Delivering the Low Carbon Electricity System

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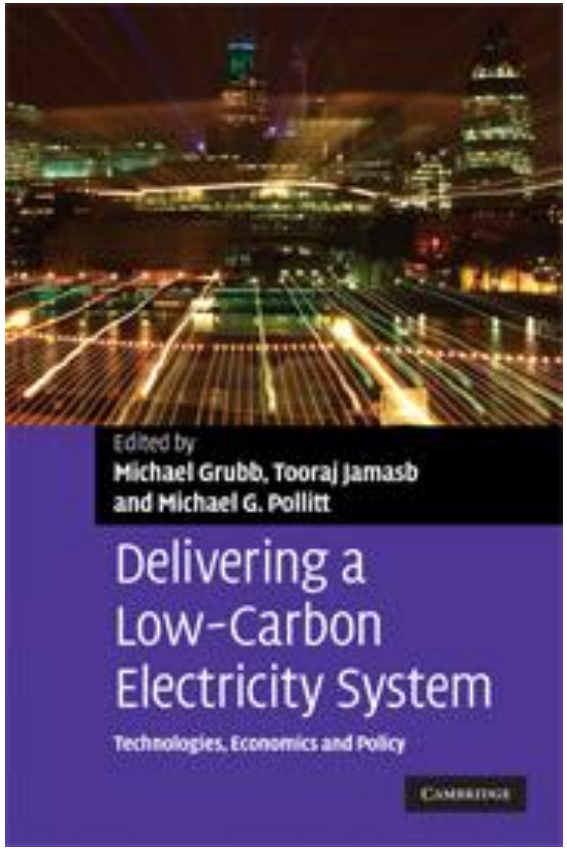
Delivering a Low-Carbon Electricity System (CUP, 2008)



Part I: System Fundamentals

Part II: System network & end-use efficiency

Part III: Investment, price and innovation

Part IV: Scenarios, options and costs

Outline

- Context of UK Energy Policy
- Nuclear
- CCS
- Renewables
- Demand Reduction
- What constitutes a sensible set of policies
- Prospects
- Conclusions

What is UK energy policy?

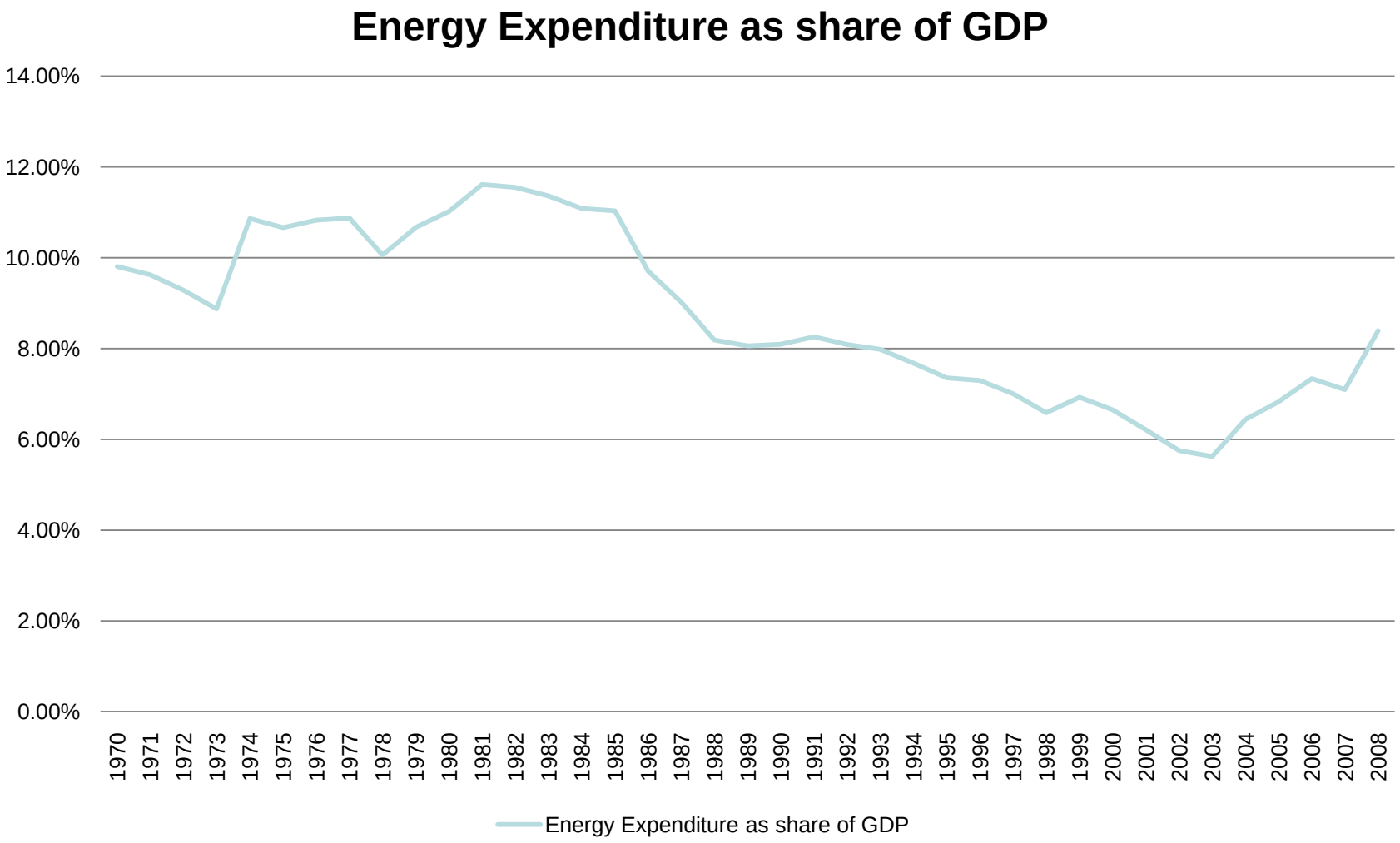
- *Secure*
- *Affordable*
- *Low Carbon*
- Energy

Macro context

- Total energy expenditure in 2008:
- £ 121bn of which:
- £ 17.7bn Gas;
- £ 30.7bn Elec;
- £ 71.6bn petroleum (£57.1bn road transport)

- Energy Taxes in 2008: £24.8bn on oils + VAT receipts + CC Levy (say £30bn in total)

Macro Context



Source: ONS

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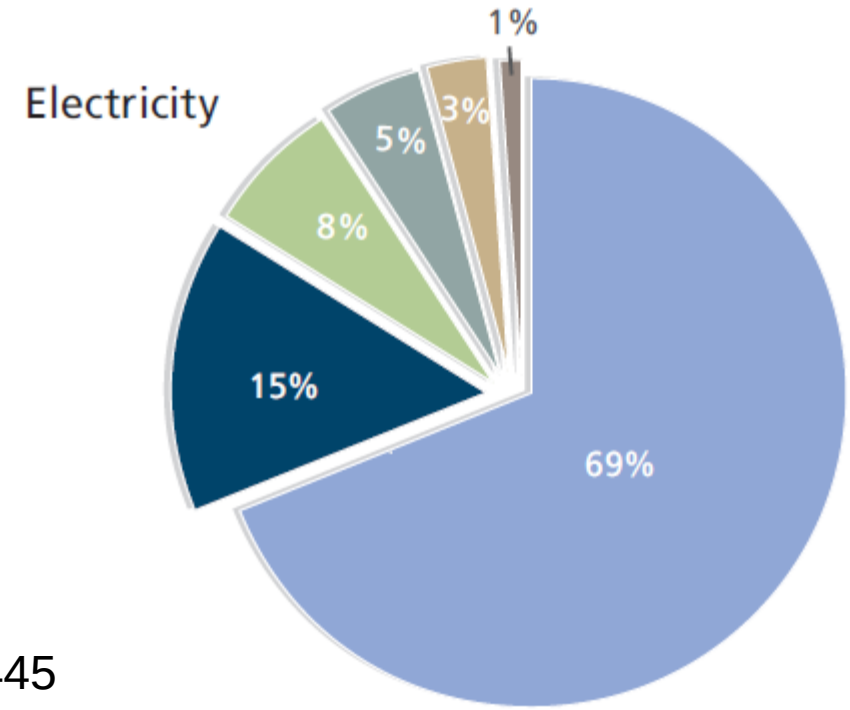
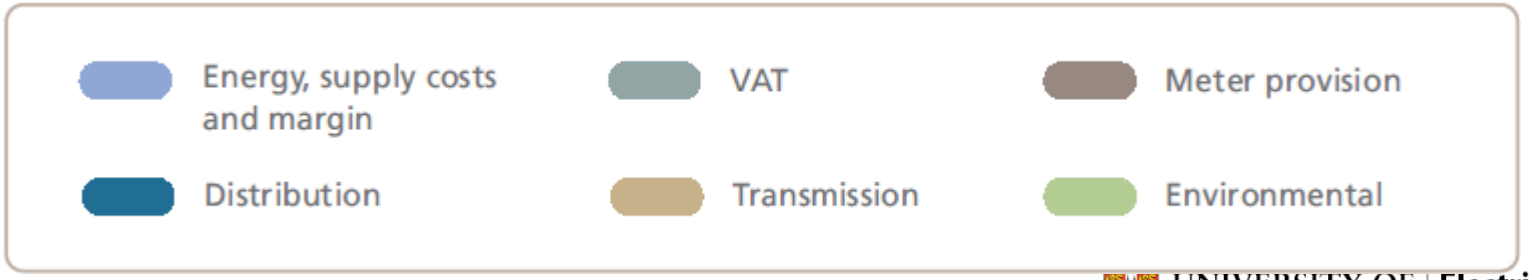
Breakdown of Household Bill



Typical amount: £445

Source: Ofgem, Aug 2009



Household electricity prices

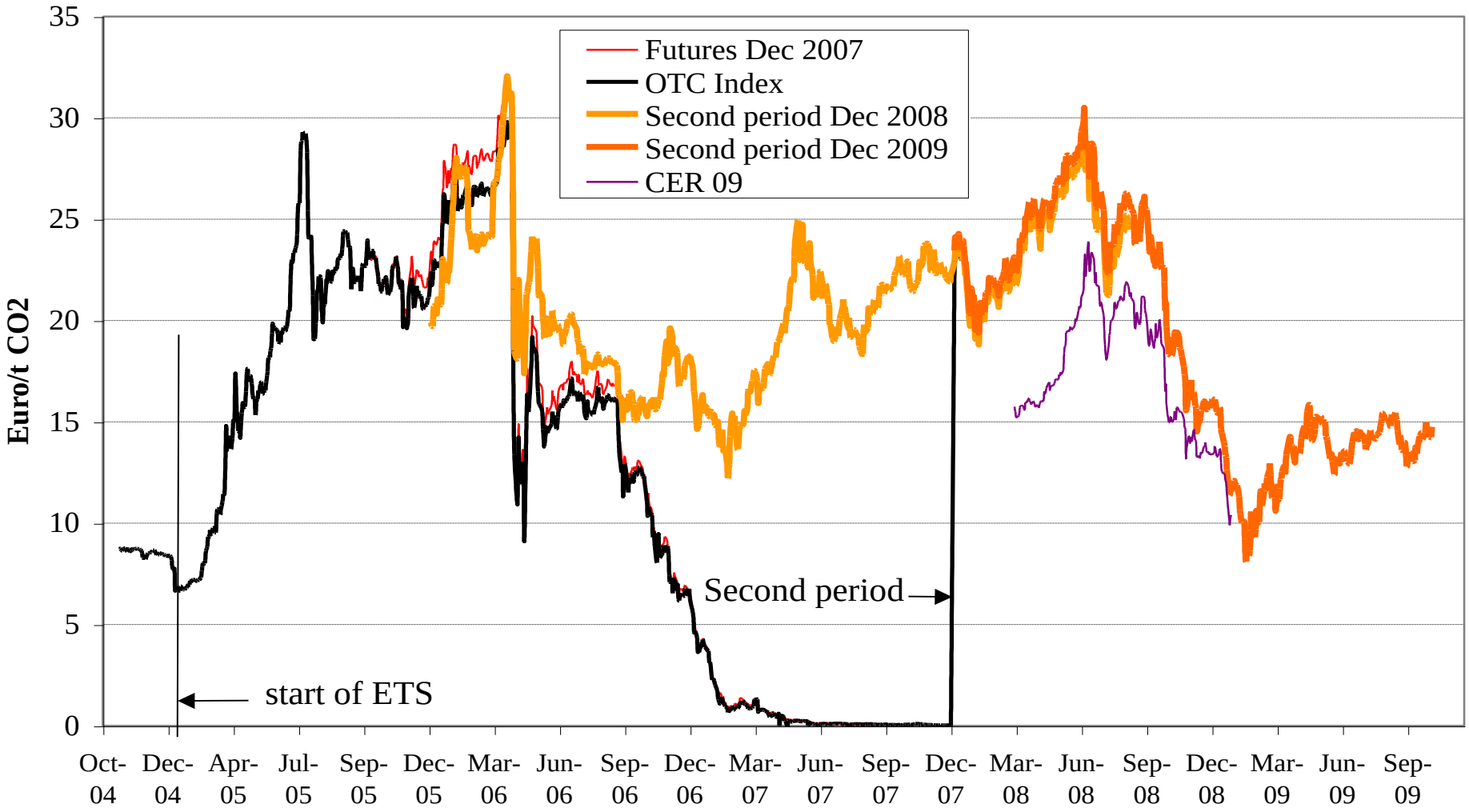
Domestic electricity prices before taxes, Euro cents per kWh

	cents/kWh
Ireland	17.9
Belgium	15.8
UK	**15.3**
Luxembourg	13.7
Germany	13.4
Denmark	13.2
Netherlands	13.2
Spain	12.8
Austria	12.7
Sweden	11.4
Portugal	10.7
Greece	10.1
Finland	9.6
France	9.3
Italy	NA

Source: Eurostat. Prices are for the second half of 2008, based on domestic customers consuming 2,500-5,000 kWh annually.

Source: Ofgem, Aug 2009.

EUA price 25 October 2004-27 September 2009



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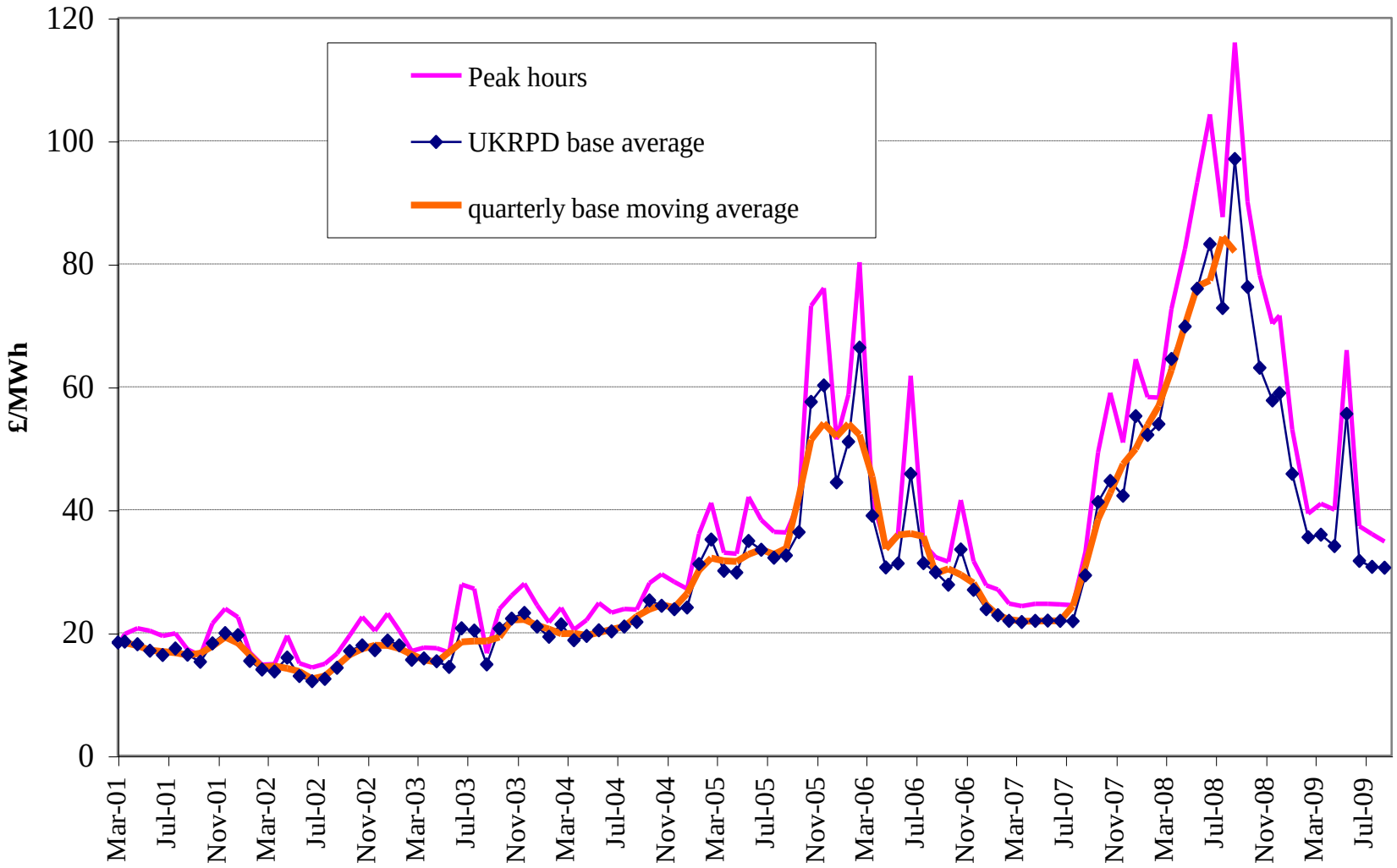
UKPX monthly average RPD day-ahead prices



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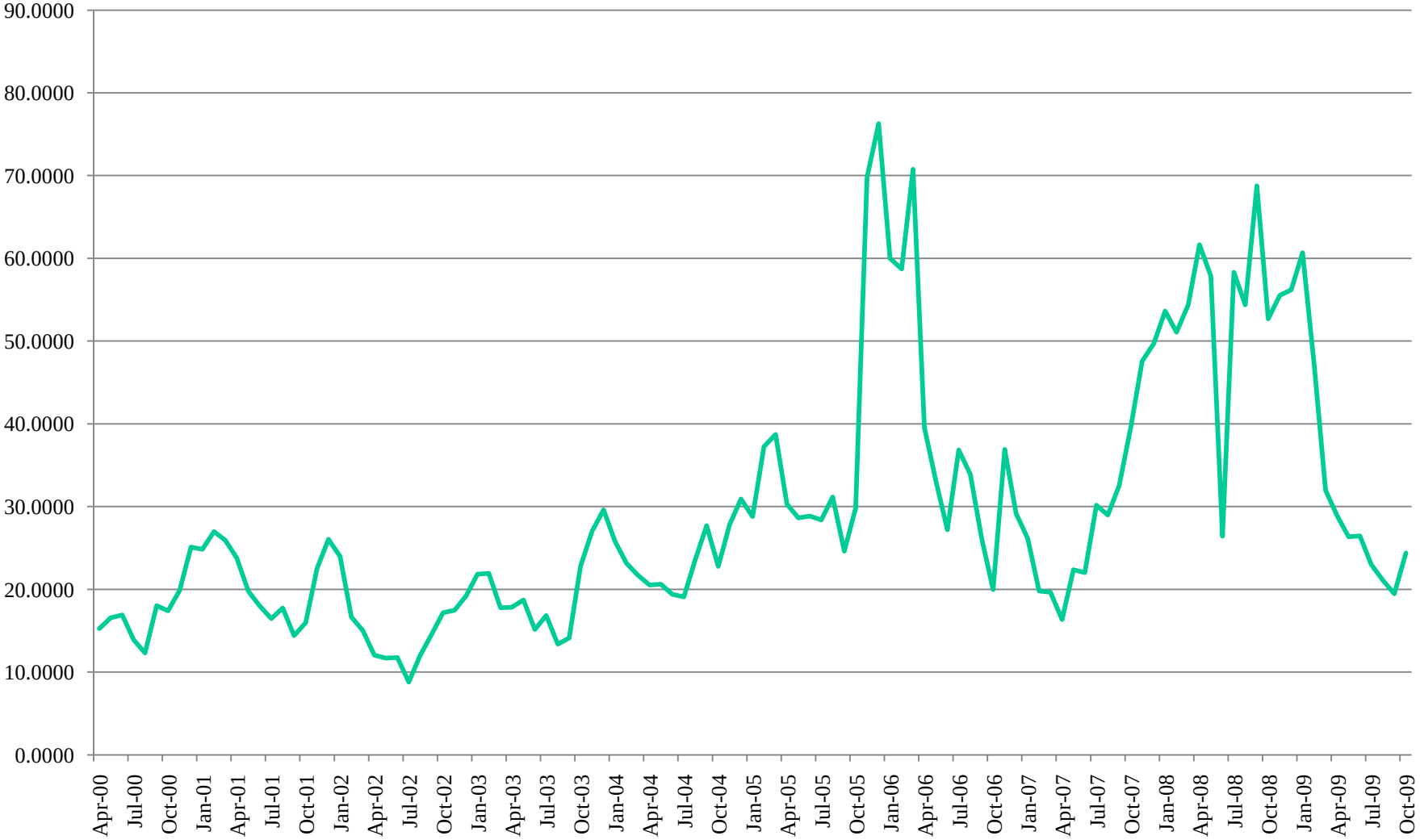
Evolution of UK Gas prices (pence / therm)



SAP p/therm (weighted average price of ALL trades for the relevant gas day on the OCM platform) (Source: http://www.apxgroup.com, OCM)

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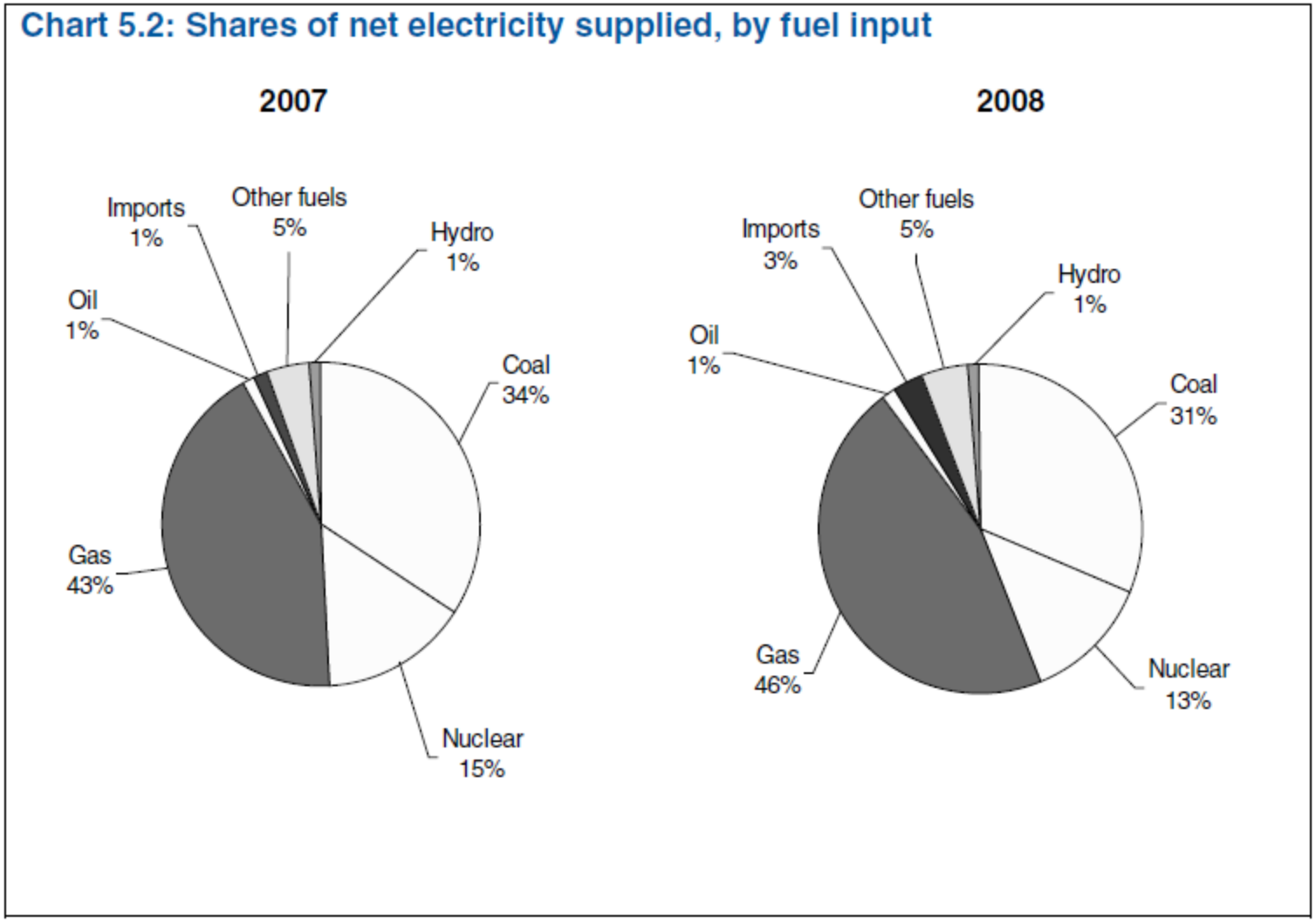
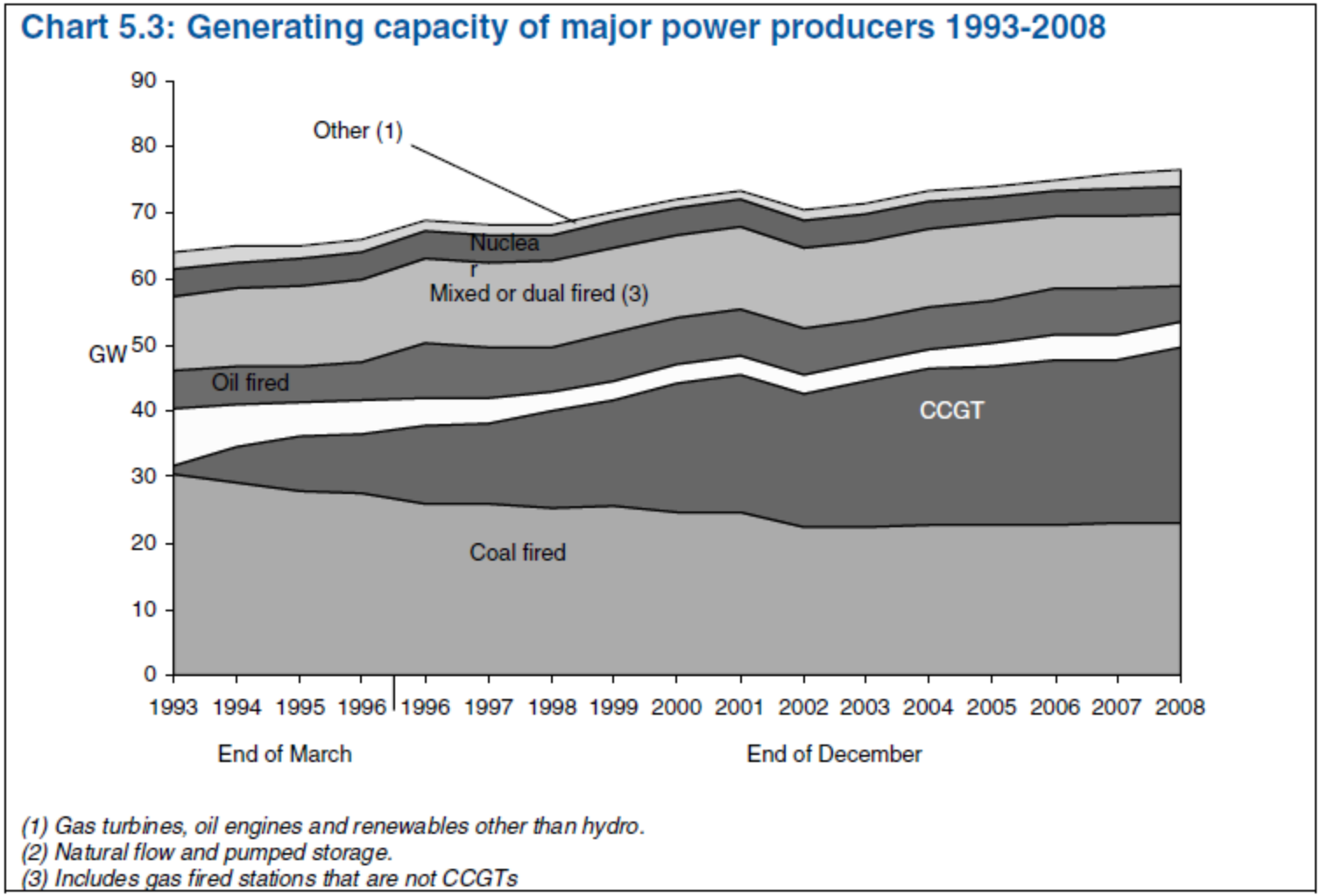
Sources of UK electricity generation



Source: DUKES, 2009

Plant Capacity



Source: DUKES, 2009

2008 Memo Numbers

- 177mt CO2 emissions from power stations
- 623mt CO2e, UK economy
- 393g CO2 per KWh, gas power stations
- 910g CO2 per KWh, coal power stations
- 0.6 Euro cent per KWh at 15 Euro / EUA for gas

2008 Memo Numbers

- 1 therm of gas = 14.6 KWh electricity (at 50%)
- 25p per gas therm = 1.7 pence / KWh
- 385 TWh, total electricity production
- 400 TWh, total electricity demand
- 5.5% share of renewable generation
- 2.7p/KWh for CCGT at 25p per gas therm
- (1 TW = 10^3 GW = 10^6 MW = 10^9 KW)

European Energy Policy Context

- 20-20-20 Targets for 2020:
- 20% reduction in CO2e (hard target)
- 20% renewable energy (indicative target)
- 20% reduction in energy intensity (aspirational target)

- Completion of Electricity and Gas markets (3rd Energy Package)

- Energy Security Directive, Energy Services Directive etc…

- Reality of patchy implementation

UK Decarbonisation targets

- UK in 2008 GHGs: -20% relative to 1990
- Kyoto Target: -12.5% by 2020

- 2008 Climate Change Act
  - 80% reduction by 2050
  - Climate Change Committee
  - Five Year Carbon budgeting
  - First report: complete decarbonisation of electricity by 2030

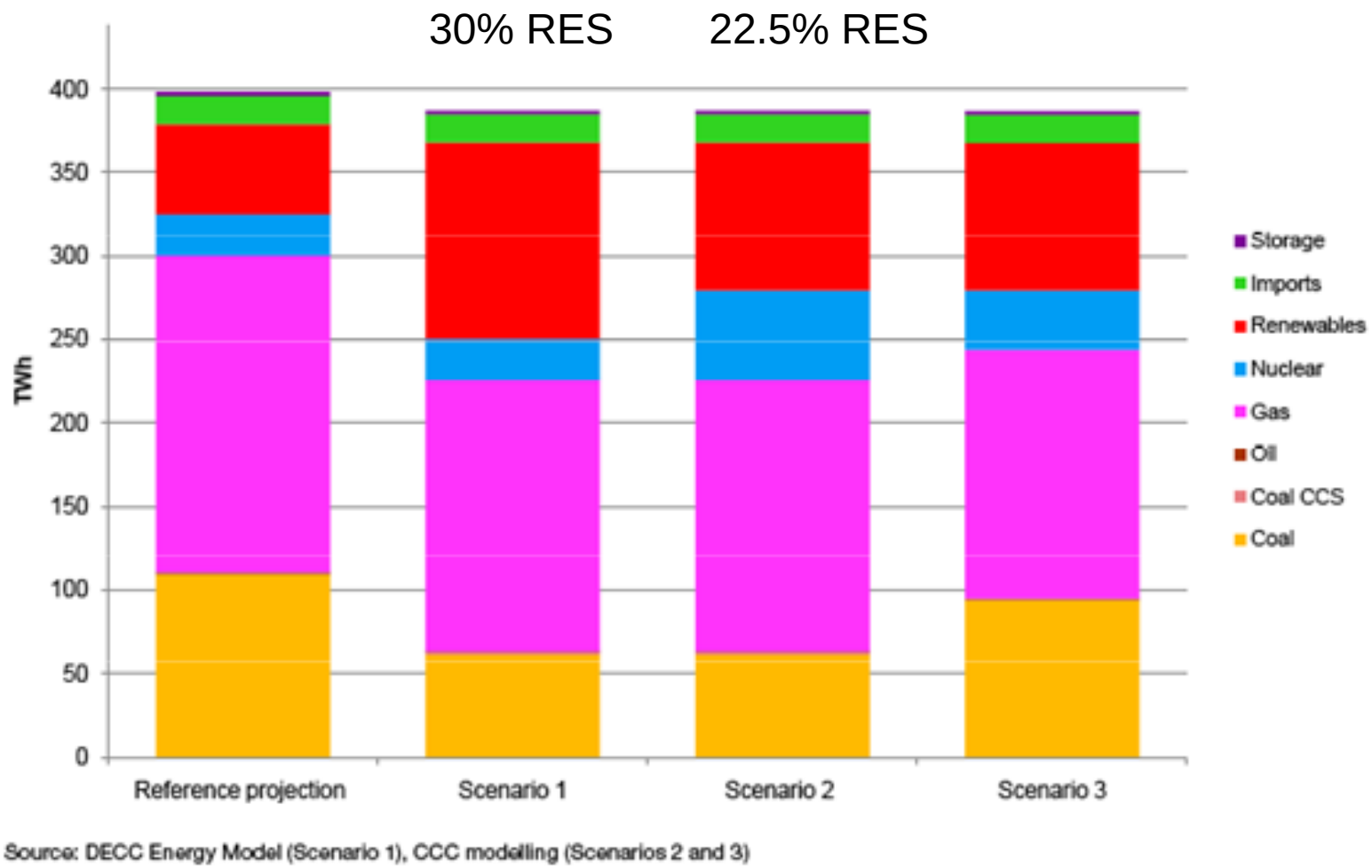
UK Renewables Targets

- UK committed (in draft) to 15% target for renewables contribution to <u>total final energy consumption</u> in 2020.

- Currently support regime only envisages 15.4% renewables in electricity by 2015-16.

- 2010 target of 10% for electricity from renewables.

Implications for UK Electricity in 2020



Source: CCC (2008, p.203)

Power station emission trends

Table E.1: CO_2 emissions by source — Million tonnes of carbon dioxide

	1990	1995	2000	2005	2006	2007	2008p
Power stations	204.5	164.2	158.7	172.6	181.2	177.3	171.3
Other energy industry	32.0	38.3	38.0	37.6	32.6	32.3	31.6
Other industrial	114.3	106.3	106.1	96.5	94.6	93.4	88.6
Domestic	78.6	79.8	85.6	83.1	79.8	76.1	80.0
Commercial and public services	25.1	26.3	25.4	22.6	21.3	20.7	20.8
Agriculture and forestry fuel use	5.1	5.3	4.7	4.5	4.3	4.1	4.1
Transport	122.6	122.2	126.7	131.9	133.6	134.9	131.6
Other sectors[1]	7.8	9.5	6.2	6.3	5.5	5.7	5.7
Total (excluding net LULUCF[2])	590.0	551.9	551.4	555.1	552.8	544.3	533.6
Net LULUCF[2]	2.9	1.3	-0.3	-1.9	-1.8	-1.8	-1.8
Total (including net LULUCF[2])	592.9	553.1	551.1	553.2	551.1	542.6	531.8
Cumulative change since 1990		-6.7%	-7.1%	-6.7%	-7.1%	-8.5%	-10.3%

[1] *Includes waste, fugitive emissions from fuels.*
[2] *Land Use, Land Use Change and Forestry*

Source: DUKES, 2009, Annex.

Three economic principles

- Carbon externality needs to be priced
- Subsidies where exists learning effect
- Net *and* gross cost effects significant

Nuclear?

Nuclear: Pros

- Delivers large blocks of decarbonisation
- Only historically proven (France and Sweden, though UK gas experience does get close)
- Build and forget

Nuclear: Cons

- Public / protestor anxiety
- Nuclear proliferation issue
- High upfront cost (£3bn+ per plant)
- Liabilities large (UK: £80bn; £2.8bn p.a.)
- Costs vary significantly on:
  - Upfront cost
  - Build time
  - Discount rate
  - Operation efficiency

Nuclear cost sensitivities

Table 3: Studies of comparative costs of new generating plants

	MIT (2003) $	DGEMP (2003) euros	T&L (2003) euros	RAE (2004) £	UofC (2004) $	CERI (2004) Can$
Capital Cost per kW						
Nuclear	2000	1280	1900	1150	1500	2347
Gas	500	523	600	300	590	711
Coal	1300	1281	860	820	1189	1600
Construction period - years						
Nuclear	5	5	5	5	5	5
Gas	2	2	2	2	2	2
Coal	4	3	3	4	4	4
Cost of capital or D rate %						
Nuclear	11.5	8	5	7.5	12.5	8
Gas	9.6	8	5	7.5	9.5	8
Coal	9.6	8	5	7.5	9.5	8
Gas price	3.50/MBTU	3.30/MBTU	3.00/GJ	2.18/GJ	3.39/MBTU	6.47/Mcf
Electricity price per MWh						
Nuclear	67	28	24	23	51	53
Gas	38	35	32	22	33	72
Coal	42	34	28	25	35	48
Electricity price, nuclear= 100						
Nuclear	100	100	100	100	100	100
Gas	57	125	133	96	65	136
Coal	63	121	117	109	69	89

Sources: see Appendix

Source: World Nuclear Association (2005, p.20)

Carbon Capture and Storage?

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CCS: Pros

- Delivers substantial decarbonisation
- Oil, gas and coal going to be substantially used
- A bridging technology
- Applicable in US, China and India

CCS: Cons

- Energy inefficient (10-40% energy penalty)
- Capture inefficiency (only 80-90%)
- Untried at scale
- Public acceptability issues
- Cost substantial (adds 1.5p / KWh +)
- Does not address energy security issues
- Only a stop-gap

Renewables?

Renewables: Pros

- Clean, green and sustainable
- High potential in the UK
- Strategic deployment leads to learning
- Some technologies now well developed

Potential for Renewables in UK

Technology Category	Technology Detail	Annual Potential
Wind power	Onshore	50 TWh
	Offshore	100 TWh
Bioenergy	Biomass	41 TWh
Geothermal	Ground source heat pumps	8 TWh
Hydro	Large scale	5 TWh
	Small scale	10 TWh
PV	Retro fitted and Building integrated	>1 TWh
Marine	Wave energy	33 TWh
	Tidal barrage	50 TWh
	Tidal stream	18 TWh
Total		**~316 TWh**

Renewables: Cons

- Issues of scalability
- Intermittency and blackout risks
- Costs of some technologies prohibitive
- Grid enforcement and backup expensive
- Costs of support high and rising

Costs of different renewables

- Onshore wind: 4.7 - 8.9 p / KWh
- Offshore wind: 6.1- 9 p / KWh
- Tidal Stream: 9 -18 p / KWh
- Severn Barrage: 10.4 - 31.7p / KWh
- Wave: 12 - 44 p / KWh
- Domestic PV 65p / KWh

- Sources: Jamasb et al., 2008, BWEA, DECC, Solar Century

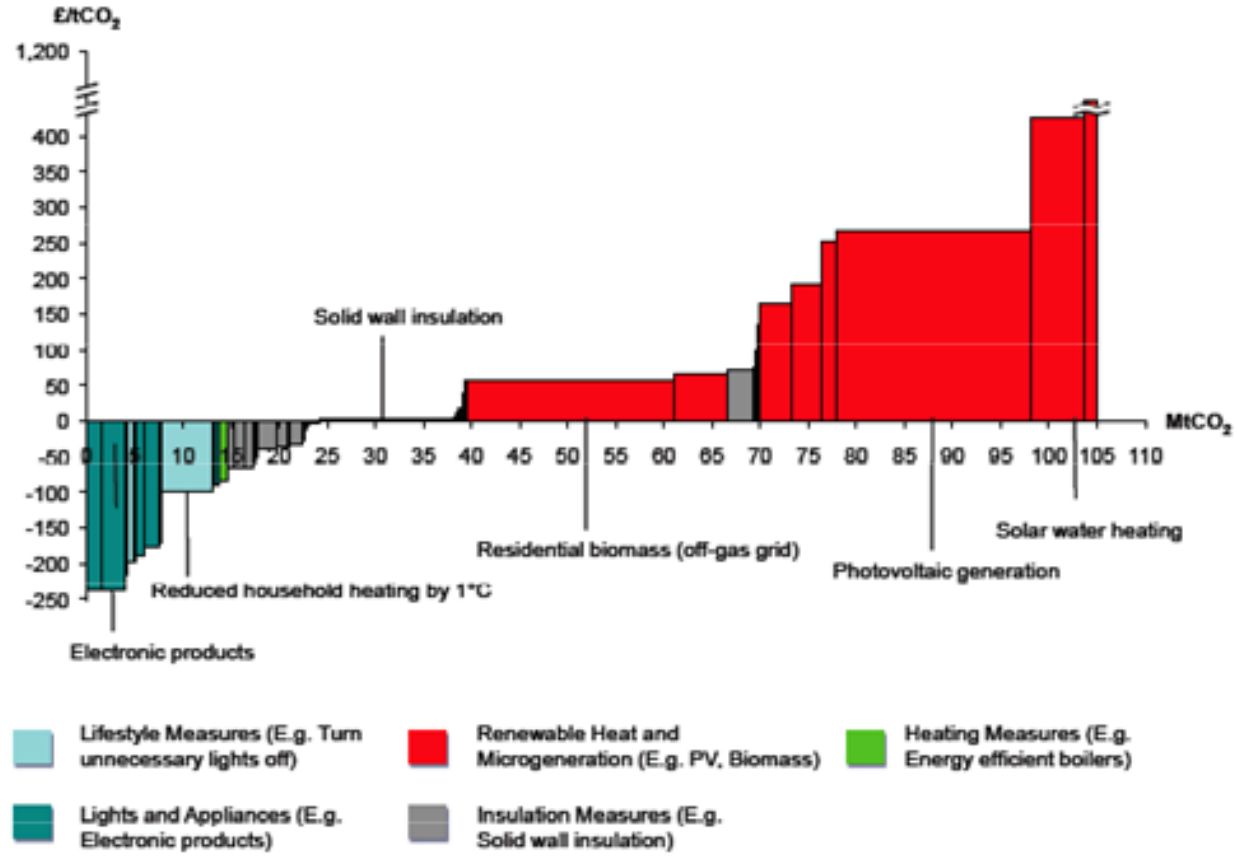
Demand Reduction

Demand reduction: Pros

- Potential is large for energy saving
- Increased focus on energy services
- Micro-gen included reducing grid costs
- Potential relative to trend important
- Engages consumer and innovation
- Improves energy security
- Reduces energy poverty
- Interacts with heat and transport

Potential for Demand Reduction

Marginal Cost of Abatement Curve in Residential Buildings to 2020 – Technical Potential.



Source: CCC

Source: CCC (2008, p.221)

Some Home Energy Economics

	Capital Cost £	Lifetime energy cost £	Total cost	Energy cost %
Lightbulb 100W	0.35	18.98	19.33	98.2%
Lightbulb low energy 100W	1	15.53	16.53	94.0%
Gas Boiler	1000	7629.05	8629.05	88.4%
TV	700	540.01	1240.01	43.5%
Fridge	300	159.56	459.56	34.7%
Car (annual)	2500		3500.00	28.6%
Computer	1000	48.84	1048.84	4.7%
Mobile phone (annual)	360	1.42	361.42	0.4%

Demand reduction: Cons

- Transaction cost issues
- ‘Behavioural’ barriers
- Can negatively impact vulnerable
- Requires decentralisation of policy
- Standard setting opaque

A sensible UK electricity policy

- Emphasis on high and stable carbon prices
- Reliance on market mechanisms for low prices
- Incentivising security of supply directly
- Technology neutral subsidies for learning

- Many individual UK policies have a rationale but are poorly targeted…

Current policies

Scheme	Description	Cost	Paid by
Renewables Obligation	Electricity suppliers must buy a proportion of their sales from renewable generators, or pay a buy-out charge	£874 million in 2007/8 [a]	Electricity consumers
EU Emissions Trading Scheme	Renewable generators indirectly benefit from the increase in electricity prices as other companies pass the cost of emissions permits into the price of power	Perhaps £300 million in 2008, given current permit prices [b]	Electricity consumers
Carbon Emissions Reduction Target	Energy companies must install low-carbon items in homes, which could include microgeneration from 2008	Total cost will be £1.5 billion over 3 years—most spent on energy efficiency	Gas and electricity consumers
Renewable Transport Fuel Obligation	Fuel suppliers must supply a proportion of biofuels or pay a buy-out charge	No more than £200 million in 2008/9 [c]	Consumers
Climate Change Levy	Electricity suppliers need not pay this tax (passed on to non-domestic consumers) on electricity from renewable generators	£68 million to UK generators; £30 million to generators abroad in 2007/8	Taxpayers, via reduced revenues
Lower fuel duty for biofuels	The rate of fuel duty is 20 pence per litre below that for petrol and diesel	£100 million in 2007	Taxpayers, via reduced revenues
Environmental Transformation Fund	Grants for technology development and deployment, including subsidies for installing renewable generation, planting energy crops and developing biomass infrastructure.	£400 million over three years from 2008/9	Taxpayers
Research Councils	Grants for basic science research	£30 million in 2007/8	Taxpayers
Energy Technologies Institute	Grants to accelerate development (after the basic science is known) of renewables and other energy technologies	Allocation (and eventual size) of budget not yet announced.	Taxpayers and sponsoring companies

Source: http://www.publications.parliament.uk/pa/ld200708/ldselect/ldeconaf/195/19509.htm#a53

Plus support for: CCS via levy

Total direct cost: c.£2.5bn in 2008/9

Plus: c.£2bn more for EUETS

Total current cost: £4.5bn

Are policies working?

- Lack of high and stable enough carbon price:
  - Inhibits demand response.
  - Has delayed nuclear investment (if truly efficient).
  - Has led to more coal and less gas being burnt (and more CO2).
  - Has slowed development of bio-fuels (land fill gas and co-firing) and prolonged their subsidy.
- As a result:
  - Mature low carbon technologies have not emerged strongly.
  - Large reliance has been placed on subsidies to less developed technologies.
  - General policy uncertainty has delayed investment and unnecessarily raised issues of ‘will the lights go out’.

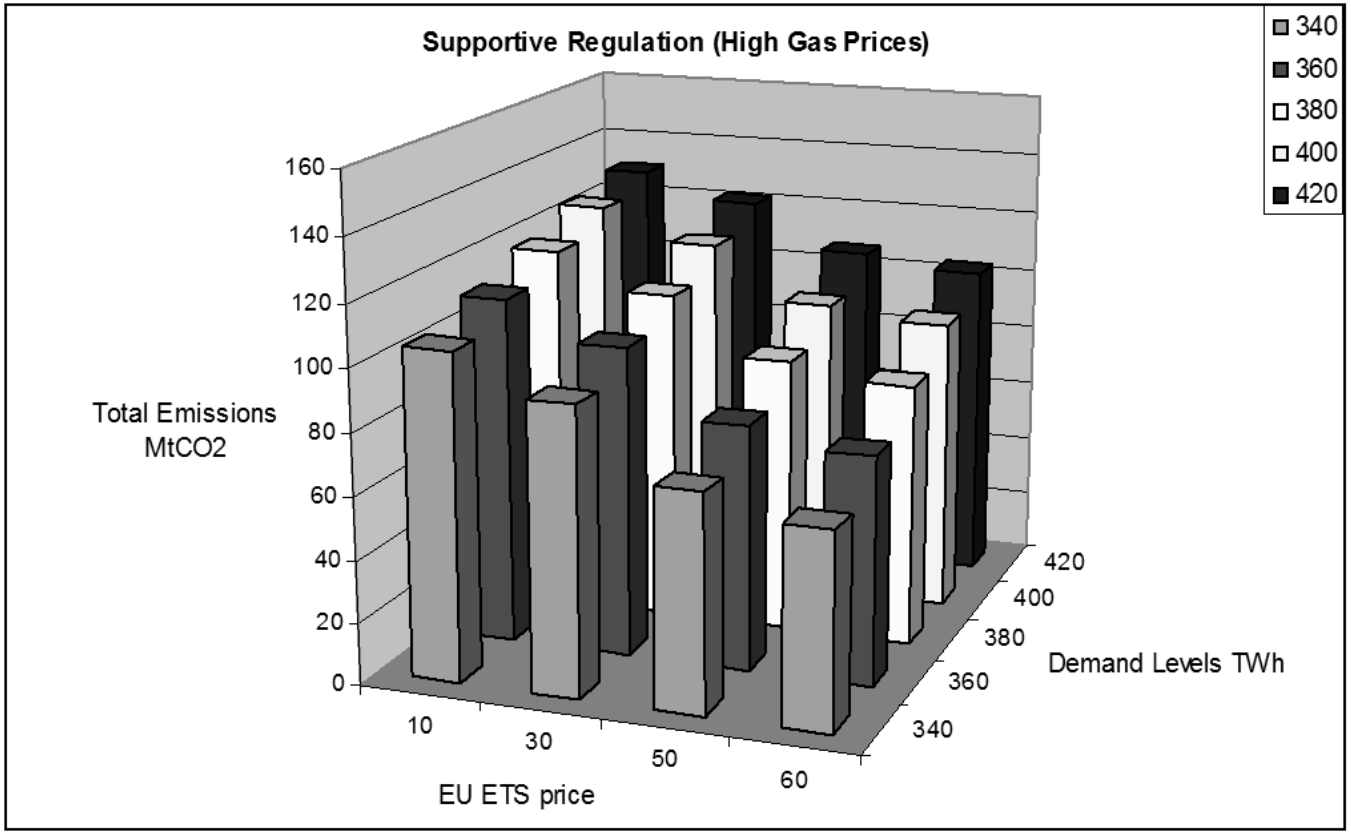
Renewables Obligation

	Target renewable share in GB	% Delivery in UK	Nominal Buyout Price £/MWh	Total Cost £m
2002-03	3.0	59%	30.00	282.0
2003-04	4.3	56%	30.51	415.8
2004-05	4.9	69%	31.59	497.9
2005-06	5.5	76%	32.33	583.0
2006-07	6.7	68%	33.24	719.0
2007-08	7.9	64%	34.30	876.4
2008-09	9.1		35.36	1036.2
2009-10	9.7		37.19	
2010-11	10.4		+ inflation thereafter	
2011-12	11.4			
2012-13	12.4			
2013-14	13.4			
2014-15	14.4			
2015-16	15.4			Estimated: ~1753m (2008-09 prices) assuming no demand growth

Renewables support in the UK

- The general policy context has placed pressure on the RO scheme to deliver.
- The performance of this scheme is poor.
- There are two scale-able renewable options:
  - Onshore wind where planning issues are key.
  - Offshore wind where cost issues are key.
- RO scheme ok for onshore: just remove unnecessary revenue recycling.
- Offshore much better to move to annual auctions for capacity (as we have for transmission capacity to wind farm) to reveal true cost. Banded ROCs costly alternative.

EUETS and Demand (Fixed plant mix)



Source: Grubb et al., 2008, p.469. Gas price 50p/therm.

Ways forward

- Sensible carbon pricing only basis for a way forward for nuclear and CCS
  - Could have technology neutral auctions for carbon reduction
- Renewables
  - Need to reduce costs relative to delivery
- Demand Reduction
  - Energy service model a long-term option
  - Needs to address fuel poverty issues

Conclusions

- Price of carbon is the problem
- More gas is obvious short term way forward
- Renewable support mechanism a disgrace
- Focus on demand side is half-hearted
- Current dithering will ensure targets are missed and electricity prices rise sharply anyway
- Careful reflection important on path to 2050
- Politicians of all parties equivocal about true cost
- Engagement with public essential

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