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Research Group**

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# Market design and support policies for a low carbon electricity future

David Newbery

**Global CO<sub>2</sub> economics**

Sønderborg, Denmark 18-19 August 2009

<http://www.electricitypolicy.org.uk>

# Outline

- How much & what low-C electricity for 2050?
- Investment risks and 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

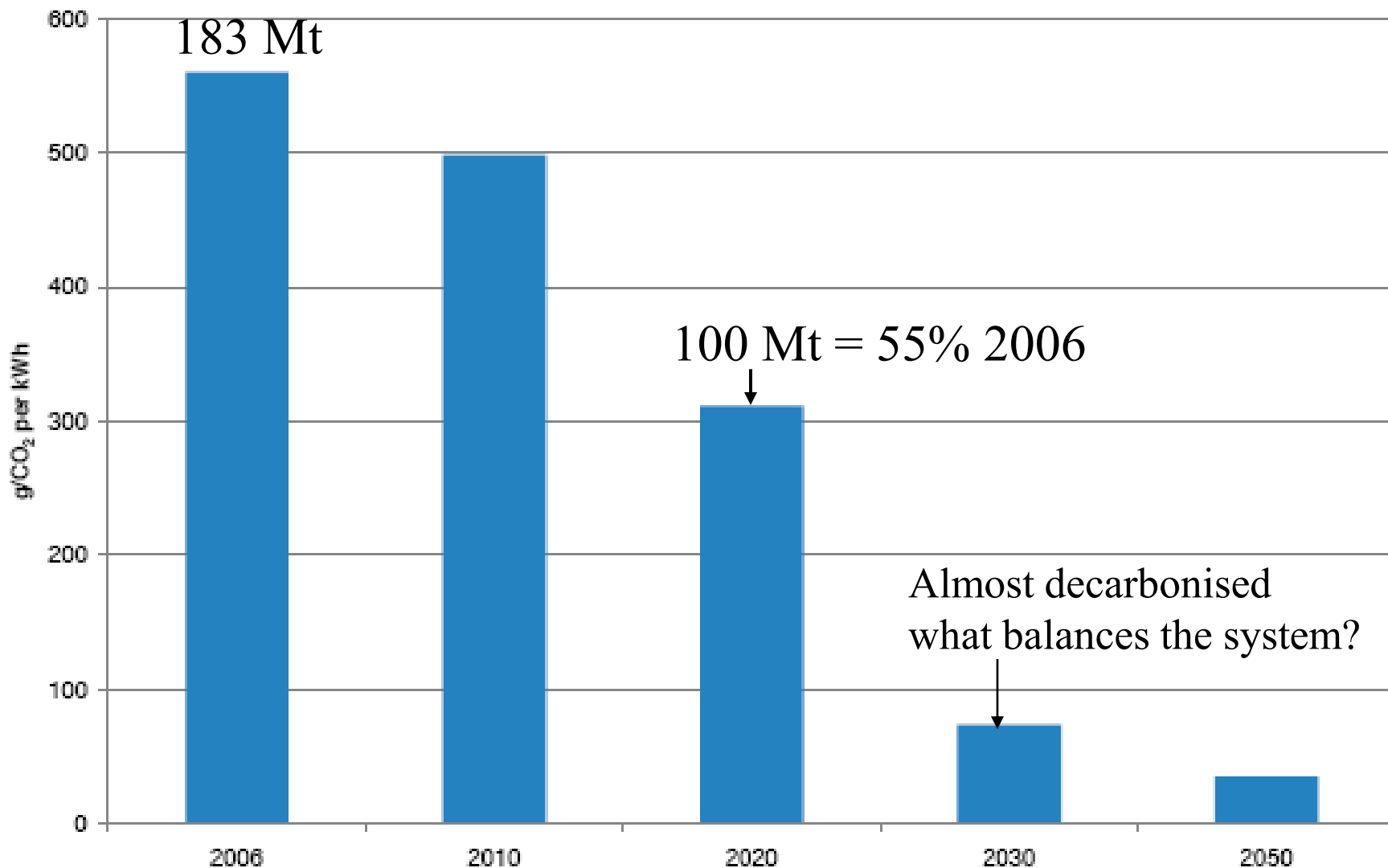
# Why low-C electricity?

- 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***

# 2020 UK's carbon targets are challenging

**Figure 5** CO<sub>2</sub> intensity per kWh of electricity generated, 2006-2050

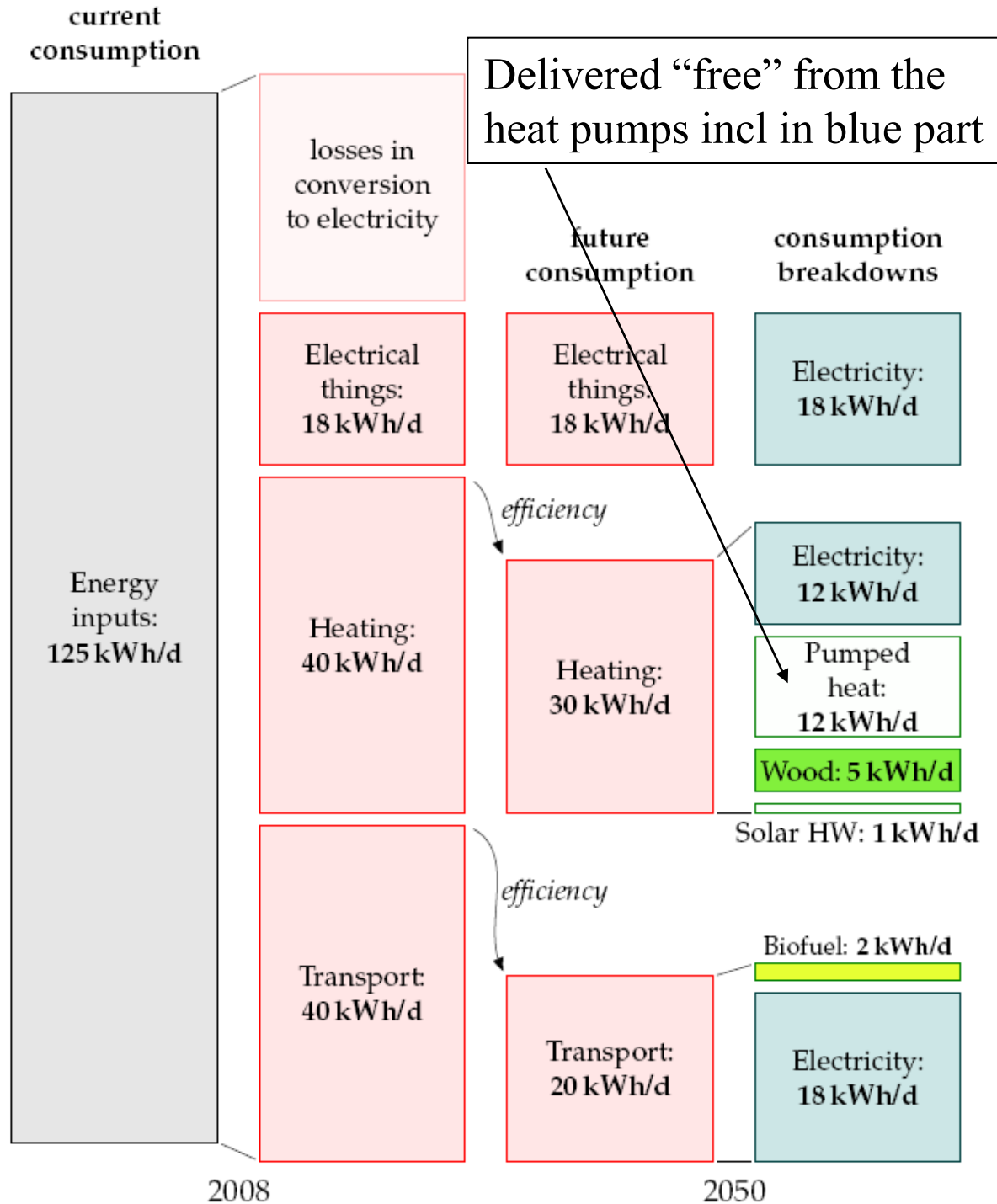


# How to de-carbonise UK

MacKay's

<http://www.withouthotair.com/>

estimates indicate the large role of low-C electricity in any future low-C UK-sized economy



# Delivering low-C electricity

- Hydro: limited EU resources (but pump storage)
- Nuclear: e.g. France post oil shock
- Wind: costs falling, but other challenges
- Wave/tidal: 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?

# Solar Concentrated Power

One Wales  
(red square)  
is enough to  
supply all  
British power  
consumption  
125 kWh/d/p;  
yellow square  
(one Germany)  
could supply  
all Europe's  
power

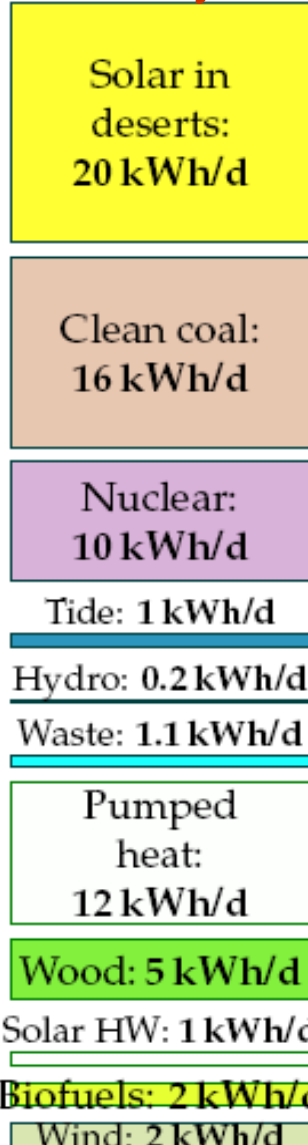


# 5 plans “that add up” for 50kWh/d/p electricity

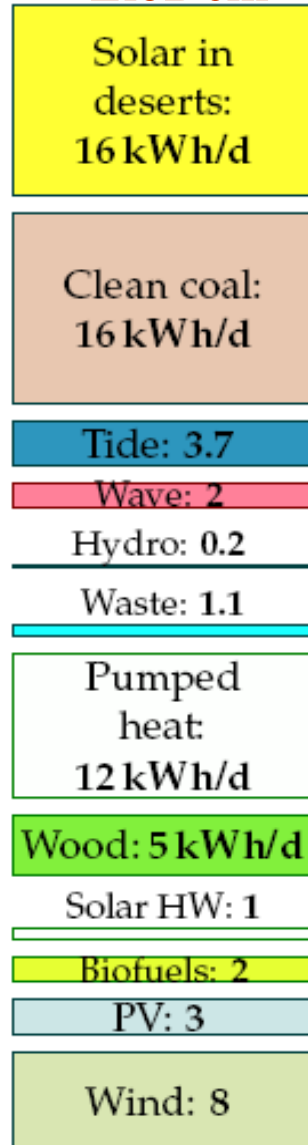
plan D  
diversity



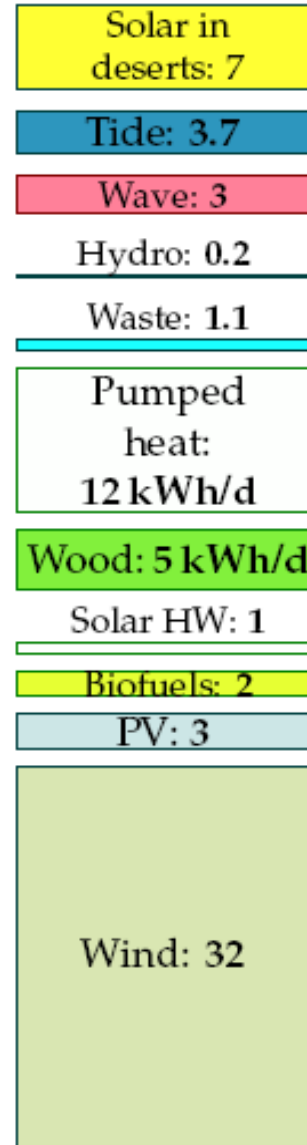
plan N  
Nimby



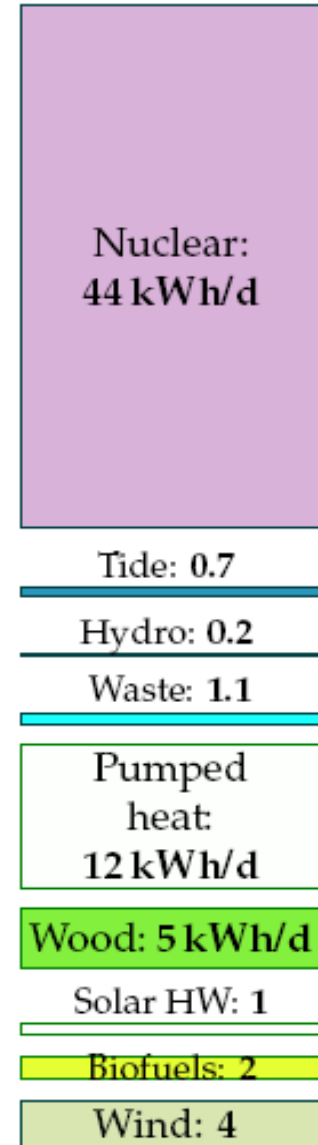
plan L  
LibDem



plan G  
Green



plan E  
Economic?



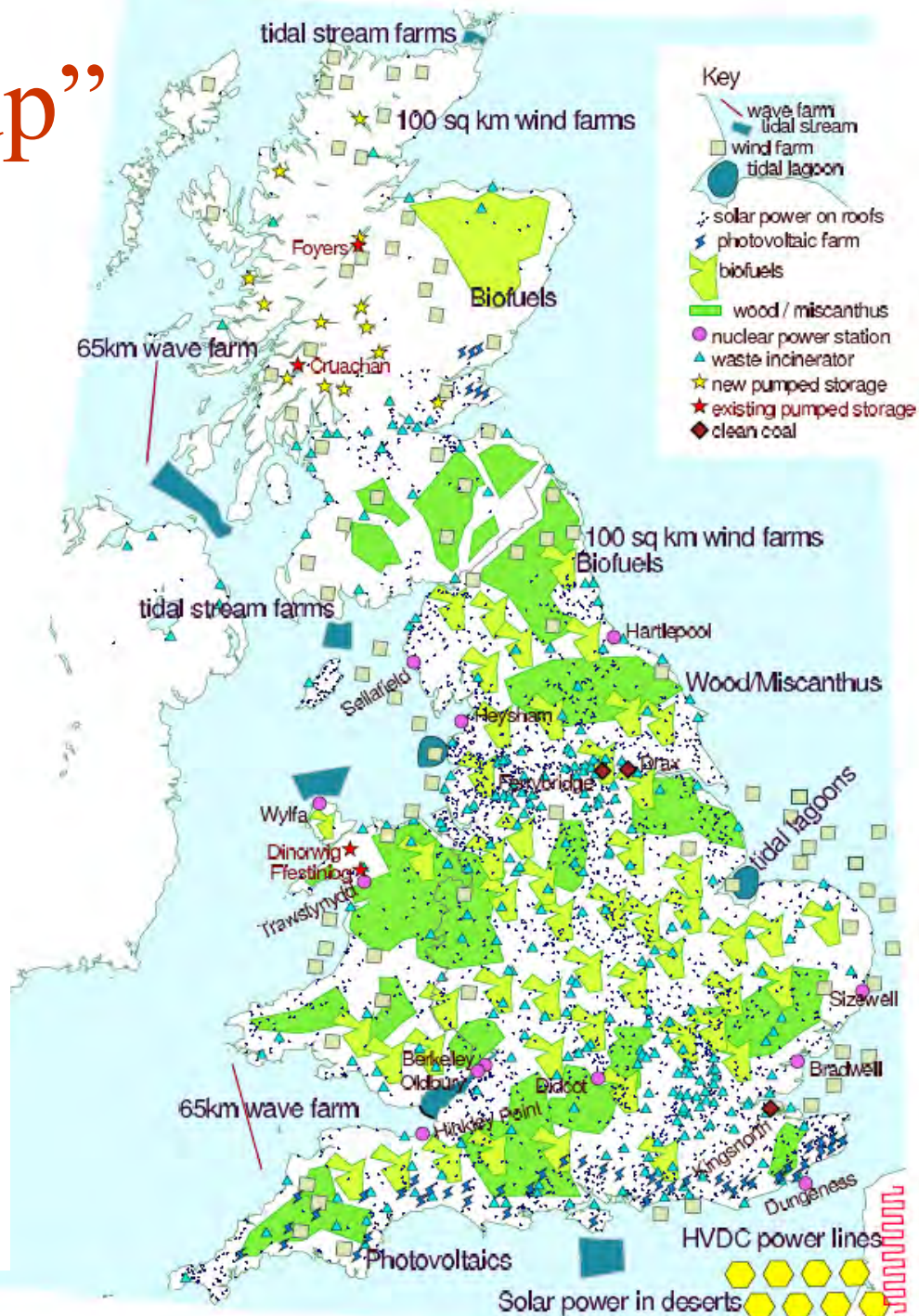


# “A plan that adds up”

Composite of  
5 plans  
with 35 GW  
onshore and  
29 GW off  
shore wind  
48 GW PV  
50 GW CSP  
45 GW nuclear

Cap cost €1,020 bn  
= €17,000/hd

Solar in deserts: 16 kWh/d
Clean coal: 3
Nuclear: 16 kWh/d
Tide: 3.7
Wave: 0.3
Hydro: 0.2
Waste: 1.1
Pumped heat: 12 kWh/d
Wood: 5 kWh/d
Solar HW: 1
Biofuels: 2
PV: 2
Wind: 8

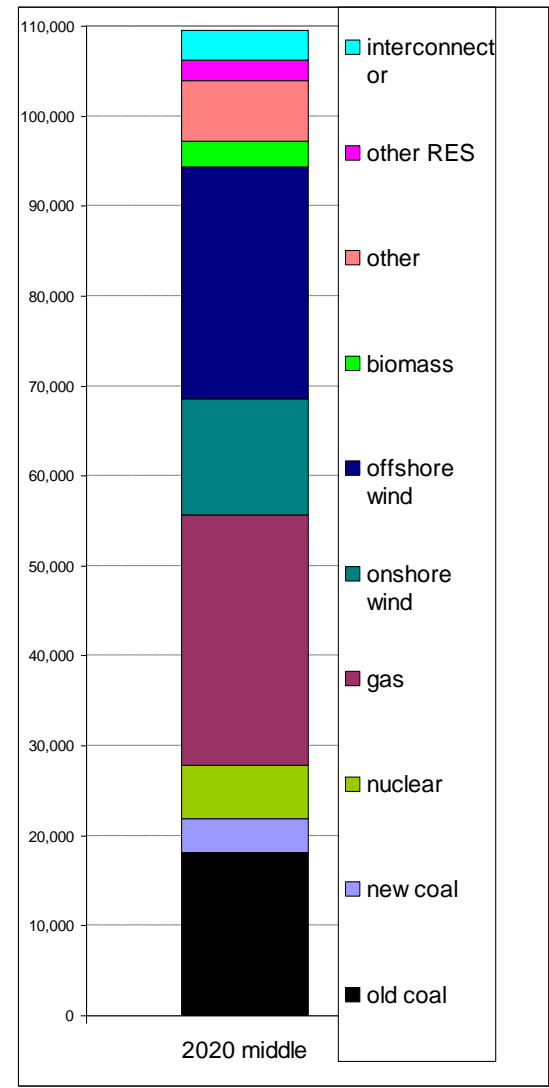
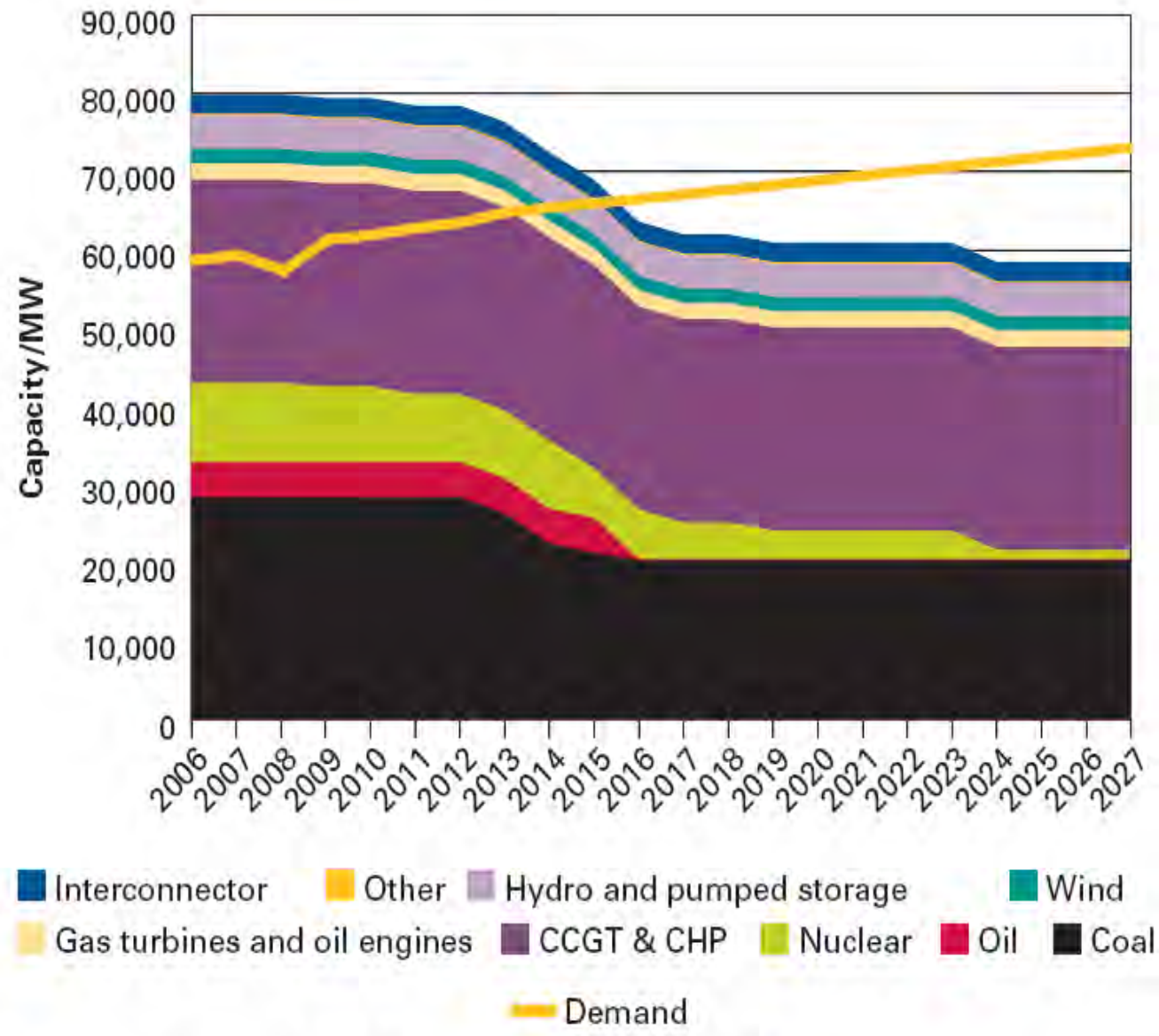


# Investment in liberalised markets

- CEC presses for single electricity market
  - based on market principles
  - with substantially more interconnection
- Capacity margins projected to fall 2016 with LCPD => investment needed
- Transmission investment needed
  - for wind, interconnection

*What are the risks facing investors?*

# Development of existing GB gen cap



SKM's  
mid-scenario  
projection

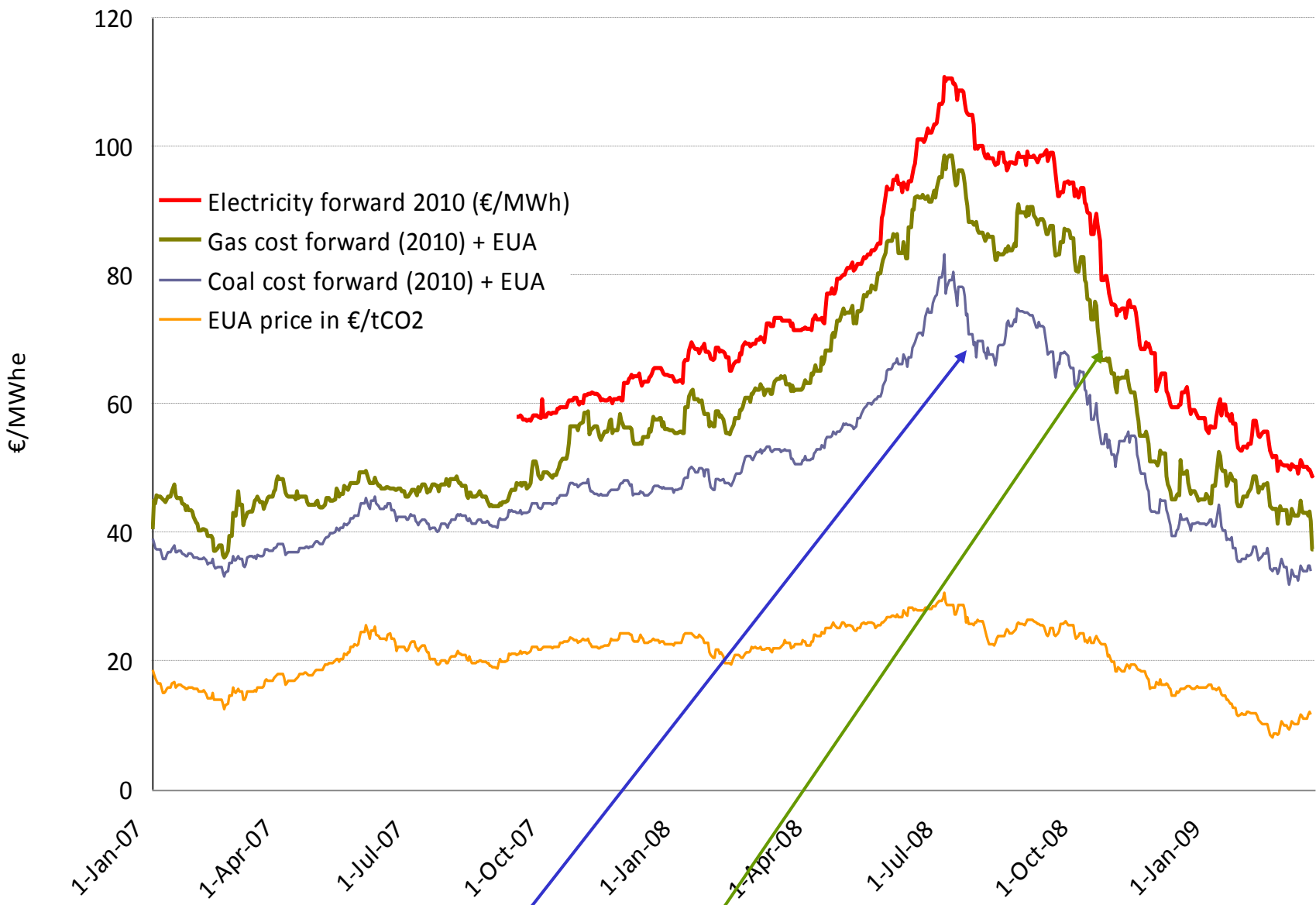
Source: Digest of UK Energy Statistics/DECC

# Electricity market risks

- Huge oil price volatility: \$145-40/bbl
  - contract price of gas linked to and lags oil
  - UK gas prices 20p/th-110, now 50p/th
  - coal prices \$50-200/t; now \$100/t
  - 2nd period EUA prices € 12-30/t, now € 14/t
- Forward clean spark spread £6-9/MWh
- Forward dark green spread \$15-25/MWh

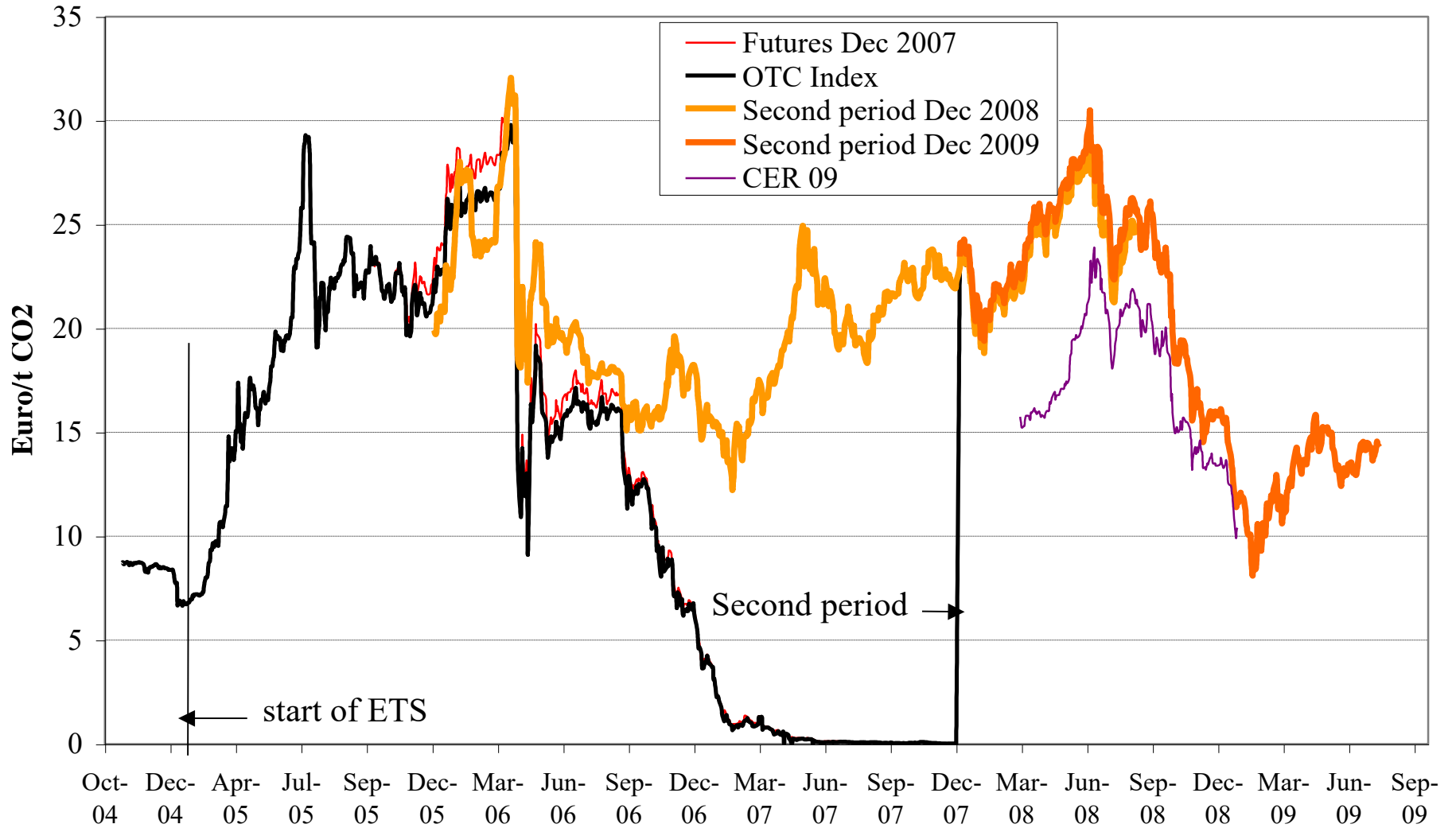
*Electricity prices mirror gas prices  
coal and gas costs move together*

# UK price movements: 2007 to 2009 in €



**Correlation of coal+EUA on gas+EUA high at 96%**

# EUA price 25 October 2004-7 August 2009



**Table 7.6 Lifetime levelised costs of plant added by 2020 (£/MWh)**

Technology	Conventional	2020 Renewable Scenarios		
		Lower	Middle	Higher
New coal	56.4	57.4	58.7	61.1
New CCGT	56.5	58.5	59.8	62.8
Nuclear	37.9	37.9	37.9	37.9
Onshore wind*	65.7	60.4	60.4	61.6
Offshore wind*	87.8	86.4	83.4	81.7
Biomass*	95.6	95.7	96.5	101.7

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

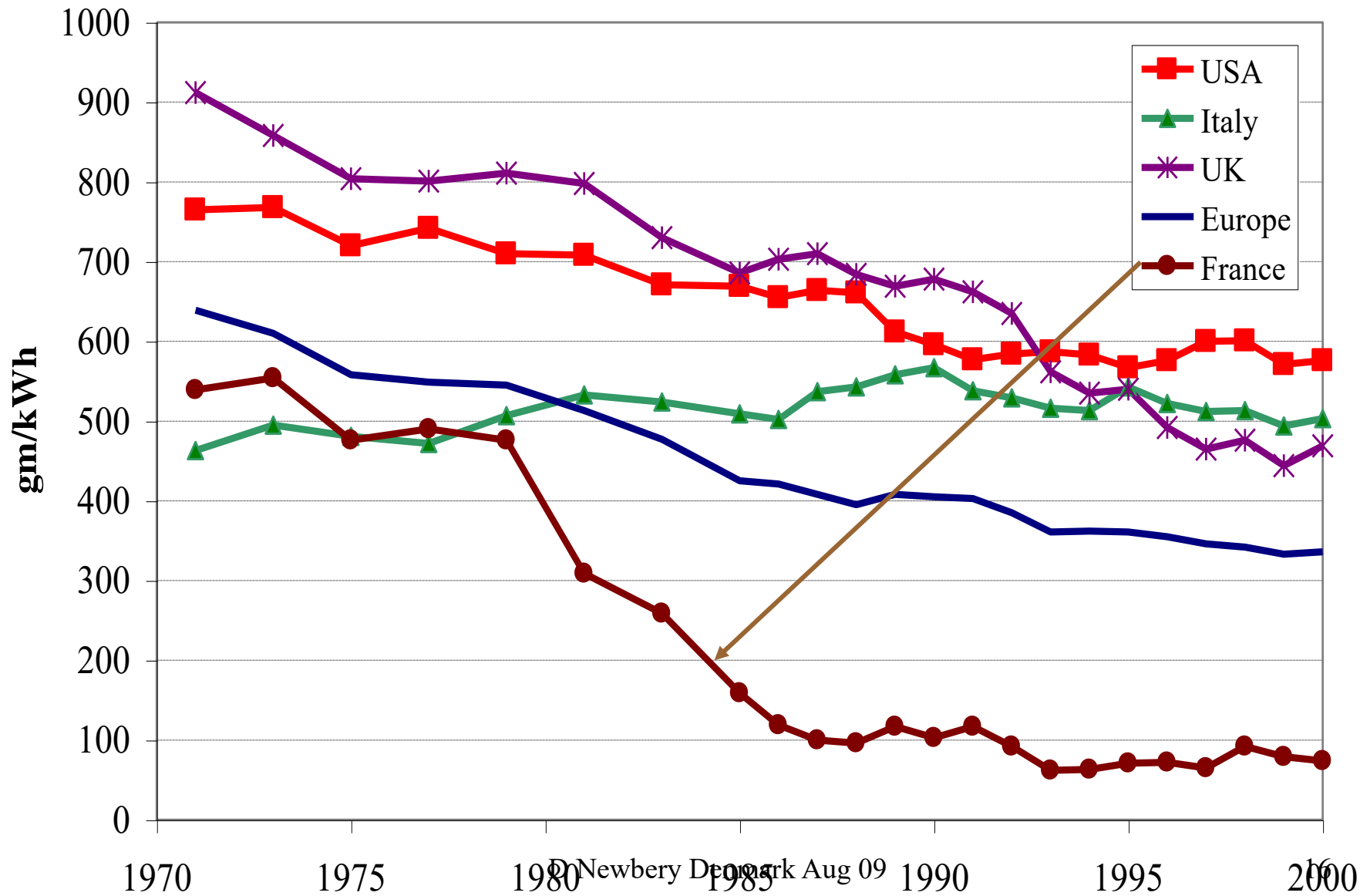
**Table 7.2 2020 Price assumptions**

Type	Price
Gas (p/therm)	55
Coal (\$/te)	110
Oil (\$/barrel)	85
Biomass fuel (£/GJ)	3.6
Carbon permit (€/te CO <sub>2</sub> )	30

Source: SKM

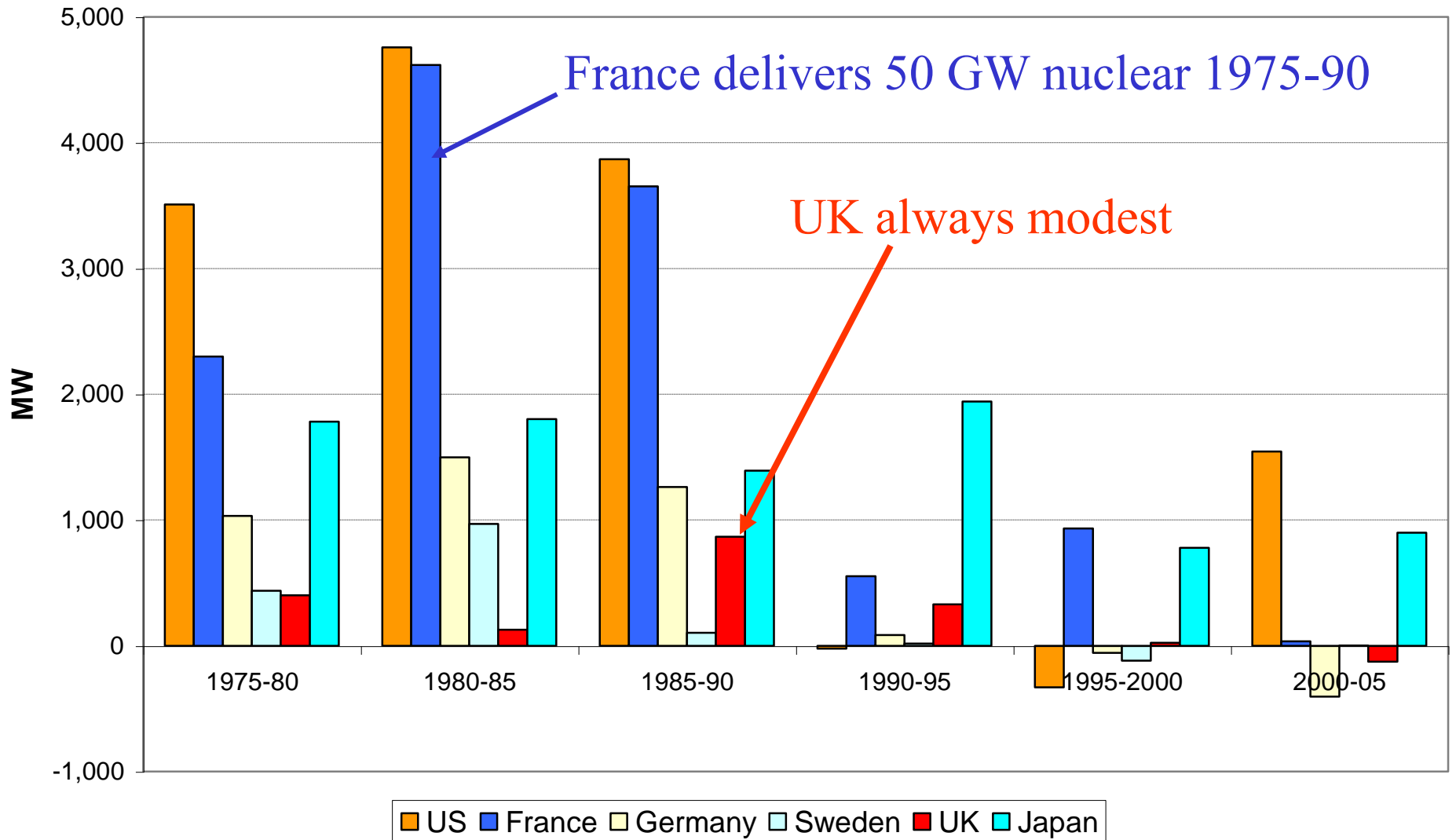
BERR URN 08/1021

# CO2 emissions per kWh 1971-2000

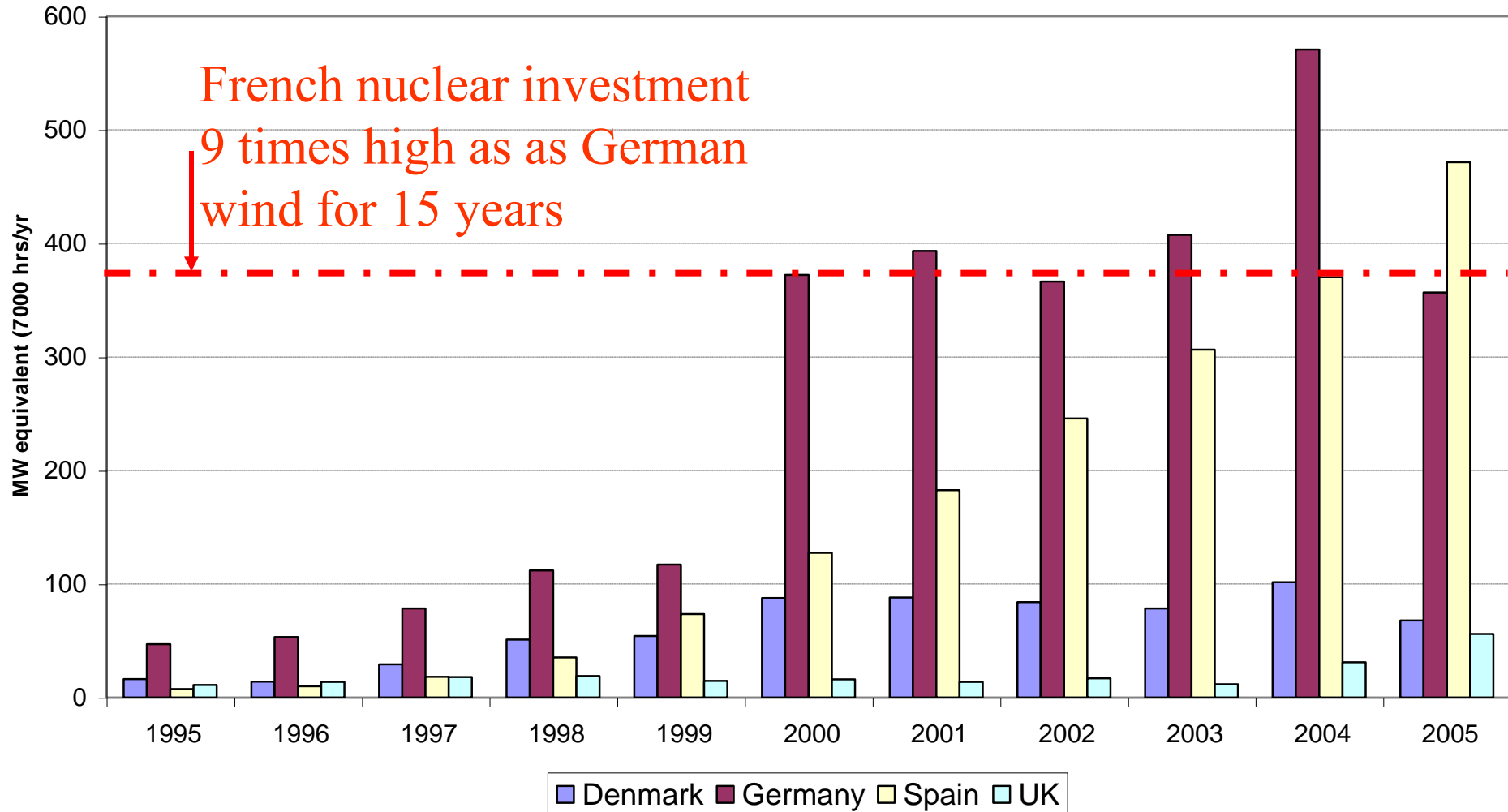




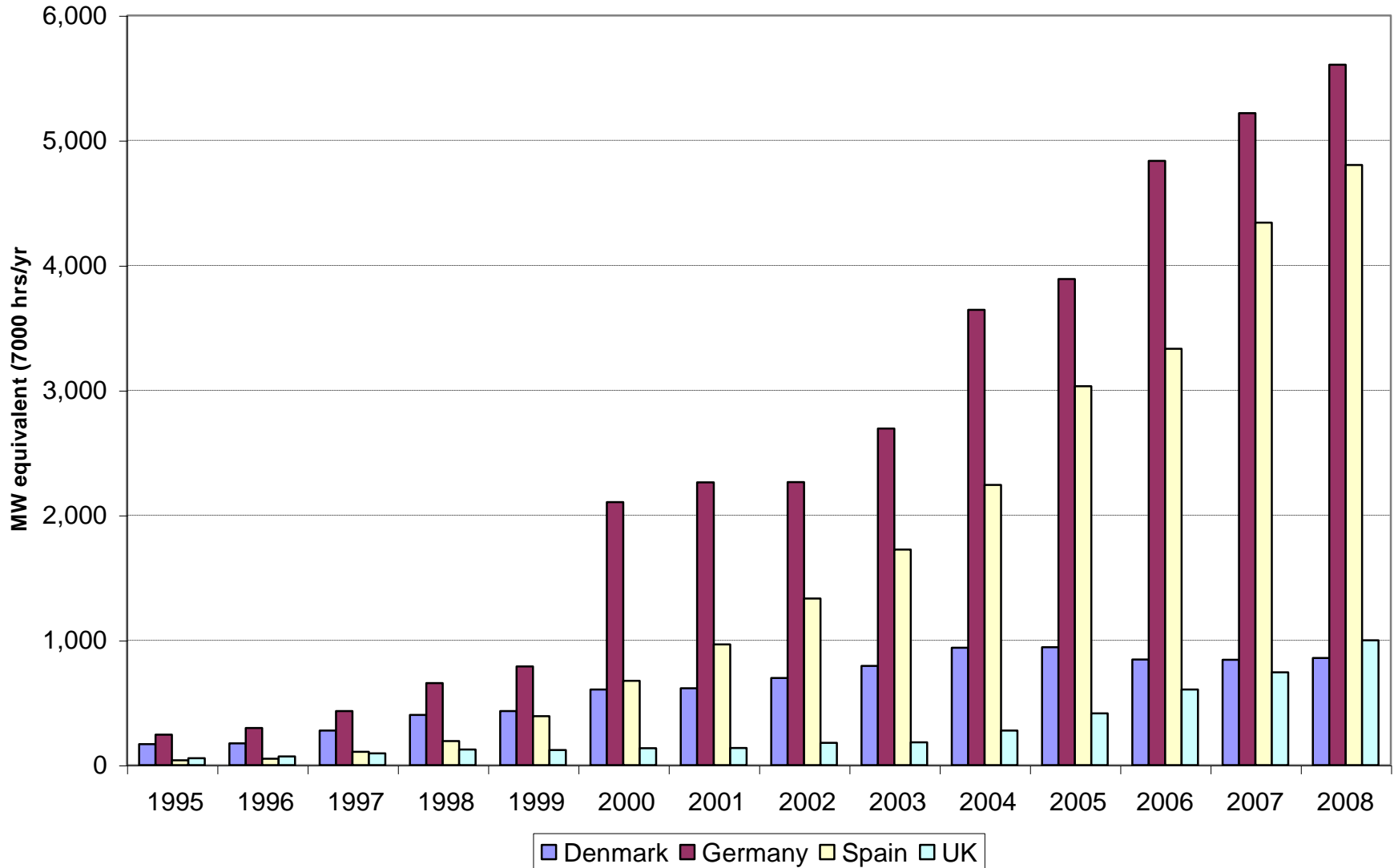
# Average annual increment to nuclear capacity



# Equivalent increment in effective wind capacity previous five years



# Effective total wind capacity



# 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**
- at acceptable cost to final consumers

# Implications for Europe

- European market operates as integrated whole
  - efficient Europe-wide dispatch
  - efficient SO/balancing across borders
- Renewables built where cheapest
  - but costs share equitably
- Cost-effective interconnection as needed
  - to reduce cost of intermittency

***None of these currently guaranteed***

# 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 CO<sub>2</sub>** c.f. €14/t current EUA

- 38 GW > demand for many hours

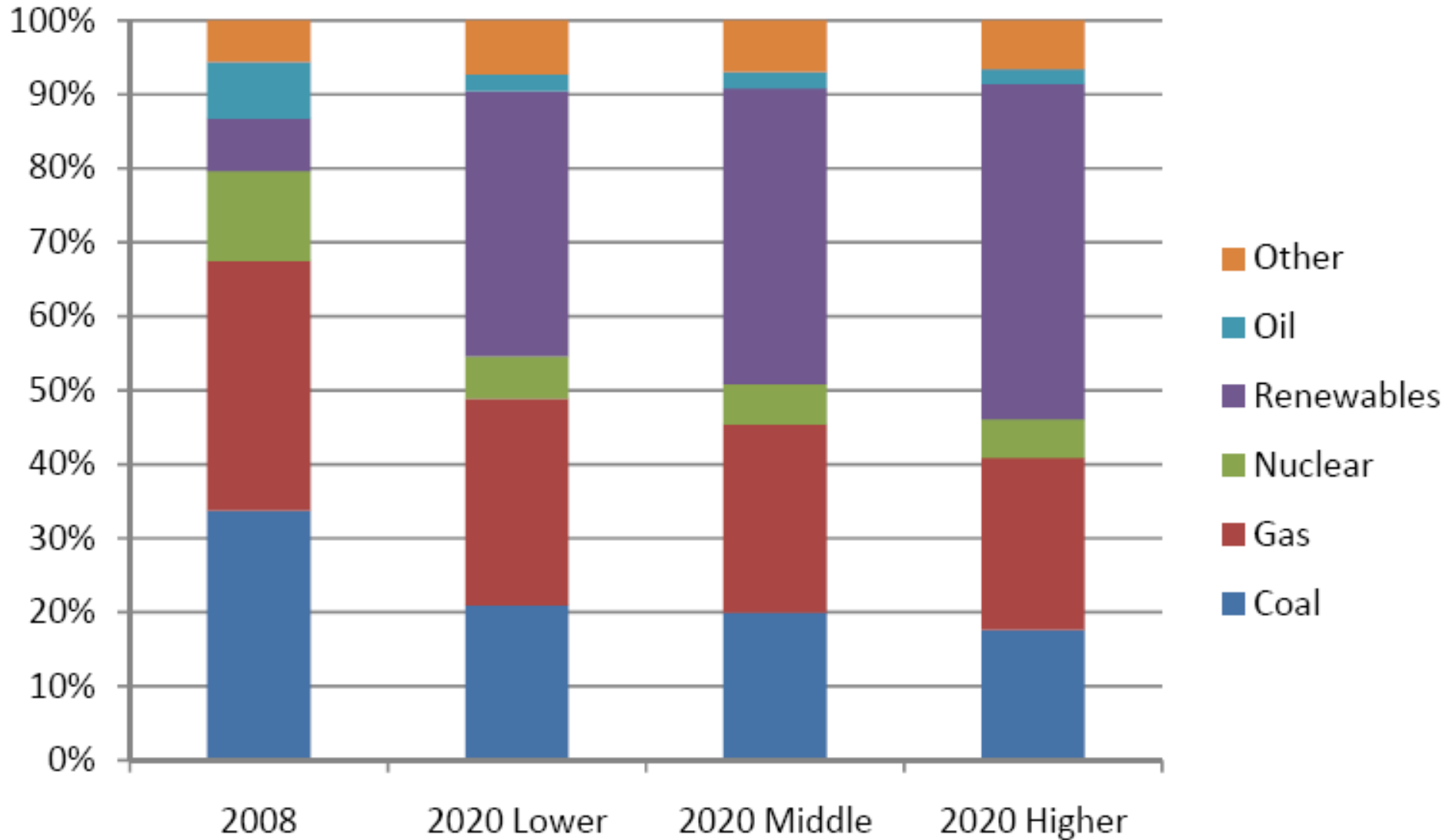
=> volatile supplies, prices, congestion, ....

- Offshore wind dependent on electricity price

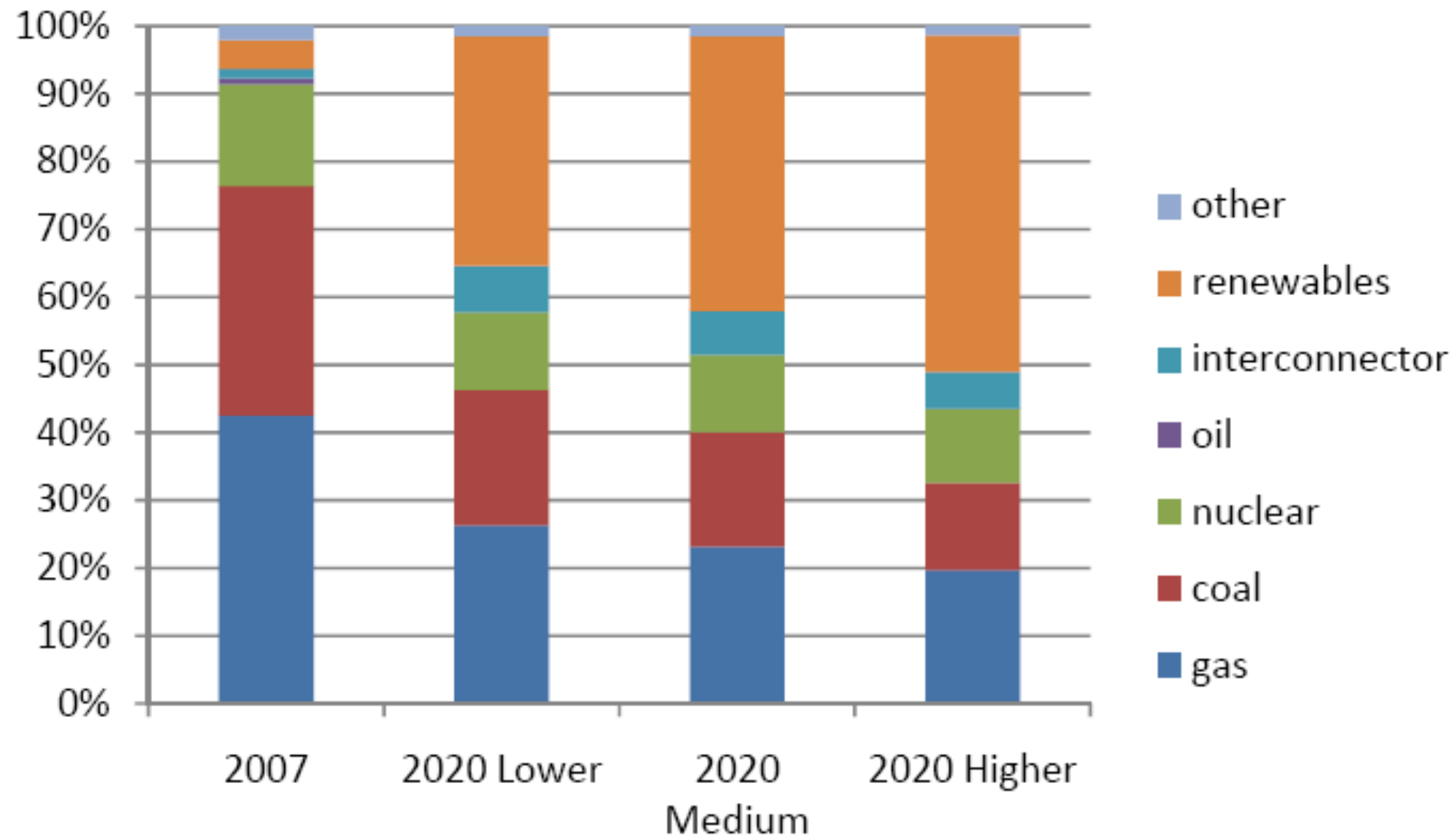
– now looks unfavourable even with banded ROCs

– FIT cheaper than HMG's banded ROCs (Redpoint)

# SKM's projected capacity mix



# SKM's projected output mix





# Implications of substantial wind

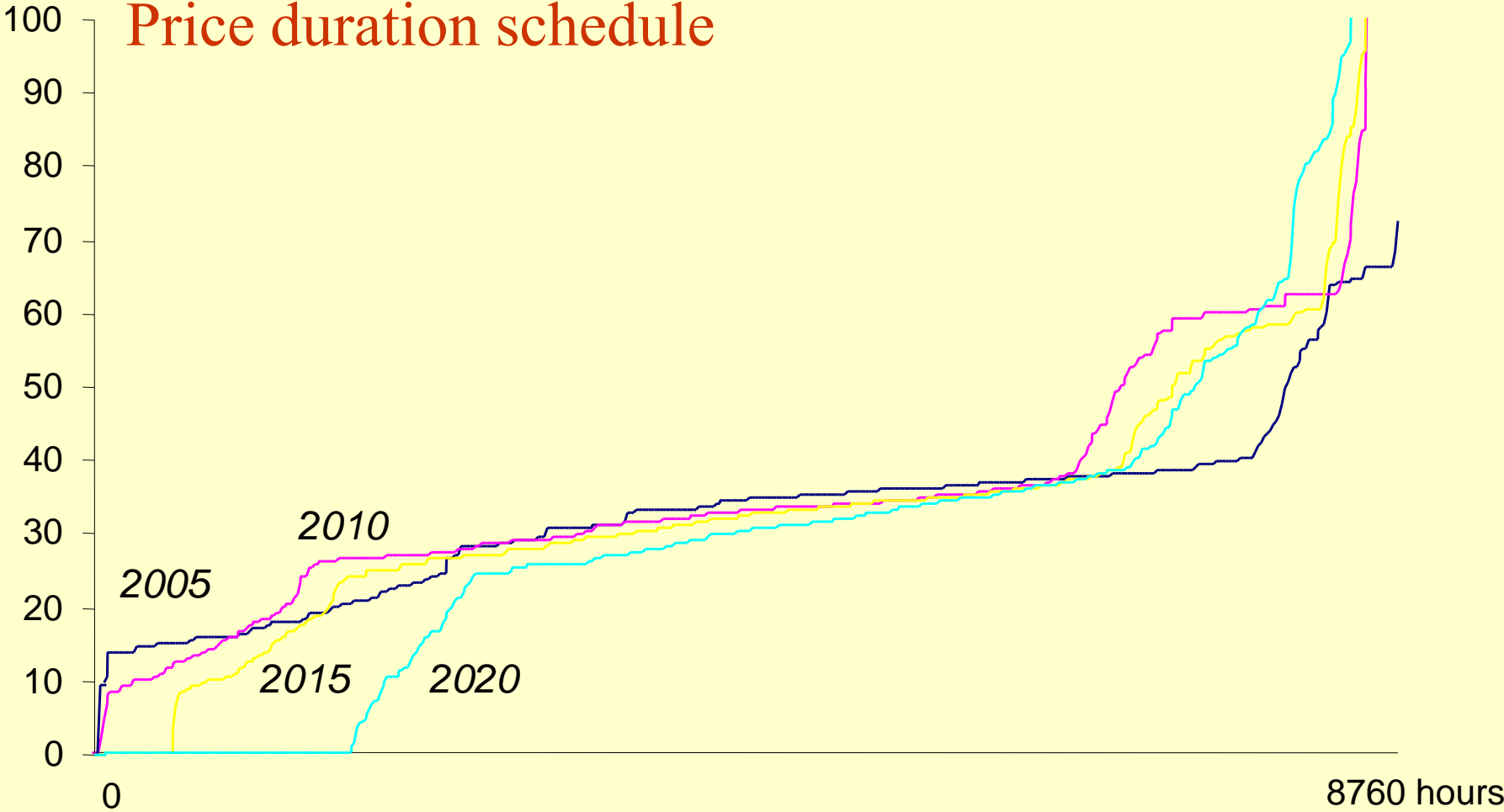
- Much greater price volatility
  - mitigated by nodal pricing in import zones
  - requires CfDs and nodal reference spot price
- Reserves (much larger) require remuneration
  - $VOLL * LOLP$  capacity payment?
  - or contracted ahead by SO?
  - Or will spot price volatility induce contracts that cover availability costs?

# Simulation – more volatility, harms baseload (nuclear)

Euro/MWh

*Illustrative*

## Price duration schedule



# 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?***

# 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

# Efficient congestion management

- Nodal pricing or LMP for optimal spatial dispatch
- All energy bids go to central operator
- Determines nodal clearing prices
  - reflect marginal losses with no transmission constraints
  - Otherwise nodal price = MC export (or MB of import)
- Bilateral energy contracts
  - Can submit firm bids => pay congestion rents
  - Can submit price responsive bids => more profit
- Financial transmission contracts hedge T price risk



# 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**
- choose any two of three?
  - Or minimise cost of achieving efficient level of security while meeting CO<sub>2</sub> and renewables objectives
- Currently costs all levied on consumers
  - and excessive because of ROCs etc

***Creates additional policy uncertainty***

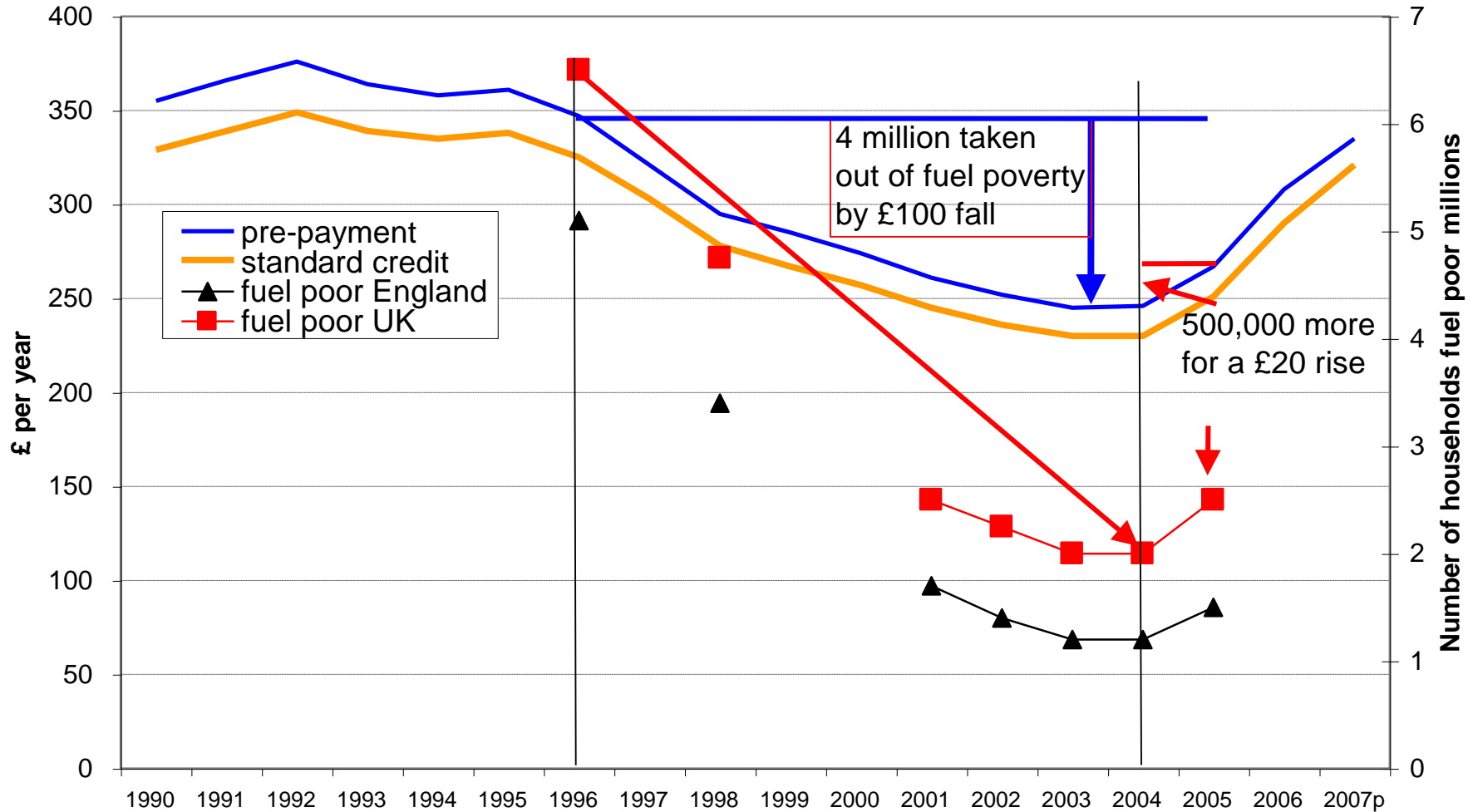
# Costs of renewables (Ofgem)

- 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***

# British fuel poverty

## Annual average domestic standard electricity bill



# Support for RD&D

- Renewables subsidy above C price justified by learning benefits => commercialise to save the planet
- Why charge electricity consumers for that?
  - VAT on energy better but still inefficient
  - except to correct energy subsidies

***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
- Efficient decisions require either Single Buyer or nodal pricing + pool/SO control
- both require transition arrangements/contracts
  - for new/old Generation



## 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*

# Conclusions - 3

- Carbon pricing: ETS needs CfDs
  - or a central carbon bank to stabilise EUA price
- RD&D support needed to lower costs
  - to commercialise in BRICs etc
- needs design driven by **learning objective**
  - burden sharing via country targets helps
  - but emphasises least cost not most learning
  - support should be from public expenditure



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# Acronyms

CCS: carbon capture and sequestration

CEC: European Commission

CfD: contract for difference

EUA: European emission allowance (for 1 tonne CO<sub>2</sub>)

FIT: feed-in tariff

GHG: greenhouse gas

G: generation

LCPD: large combustion plant directive

LMP: locational marginal pricing

MC, MB: marginal cost, marginal benefit

PV: photo-voltaic

# Acronyms

RES: renewable electricity supply

ROC: renewable obligation certificate

SO: System operator

T: transmission

TEC: transmission entry capacity (to access grid)

TSO: transmission system operator