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Designing efficient renewable electricity support schemes

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Outline

- **Net zero** => massive variable renewable electricity (VRE)
- Past support policy – target-driven, inefficient
- **EU Clean energy package –** good principles for support
  - Overarching aim net zero, no country-specific RE targets
  - RE cost decline => mandate market friendly support
  - VRE high capital, low variable cost – future policy/prices uncertain

  => Need long-term contract on capacity
- Problems with past RE support schemes (RESSs)

⇒ ***Incentive-compatible efficient new RESS***

⇒ Ensure carbon price efficient

⇒ Grandfather existing schemes

⇒ then auction new contract for future RES

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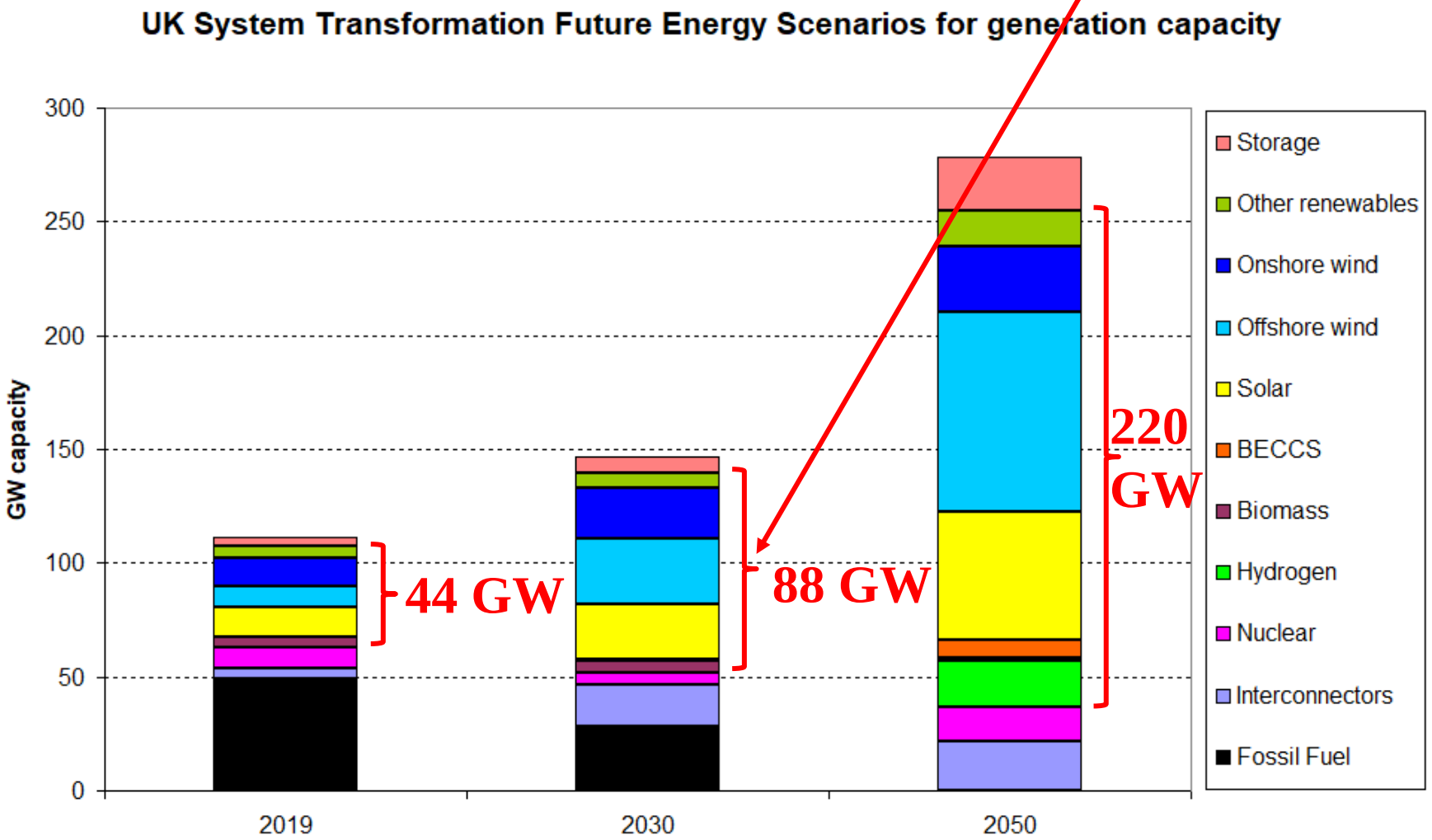
UK renewable electricity capacity to *double* by 2030



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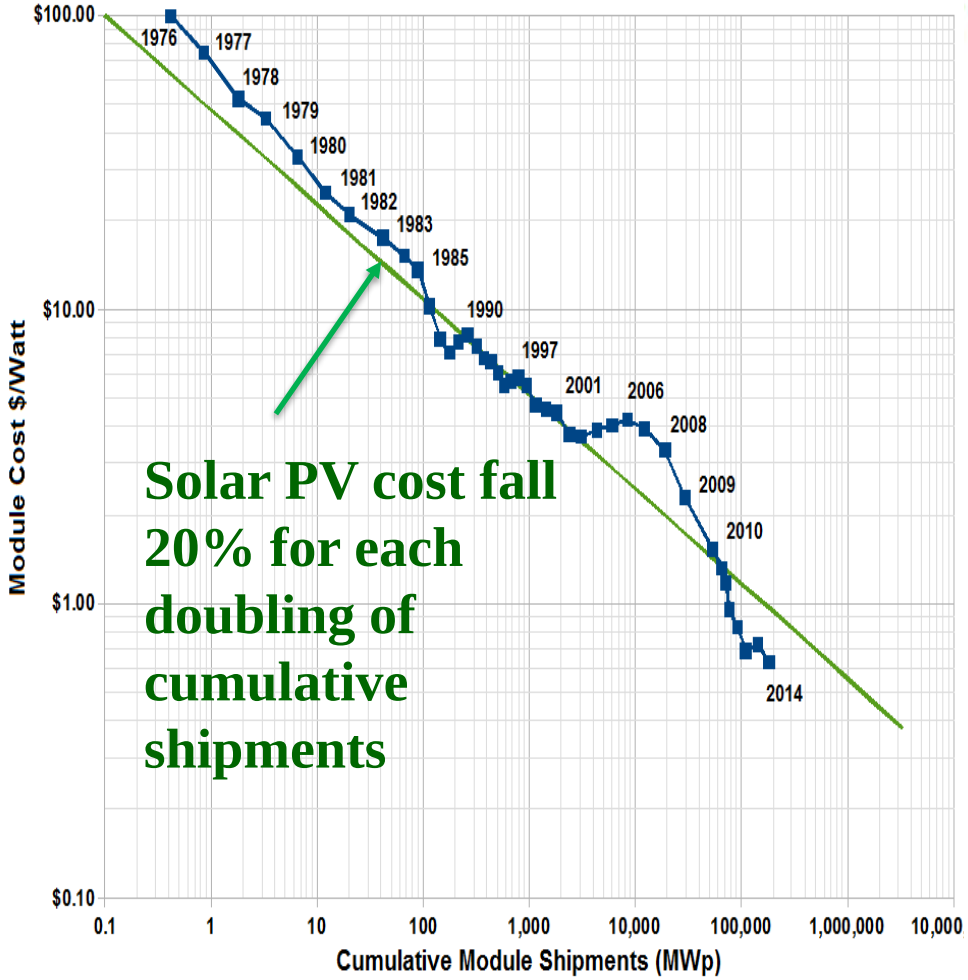
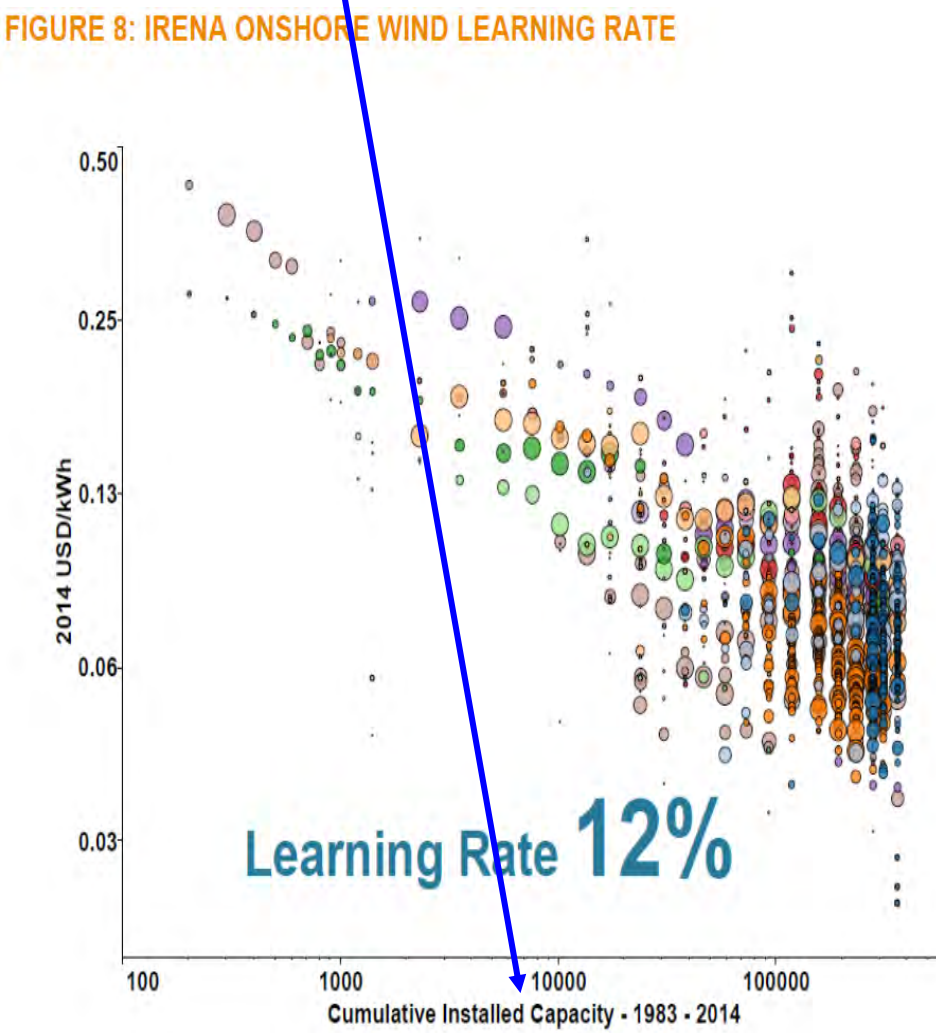
Learning benefits depend on cumulative *capacity* not output





The EU missed an opportunity not setting capacity or financial targets

Why support renewables?

- Installation drives improvements (RD&D, scaling up, supply chains, confidence in lending, etc.)

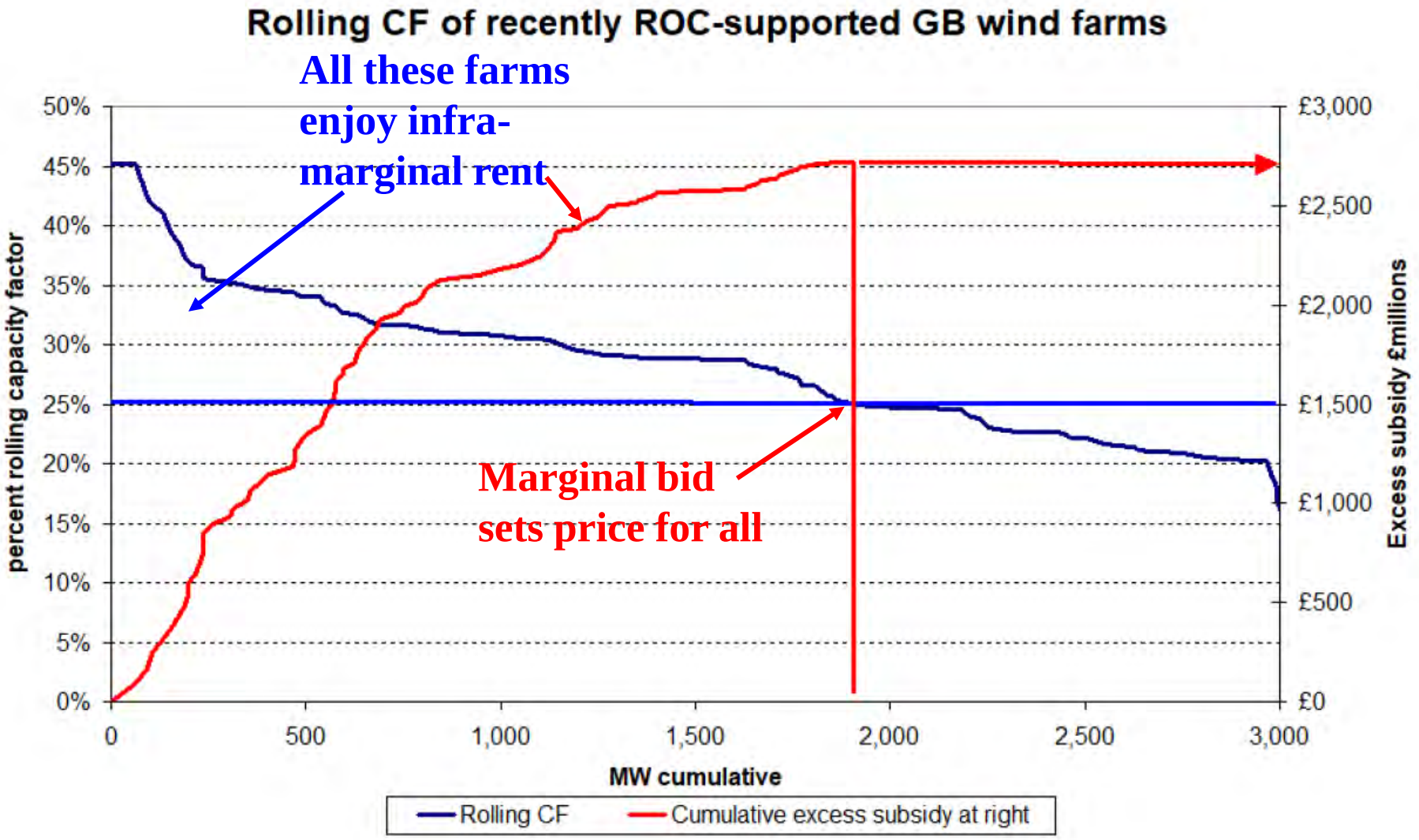
=> **Support investment**, not output

- But avoid cheap ineffective investments driven by e.g. immediate investment credit

=> pay on delivery up to a fixed MWh/MW capacity

  - E.g. 30,000 MWh/MW
- Greatly decreases advantage of high resource locations
  - which deliver the 30,000 full operating hours slightly sooner
- Marginal bid sets price, this lowers infra-marginal profit

Cumulative excess subsidy from a time-based contract



EU 20-20-20 renewables support

- Target driven by country = set RE share of 2020 output
- Encourages output support: price or quantity?

Price-based with admin price or premium

- Feed-in tariffs (FiTs) or Premium FiTs

  => Good for rapid deployment

  => excessive cost => collapse, sometimes ***retrospective cancellation***

Quantity-based

- Green or RO certificates: market determines price

  => excessively risky, poor take-up, miss target

- Solution: **auction sets price of FiT**
  - for fixed volume (MW) or revenue

  => Stability of revenue

=> Dramatically lowers cost

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FiT most popular in EU

Type of support	RESS costs (€ m.)	share total support	GWh	share GWh	Cost per MWh
Call for tender	€ 10.3	0%	219	0%	€ 47
FIP	€ 11,011	31%	79,099	27%	€ 139
FIT	€ 19,358	54%	147,908	50%	€ 131
Green Certificates	€ 5,196	15%	66,966	23%	€ 78
Investment grant	€ 1	0%	48	0%	€ 21
total	€ 35,576	100%	294,240		€ 121

Costly but fast or cheaper but slower

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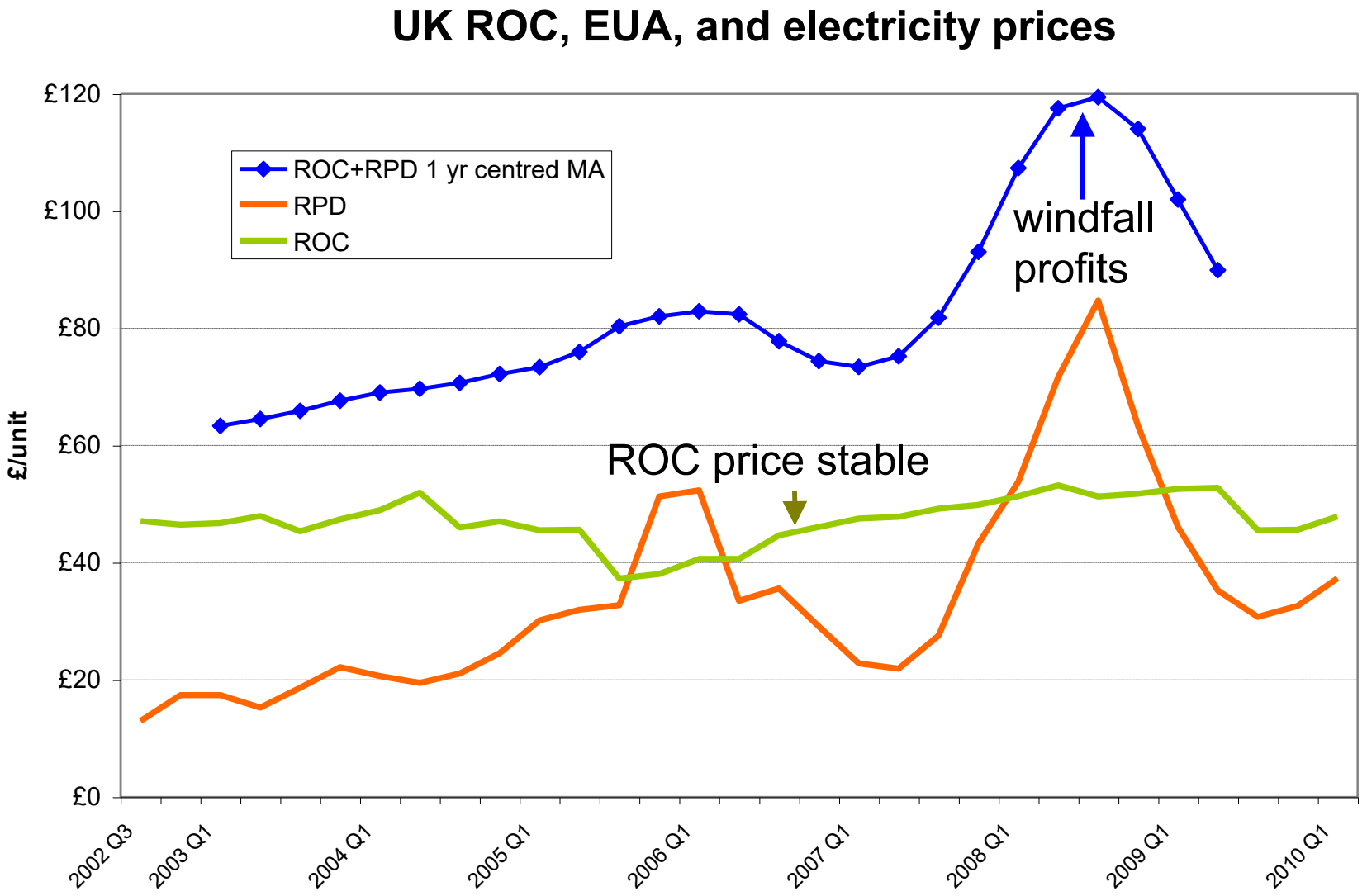
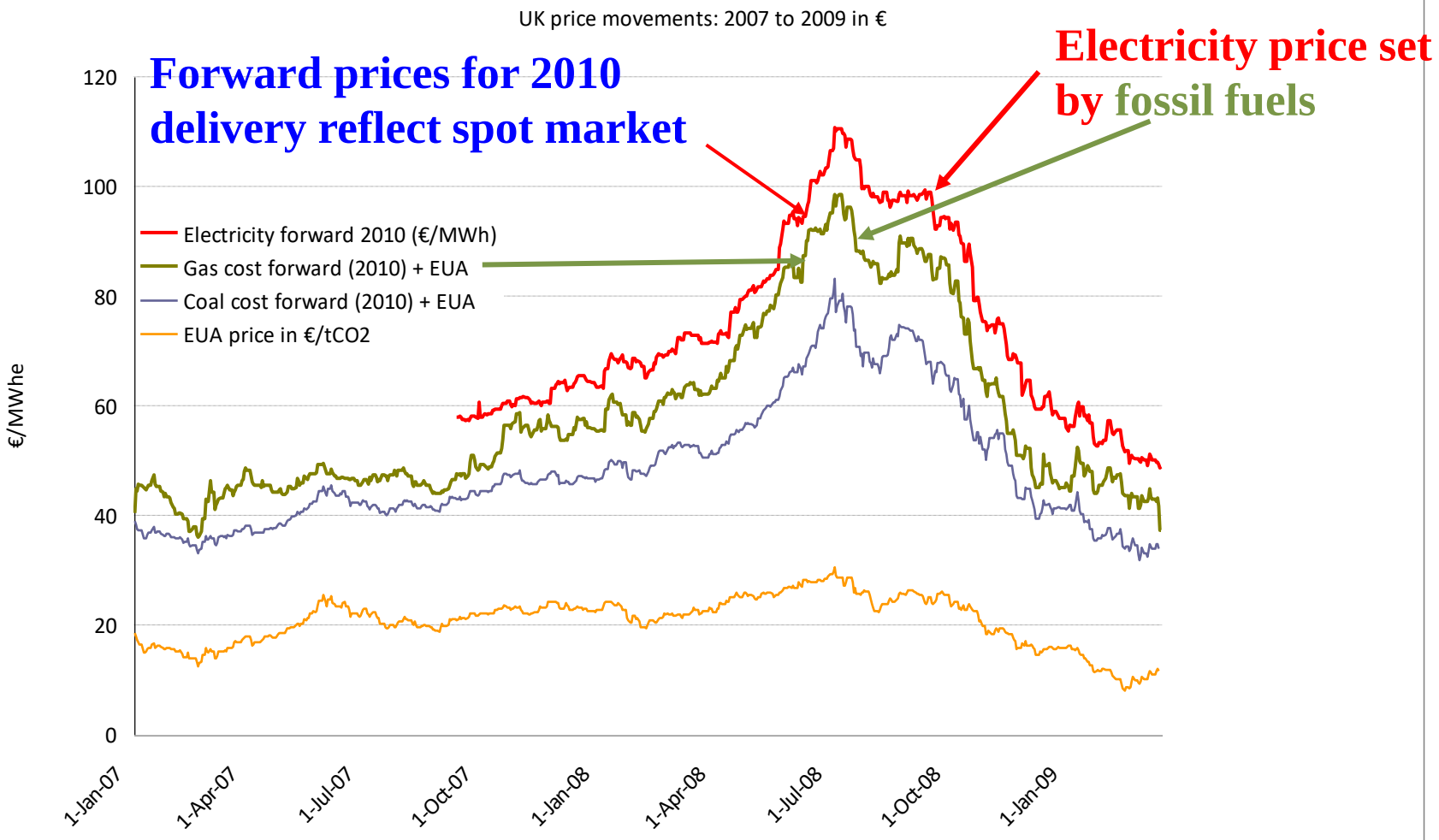
GB Renewables obligation certificates (ROCs) are risky

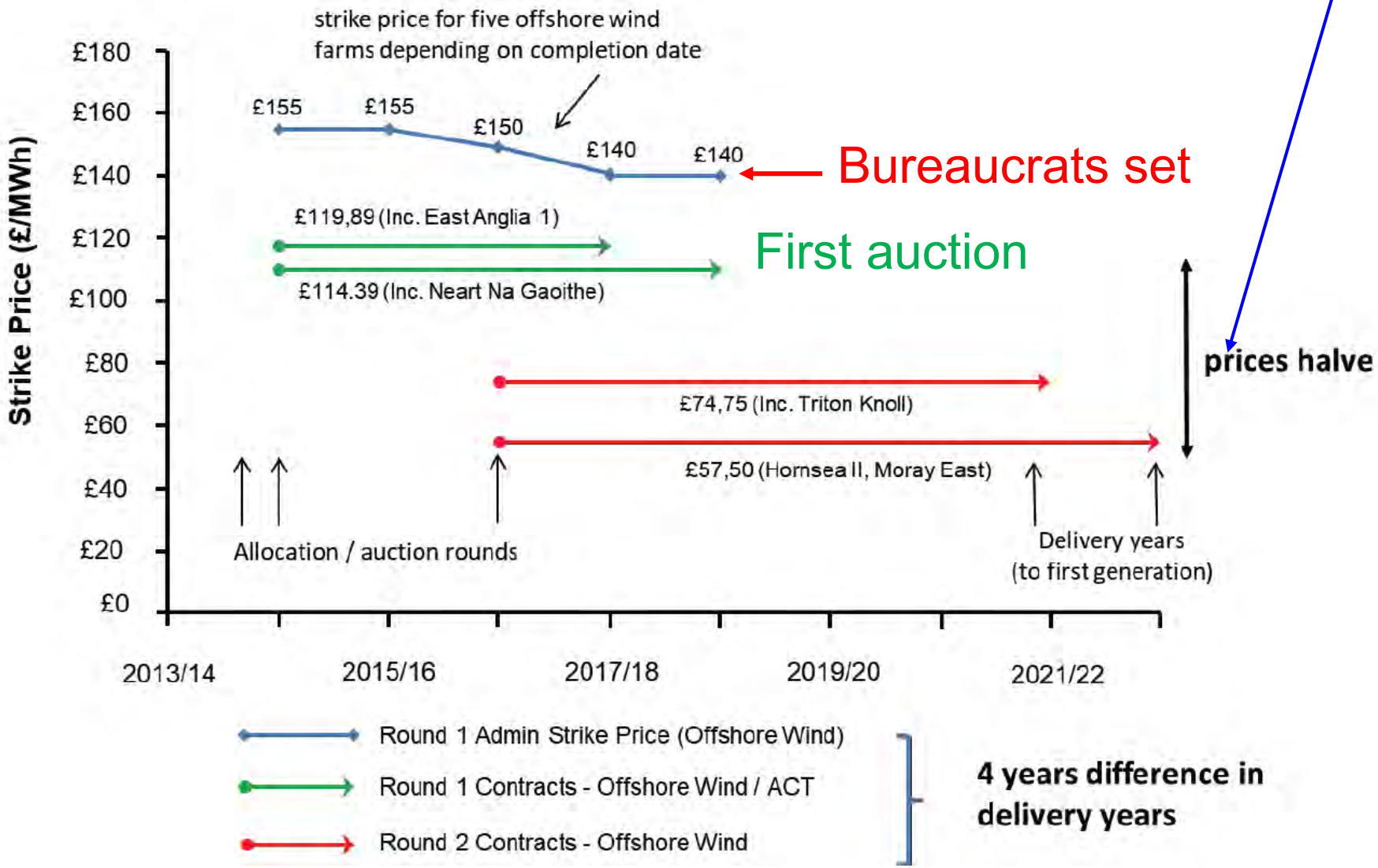


ROCs face more profit risk than fossil generation (sales less fuel price)



EMR: Auction for CfDs with FiTs

UK off-shore wind prices show power of a sequence of auctions in driving down prices



Criteria for efficient VRA support

Criteria: New VRE locates optimally and is dispatched optimally at least social cost (cf. CO_2 and learning)

⇒ auction for different pots

⇒ Distinguished by maturity and learning rates

⇒ clarity on future market design and rate of VRE entry

- Predictability of revenue stream to lower WACC

  => guarantee price but limit number of full operating hours

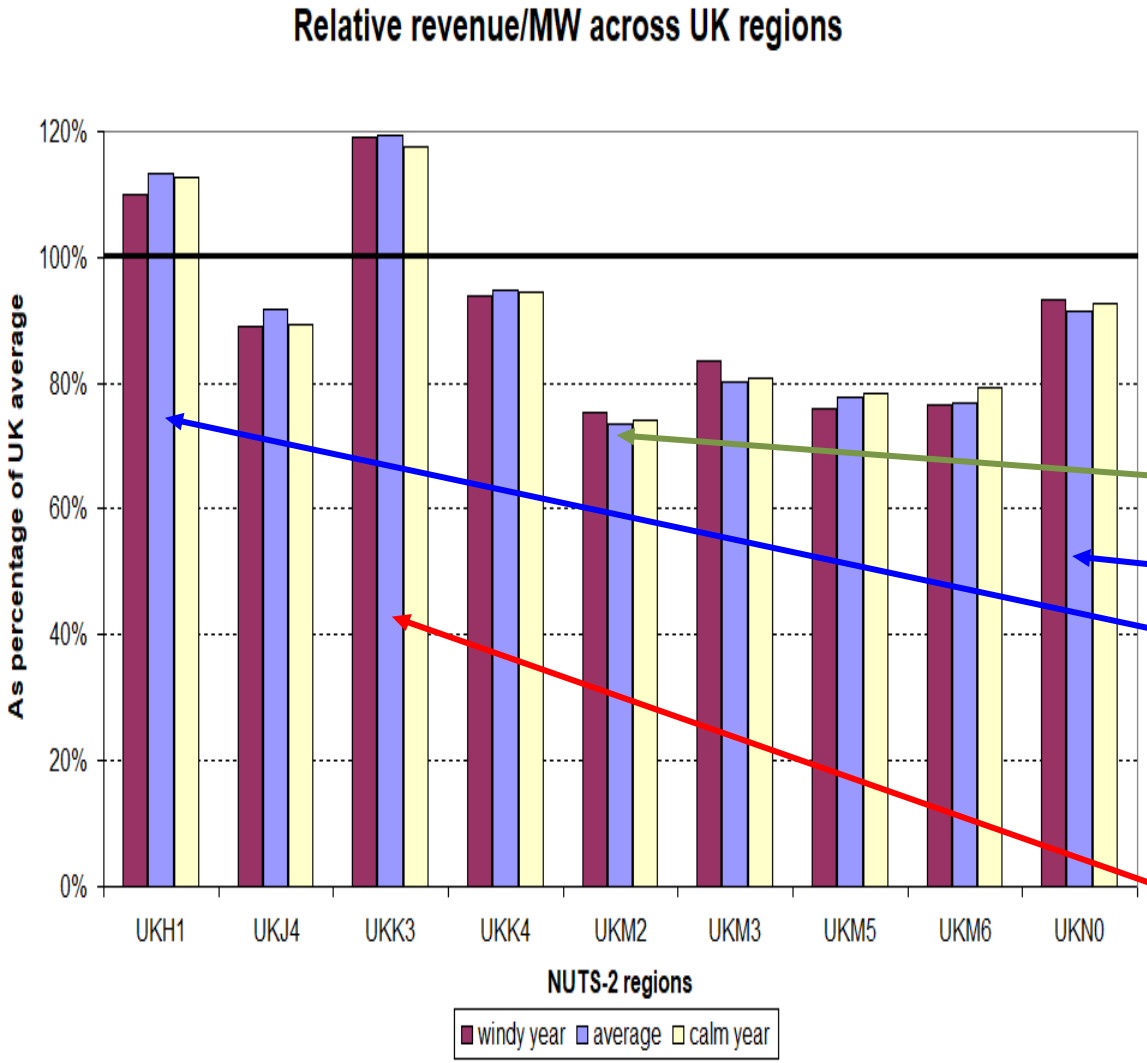
- Spot value varies over time and space

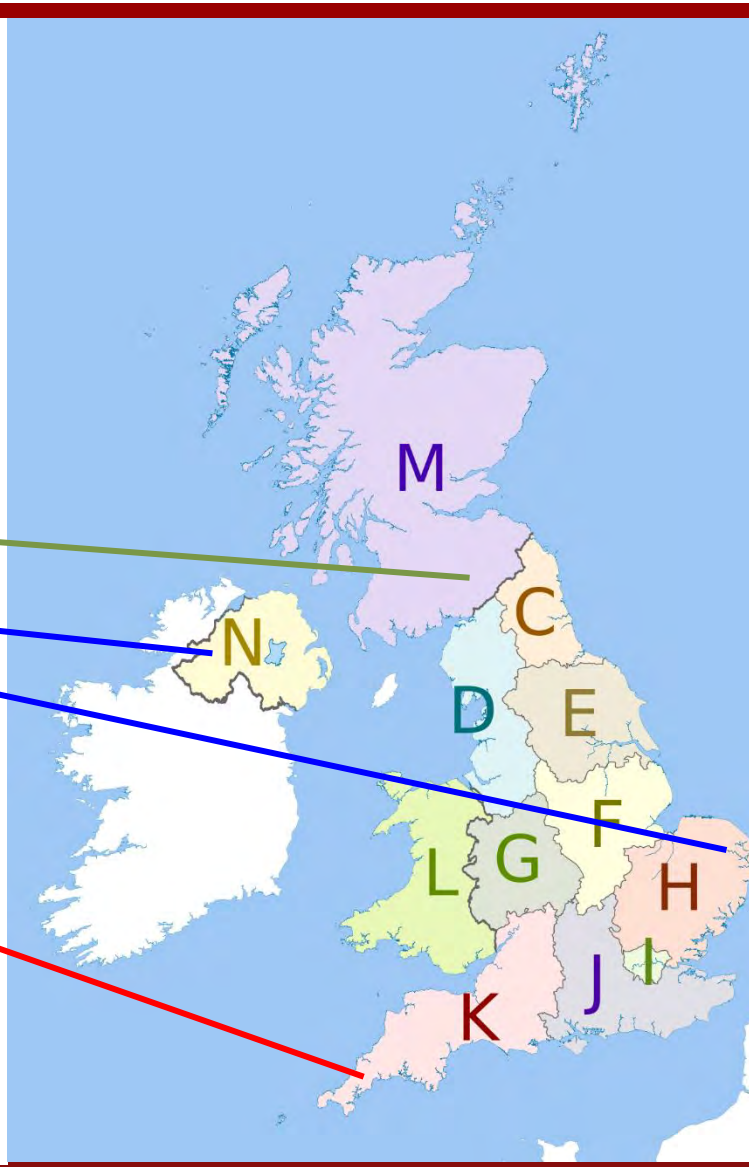
=> self-curtail if local price < var. cost (€5-€12/MWh wind, €0 PV)

  – Or deny negative price bidding

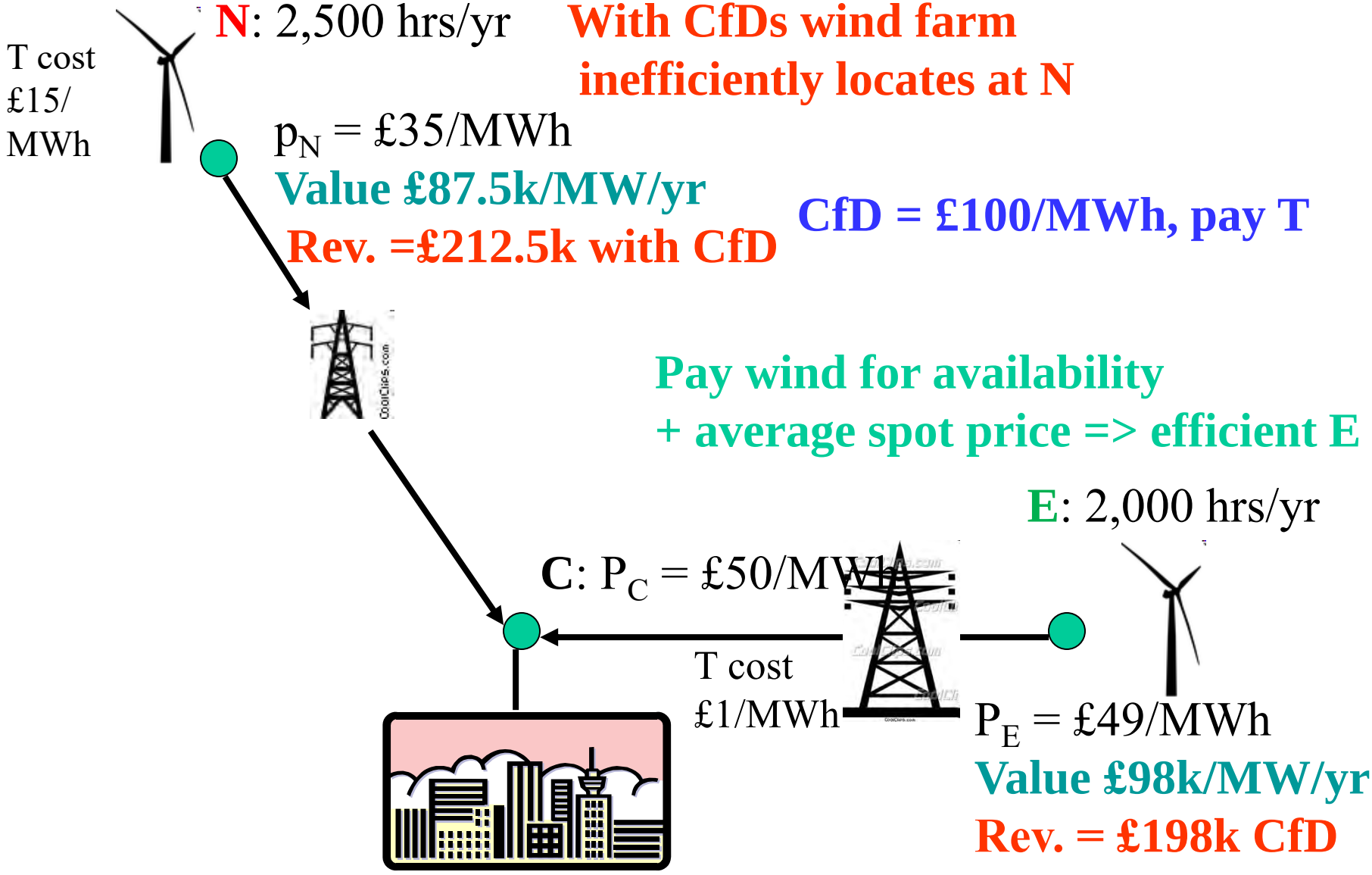
- Discourage local saturation

Output and value/MW vary across regions (from SW to NW and NI)





Wind location choices: CfDs with FiTs; contract for N years



Hedging risk

Contrast fossil CfD with GB VRE CfD with FiT for 15 years

- **Fossil CfD**: spot price *p*, MC = *c*
- strike price *s* £/MWh, volume *M* MW, pays (*s*-*p*)*M*:
  - if *p* > *c*, sell *Y* > *M* at *p*, profit (*p*-*c*)*Y* + (*s*-*p*)*M;* if *Y*=*M*, ***Π* = (*s*-*c*)*M***: perfect hedge
  - if *p* < *c*, do not produce, receive (*s*-*p*)*M* > (*s*-*c*)*M* (> 0)
- GB VRE **CfD with FiT**
- strike price *s* £/MWh on metered output *Y* MW, pays (*s*-*p*)*Y*
  - Variable revenue, on average fairly predictable

  => go to location with max output/MW

Result, distorted location, local saturation

An efficient yardstick contract

Assume

- right price for CO_2 (currently £50 or €50/tonne)
- Spot market workably competitive
- Transmission charges are correct spatially (or nodal pricing)

- Efficient dispatch *and* risk-sharing requires CfD for amount ***independent of output***

$\Rightarrow$ Yardstick CfD: strike price s, spot price p_h (in hr h), region r ***forecast*** capacity factor θ_{rh}, pays $(s - p_h)\theta_{rh}K$

Proposition 1 An auctioned yardstick CfD (for the strike price) for a fixed number of full operating hours (MWh/MW) encourages efficient dispatch at least cost

Addressing locational correlations

- The previous CfD ensured efficient dispatch but not necessarily the location that takes advantage of low correlations*
- Yardstick CfD: strike price s_r, spot price p_h (in hr h), region r ***forecast*** capacity factor θ_{rh}, pays $(s_r - p_h)\theta_{rh}K$ where
  $s_r = f + b_r$, $b_r = E(\theta_{rh}P_h)/E\theta_{rh}$ (correlation incentive), f is premium set at auction

Proposition 2 An auctioned yardstick CfD (for the strike price) for a fixed number of full operating hours (MWh/MW) encourages efficient dispatch **at the optimal location** at least cost

* this second correction becomes more important with higher penetration

Conclusions

- Most support schemes distort location and dispatch
  - Location distortions most important as durable and require costly grid investment
- Limiting support to e.g. 30,000 MWh/MW avoids spatial distortion
  - reduces excess profits of inframarginal projects
- Hedging risk is key to lowering cost
  - Prices set by fossil fuel prices amplify price risk
- Standard CfDs hedge risk for an amount independent of output
- CfDs with FiTs for wind, PV are on metered output => distortive

=> Design yardstick CfD for VRE for fixed MWh/MW => efficient dispatch and location – can adapt to encourage low correlation locations

- Auctions deliver at least cost and satisfy State Aids requirements

=> auction sets strike price for yardstick CfDs

Designing efficient renewable electricity support schemes

References, acronyms and additional slides

References

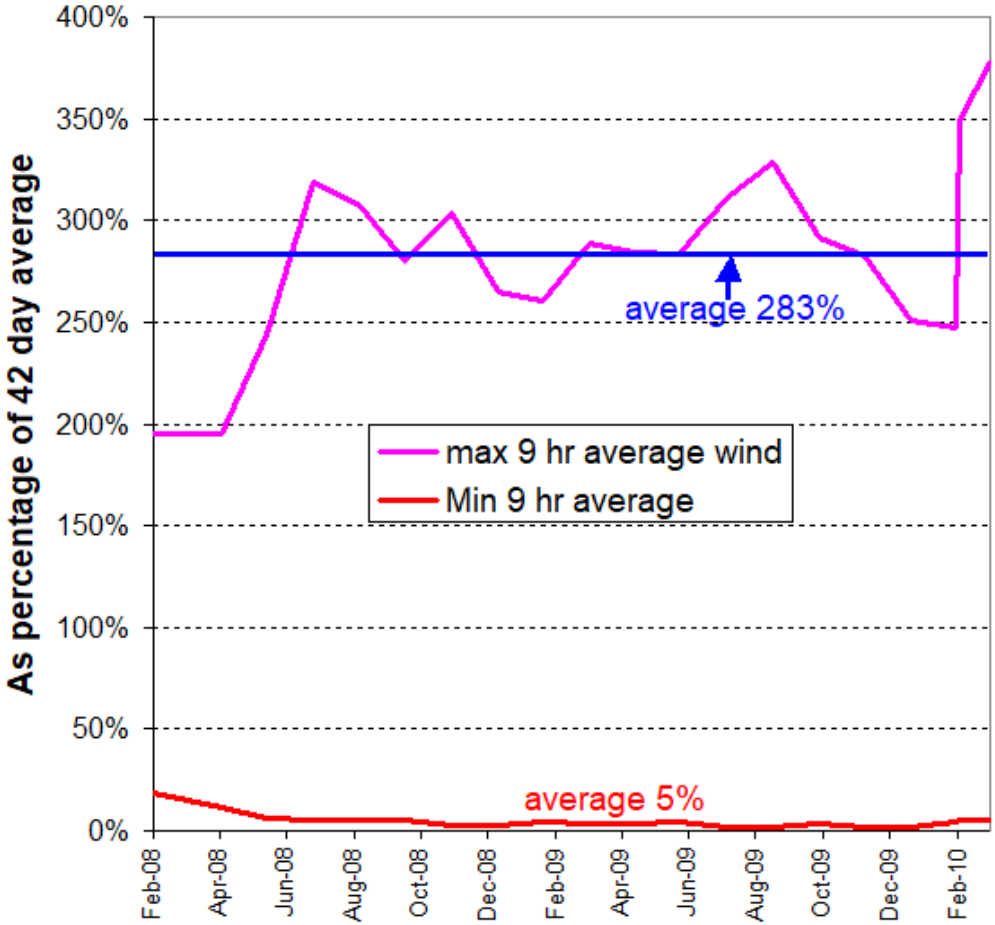
- Newbery, D., 2021. Designing efficient Renewable Electricity Support Schemes, at https://www.eprg.group.cam.ac.uk/eprg-working-paper-2107/
- Newbery, D., 2020. Club goods and a tragedy of the commons: the *Clean Energy Package* and wind curtailment, at https://www.eprg.group.cam.ac.uk/eprg-working-paper-2036/

Acronyms

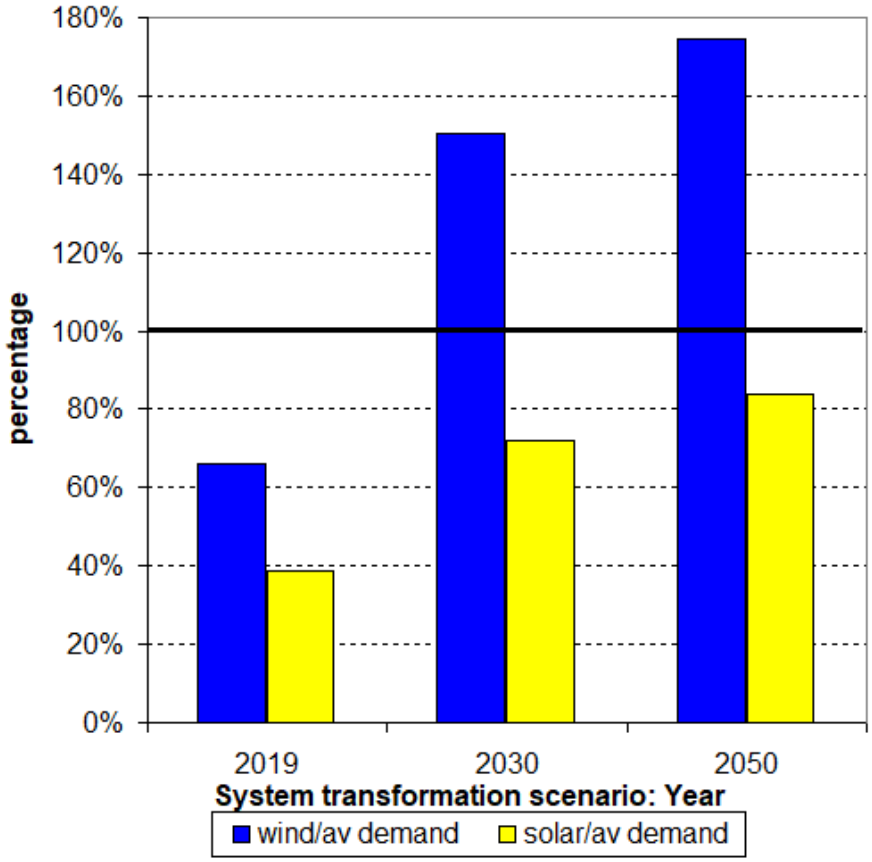
CfD: Contract for Difference
EUA: EU Allowance (to emit 1 tonne CO_2
FiT: Feed-in Tariff
MC: marginal cost (=variable cost)
RE: Renewable electricity
RESS: Renewable electricity support schemes
RO(C): Renewable obligation (certificate)
SEM: Single electricity market of the island of Ireland
VRE: variable renewable electricity

Wind and sun are variable, 9 hr periods high or low output: important to get dispatch right (replacement power, spilling wind)

Wind variability SEM 2008-2010



Ratio of capacity to average demand



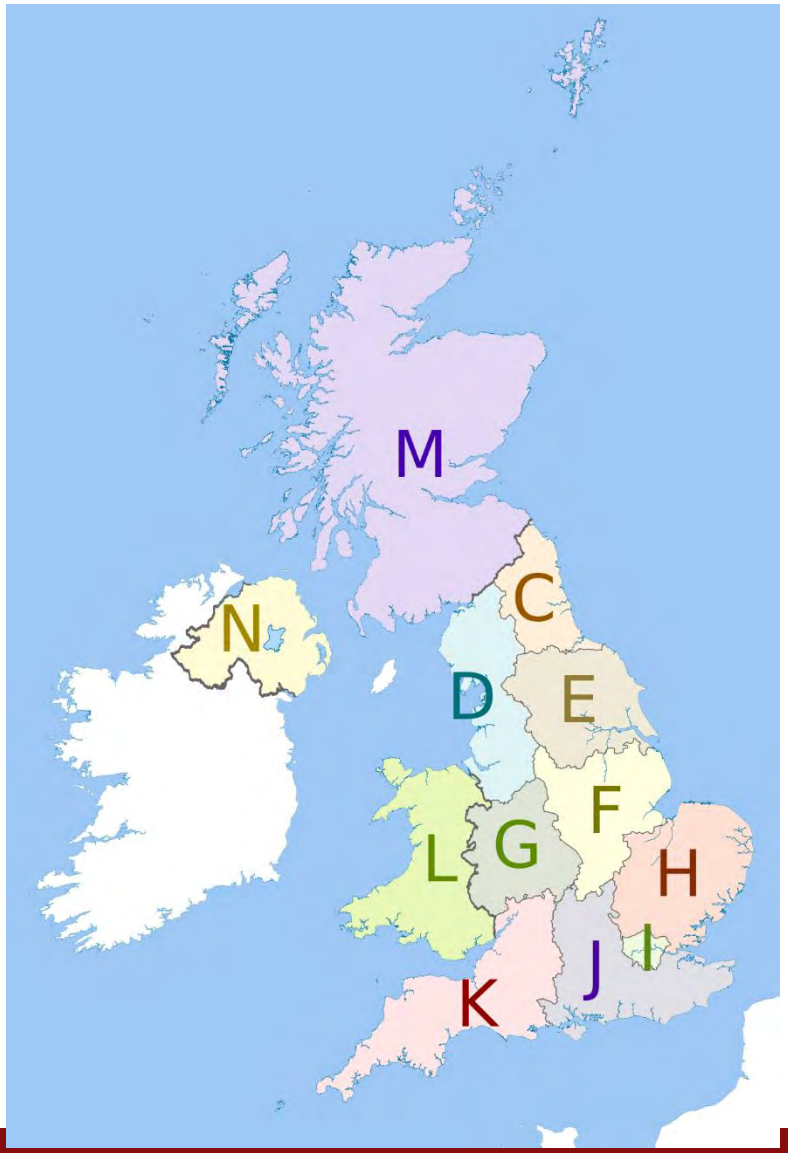
Locate with least correlation with total wind to avoid cannibalisation

Ratio of annual wind revenue selling in different regions at the spot price of its hour to the UK average, 2005-11

	UKH1	UKJ4	UKK3	UKK4	UKM2	UKM3	UKM5	UKM6	UKN0
2011	115.4%	92.3%	118.6%	93.7%	73.3%	78.9%	78.7%	77.6%	89.3%
2010	117.5%	95.7%	122.7%	92.4%	71.9%	77.4%	81.6%	75.7%	86.5%
2009	109.9%	89.1%	119.2%	93.9%	75.2%	83.7%	75.8%	76.7%	93.4%
2008	113.7%	93.2%	120.2%	97.5%	72.8%	79.2%	75.9%	74.1%	90.0%
2007	113.1%	93.7%	117.1%	94.6%	73.2%	79.8%	75.7%	77.3%	92.2%
2006	113.4%	92.3%	121.3%	97.1%	72.9%	80.4%	77.6%	75.4%	91.3%
2005	112.7%	83.8%	115.3%	88.8%	75.9%	82.0%	83.5%	82.7%	91.7%
Average	113.7%	91.4%	119.2%	94.0%	73.6%	80.2%	78.4%	77.1%	90.6%
SD	2.3%	3.9%	2.5%	2.9%	1.4%	2.1%	3.1%	2.7%	2.3%

Sources:
https://www.renewables.ninja/country_downloads/GB/ninja_wind_country_GB_current_merra-2_nuts-2_corrected.csv, Green and Vasilakos (2010)

H1 is East Anglia; J4 is Kent; K3 is Cornwall; M2 is East Scotland; M5 is Aberdeen; M6 NW Scotland, NO is N. Ireland; **all coastal locations**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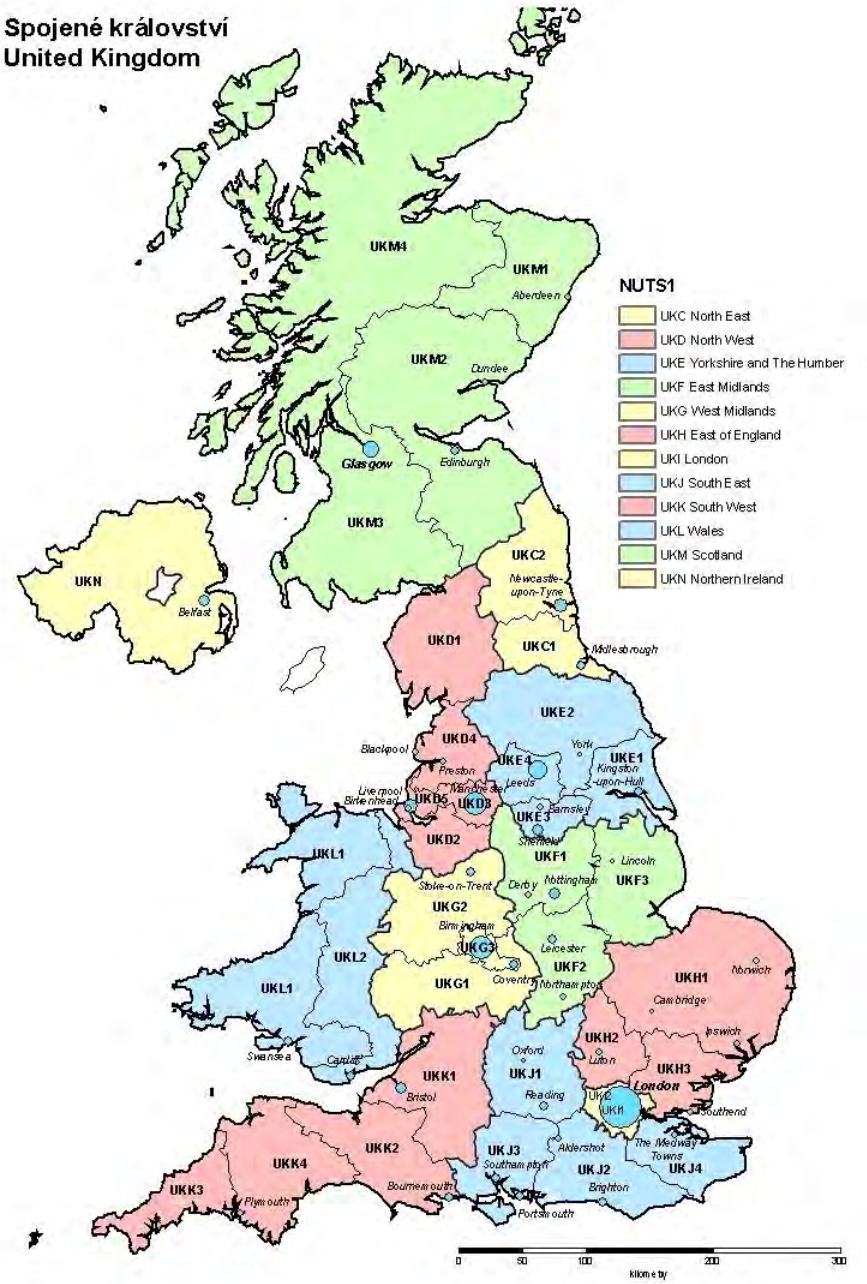
Spojené království
United Kingdom
NUTS1
UKC North East
UKD North West
UKE Yorkshire and The Humber
UKF East Midlands
UKG West Midlands
UKH East of England
UKI London
UKJ South East
UKK South West
UKL Wales
UKM Scotland
UKN Northern Ireland
UKM4
UKM1
UKM2
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