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Reforming Electricity Markets for a Decarbonised Energy System

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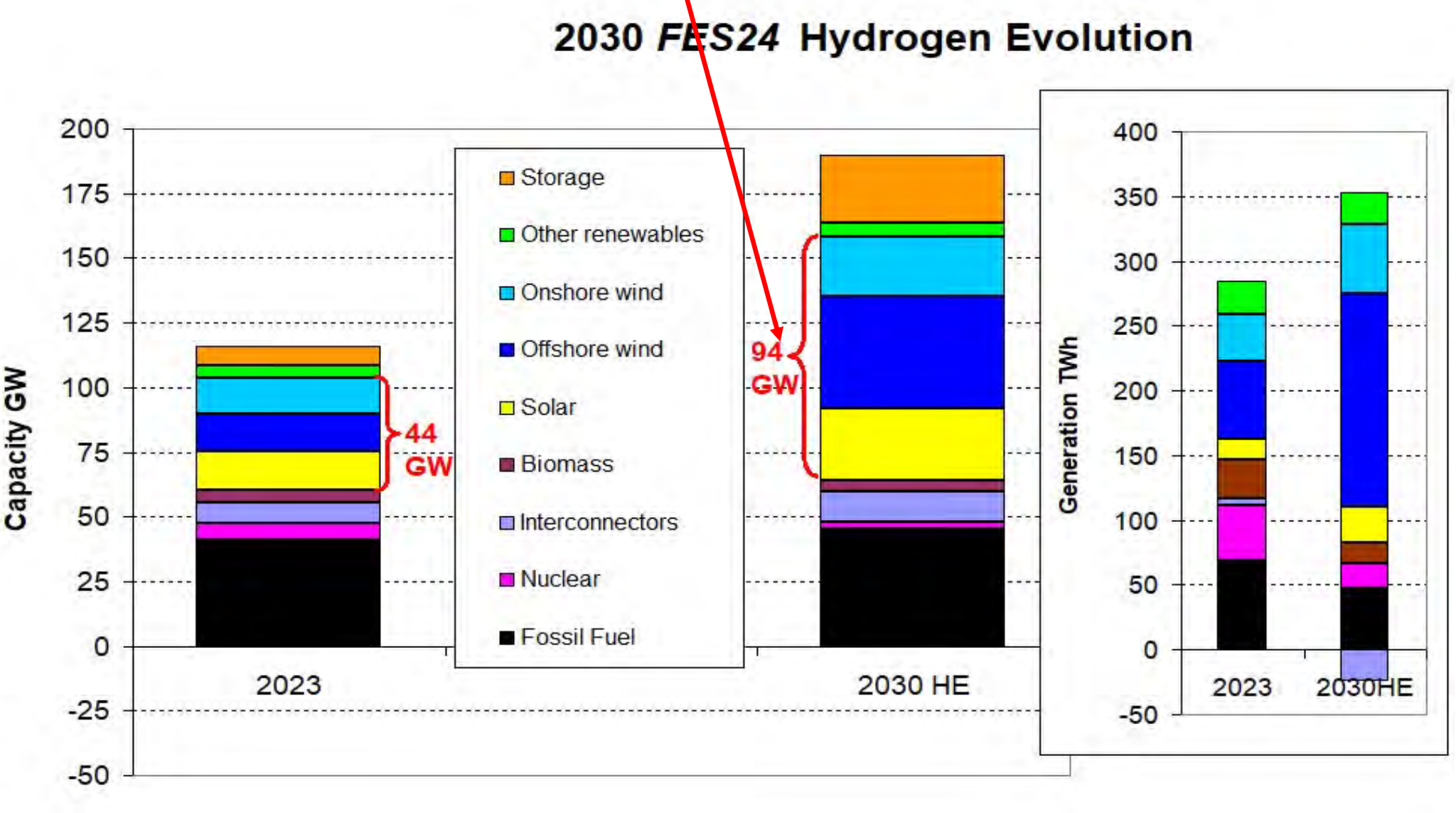
18th September 2025

*I am a member of STAC, DESNZ, but there are purely personal views

Outline

- 2030 net zero electricity => new market design
  ⇒ **Reform of Electricity Market Arrangements (REMA)**
- Implications of least system cost
  - **Locational pricing** – where are we?
  - Coordinating network and generation investment
  - Problem of curtailment
  ⇒ Reform **CfDs** for **V**ariable **R**enewable **E**lectricity- VRE
- Problems remaining – managing interconnectors
  - Mismatch between real-time and day-ahead prices?
  => Massive compensation or markets collapse?

UK VRE capacity to *double* by 2030 in 7 years



Net Zero messages

- Locating new generation is critical
  - wrong locations increase congestion, curtailment
  - need better locational guidance
- Renewables – CfD support needs reform
  - Need **better hedge** against uncertain future prices
  - and incentives to curtail with modest penalty
- High VRE increases importance of interconnectors
  - ensure efficient dispatch of surplus Scottish wind
  - hard to do without zonal prices

GB Reform status

- Reform of Electricity Market Arrangements 2023-4
  - "market forces alone are currently unable to deliver our objectives"
  - Need better locational signals for massive renewable investment

  ⇒ consultation (2024) rules out LMP*, consider zonal charges

  ⇒ Zonal charges ruled out 2025 - **so now what?**
- Electricity Networks Commissioner's report 2023
  - New generation very different locations to fossil plant
  - Currently 14 yrs to deliver new transmission => **reduce to 7yrs(?!)**
  - Need to **reform planning system** to avoid massive delays
- National Energy System Operator (NESO) 2024
  - Taken into **public ownership** to coordinate all networks
    - Deliver Strategic Spatial Energy Plan & Regional Energy System Plan(s)

* Locational Marginal or nodal Prices

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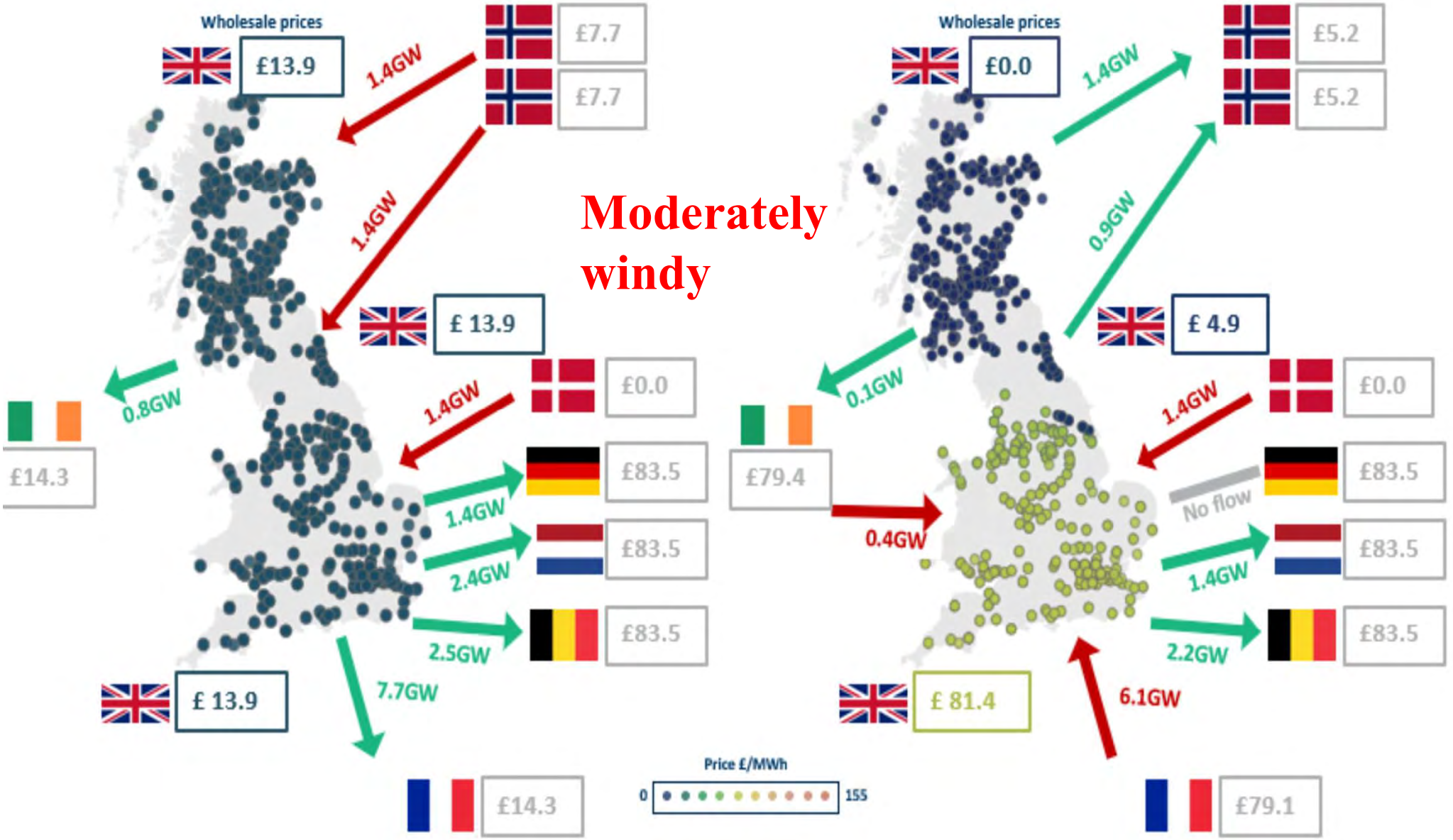
Reason for locational pricing: impact on interconnectors



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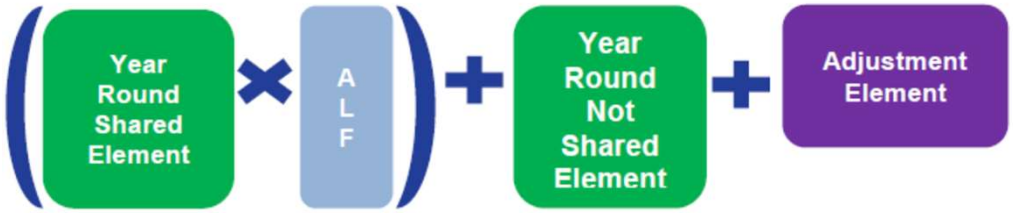
Current transmission charging methodology

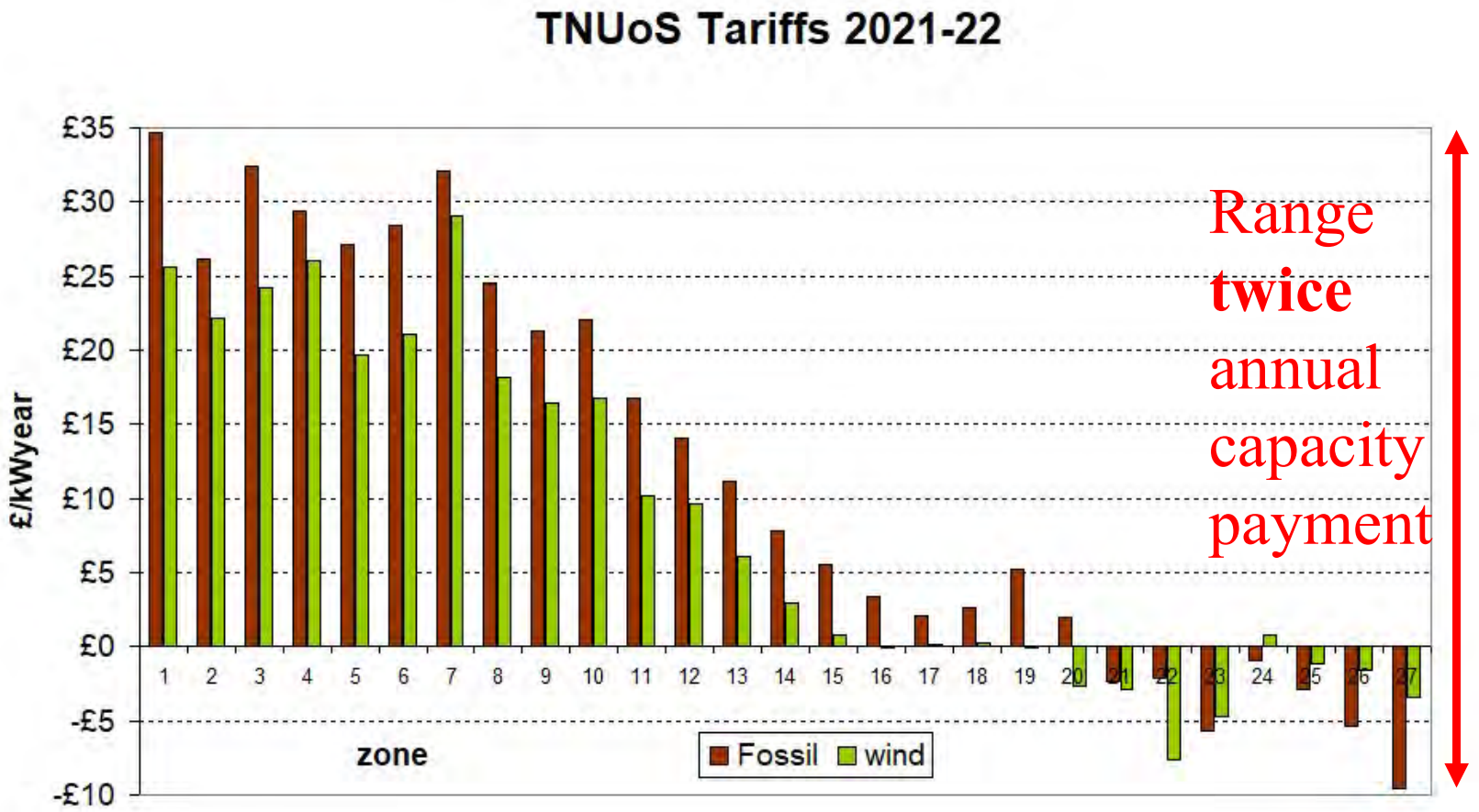
Intermittent Generators

(Wind, Wave, Tidal)



Transmission Network Use of System (TNUoS) charges set annually for Generation

Residual regulated revenue recovered from Load



Range **twice** annual capacity payment

Guiding location decisions: possible approaches

- Current: set locational TNUoS charges to guide location
  - TNUoS based on Investment Cost Related Prices (ICRP ≈ LRMC)
    - £/MWkm; zones defined by LMPs; assumes **instantly adjustable**
- Problems of TNUoS:
  - Changed annually even for plant that cannot move
  - changes muted to avoid excessive investor uncertainty
  - Adjusts slowly at best, poor short-run decisions

⇒ **long-term** TNUoS contracts guide ***efficient*** location

- Alternative: firm connections in uncongested zones
- Non-firm connections where constraints
  - last entered first curtailed off
  - no compensation if curtailed

Minor or major changes?

- Minor change:
  - NESO predicts **least cost entry** to plan network expansion
    - decides what strong signals to send **now** on **where to locate**
  - **Long-term TNUoS contracts** to guide timing and location decisions updated each year before VRE auctions
- Moderate change
  - Reform real-time market to give different prices by zone?
    - export Northern wind to Norway, import French nuclear to South
    - But risks of either massive congestion compensation or collapse of DAM
- Radical change
  - Empower NESO:
    - Secures consents for best sites for entry and network expansion
    - Sites auctioned at optimal date for connection and output contract

Variable Renewable Electricity
VRE: wind, PV

- Peak:average output for wind 2-4:1, PV 8-11:1

⇒ increasing volumes curtailed as VRE rises

⇒ exacerbated by transmission constraints

- **Marginal** curtailment is **3+ times average**
  - i.e. last MW curtailed 3+ times average

⇒ critical to locate new VRE at uncongested nodes

⇒ need strong locational connection signals

⇒ + integrated network and generation location planning

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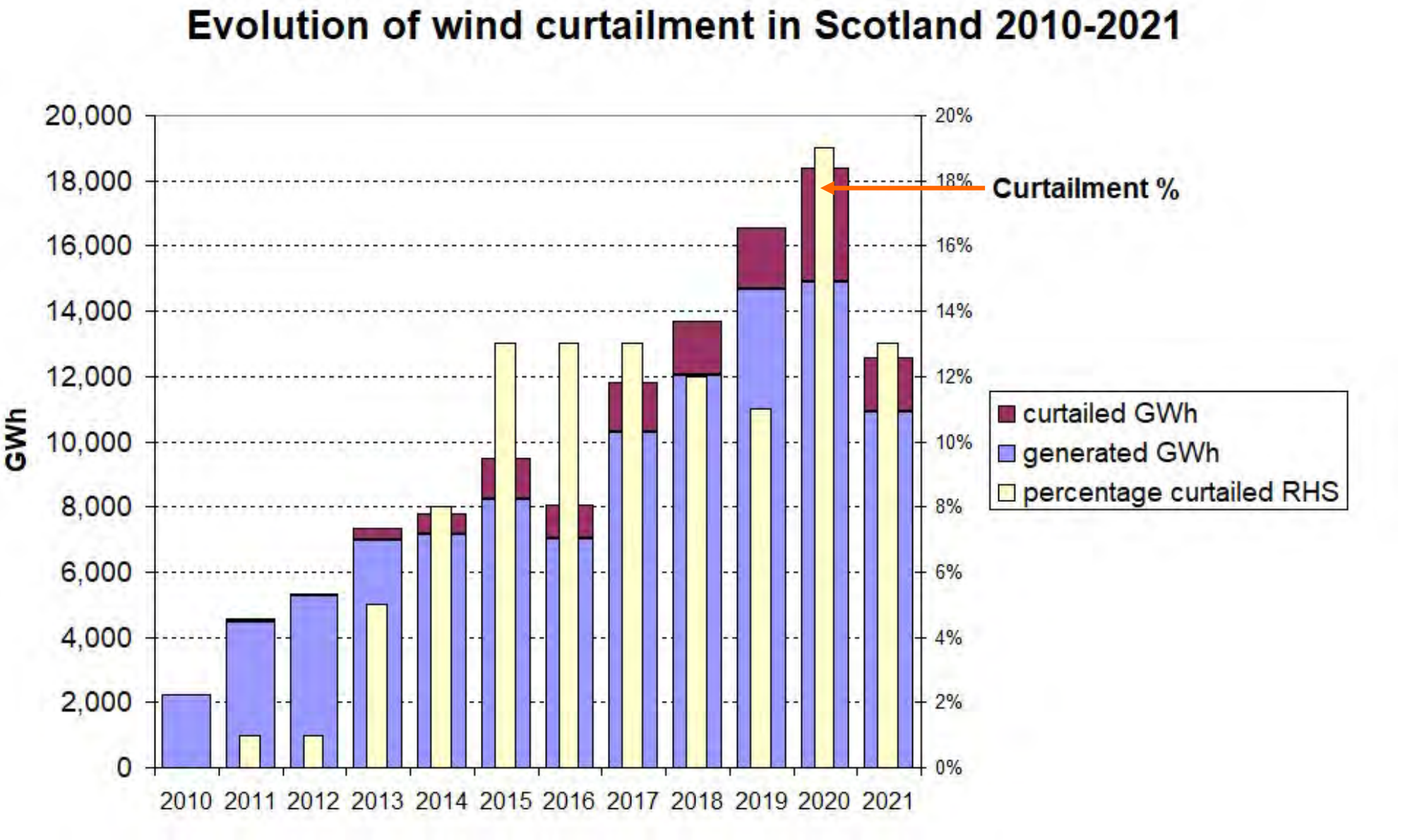
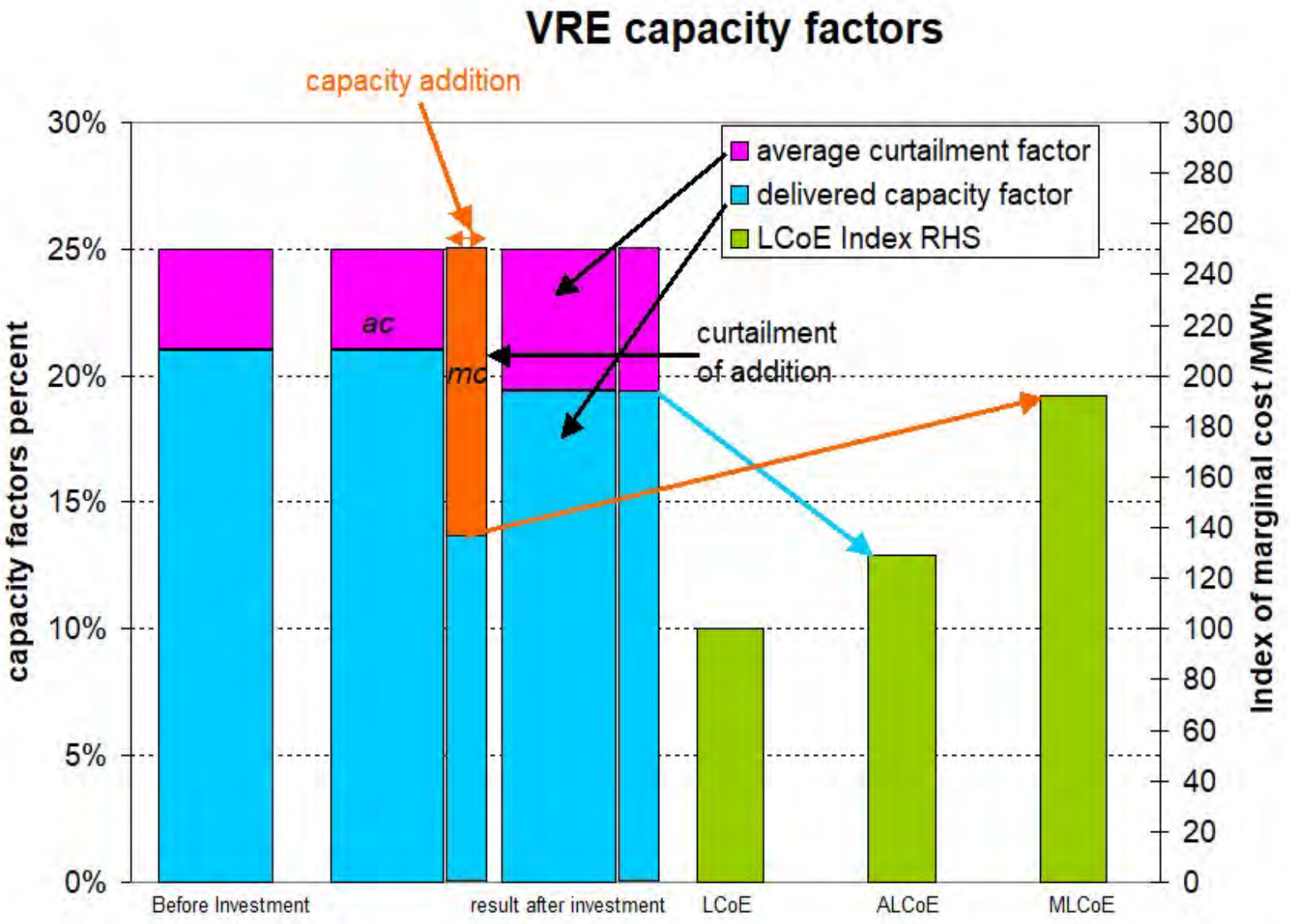
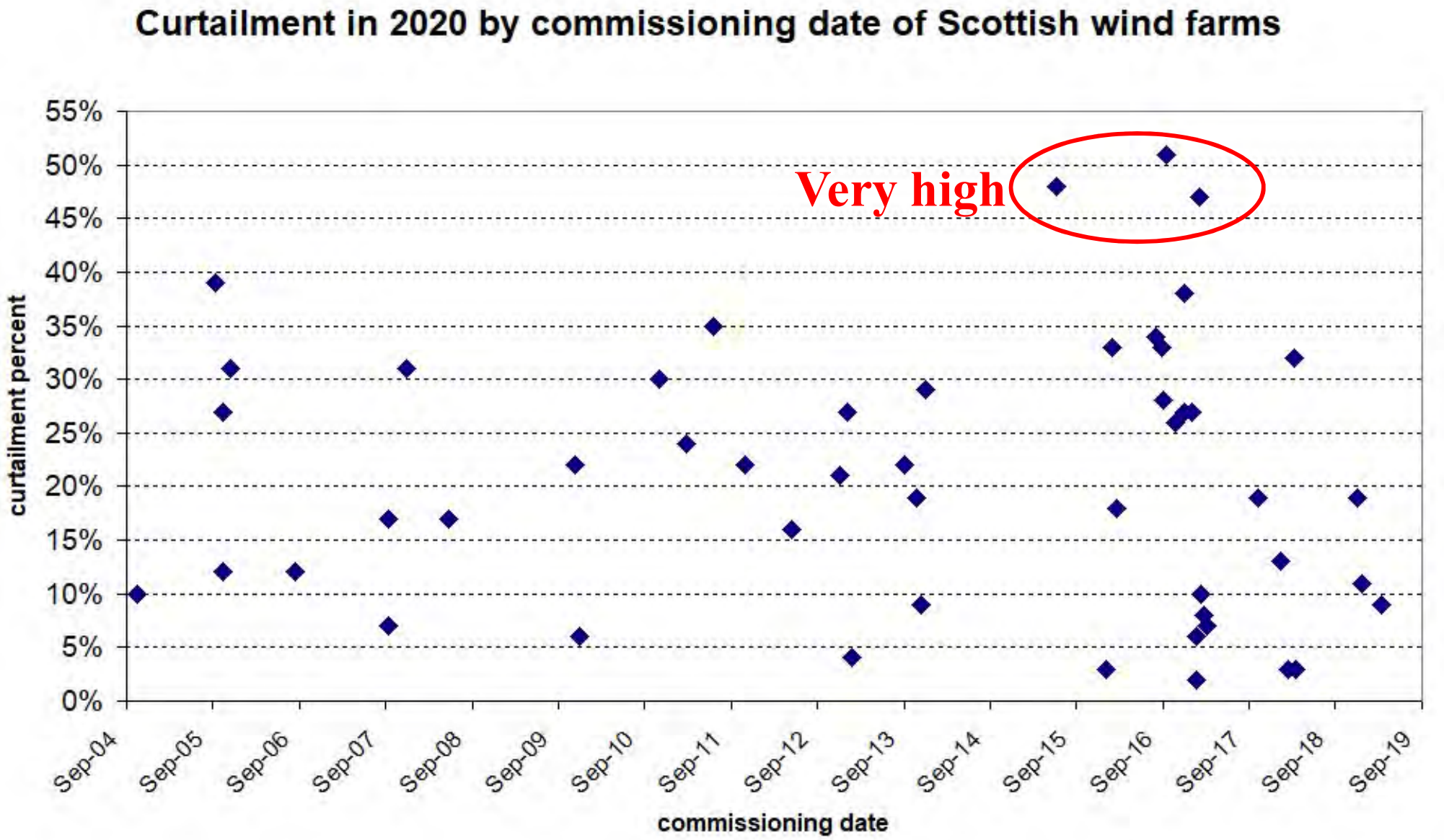
Transmission congestion curtails Scottish wind



Average vs marginal curtailment



Scotland transmission constraints already very serious



EC Regulation 2024/1747

- "the energy crisis.. has revealed a number of shortcomings and unexpected consequences" (9)
  - One-sided CfDs and Feed-in Premium => ***windfall profits***
- Public support schemes "should be two-way CfDs" (35)
- should be voluntary (37)
- CfDs holders "should participate efficiently in the electricity markets" (41)

UK CfDs with FiTs meet some but not all of these

Reforming CfDs to be market responsive - 1

Designing long-term low-risk VRE contract

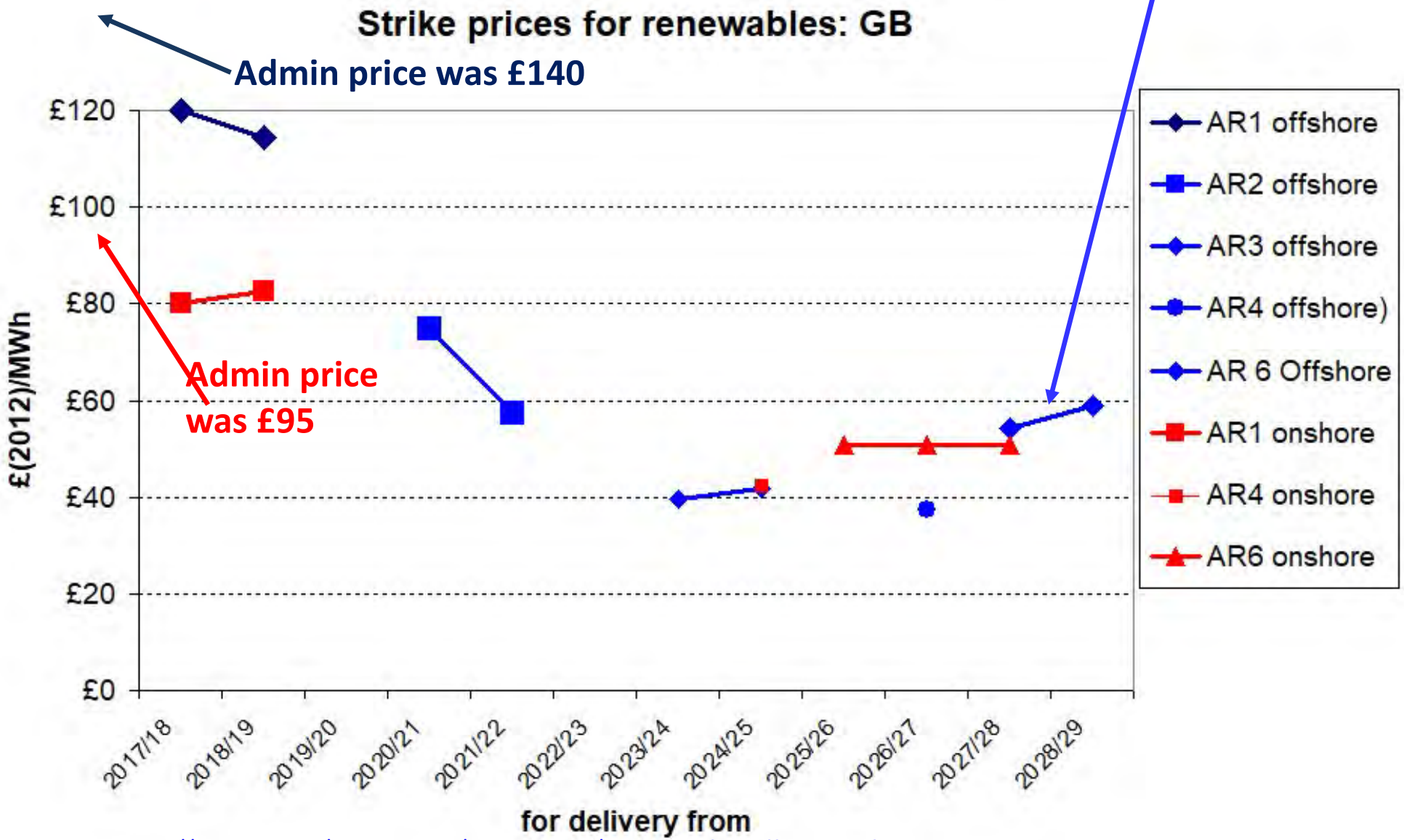
- Current CfD with FiT pays fixed price for metered output
- Standard CfD: contract independent of output
  => Generate if **price>variable cost**, not if not (buy cheaper from the market)

⇒ Make contracted amount = **forecast output**/MW of wind/PV

  ⇒ Or based on regional neighbours as in Spain

- Limit number of full operating hours to remove location distortion
  - E.g. 40,000 MWh/MW (see (BEIS p59 fn 31, p80 = deemed generation)
  - Provides guaranteed revenue for contract duration
- **Auction** to determine strike price ***s*** for new contracts
- **Grandfather** existing contracts as location decision has been made

Earlier auction price falls reversed



Source: https://www.gov.uk/government/publications/contracts-for-difference-cfd-allocation-round-6-results

Market responsiveness - 2

- **Alternative** to a financial or yardstick CfD:
- No CfD payment if hourly spot price is **≤ €0**

  ≈ avoidable cost of VRE

  => avoids inefficient dispatch order – main inefficiency
- Simpler to design/introduce
  - Already adopted by some countries
  - Works better with contract in MWh/MW not years
- Does it encourage efficient spot/balancing trading?

  – only with nodal pricing at least in real-time market?

Merchant exposure?

- Developer may prefer more market exposure
  - possible upside compensates for low prices

  ⇒ Partial cover: 2-sided CfD via auction for 80% capacity
  - remaining 20% capacity exposed to market
- Popular in Australia, lower public exposure
  - Similar risk to 100% cover, allows more VRE for given auction size
- Consistent with Regulation's voluntary contracting

Conclusions: market design

- GB recognises market reforms needed
- Location decisions for new generation critical
  - ⇒ Better locational investment signals

⇒ **Long-term TNUoS contracts for new entrants**

  - – only new entrants can choose where to locate
  - – current TNUoS for existing generators for **smooth transition**

- Zonal prices to guide IC flows (real-time market)?
  - ⇒ big problems/costs if real-time price different from DAM price
- Network planning through NESO
  - – should be more pro-active in securing good VRE sites
- Minor reforms to CfDs to make them market responsive
  - –Can be introduced before each auction round

Conclusions: CfDs

- 2-sided CfDs need to be made market responsive
  - yardstick CfD or no payment at/below zero price
  - pay on forecast output, compensate by fixed-hour contact
- VRE needs good locational investment signals
  - to minimise congested curtailment
  - no more wind in Scotland until ***massive*** new transmission
- Minimise excess rent from high resource locations
  - e.g. 40,000 MWh/MW contracted
  - auctions: encourage numerous competitors

2-sided CfDs: good but not good enough

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References

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Acronyms

CfD:	Contract for Difference
ESO:	Electricity System Operator
FES:	Future Energy Scenario (of NG ESO)
FiT:	Feed-in Tariff (paid on metered injection)
LMP:	Locational marginal (nodal) price
LRMC:	Long-run marginal cost
NG ESO:	National Grid ESO
NESO	National Energy System Operator
OWF:	Offshore wind farm
REMA:	Review of electricity market arrangements
RPD:	electricity half-hourly price index
RO(C):	Renewable obligation (certificate)
TNUoS:	Transmission Network Use of System charges
VRE:	variable renewable electricity
WACC:	weighted average cost of capital

Network costs: benefits of coordination

Current GB Off-shore regime:

- Developer gets consent (5yrs), bids for CfD in auction (£/MWh,15yr)
  - builds wind farm and connection (offshore transmission, OFT)
  - OFT auctioned, repays developer in return for **20 yr OFTO charge £/kWyr**
  - Wind farm also pays on-shore TNUoS charge (can change annually)

=> why not offer a 20yr ***on-shore*** TNUoS charge?

- NG ESO *Holistic Network Design* for offshore wind:
  - ***Optimised*** cost to deliver 50 GW offshore wind target = £54 bn
  - Compares current responsive to coordinated approach
  - Saves £7.6bn (14%) to just connecting each OWF separately
    - Requires **coordination** between off-shore wind developers

Coordinating location of new on and off-shore wind and network likely to reduce system costs considerably

Response to Winser report suggests this in Strategic Spatial Energy Plan

Reforming VRE support

- Aim: minimise cost of finance while ensuring market responsiveness
- VRE and grid contracts should
  - Hedge long-term risks
  - Signal **least system-cost** location for each technology
  - Provide short-term operating signals (congestion, curtailment, flexibility)
  - Minimise infra-marginal rent to favoured locations
  - Maximise competition => **auction** sets single country-wide strike price
- Pay for **capacity** not output for efficient technology choice

  ⇒ Costs are up-front, running costs independent of market prices

⇒ **Efficient** grid charges guide **location**

⇒ Long-term efficient nodal TNUoS (transmission) charges

⇒ 20 yr fixed charge updated for new contracts with new system information

⇒ Provides **future cost certainty** before VRE bids in **auction**

Case for CfDs

- CfDs address future market price risk
  - Generators lose when prices low, while retailers gain & vice versa

⇒ conventional CfD is a mutually attractive price hedge

⇒ Leave to market, standardise for liquidity

⇒ Purely **financial**, does not distort production/trading

- Long-term price hedges can reduce cost of capital
  - PPAs work with credible asset-heavy counterparty
  - But limited potential, **insufficient for massive renewables**
  - For which only credible counterparty is state or regulator

Long-term contracts replace missing futures market

UK CfD with FiT design

- Standard 2-sided CfD specifies volume *M* MW, strike price *s*
- Generator receives (or pays) $(s - p)M$ regardless of output
  - May be paid or pay depending on expected **reference price *p***
- If $p > c$ (avoidable cost) generator produces $y > M$ MW
  - Profit is $(s - p)M + (p - c)y = (s - c)M + (p - c)(y - M)$
  - **both positive**
- If $p < c$ generator produces zero
  - Profit is $(s - p)M$ as $y = 0$
  - Financial arbitrage pushes *s* towards expected future price, *p*
- CfD incentivises efficient market response
- CfD with FiT pays $(s - p)y$ on metered output *y* for 15 yrs
- Profit is $(s - p)y + (p - c)y = (s - c)y$

No incentive to change output in response to p