UNIVERSITY OF CAMBRIDGE | Electricity Policy Research Group

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

Adapting energy markets to a low-carbon future

David Newbery

12th ACCC Regulatory Conference

Brisbane 28th July 2011

http://www.eprg.group.cam.ac. uk

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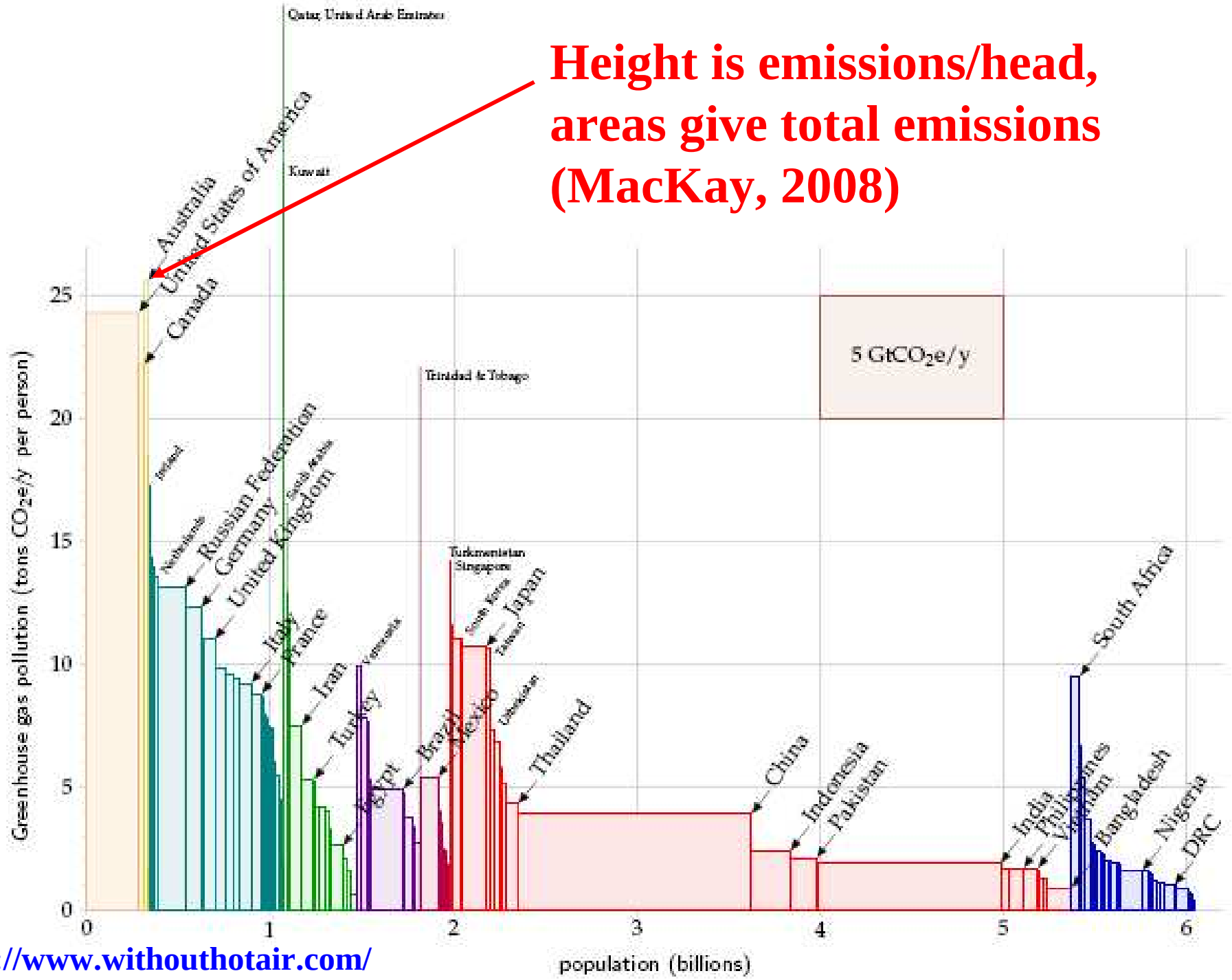
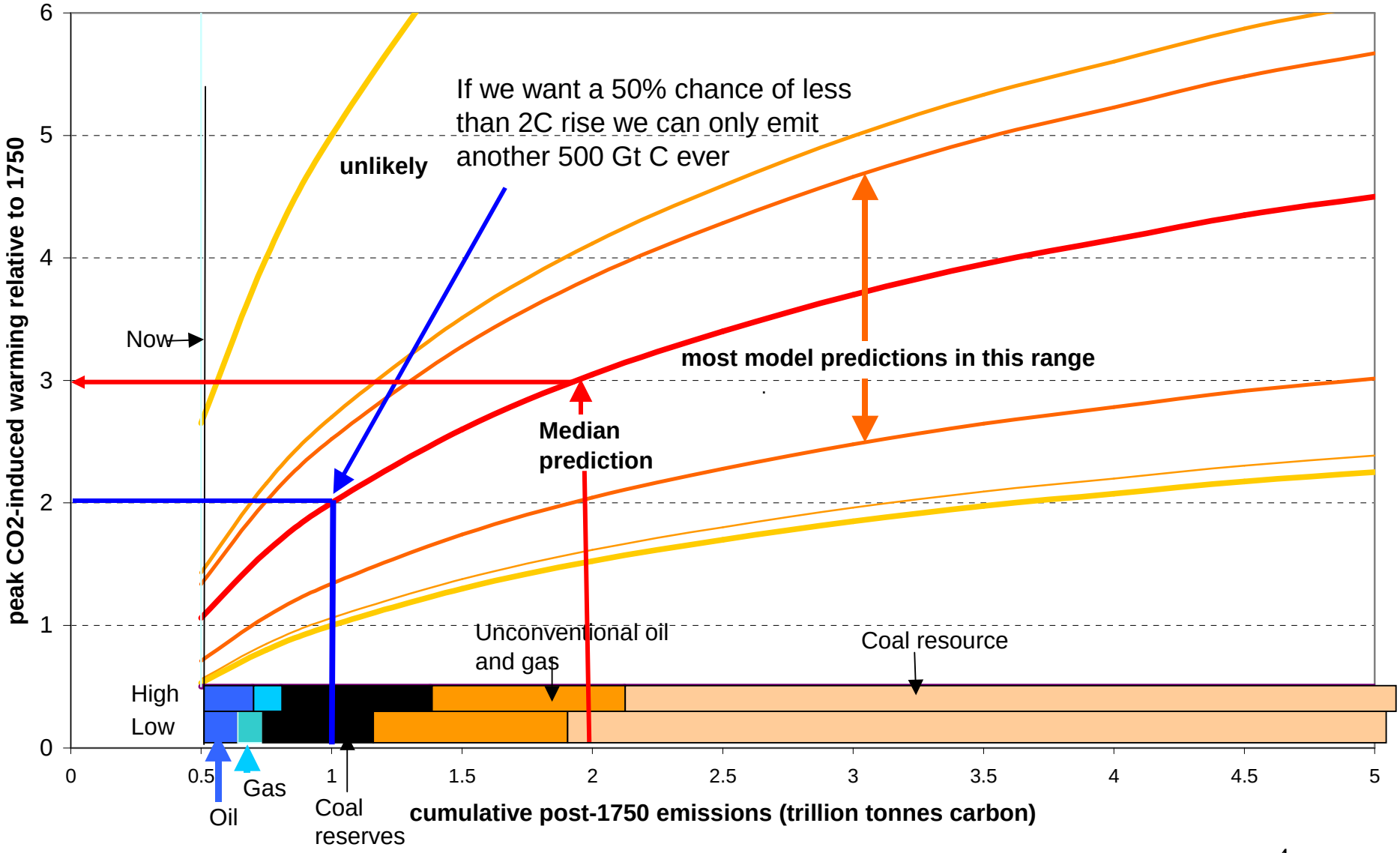
Outline

- The Challenge: climate change
- What is needed to deliver low-C electricity?
  - What is wrong with carbon trading as in ETS?
- Delivering low-C at reasonable cost
  - Contracts to lower cost of capital
  - address carbon pricing
  - care in designing renewables support
- UK's Electricity Market Reform and Ofgem's Low Carbon Network Fund



http://www.withouthotair.com/

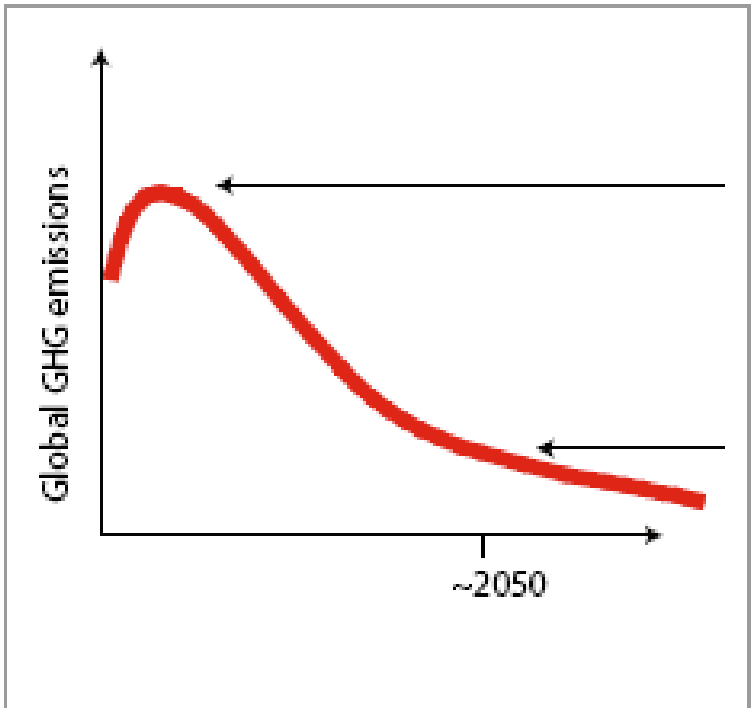
Peak CO_2-warming vs cumulative emissions 1750–2500



After MR Allen *et al. Nature* **458**, 1163-1166 (2009) doi:10.1038/nature08019

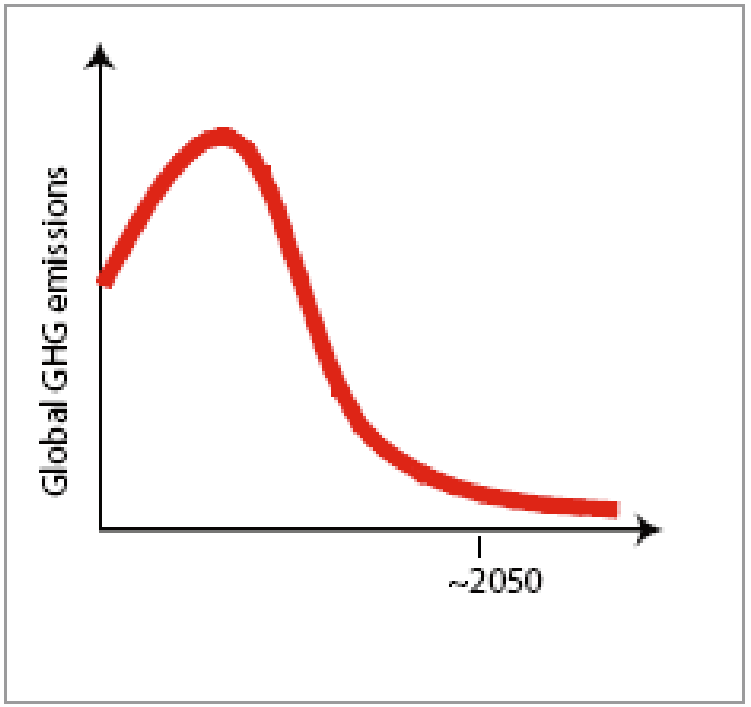
nature

Total cumulative emissions determines global warming



Lower peak

Gradual reduction after peak



Higher / later peak

Faster reduction after peak

- Delaying peak requires a faster subsequent decline
- peak should be before 2020

Source: ENEP Emissions Gap Report 2010

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Policies to mitigate climate change

- GHG emissions are a global stock public bad
  - uncertain distant damage with uneven impacts
    => very hard to agree coordinated policies
  - damage regardless of emissions location, persistent
    => damage moderately independent of date of emission
  - much irreversible over historical time scales
- Solution: uniform charge for GHG emissions,
  - rising at discount rate: Australia has right approach
  - reset in light of new information

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Failures of EU emissions trading

- Current ETS sets quota of total EU emissions
  - Weitzman argues for tax/charge not quota
- EU Renewables Directive increases RES

  => increased RES does not reduce CO_2

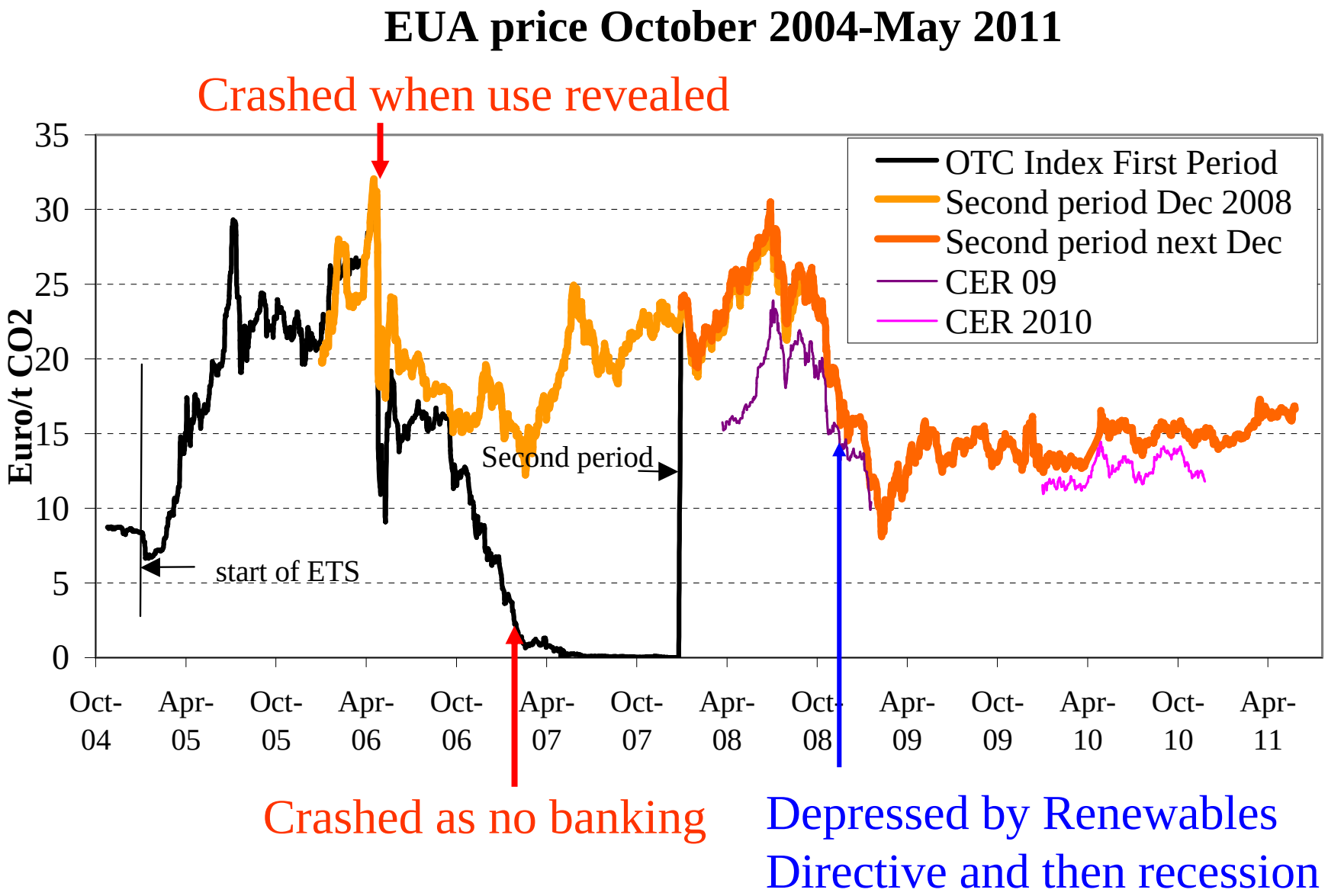
  => reduces price of EUA

  => prejudices other low-C generation like nuclear
- Risks undermining support for RES

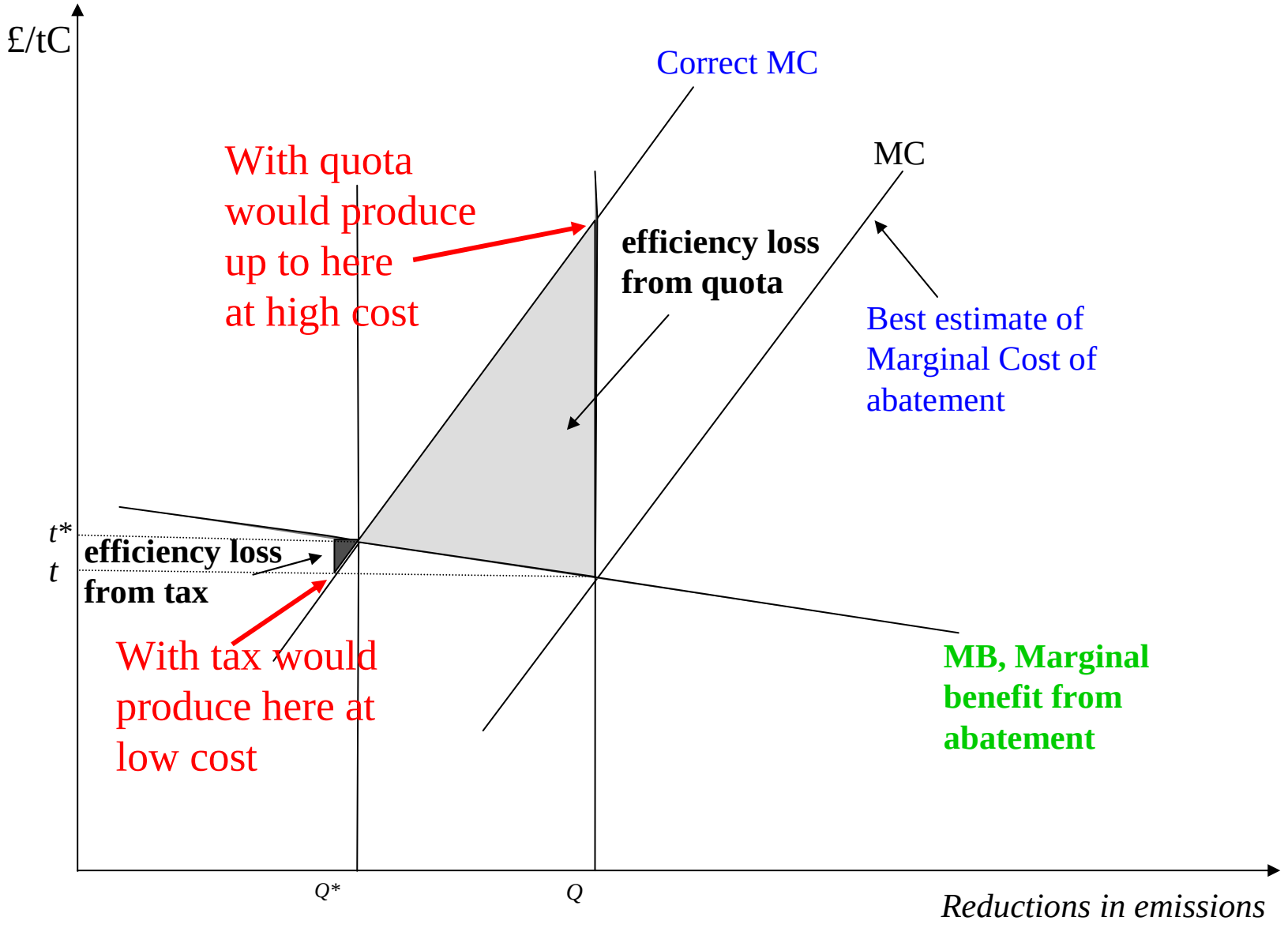
Solved by fixing CO_2 price instead of quota

or choosing a carbon tax!

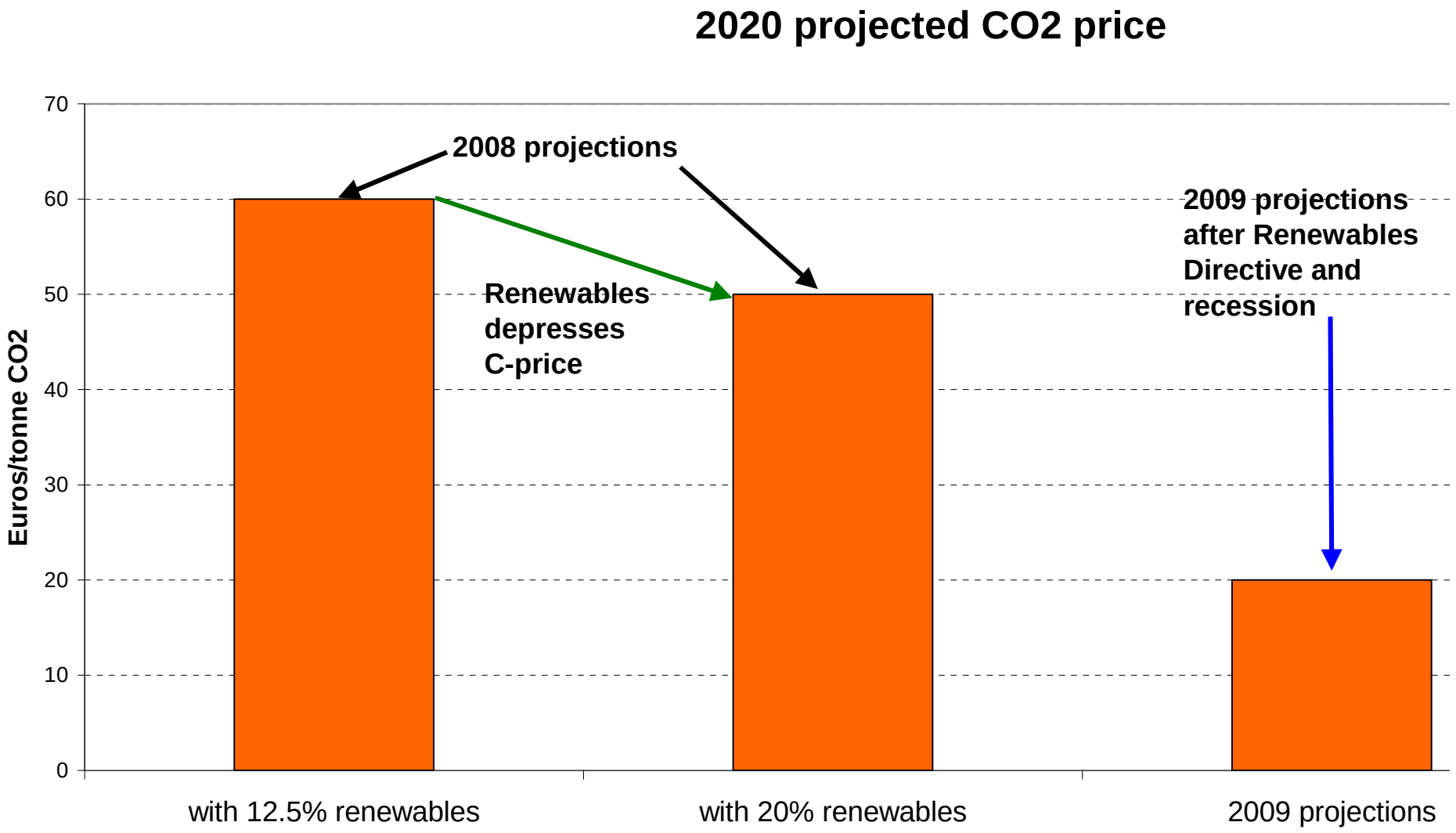
ETS is neither stable nor supports adequate carbon price



Costs of errors setting prices or quantities



Renewables target undermines CO_2 price



Source: Committee on Climate Change, 2008 and 2009

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Making carbon prices credible

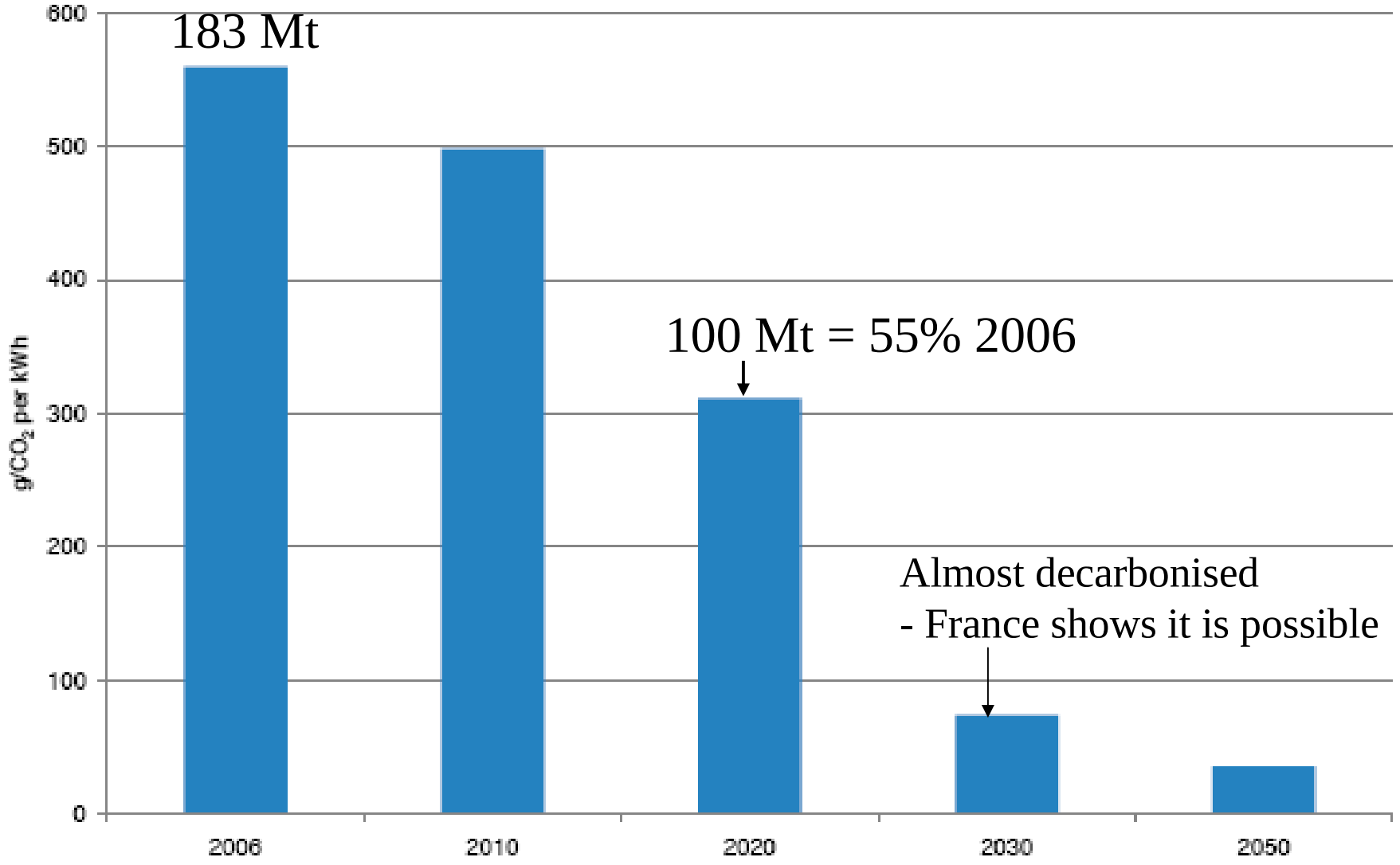
- Carbon taxes - can be readily changed
- Emissions trading + banking=> rising price floor
  - but vulnerable to shocks - credit crisis, Fukushima,..

  => Carbon Bank trades EUAs to stabilise price?
- need credible future C price over 20+ yrs
  - €25/EUA 2010 => €34 in 2020, €61 in 2040 ...
  - Make it credible: write CfD on this path
  - or write a contract for low-C generation

make low carbon investments financable

2020 CCC's ESI carbon targets are challenging

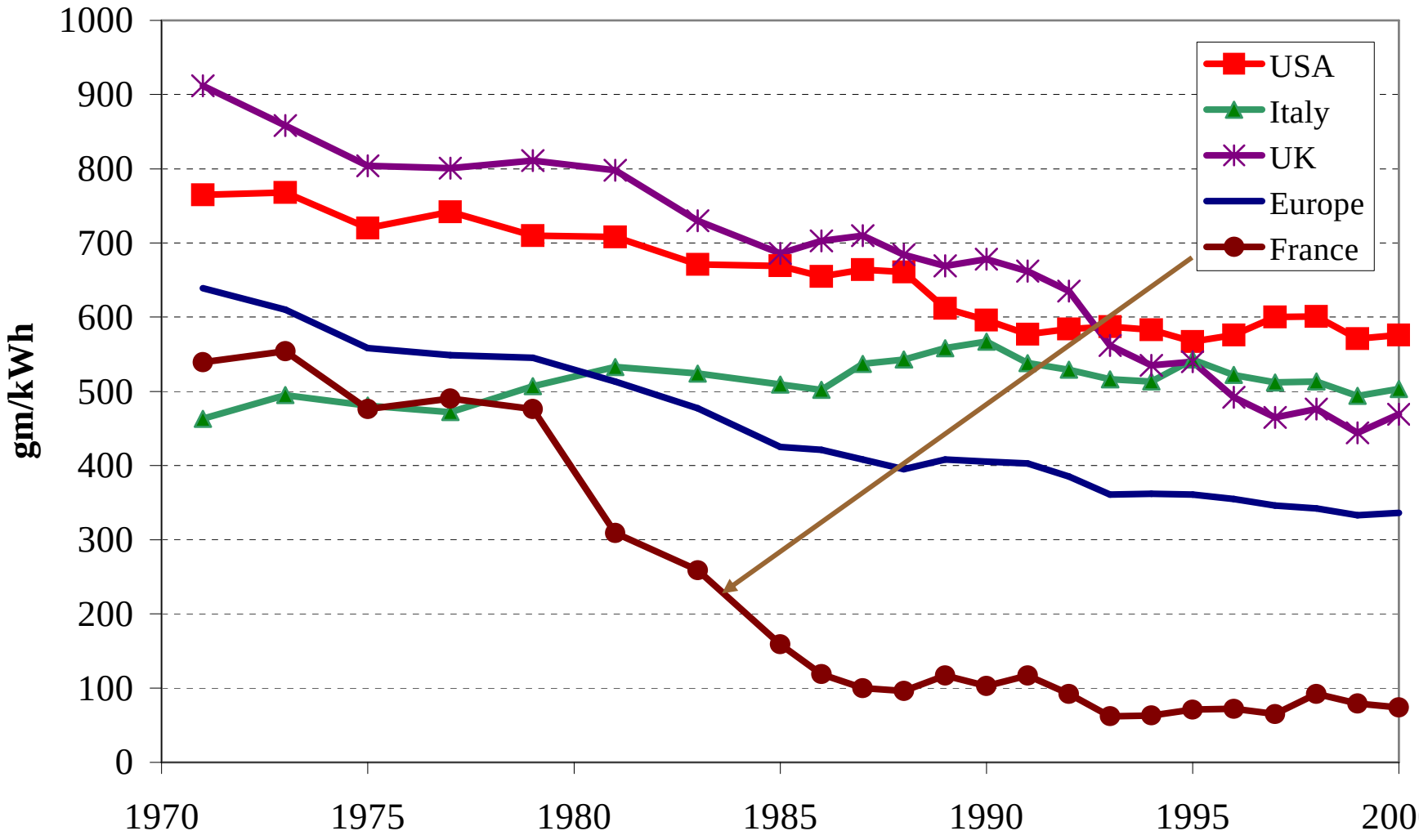
Figure 5 CO_2 intensity per kWh of electricity generated, 2006-2050



Source: CCC

Rapid decarbonisation of electricity is possible - **with nuclear power**

CO2 emissions per kWh 1971-2000



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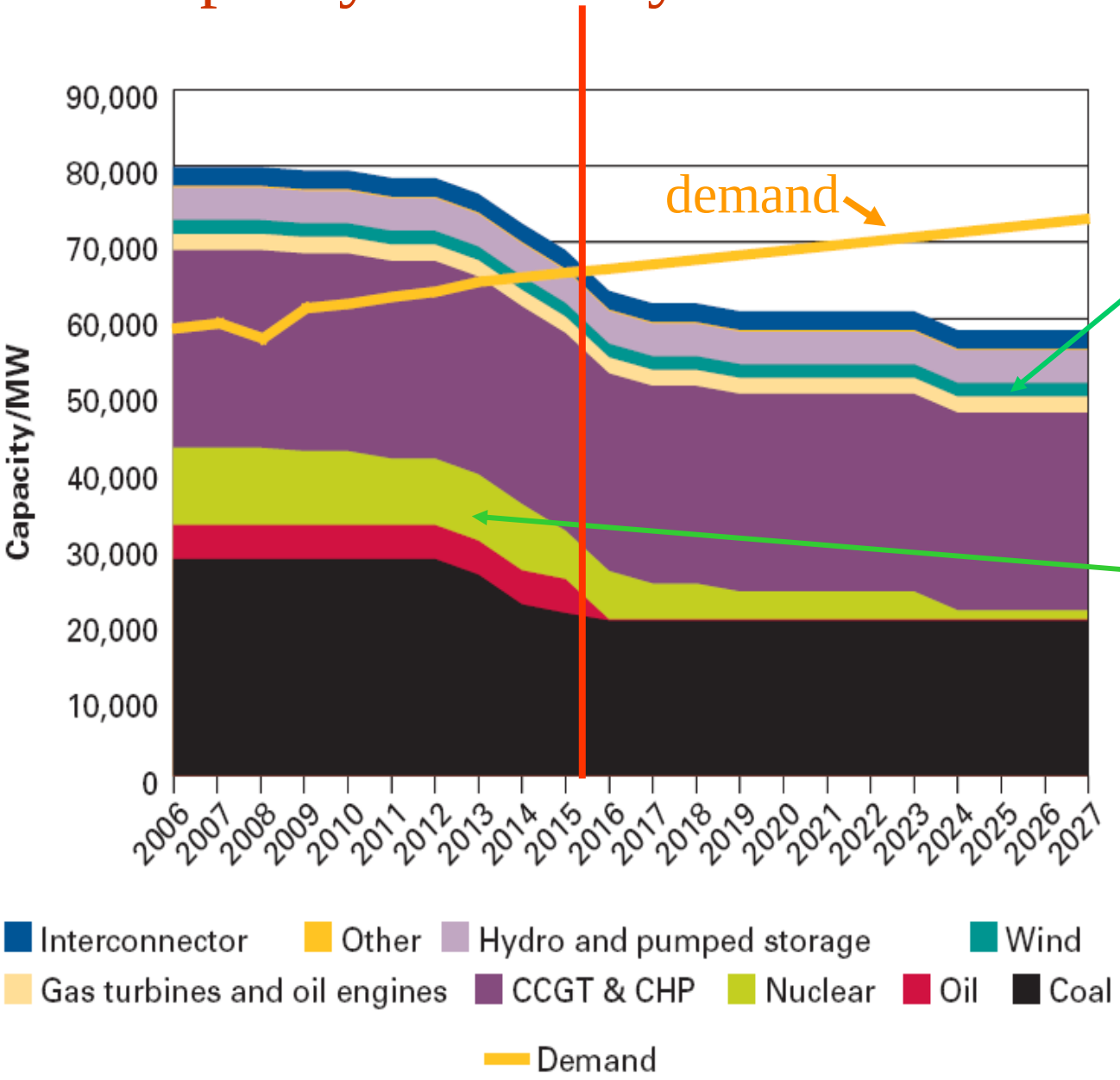
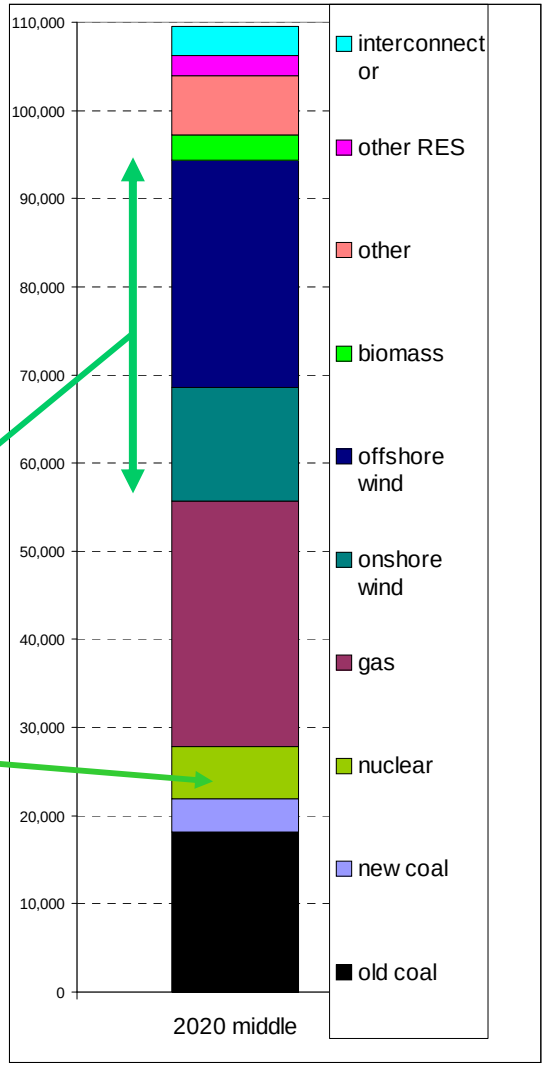
Background to EMR

- Security of supply: reserve margin falling fast
  - 12 GW coal decommissioned by 2015 because of LCPD (20% of peak demand)
  - 6.3 GW nuclear decommissioned by 2016
  - extra flexible generation needed to handle wind
- Climate change challenge: reach <100gm/kWh 2030
  - Renewables falling short of targets
  - Nuclear not attractive at current CO_2 price
- Cost rising: 2020 targets might cost £200 bn

  = £760 per household/yr, current elec bill = £450/yr

More capacity needed by 2015





SKM (2008) mid-scenario projection

Source: Digest of UK Energy Statistics/DECC

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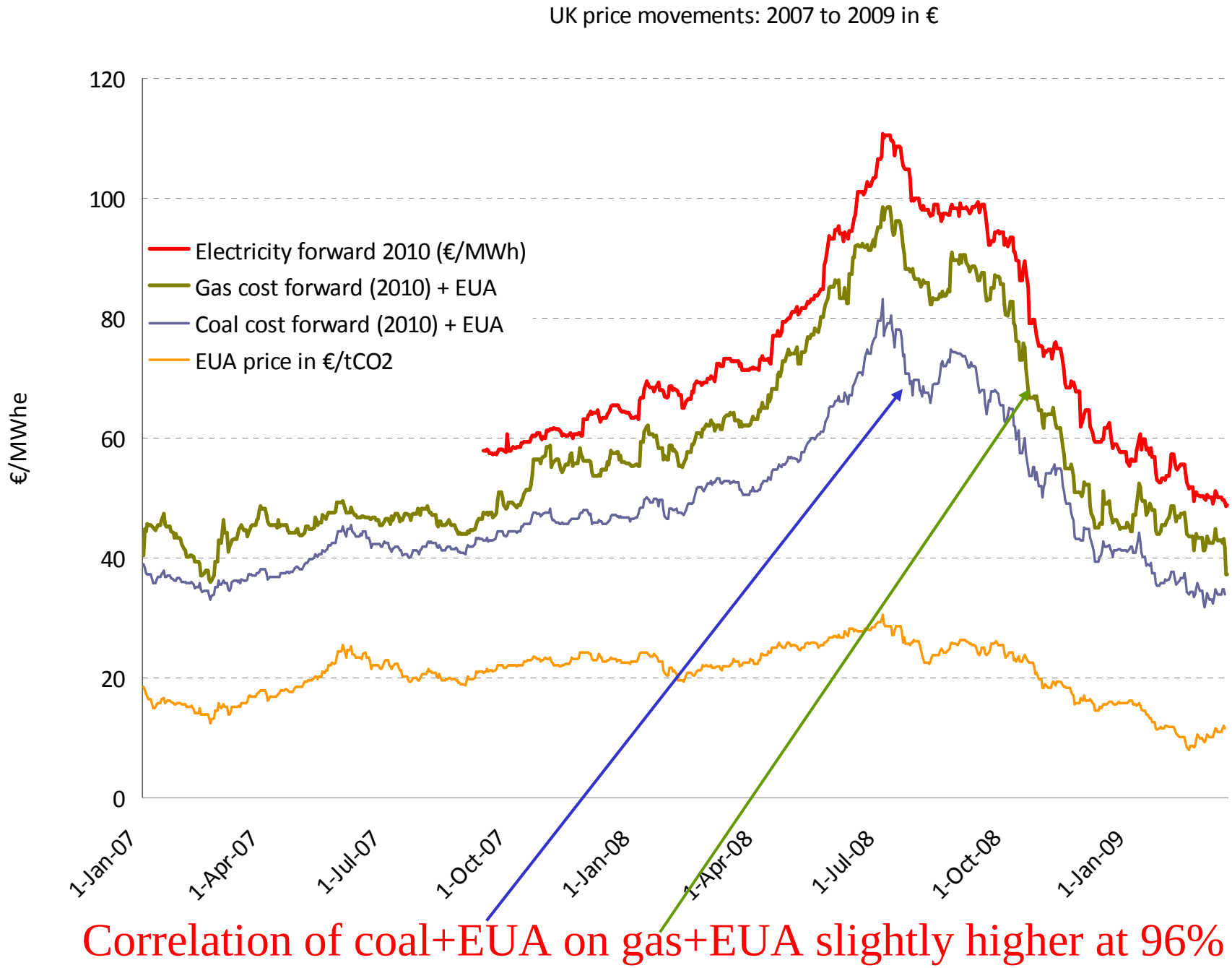
UK climate change policy

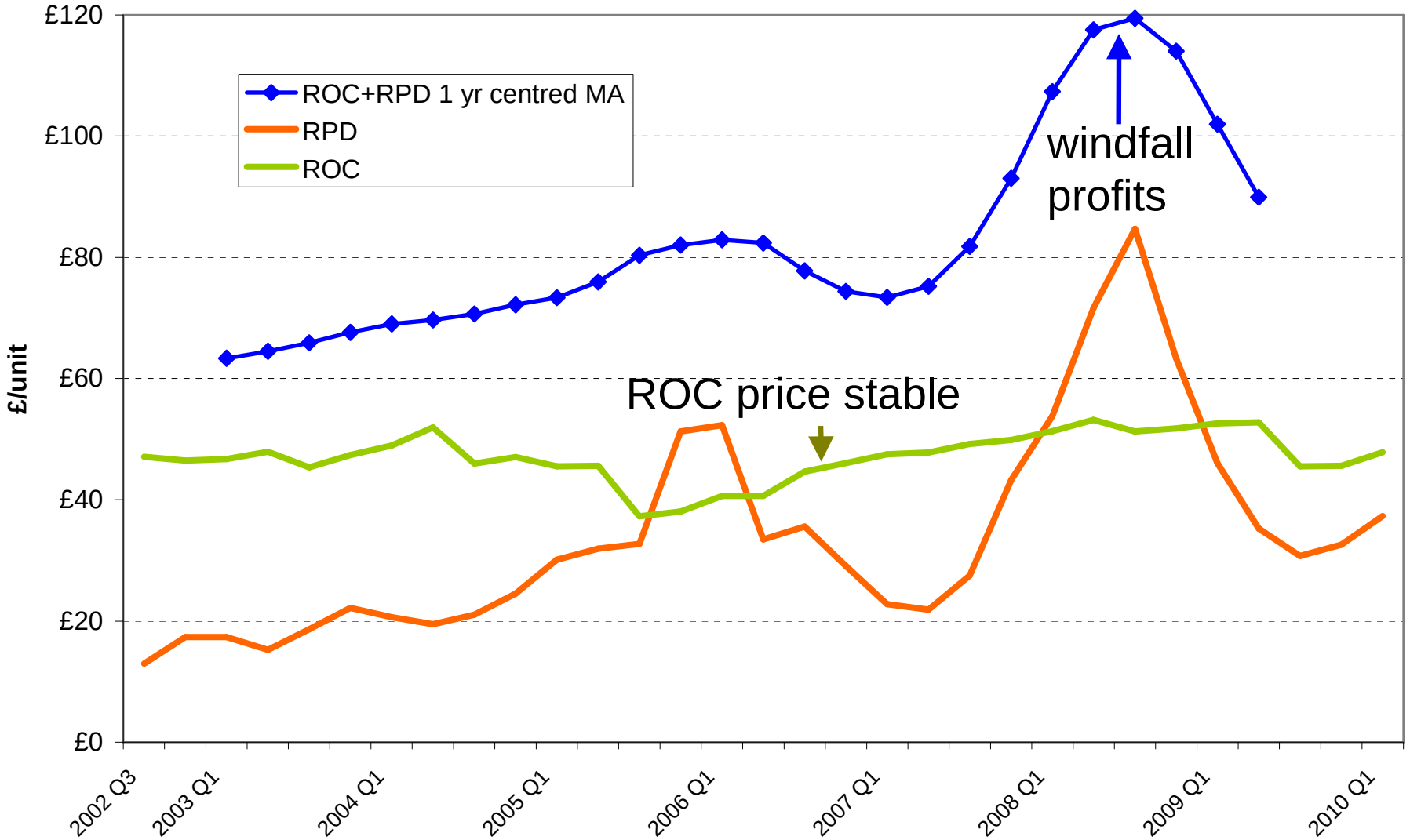
- 2027 legal target: 50% C reduction from 1990
- Zero-C generation faces more risk than fossil
  - electricity price set by gas or coal
- Renewables support is expensive
- return depends on electricity price
  - set by gas and carbon price
  - and scarcity of ROCs - rewards failure

need to de-risk zero C investment



Correlation of coal+EUA on gas+EUA slightly higher at 96%

UK ROC, EUA, and electricity prices



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EMR White Paper 12/7/11

- To de-risk and incentivise low-C investment

=> Long-term contracts for credibility

=> C-price floor to underwrite wholesale price

  - ensures nuclear is not "subsidized"

=> Capacity payments - targeted or general?

=> EPS 450gm CO_2/kWh to deter unabated coal

- "technical update" by end of year
  - details of capacity mechanism
  - "more details" on contracting institution

Aim at law on statute book by spring 2013

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Long-term contracts

- Electricity price is driven by fossil prices
  - exposes nuclear and renewables to market risk
- CO_2 price unpredictable, not credible
- => long-term contract enforceable in courts
- but technologies differ and so should contracts

  => simple FIT for on-shore wind

  => auctions for off-shore wind?

  => Complex contract for nuclear?

Contracting institution left for consultation

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Carbon price floor

- Needed because EUA price is volatile, too low and lacks longer-run credibility
  - undermined by 20-20-20 Directive and recession
- to bring C-price up to appropriate level
  - reduce implicit subsidy to CO_2 emissions

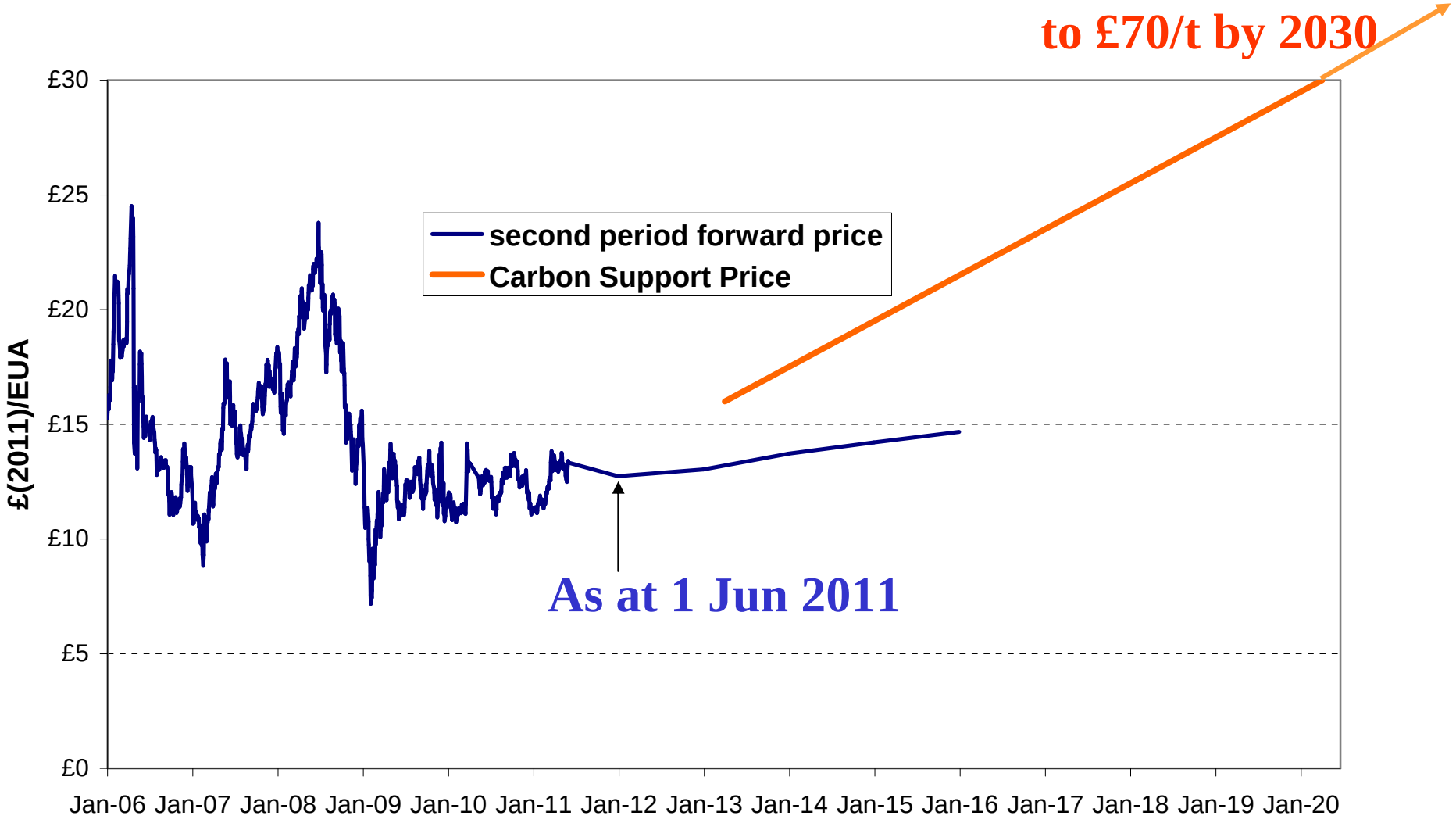
=> ensures wholesale electricity price adequate to support mature low-C investment

- => nuclear power will not then be subsidized

Introduced in Budget March 2011

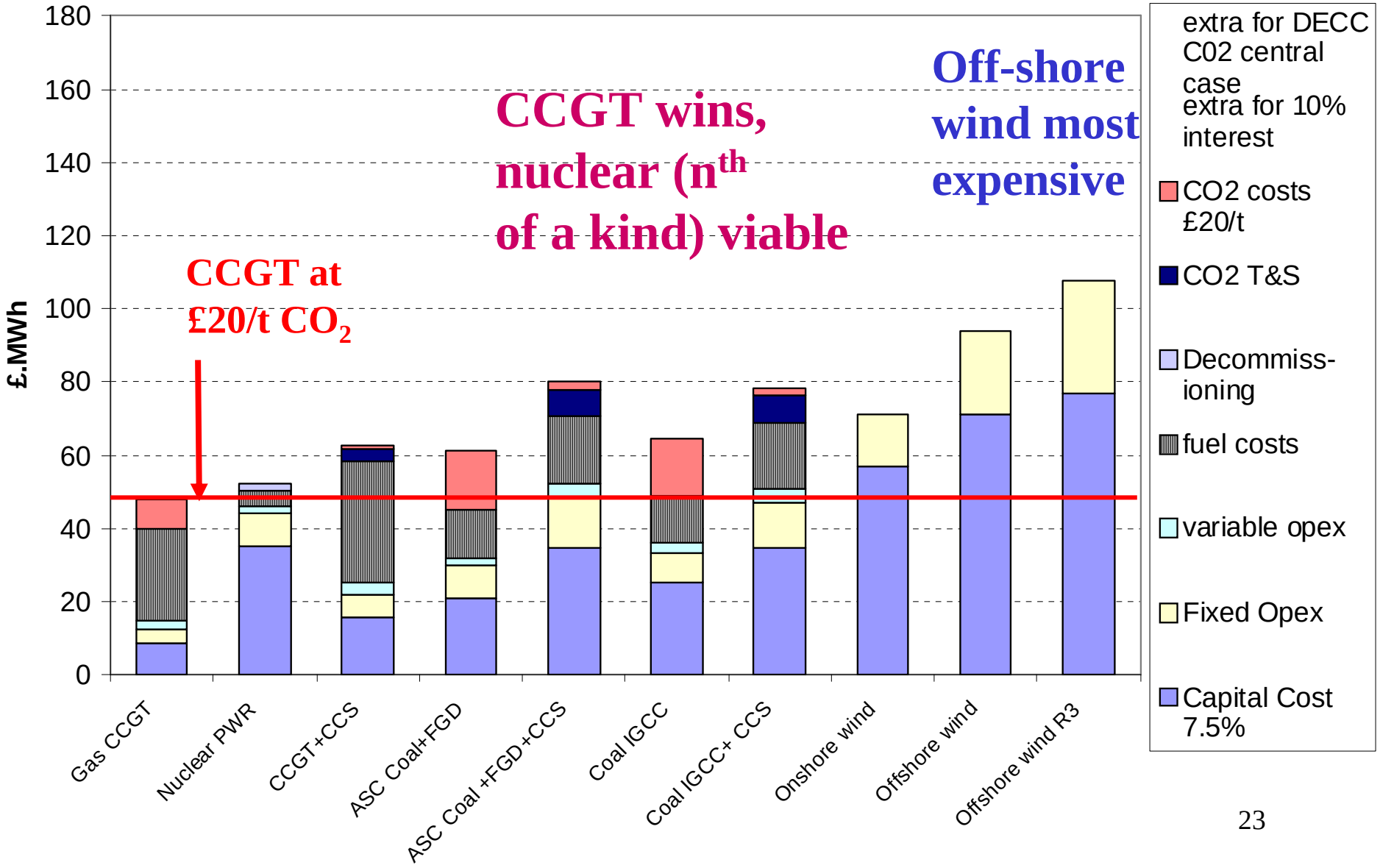
UK's Carbon Price Floor

EUA price second period and CPS £(2009)/tonne



Source: EEX and DECC Consultation

Projected levelised generation costs 2017 NOAK



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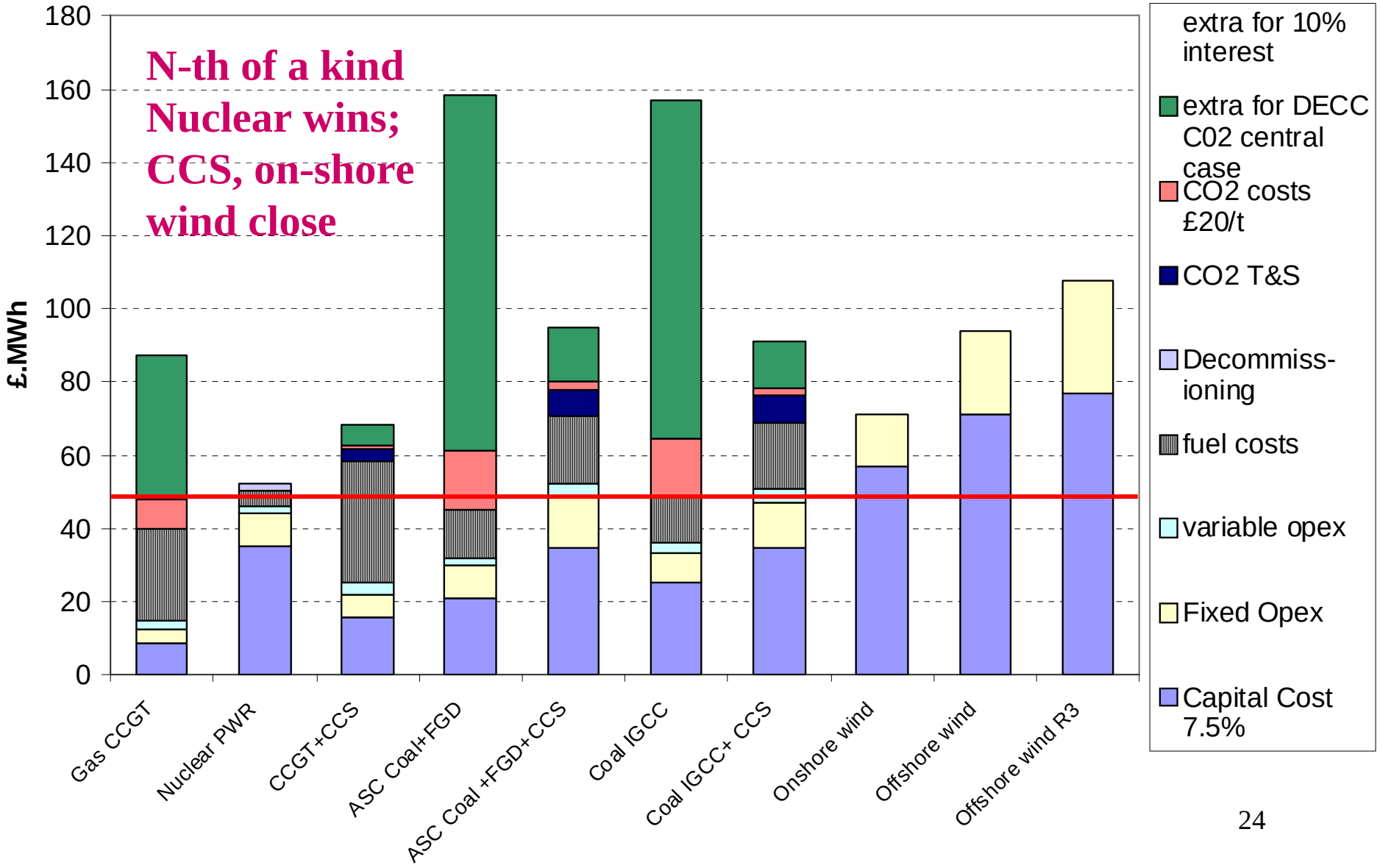

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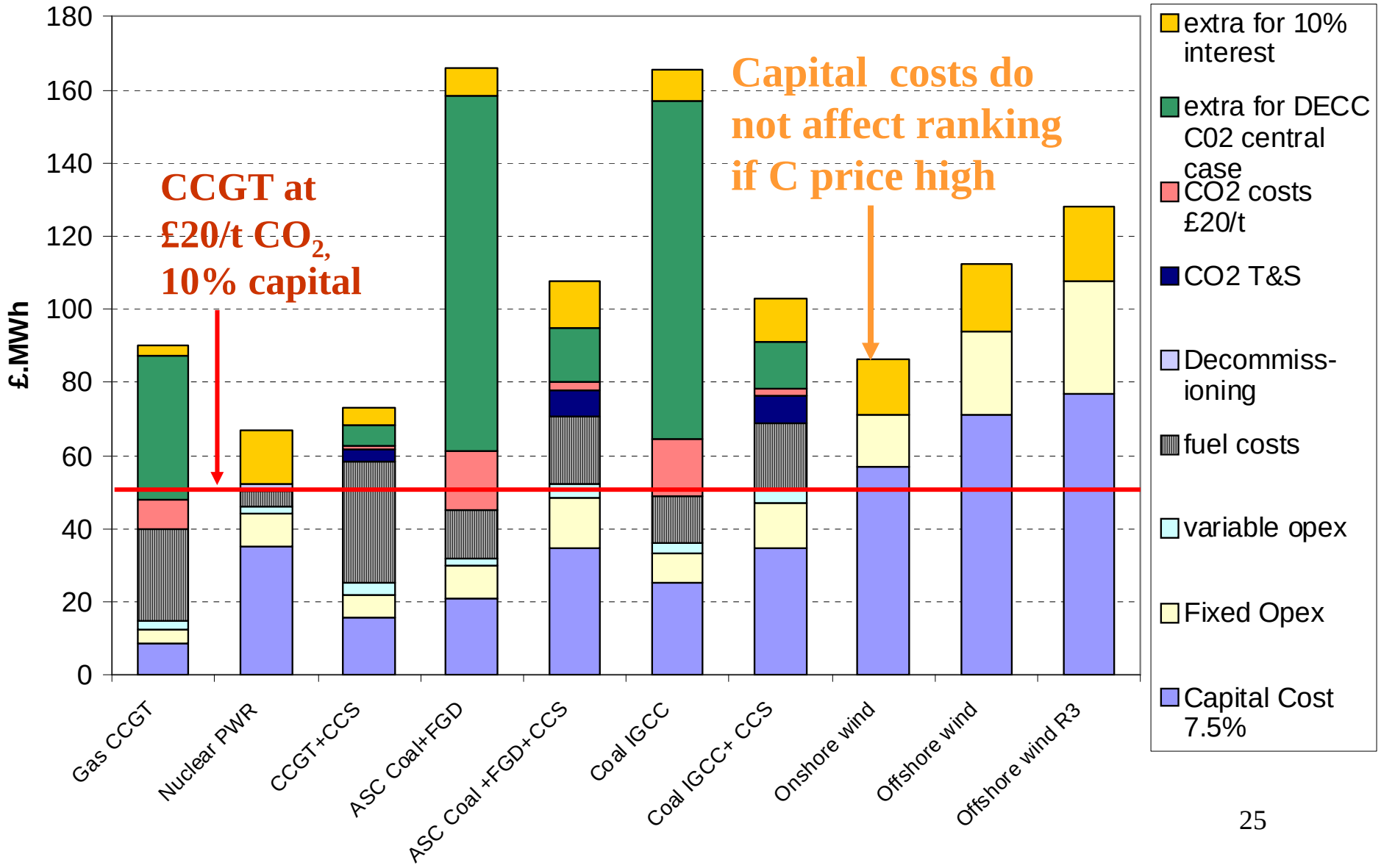
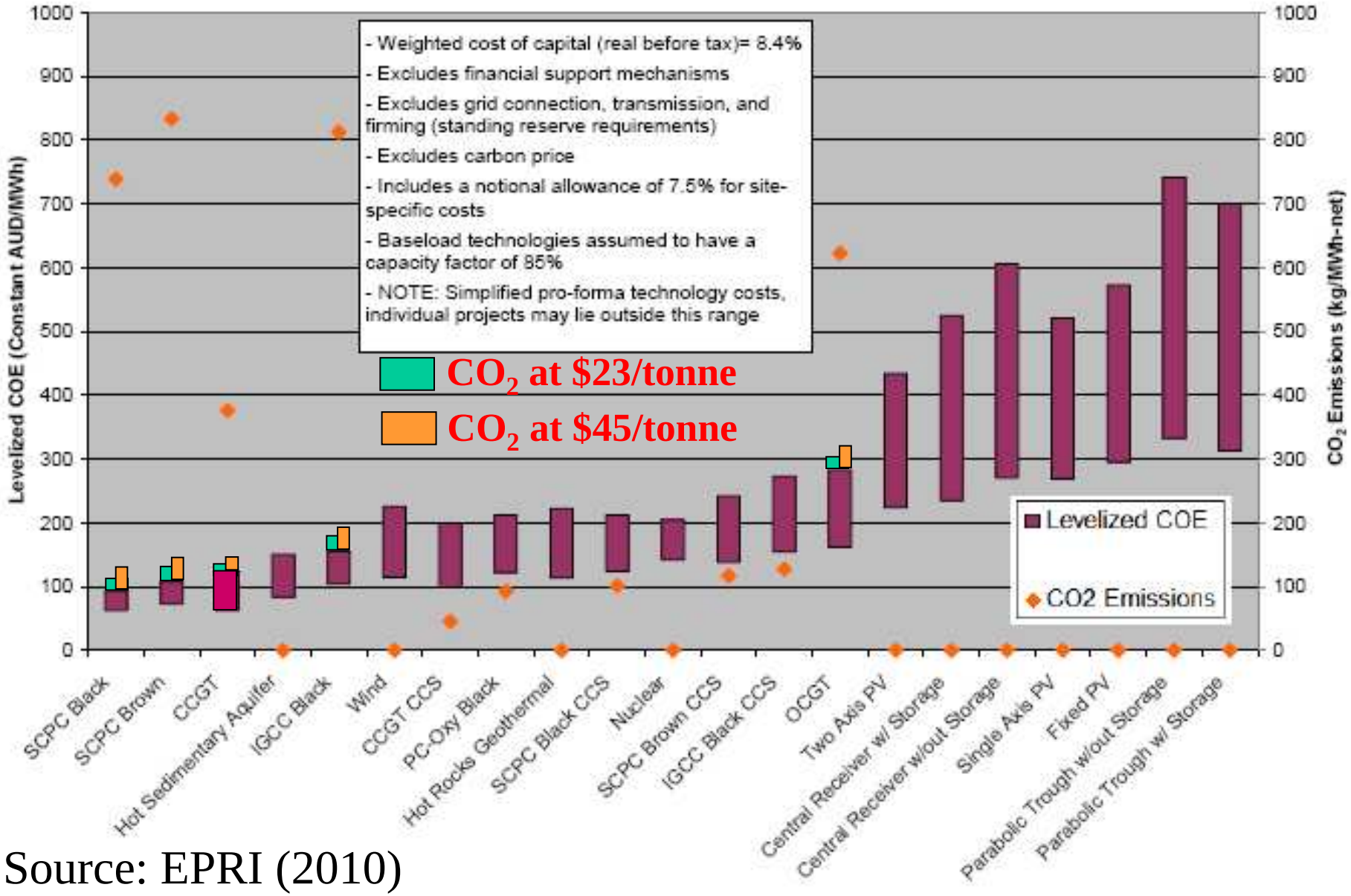
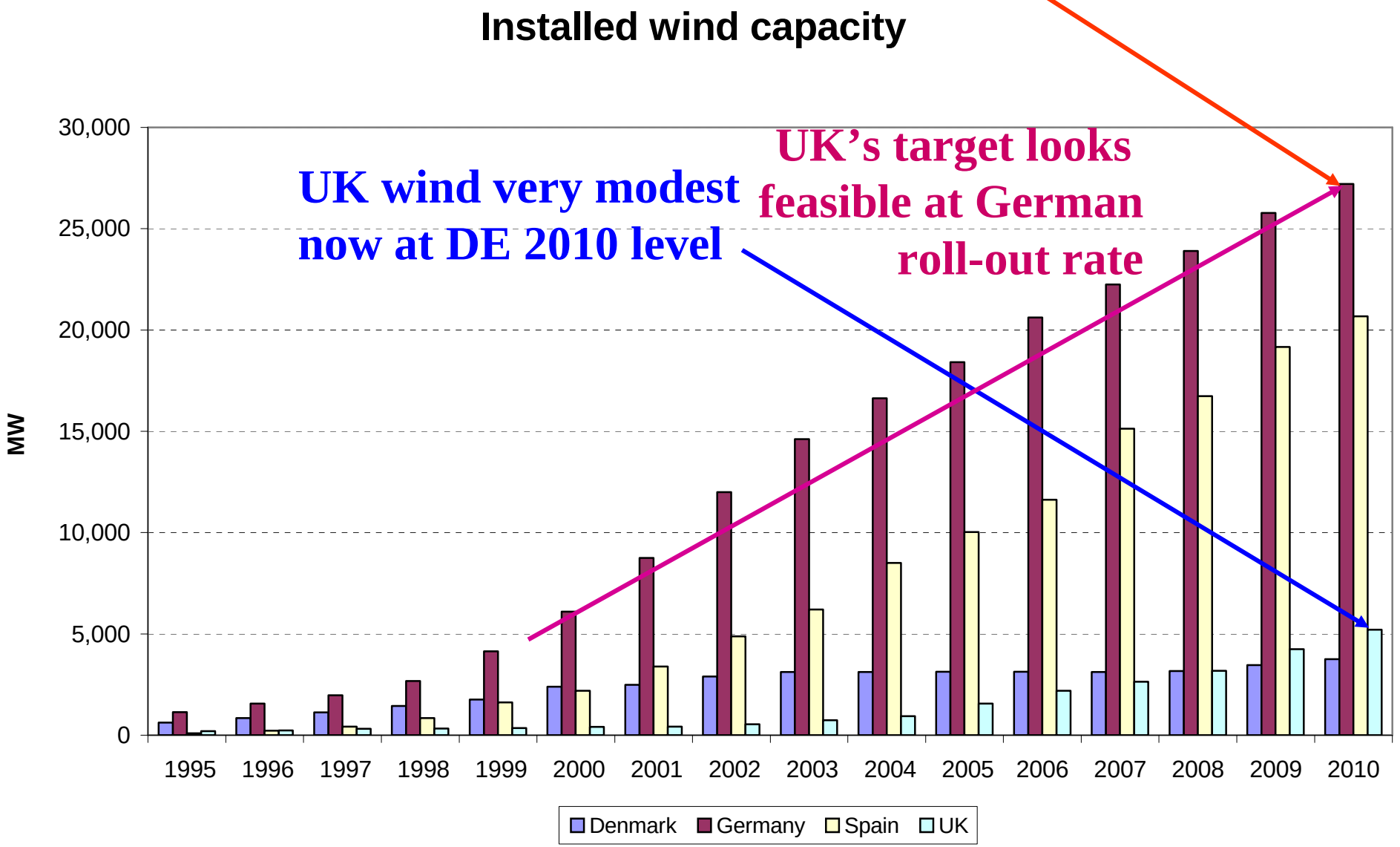


Levelised costs 2015, Australia

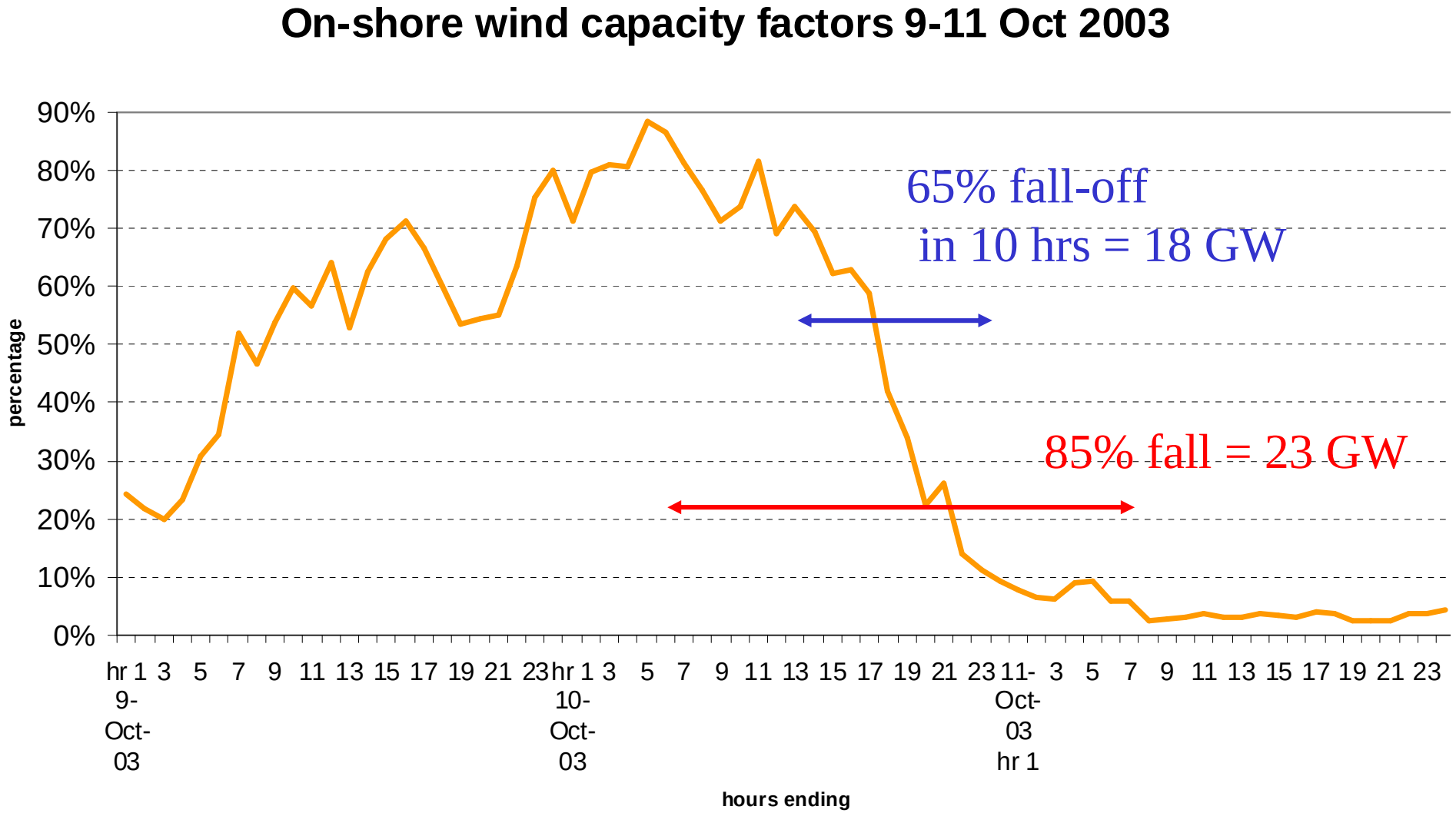


Source: EPRI (2010)

CCC'09 UK 2020 target is 27,000 MW



Variability and need for back-up



Source: Green and Vasilakos (2010)

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Capacity mechanisms

- Concern over backup needed for massive wind
  - could have 7+ days of low wind at winter peak
  - demand side unlikely to help much here
- such events are hard to predict
  - so without a contract no-one would build just for that
- Do we need it now? Wait and design carefully?
- Is the US approach to a demand curve good?

Choice left for discussion - targeted or system wide; SO or contracting agency?

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Flaws in wholesale market

- Bilateral, thin illiquid markets that stimulated extensive vertical integration
- current design rules out pool & VOLL LOLP
  - the old pool model now looks good
- SO could run a voluntary pool for new entrants and renewables?
- Market coupling mandated by 2014
  - could provide a better spot price

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Regulation for low carbon

- Generation needs incentives and standards- EPS
- Networks are regulated
  - have revenue stream, regulator can set rules
- Challenge fund for innovation - the Low Carbon Network Fund
  - learn how to make distribution networks smarter
- Transmission charges to influence location
  - ensure renewables delivered efficiently

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Low Carbon Network Fund

- Ofgem's LCN Fund = £500m 2011-2015
  - for DNOs financed by customers
  - £150m divided among all DNOs for projects
  - £350m open competition, £64 m for first round
- Aim: to stimulate DNOs innovation
  - to facilitate move to low-carbon future
  - DNOs thought to be passive, regulated utilities
  - "oversize, bury and forget" rather than "optimize, monitor and control"

Ofgem concerned whether incentive regulation stimulates innovation

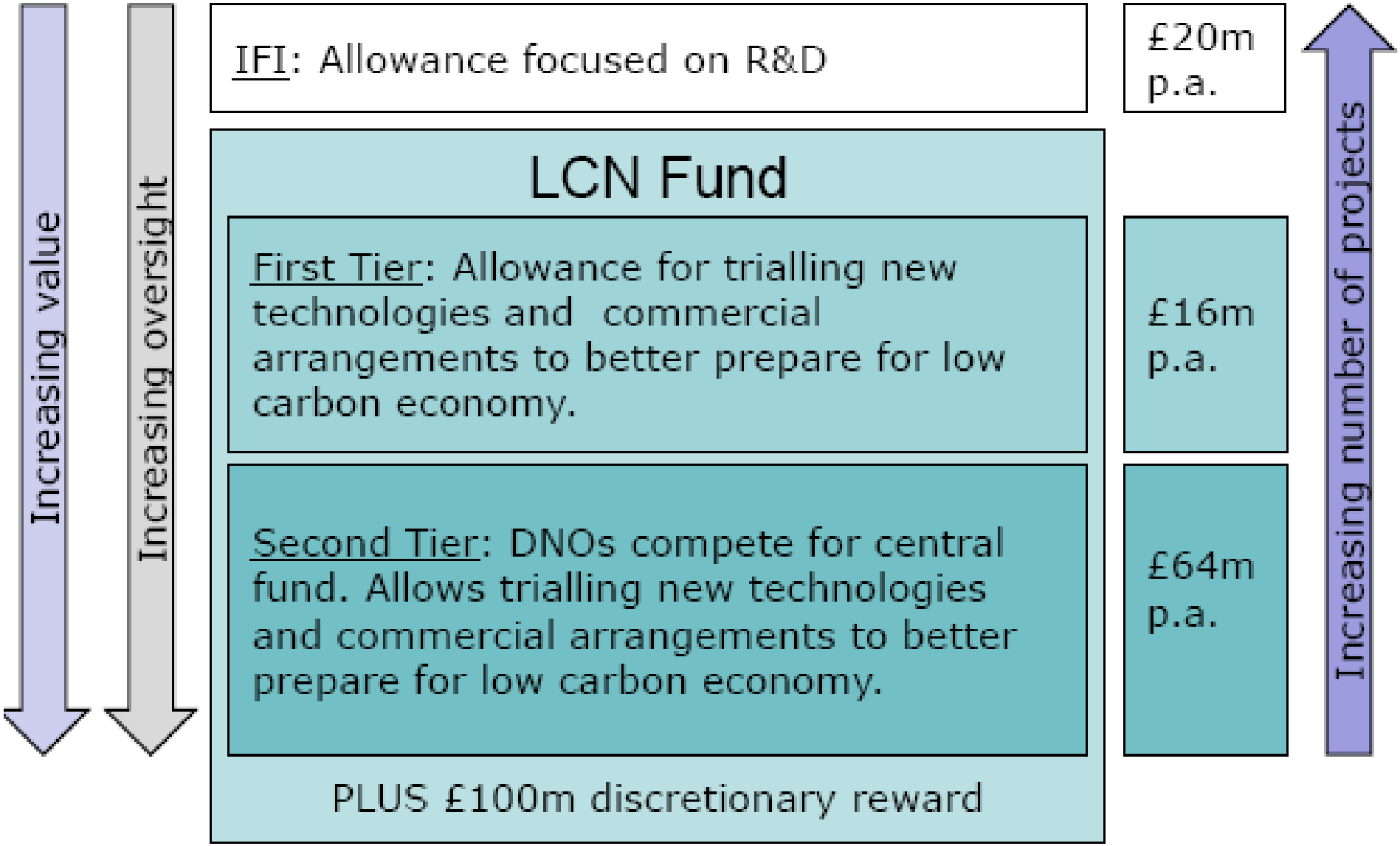
Rationale for LCNF

- RPI-X for efficiency, not innovation
- DNs low risk - failure not funded
- No market reward from innovation

Value of LCNF

- LCNF sufficient for several flagship scale trials
- leverage: trial results disseminated to all DNOs
- Competition mimics market reward for innovation

LCN Fund structure



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Criteria

- Accelerates development of low-carbon future
  - has direct impact on operation of DN
- DNOs co-fund (>10%) for commitment
  - involves other partners and external funds
- Involves risk, generates new knowledge

  => disseminate all findings
- demonstrates robust methodology, readiness, relevance and timeliness
- has potential to deliver customer benefits

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LCNF results

- First round: 11 bids (£180m) received , 4 chosen
  - competitive bidding highly successful
  - innovative proposals with University analysis
- CE Electric in NE England (£27m + £27m other
  - flexible tariffs, advanced voltage control, storage
- UK Power Networks in London (£24m + £12m)
  - smart meters/tariffs, EVs, emulates 2020
- Western Power in S Wales (£7.8m + £1.2m)
  - monitor 1000 substations, 100k customers in real time
- Central Networks in E Lincs (£2.8m+£0.7m)
  - dynamic voltage control to increase wind access

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Assessment

- DNO's proved very responsive
  - incentives and competition matter
- Wide range of partners involved
  - encourages learning, integrates with smart meter trials and EV experiments
  - innovative ways of overcoming local inertia
- Universities involved in data analysis
  - ensures wide dissemination and independence

Network innovation needs regulatory encouragement

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Conclusions

- Central element is contracting
  - need careful design and a commissioning body
  - wind needs location specific FIT
- CPF underwrites CfD but distorts trade
  - need to argue for EU carbon tax or equivalent
- EPS rules out unabated coal
- Capacity mechanism
  - needed for peak and wind back-up
  - will depend on form of wholesale market

But EMR does not reform Market!

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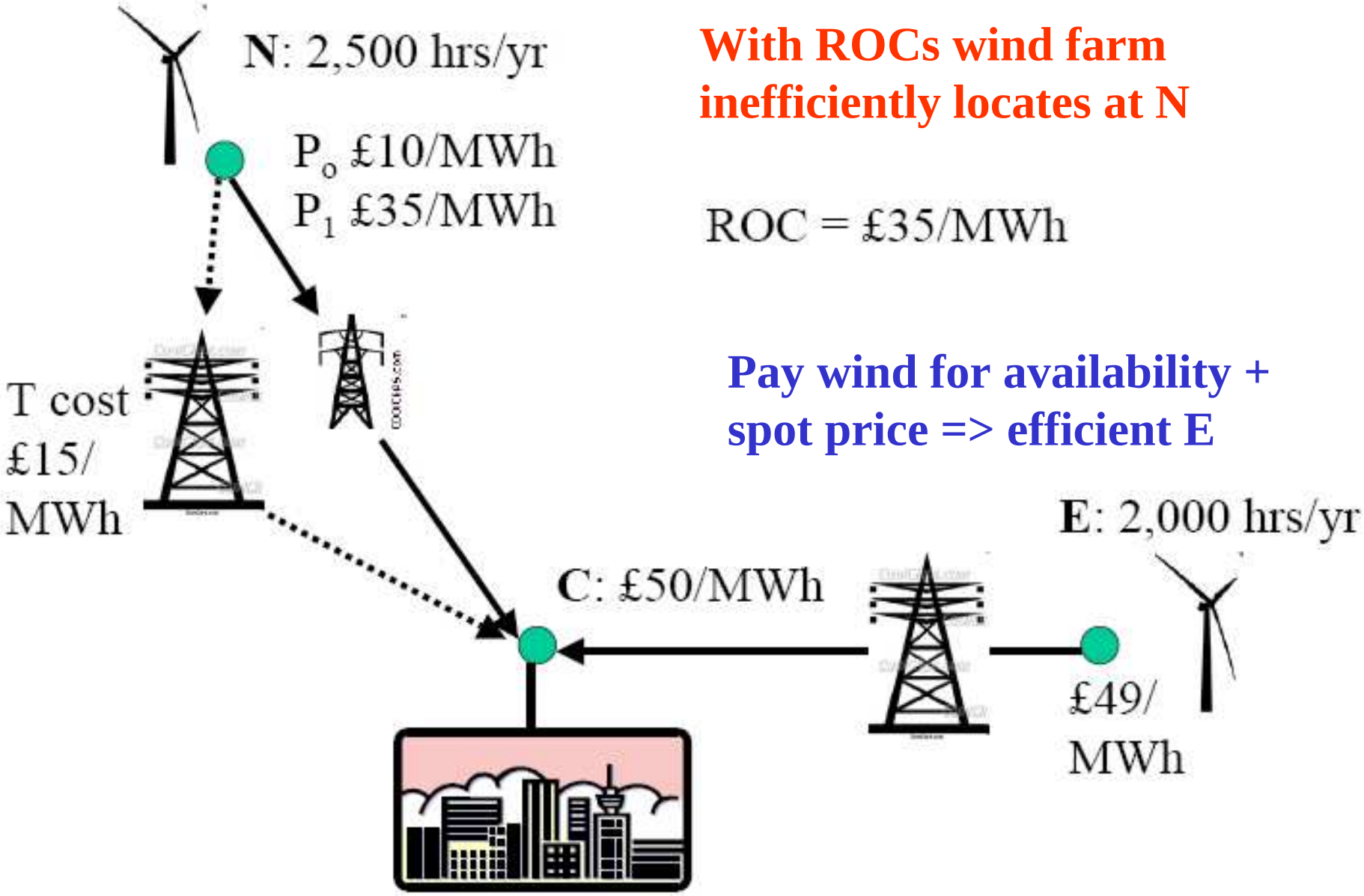
Supporting renewables

- ROCs pay high price for generation
  - but the support should be for delivering capacity not output as that is where the learning lies
- At present wind pays higher annual costs in distant locations to reflect transmission costs
  - but Scotland is lobbying for a uniform charge

=> both greatly encourage v costly and distant wind farms

FITs could handle this if sensibly designed

Location choices under LMP and spot pricing for wind



With ROCs wind farm inefficiently locates at N

ROC = £35/MWh

Pay wind for availability + spot price => efficient E

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Acronyms-1

CfD	contract for difference
CCGT	Combined Cycle Gas Turbine
CCS	carbon capture and storage
CPF	carbon price floor
CCC	Committee on climate Change
DN(O)	Distribution Network (Operator)
EMR	Electricity Market Reform
EPS	emissions performance standard
ETS	EU emissions trading system
EUA	EU Allowance for 1 tonne CO_2
FIT	Feed-in tariff: fixes price for power

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Acronyms-2

GHG Green house gas (such as Carbon Dioxide, CO_2)

LMP Locational Marginal Price (nodal price as in the US)

LNC(F) Low Carbon Network (Fund)

LOLP Loss of Load Probability

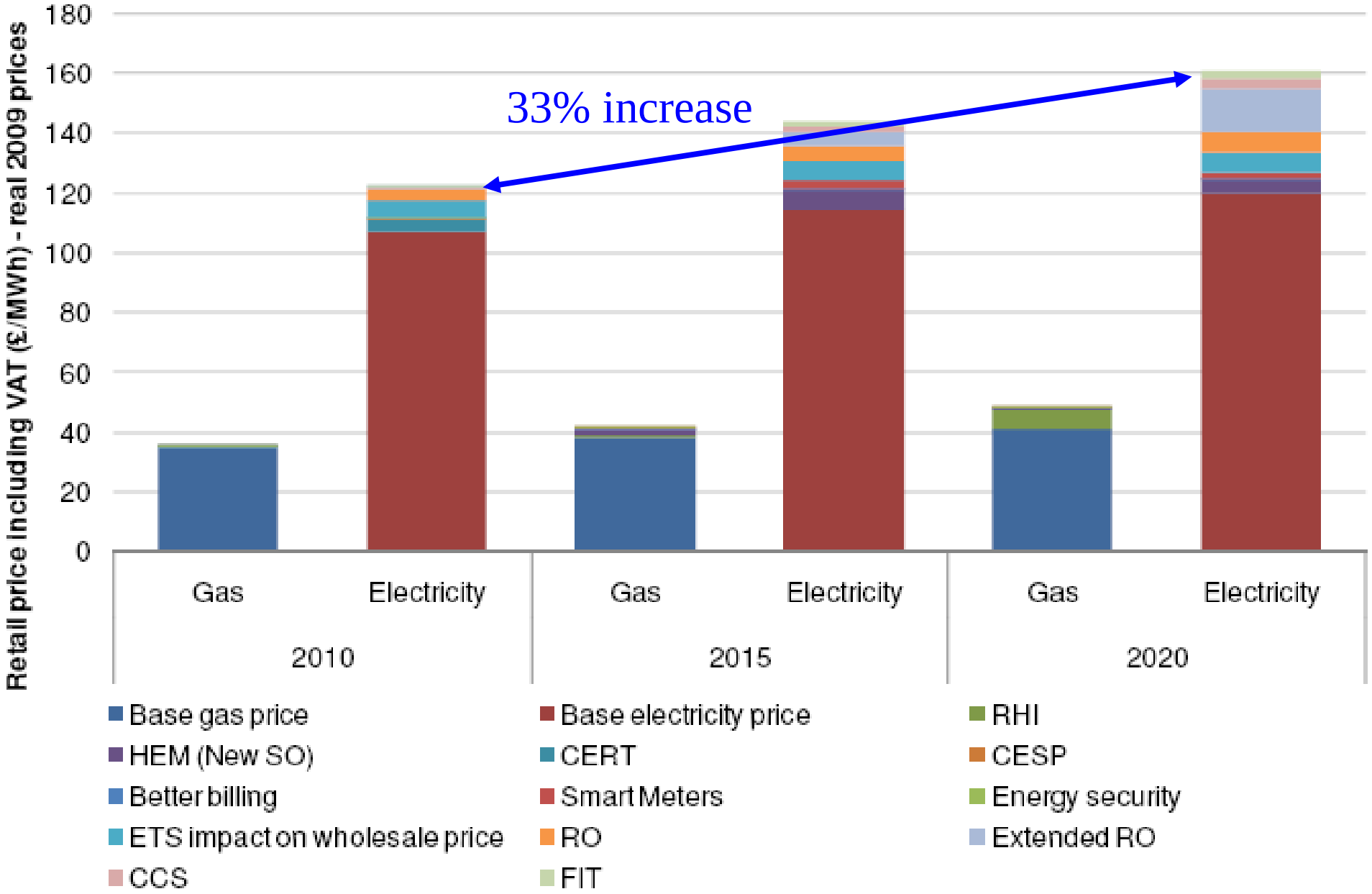
RES Renewable electricity supply

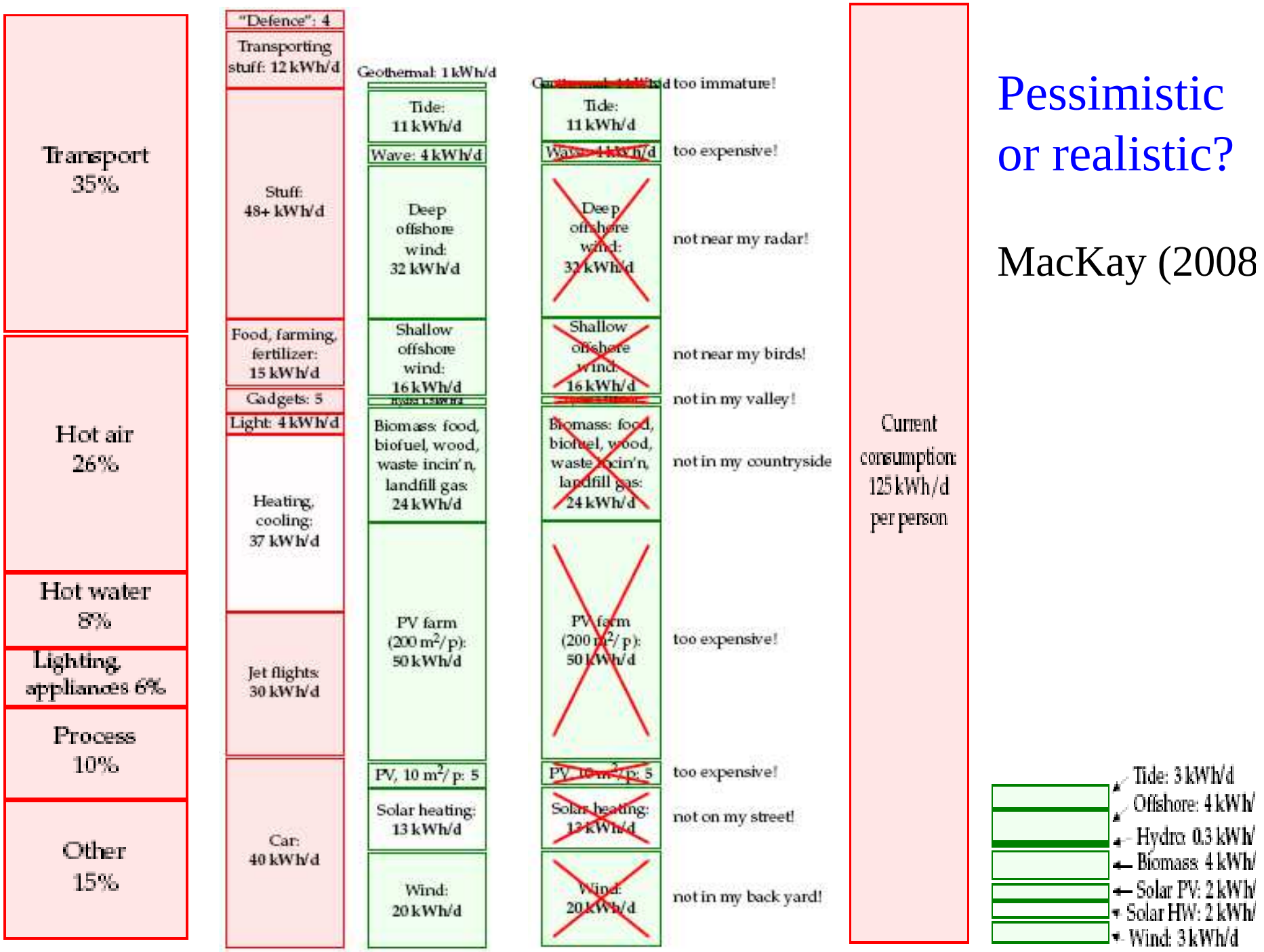
ROC Renewable Obligation Certificate

SO System Operator

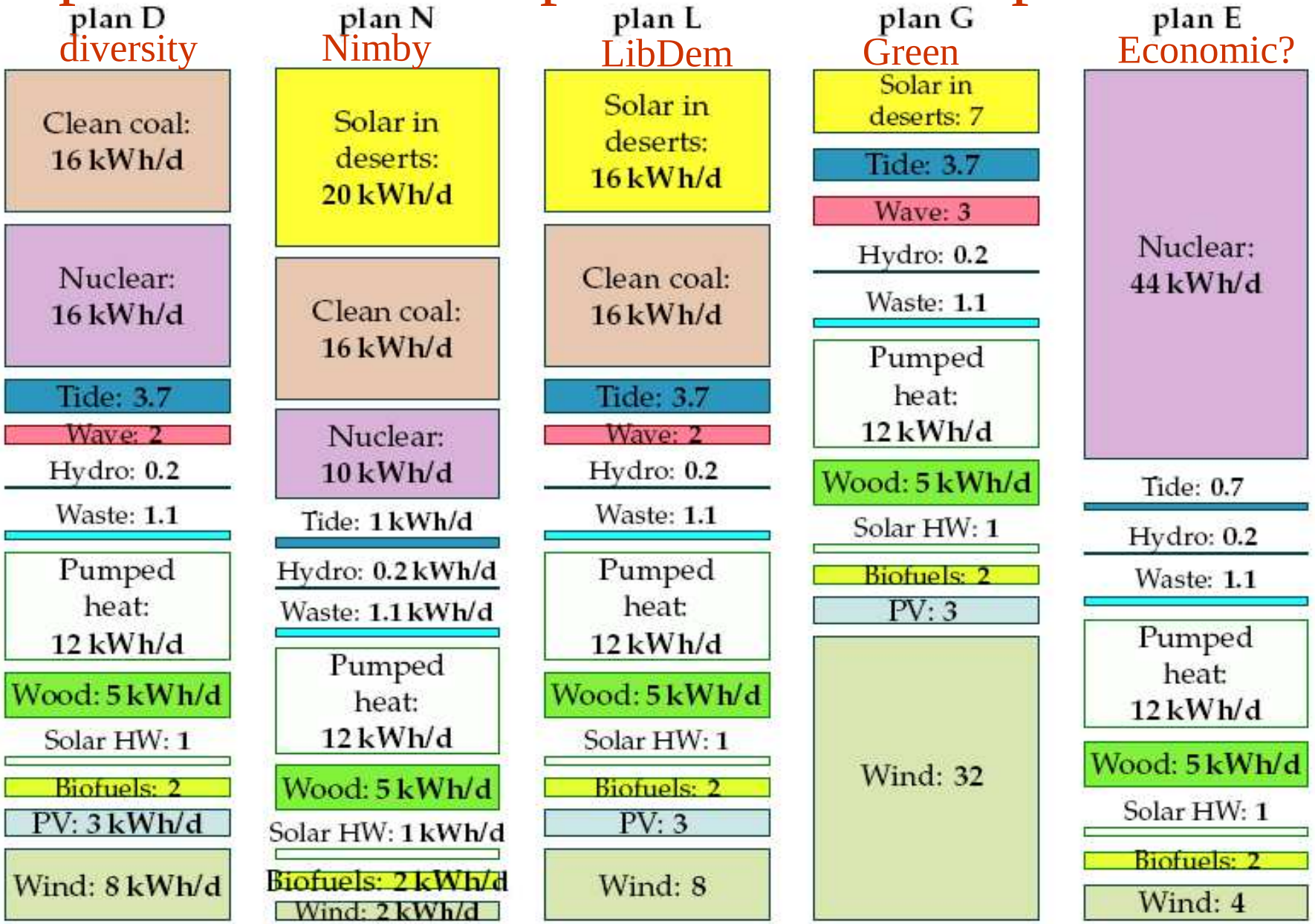
VOLL Value of Lost Load (now £9,999/MWh)

Estimated impact of EMR on averaged domestic retail gas and electricity prices (including VAT)




Transport 35%
Hot air 26%
Hot water 8%
Lighting, appliances 6%
Process 10%
Other 15%
"Defence": 4
Transporting stuff: 12 kWh/d
Stuff: 48+ kWh/d
Food, farming, fertilizer: 15 kWh/d
Cadgets: 5
Light: 4 kWh/d
Heating, cooling: 37 kWh/d
Jet flights: 30 kWh/d
Car: 40 kWh/d
Geothermal: 1 kWh/d
Tide: 11 kWh/d
Wave: 4 kWh/d
Deep offshore wind: 32 kWh/d
Shallow offshore wind: 16 kWh/d
Biomass: food, biofuel, wood, waste incin'n, landfill gas: 24 kWh/d
PV farm (200 m²/p): 50 kWh/d
PV, 10 m²/p: 5
Solar heating: 13 kWh/d
Wind: 20 kWh/d
too immature!
Tide: 11 kWh/d
too expensive!
not near my radar!
not near my birds!
not in my valley!
not in my countryside
too expensive!
too expensive!
not on my street!
not in my back yard!
Current consumption: 125 kWh/d per person
Pessimistic or realistic?
MacKay (2008
Tide: 3 kWh/d
Offshore: 4 kWh/
Hydro: 0.3 kWh/
Biomass: 4 kWh/
Solar PV: 2 kWh/
Solar HW: 2 kWh/
Wind: 3 kWh/d

5 plans “that add up” for 70kWh/d/p electricity



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Levelised costs, 2030