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E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Market design and support policies for a low carbon electricity future

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Global CO_2 economics

Sønderborg, Denmark 18-19 August 2009

http://www.electricitypolicy.org.uk

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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

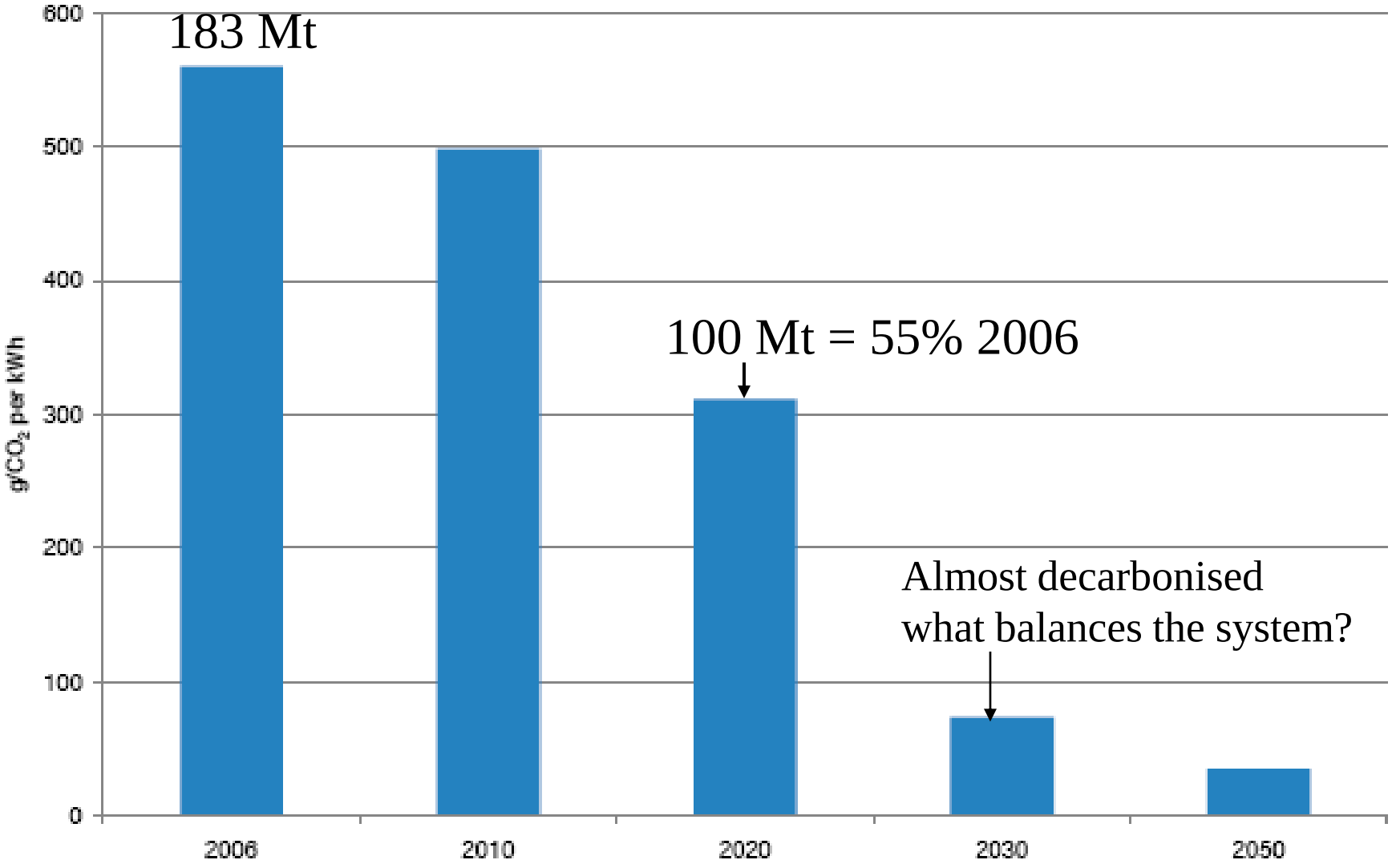
Why low-C electricity?

- 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_2 intensity per kWh of electricity generated, 2006-2050



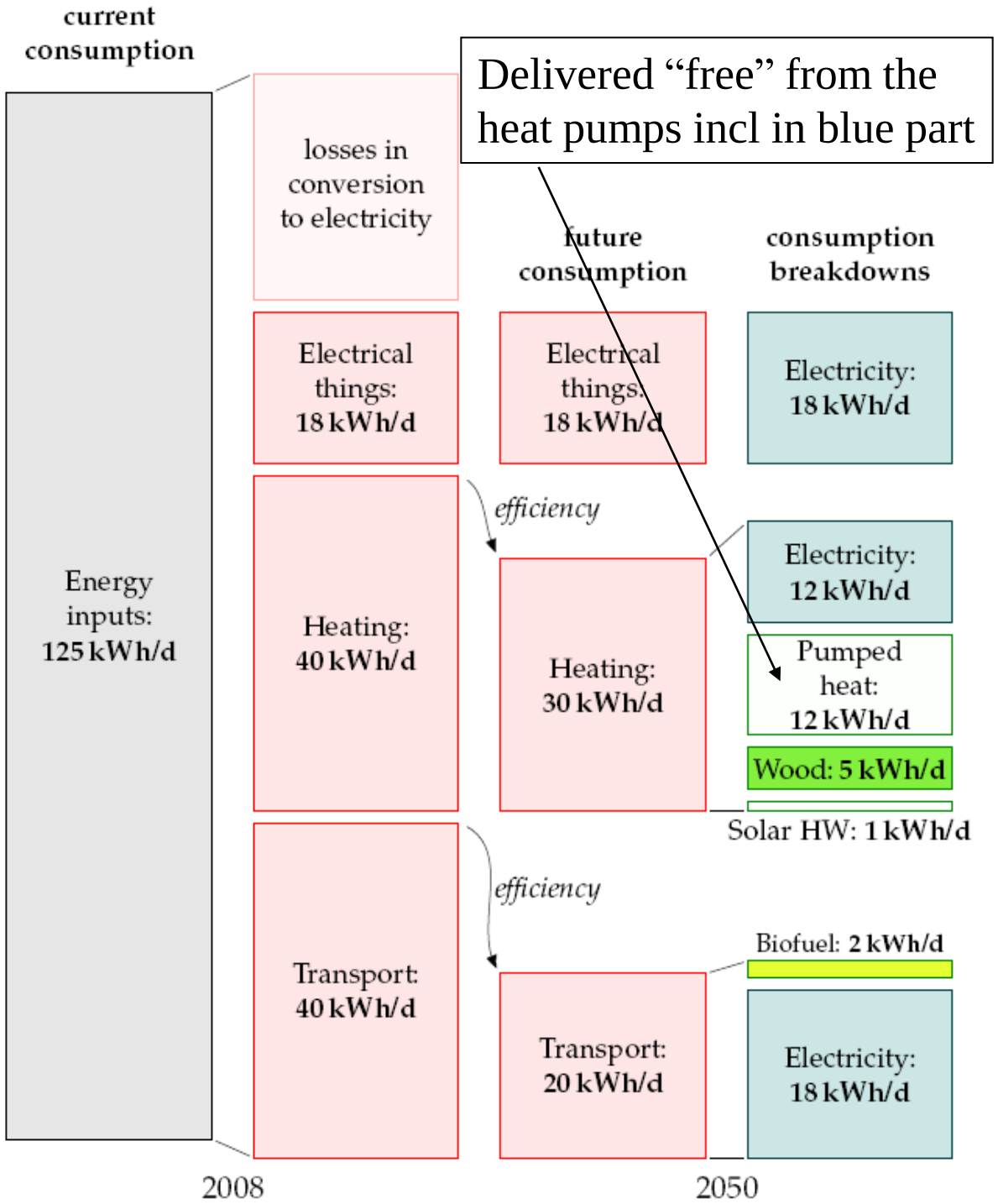
Source: CCC

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

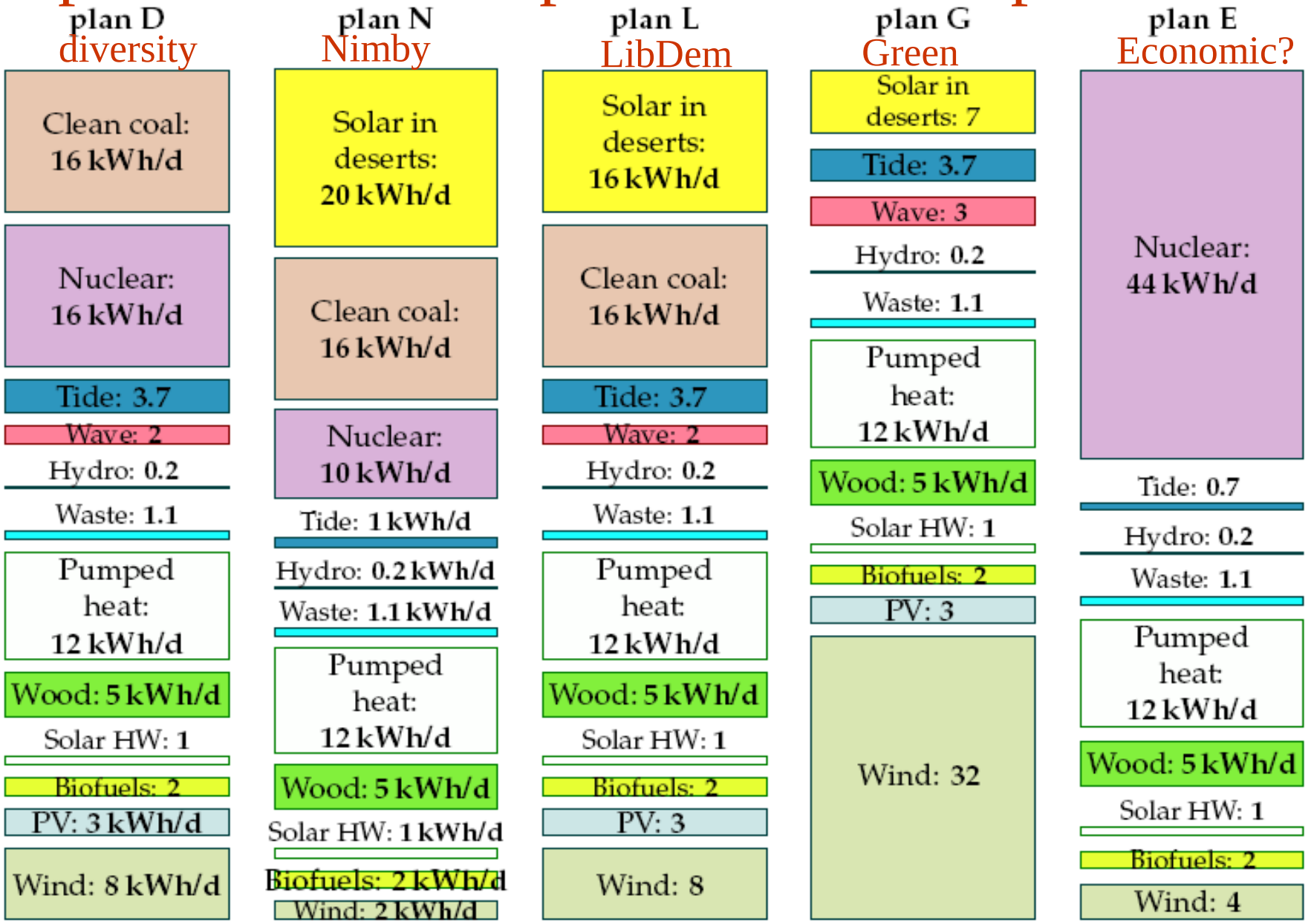
- Hydro: limited EU resources (but pump storage)
- Nuclear: e.g. France post oil shock
- Wind: costs falling, but other challenges
- Wave/tidal: costly
- Biomass: more efficient for heat raising?
- CCS: moderately mature but expensive
- Solar PV: too expensive? Could become cheaper?
- Solar Concentrated 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

http://www.withouthotair.com/

5 plans "that add up" for 50kWh/d/p electricity



http://www.withouthotair.com/

“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

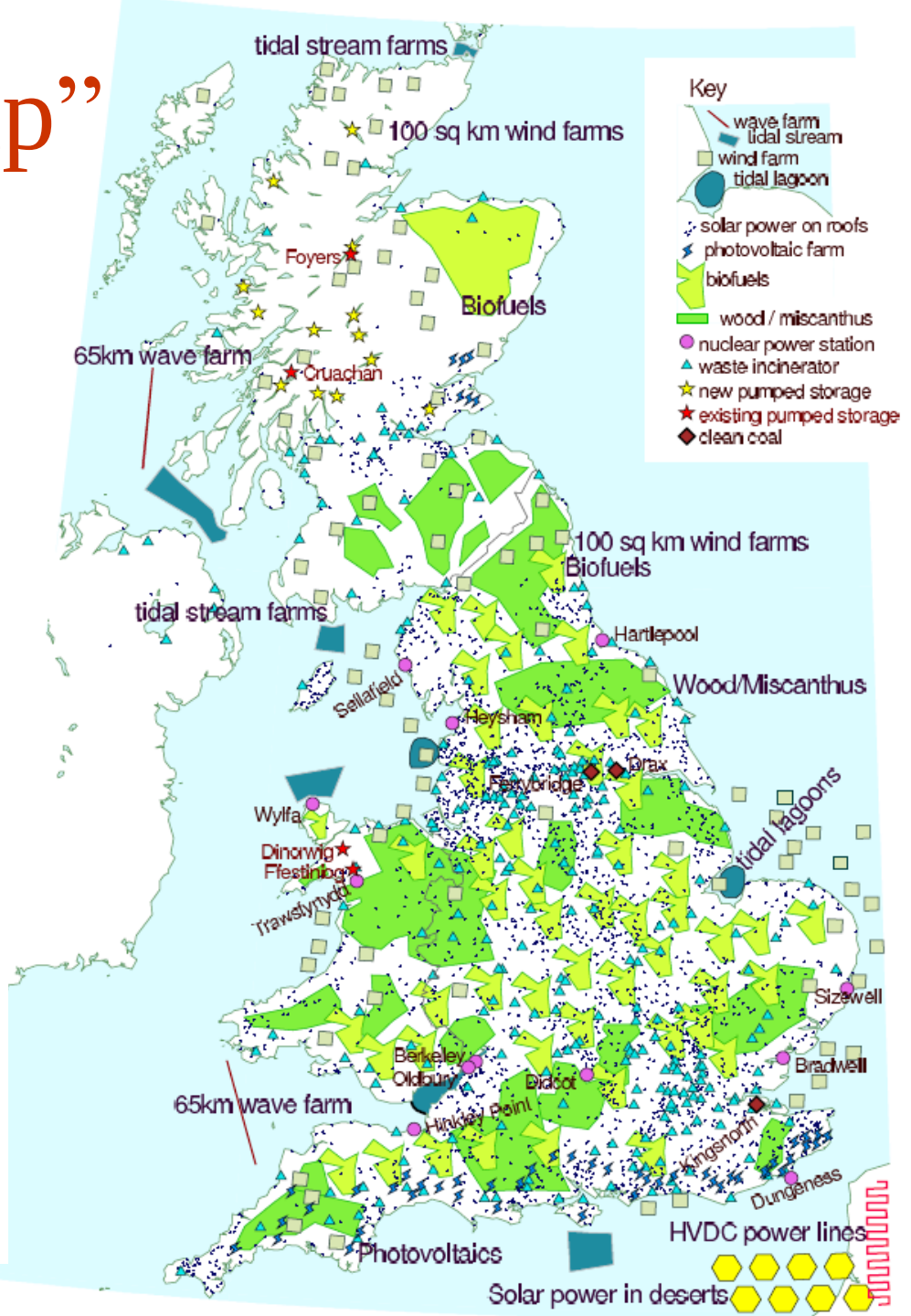
Wood: 5 kWh/d

Solar HW: 1

Biofuels: 2

PV: 2

Wind: 8



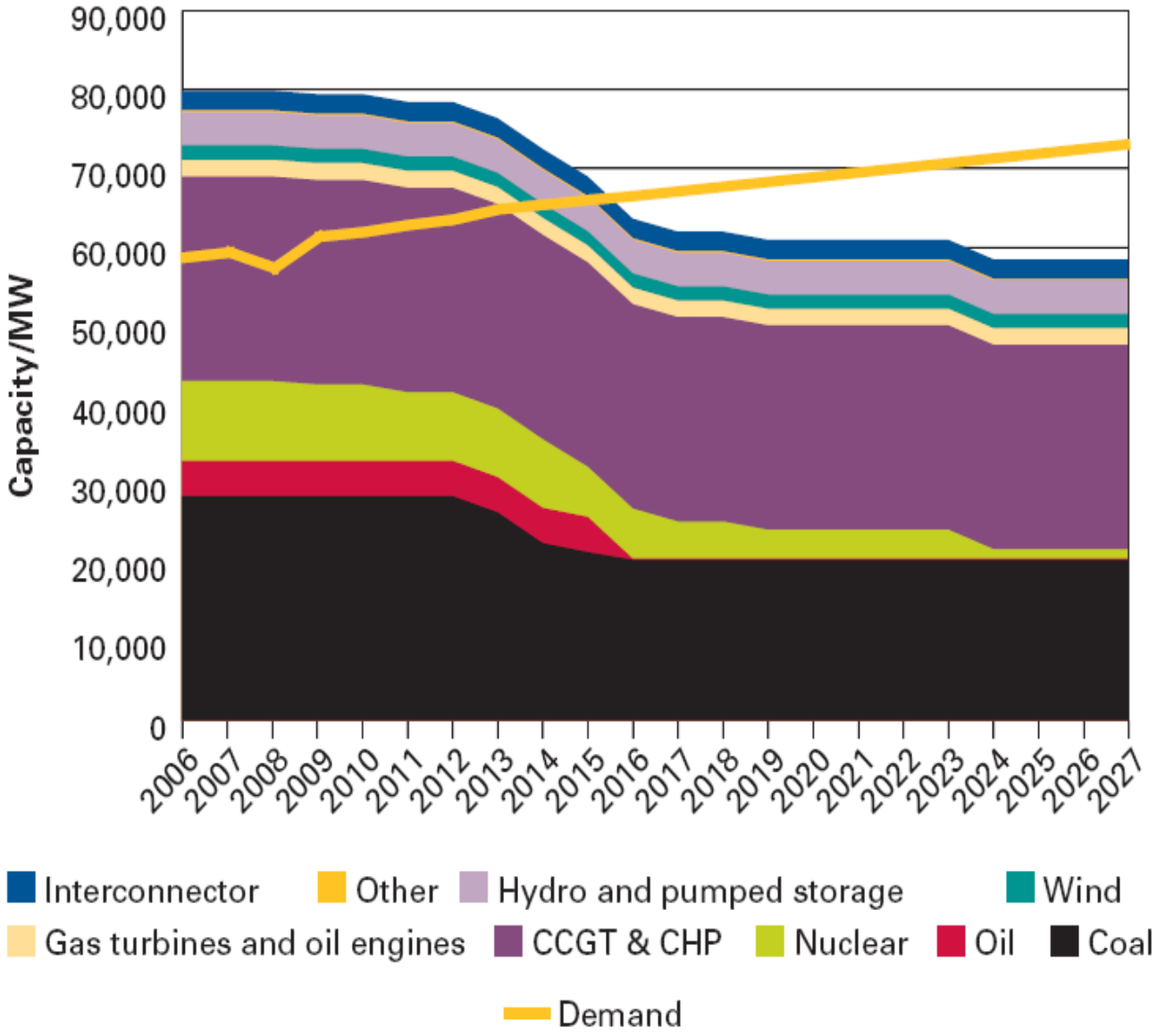
http://www.withouthotair.com/

Investment in liberalised markets

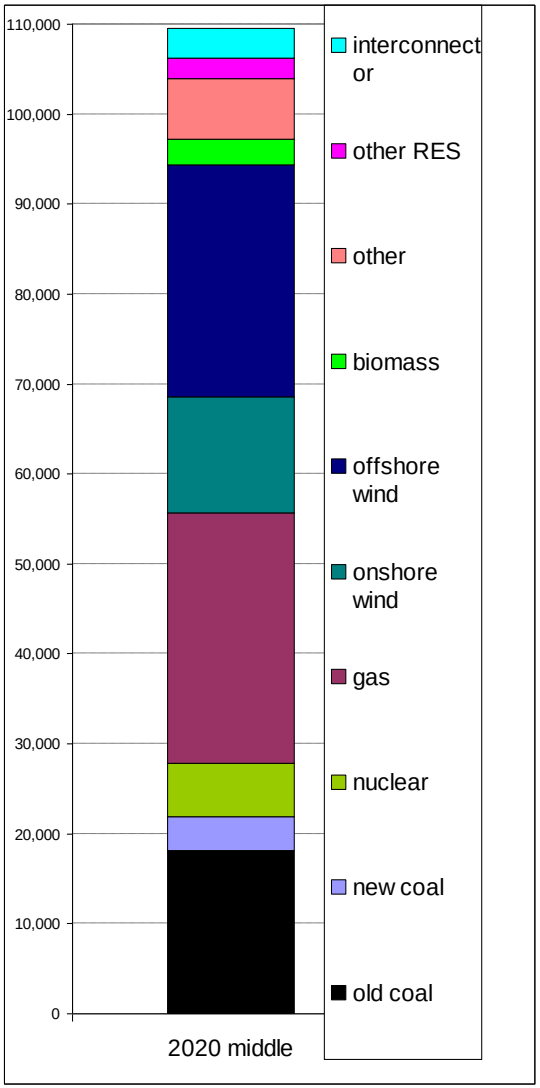
- CEC presses for single electricity market
  - based on market principles
  - with substantially more interconnection
- Capacity margins projected to fall 2016 with LCPD => investment needed
- Transmission investment needed
  - for wind, interconnection

What are the risks facing investors?

Development of existing GB gen cap



Source: Digest of UK Energy Statistics/DECC



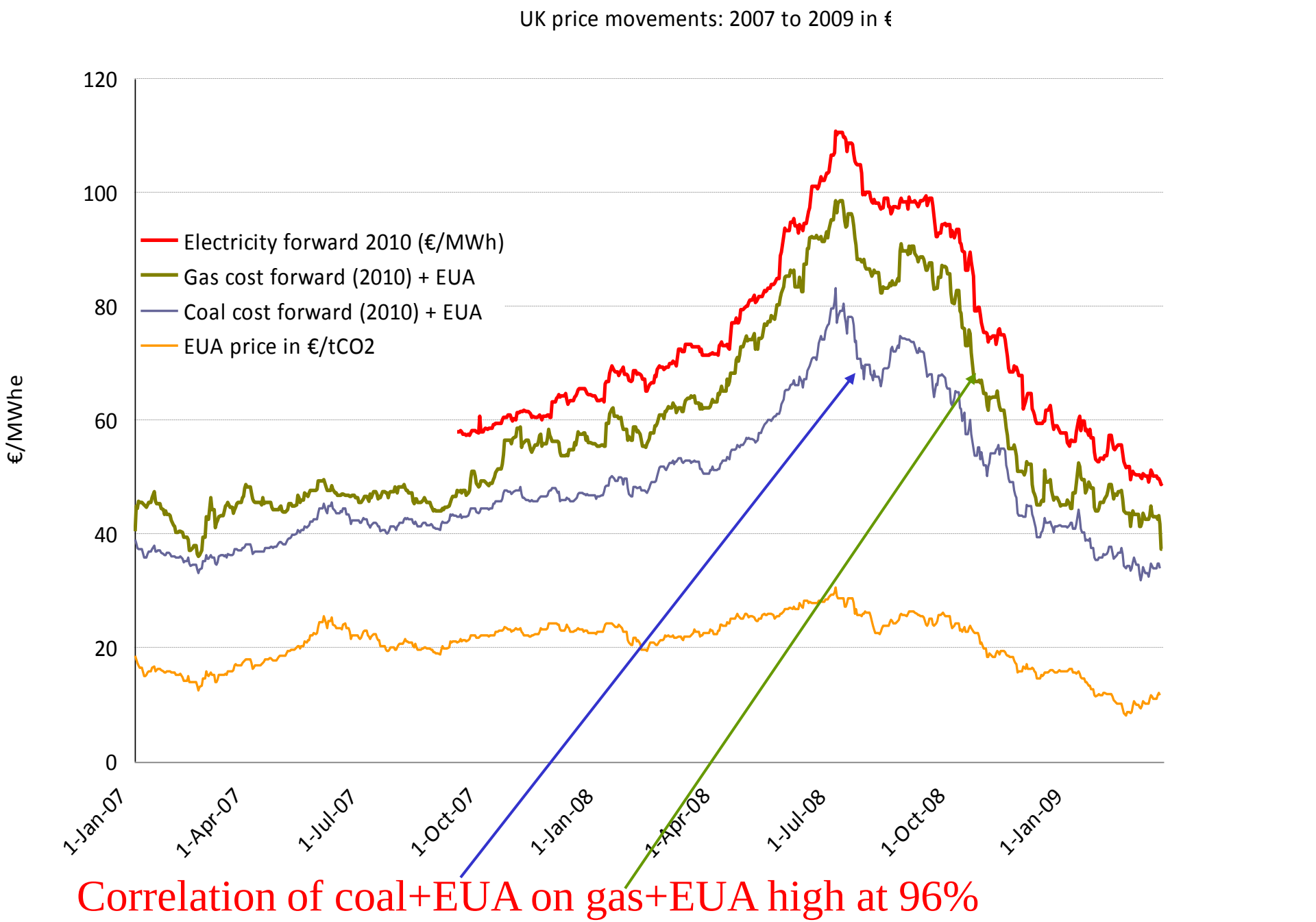
SKM's mid-scenario projection

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 <u>costs</u> move together


UK price movements: 2007 to 2009 in €
120
100
80
60
40
20
0
€/MWhe
Electricity forward 2010 (€/MWh)
Gas cost forward (2010) + EUA
Coal cost forward (2010) + EUA
EUA price in €/tCO2
1-Jan-07
1-Apr-07
1-Jul-07
1-Oct-07
1-Jan-08
1-Apr-08
1-Jul-08
1-Oct-08
1-Jan-09
Correlation of coal+EUA on gas+EUA high at 96%

EUA price 25 October 2004-7 August 2009

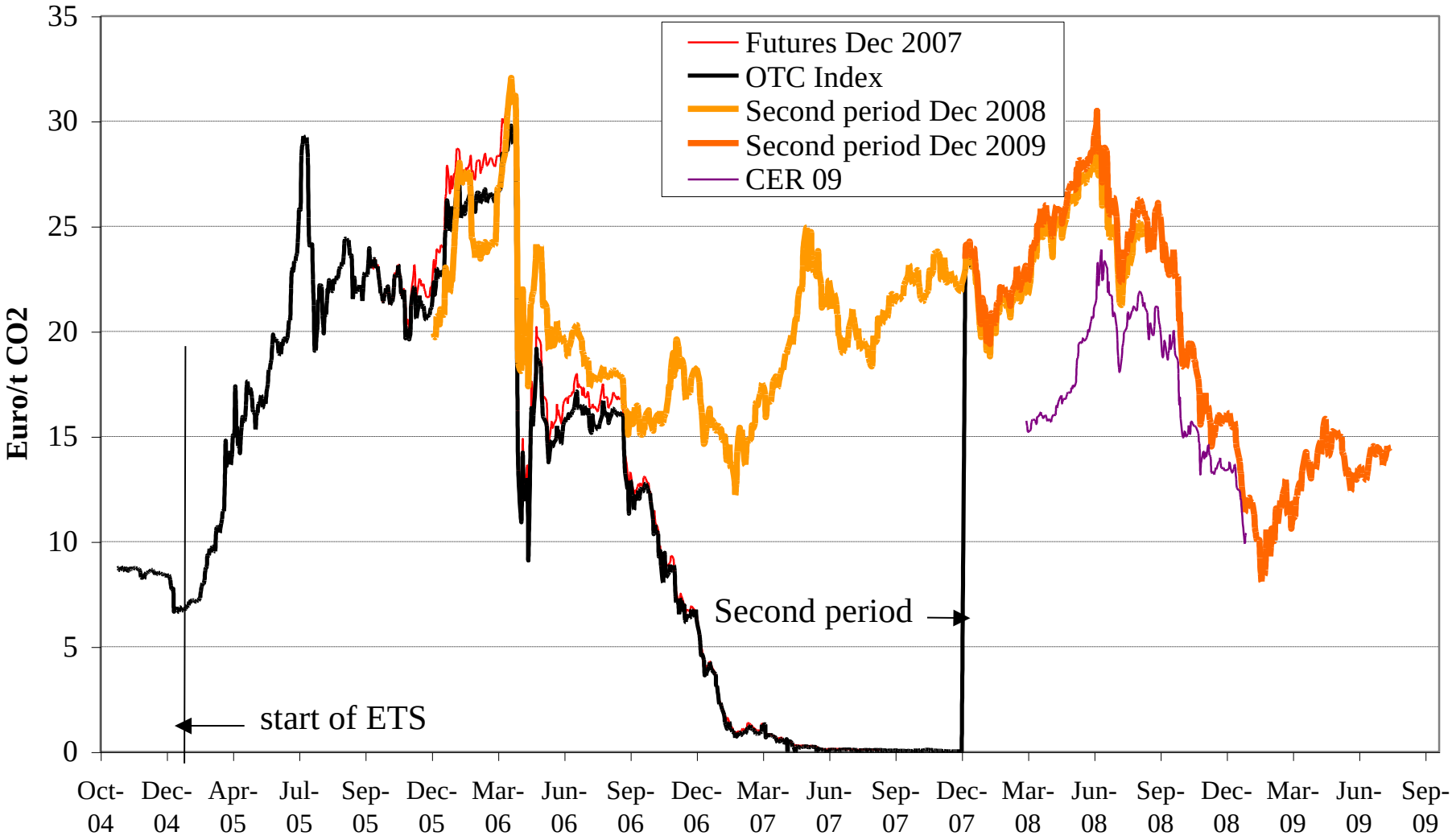


Table 7.6 Lifetime levelised costs of plant added by 2020 (£/MWh)

		2020 Renewable Scenarios		
Technology	Conventional	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

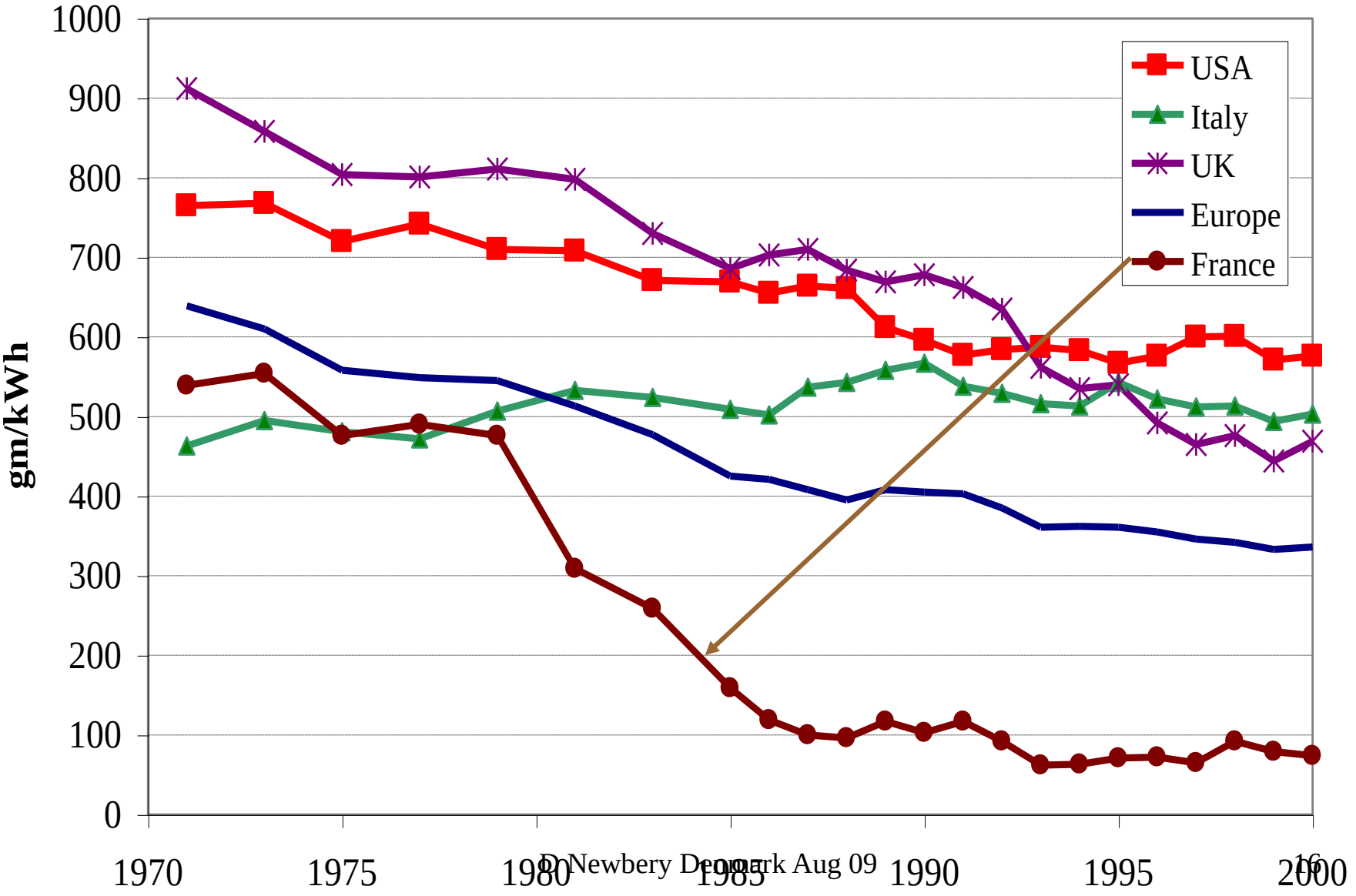
*Before any ROC subsidy, currently around £40-45/MWh

Source: SKM
BERR URN 08/1021

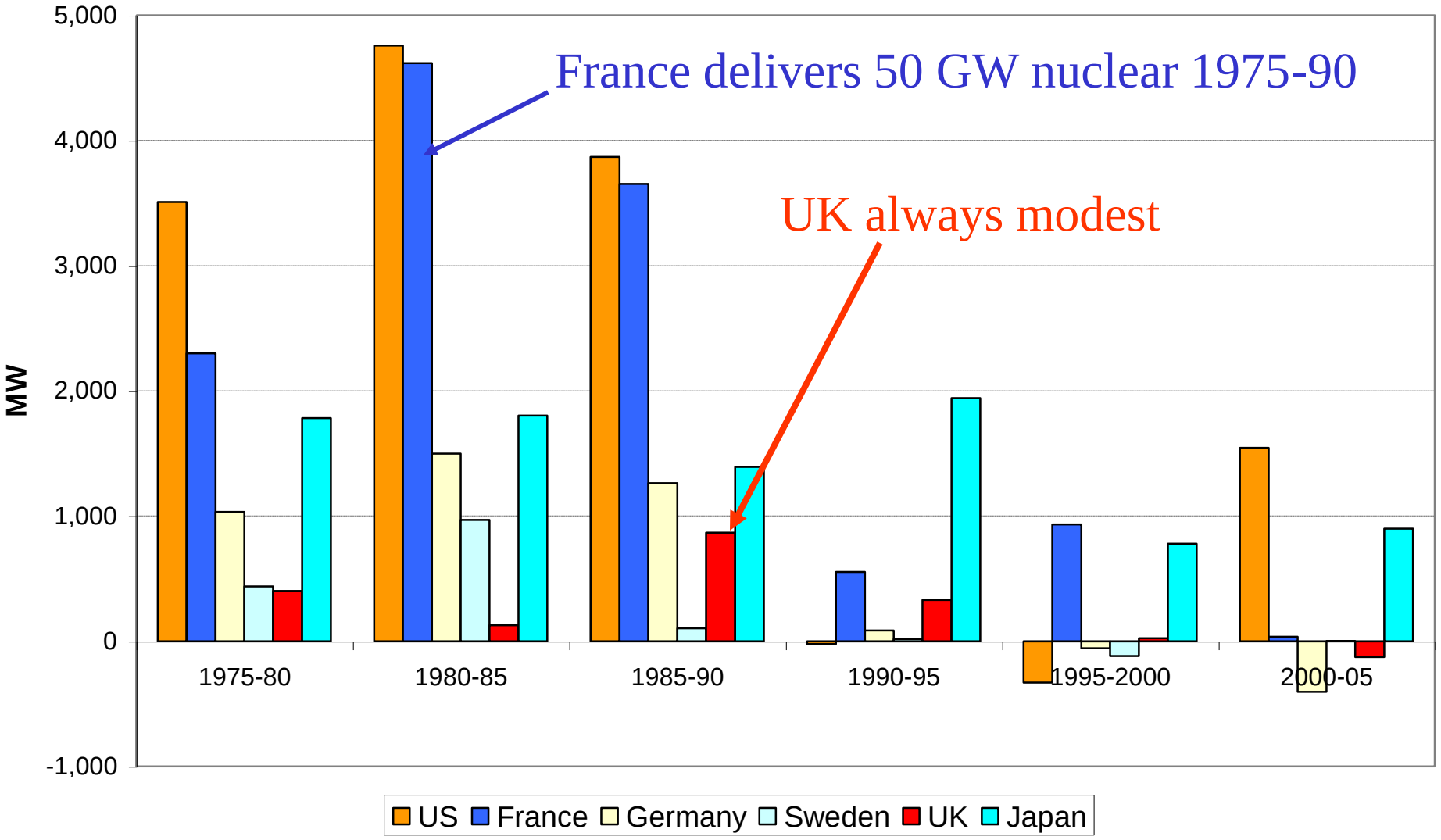
Table 7.2 2020 Price assumptions

Type	Price
Gas (p/therm)	55
Coal ($/te)	110
Oil ($/barrel)	85
Biomass fuel (£/GJ)	3.6
Carbon permit (€/te CO2)	30

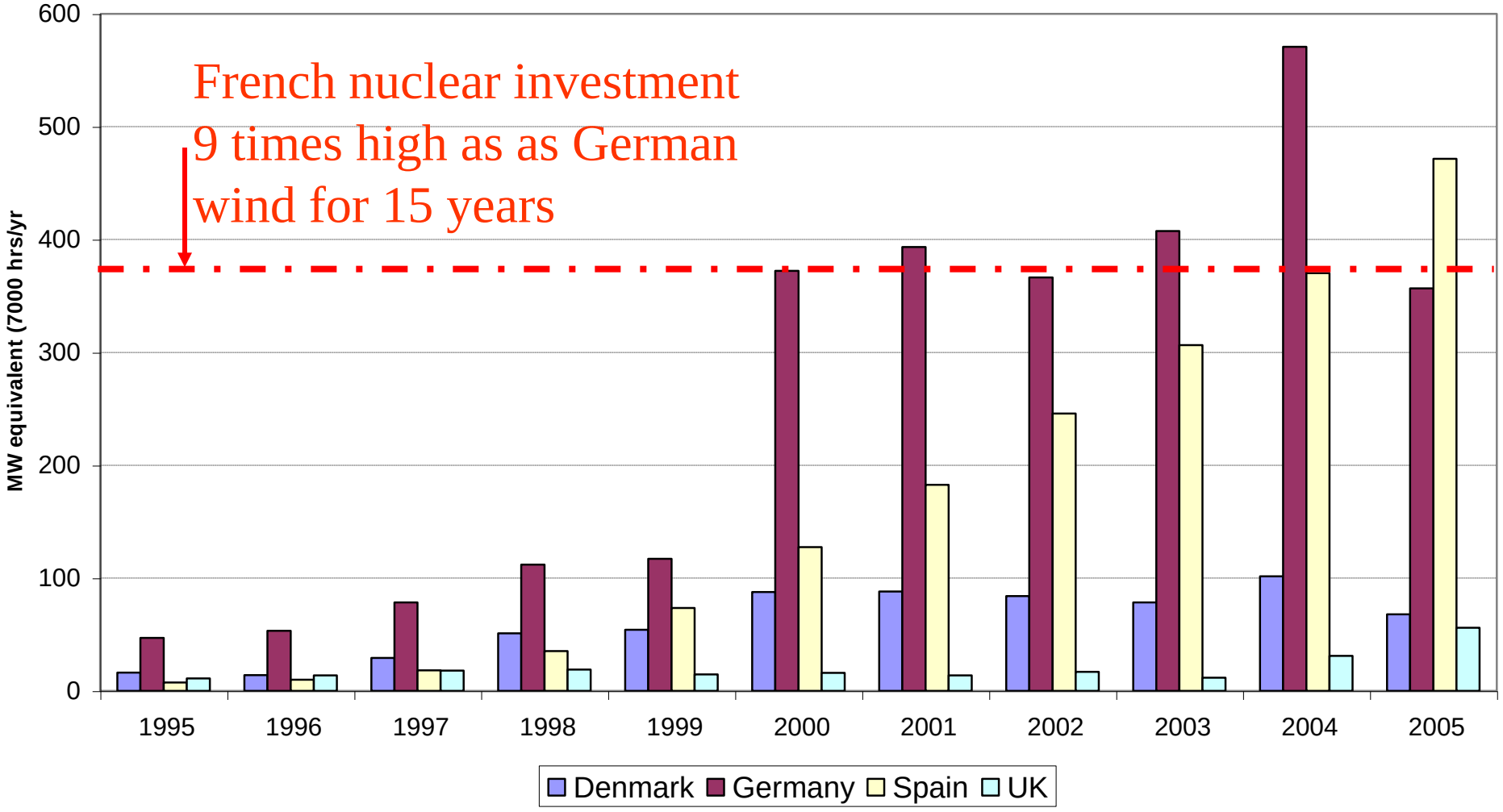
CO2 emissions per kWh 1971-2000



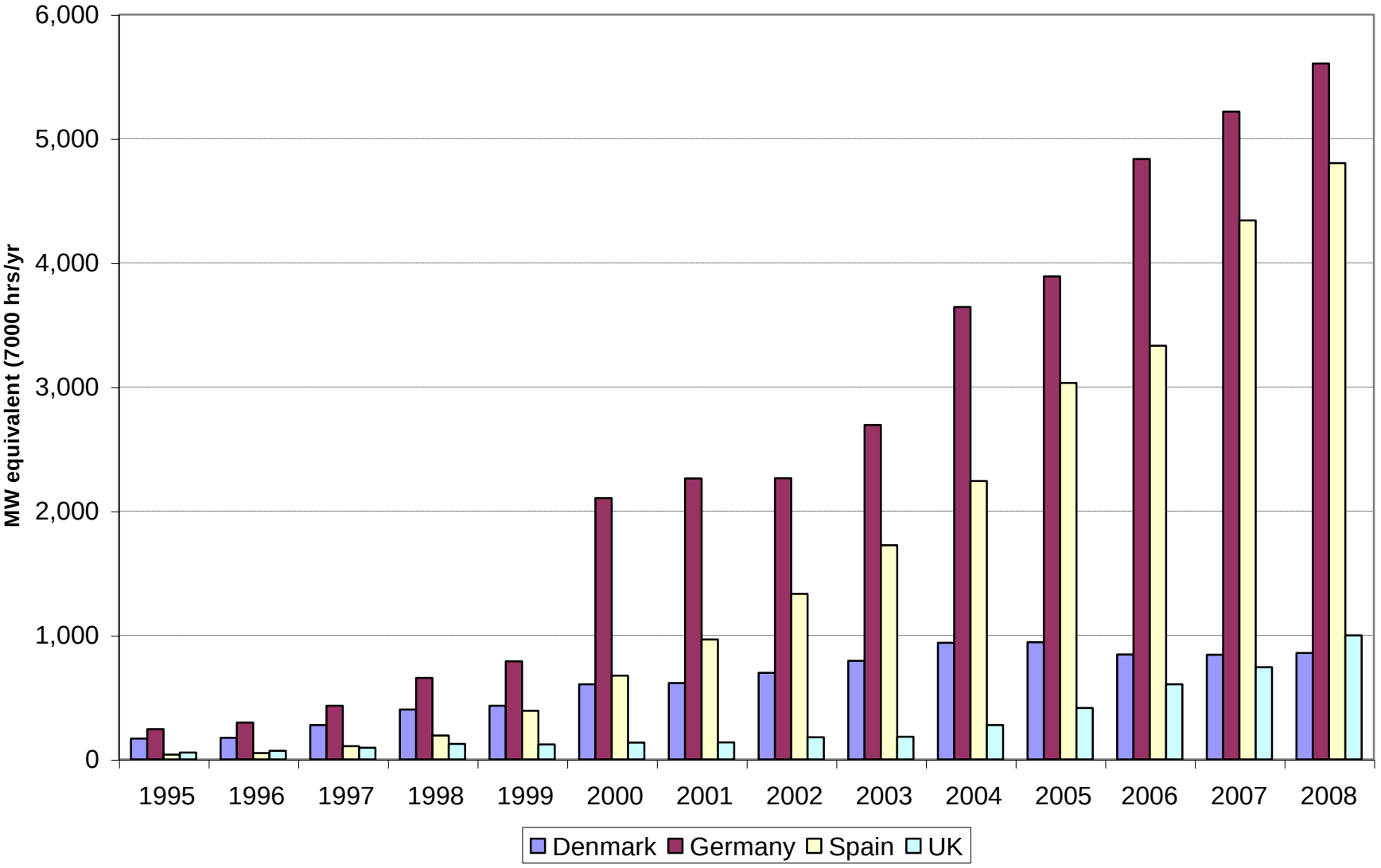
Average annual increment to nuclear capacity



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

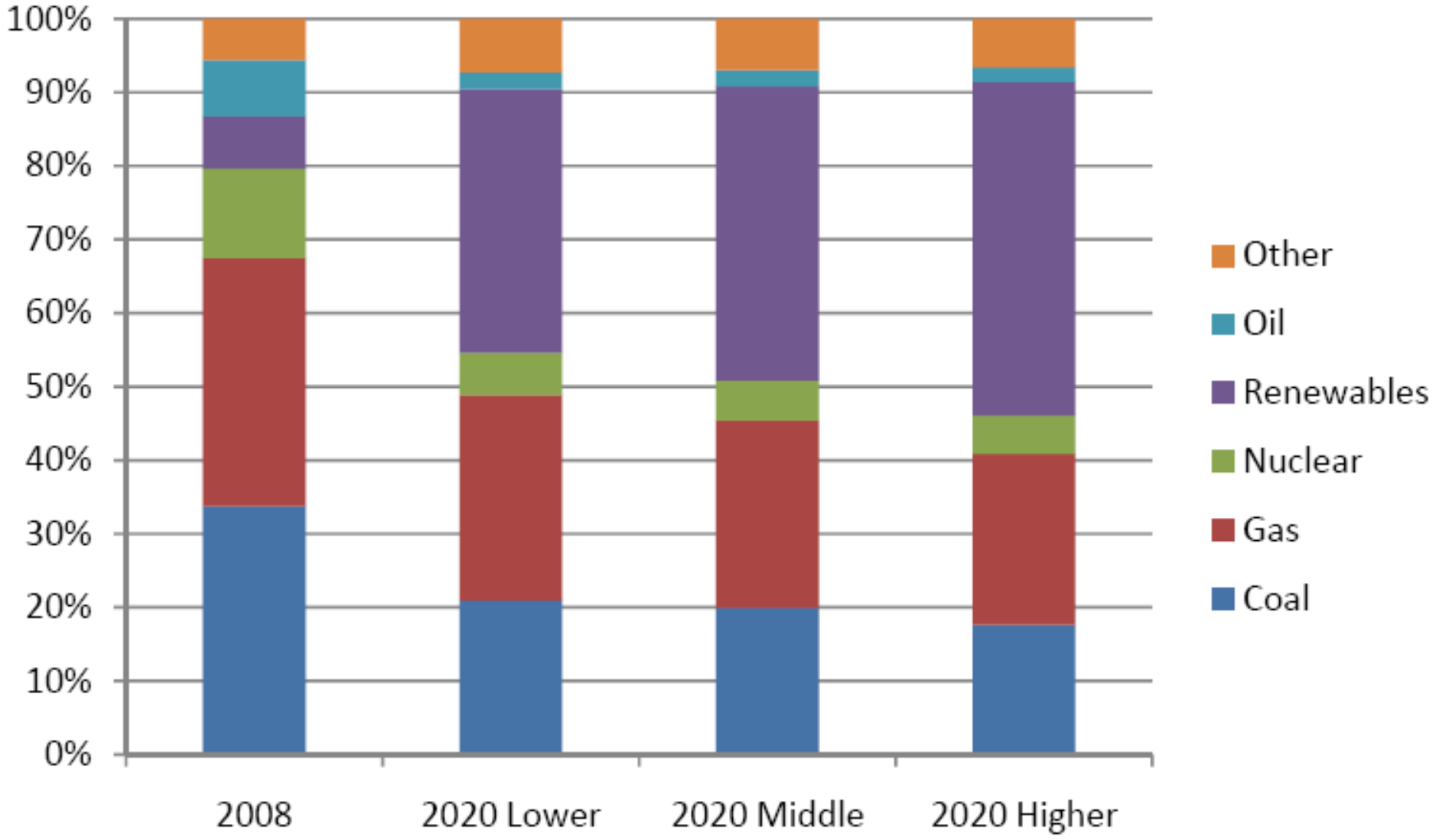
- 56 GW conventional @ 31% fossil fuel load factor
- investment cost of renewables = €70 bn + €15 bn grid
- of non-renewables = £12 b, (£coal=3.9b; nuclear = £3.9b)

= €95/t CO_2 c.f. €14/t current EUA

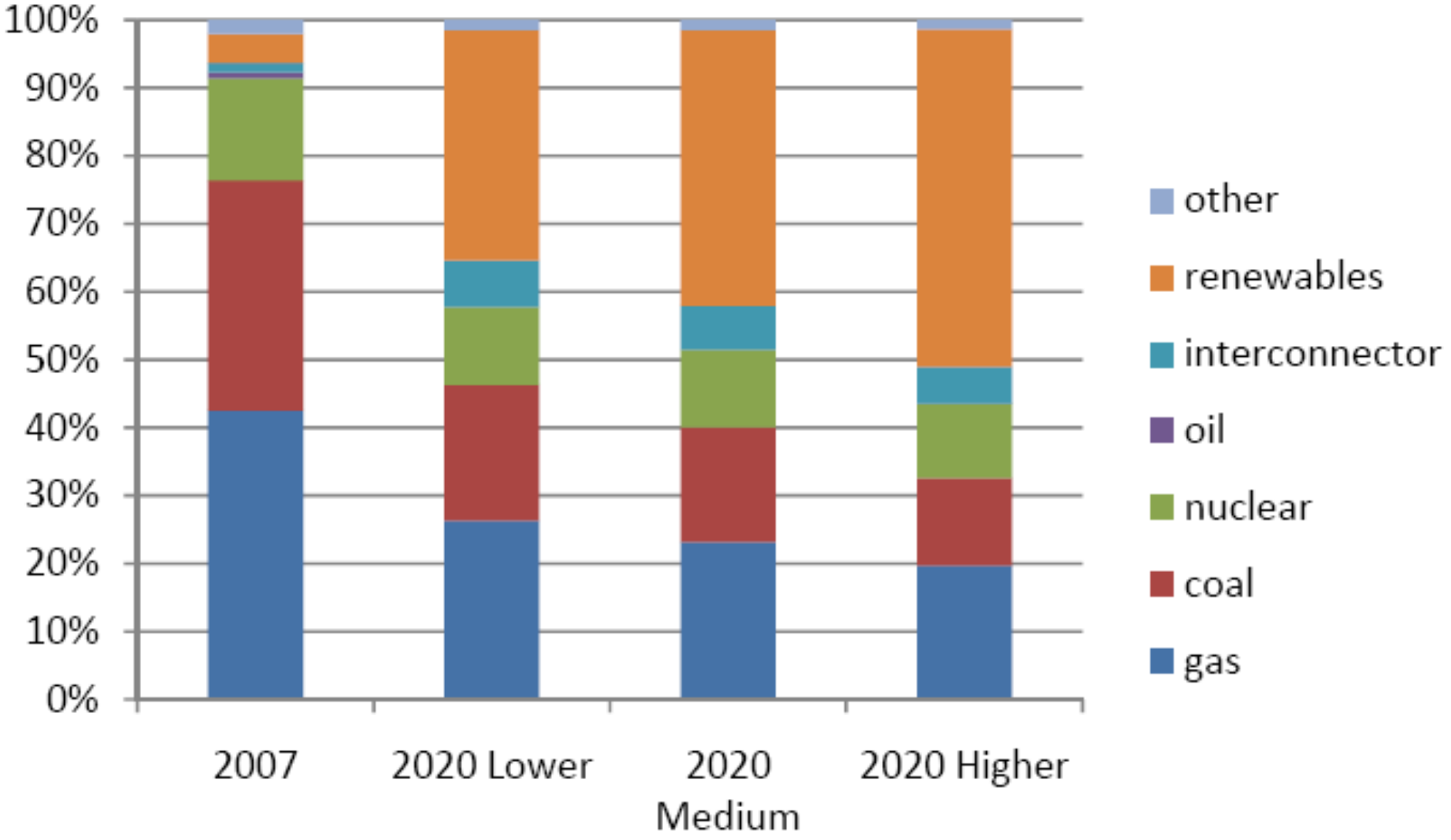
- 38 GW> demand for many hours

  => 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



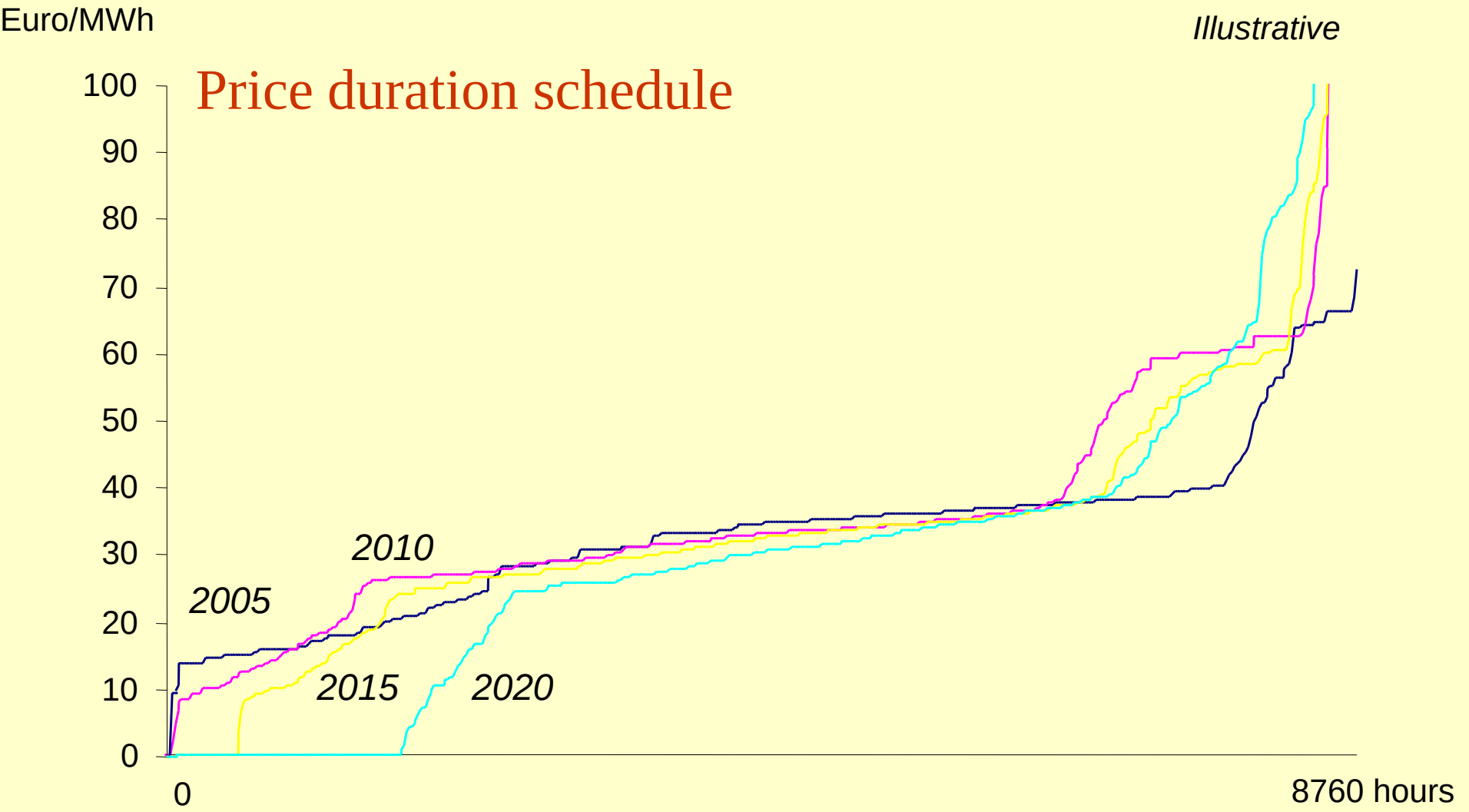
SKM's projected output mix



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)



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_2 and renewables objectives
- Currently costs all levied on consumers
  - and excessive because of ROCs etc

Creates additional policy uncertainty

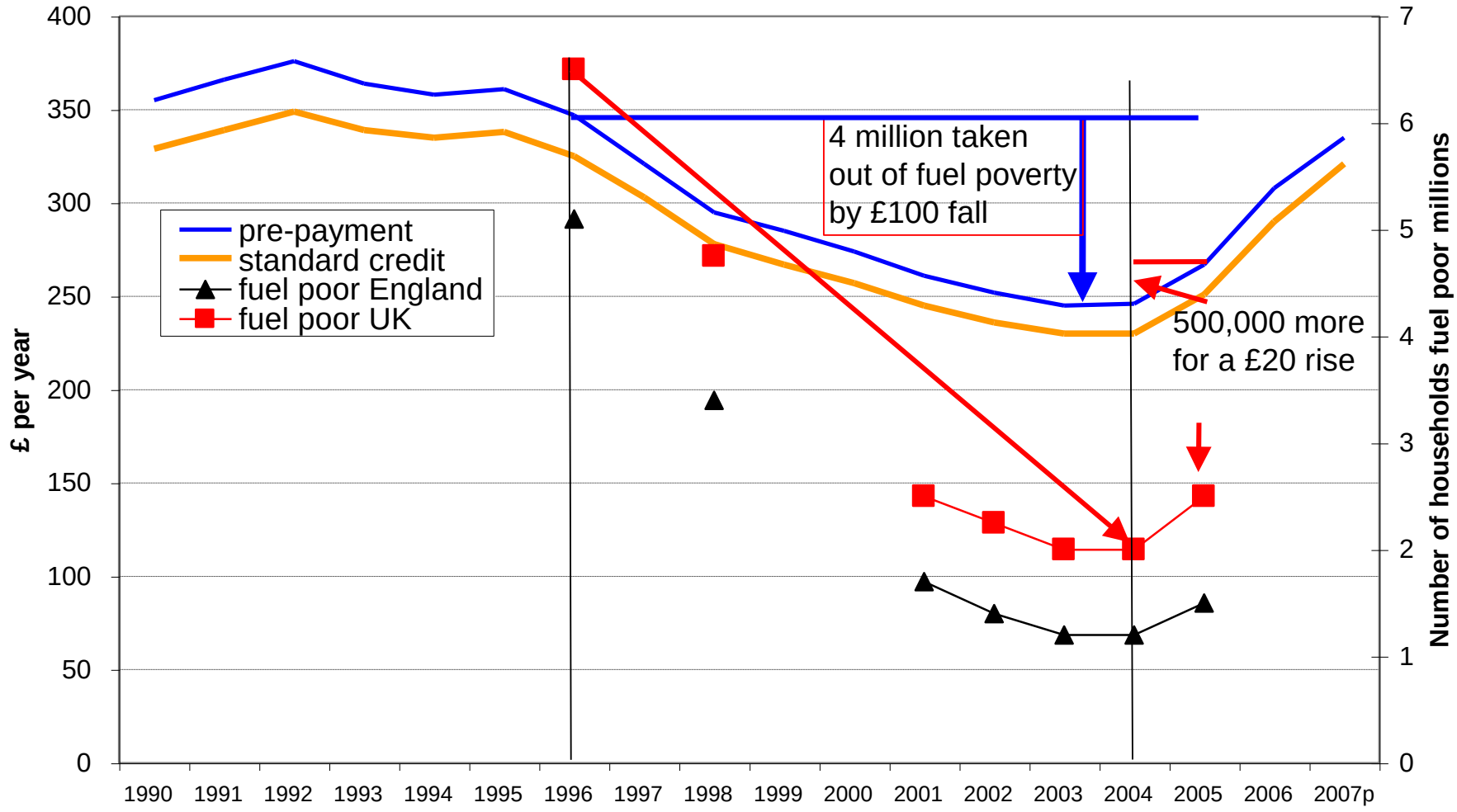
Costs of renewables (Ofgem)

- 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 emphases 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_2)

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