the ‘BNC’ range of affordability, if & as system evolves
Dramatic (80%) fall since 2012: first hours without coal power for over a Century
Driven as declining gas price meets rising carbon price, and renewables
Falls 2012-15 offset by rising renewables; increased gas in 2016

UK Electricity Generation from coal (TWh), 2012-16

- C-price support introduced
- C-Price support doubled to £18/kWh

Carbon floor price impacts coal
First auction, Dec 2014 - for delivery in 2018/19

- Cost 40% of that predicted due to more smaller-scale generation

• 49.3GW awarded at clearing price of £19.40/kW/year. Total cost of £960m (in 2012 prices), under half prior estimates of government (and wider expectations).
• £960m == £11 per average household, but market expected to react with lower wholesale prices, so the net impact lower, estimated c. £2 per household.

• Mix of 1-year, 3-year (refurbishment) and 15 year (new build) contracts
• Mainly old gas and coal generators successful
• One new CCGT (1,650MW) wins an agreement – still awaiting final investment
• Only 174MW of demand side response

Despite six years of autumnal press headlines about ‘lights out’, no interruption to supply as of Dec 2016 – except due to severe weather impacts on distribution system
What will replace 14GW UK coal?

What is needed
- Short-run frequency response
- Back-up for windless winter days

What the government wants
- More Combined Cycle (CCGT)

What NGO’s want
- Batteries, demand response

What we will get
- Few years of some low load factor coal
- Embedded small gas (+some diesel)
- + Interconnectors
- + transport (and maybe heat) integration
- Innovation on distributed service providers

System / consumer costs now well within range of ‘Bashmakov-Newbery’ constant of energy expenditure
Target consistent carbon values: UK ‘Social cost of carbon’ across public policy decision-making, and guide to carbon floor price

- Scenarios include measures available at lower cost than Government carbon values
- And reflect need to ensure that measures required to meet 2050 target are available to be deployed when needed
By 2030 (except for ‘No progression’ scenario):
• Growing periods when wind and solar meet all projected demand
• The capacity of ‘firm’ inputs (like gas, nuclear, biomass, interconnectors, storage etc) required to operate more than half the year is reduced to 20GW overall

Decarbonising power contributes into other sectors

Renewables (Wind, solar, tidal and marine, biomass), nuclear, CCS

Application of power to transport and heat

Electricity emissions intensity to 2050
Electricity demand to 2050
Transition needs to extend into other sectors and more integrated systems
UK Energy Market Reform

Key lessons

• For Strategic (“Third Domain”) investments – eg security and sustainability inc emerging renewables - a role for government is inescapable
  – *The public benefits exceed any risk-adjusted return in spot market*
• Can shifting some risk to government (eg. long term contract) be good? Yes if
  – *the risks arise from private perception of policy risk*;
  – *markets (particularly capital markets) are myopic*; or
  – *the benefits are partly public (eg. Due to inadequate environmental pricing, or innovation / learning, etc)*
• Do we need a Capacity Mechanism in addition to low carbon supports?  
  – *Yes in UK conditions – but scope is crucial, so too is design*
• Auctions are very valuable – competitive pressures remain important
  – Better than government decision at cutting costs / finding options
• Institutional complexities
  – *contracting bodies and their governance*
UK Energy & Market Reform

Some outstanding questions

• Does the EMR takes us back towards public control or new forms of competition arising from auctions?
  – More State involvement – but still using competition, in more efficient way?
  – Some risks of perverse incentives remain (eg. Metered output)
  – “Subsidising” coal (CM) whilst trying to phase it out (CfDs)

• As renewables grow, will need more time- and location-market signals

• “Exit Strategy?” - Revolution or evolution?
  – May be an evolving revolution
  – Can / should we move towards a “contracts market” (eg. long term green consumer contracts, community energy, bundled service contracts) as renewables costs fall?
To minimise ‘state management’, one possibility: to develop competition *between* multiple markets.
Planetary Economics: Energy, Climate Change and the Three Domains of Sustainable Development

1. Introduction: Trapped?
2. The Three Domains

Pillar 1
- Standards and engagement for smarter choice
- 3: Energy and Emissions – Technologies and Systems
- 4: Why so wasteful?
- 5: Tried and Tested – Four Decades of Energy Efficiency Policy

Pillar II
- Markets and pricing for cleaner products and processes
- 6: Pricing Pollution – of Truth and Taxes
- 7: Cap-and-trade & offsets: from idea to practice
- 8: Who’s hit? Handling the distributional impacts of carbon pricing

Pillar III
- Investment and incentives for innovation and infrastructure
- 9: Pushing further, pulling deeper
- 10: Transforming systems
- 11: The dark matter of economic growth

12. Conclusions: Changing Course

Published Routledge 2014 6-page ‘Highlights’ paper available

http://climatestrategies.org/projects/planetary-economics/ for further information #planetaryeconomics