UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Secure, sustainable and affordable electricity: the challenges

David Newbery, *EPRG,*
University of Cambridge

7th GREEK-BRITISH SYMPOSIUM 2023: London

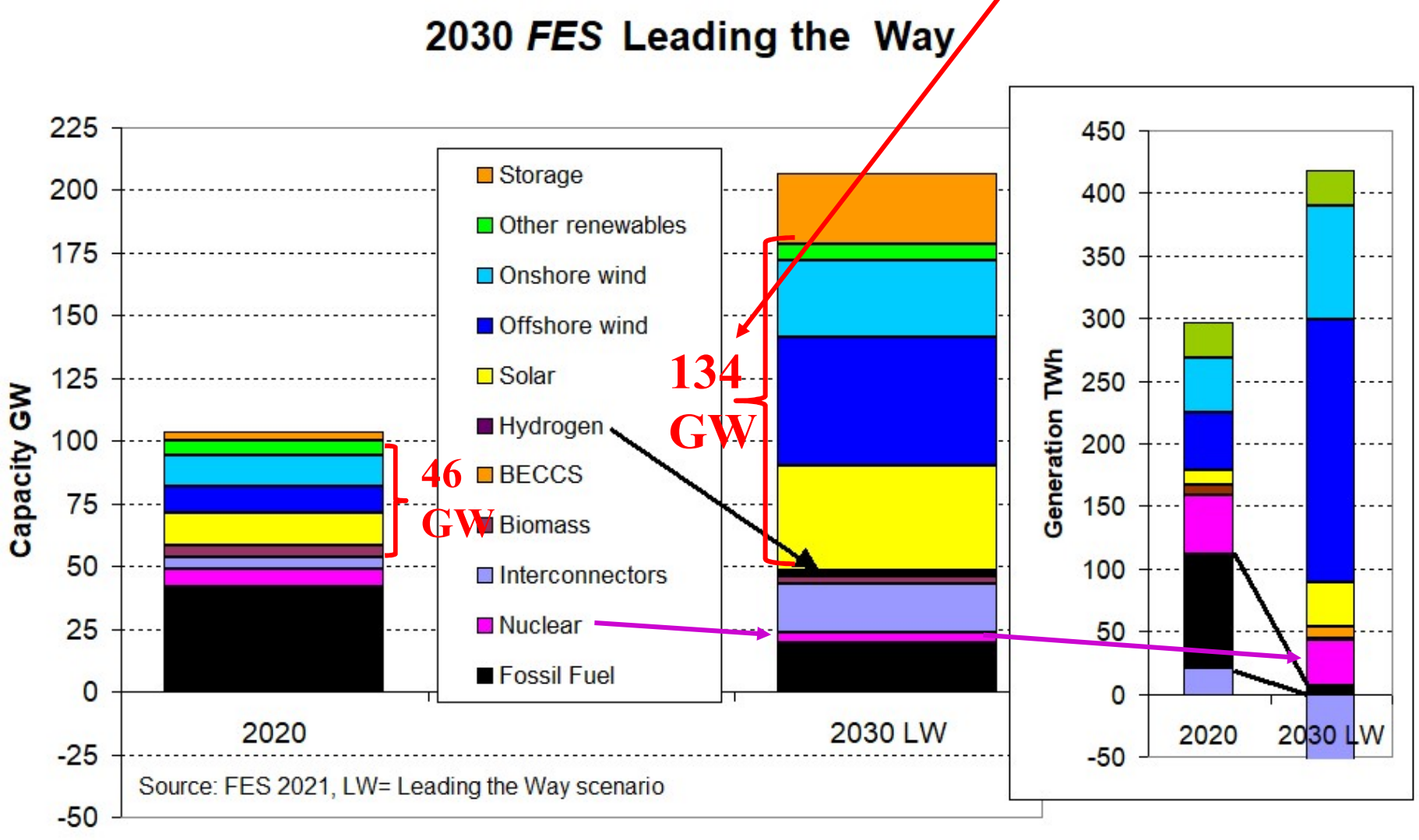
17th October 2023

Outline

- Security: renewable electricity (RE) reduces gas imports
- Sustainable: RE reduces emissions
- Affordable: wind & PV now cost-competitive
- Challenges: RE located differently from fossil
  - ⇒ needs massive network expansion
  - ⇒ which needs speedier delivery (permits, acceptance …)
- Variable RE has high peak to average
  - ⇒ curtailment if not stored or exported
- Conclusions

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

UK renewable electricity capacity to *treble* by 2030

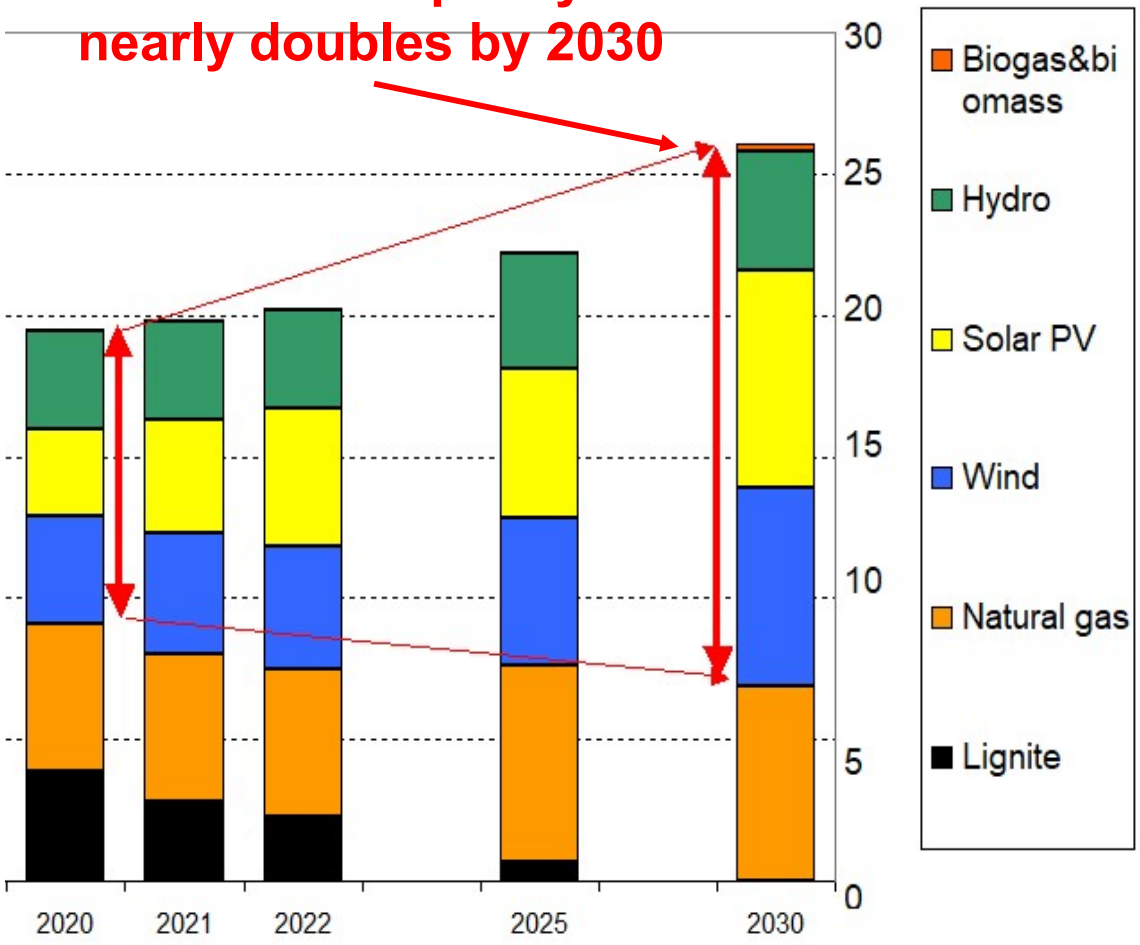


UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

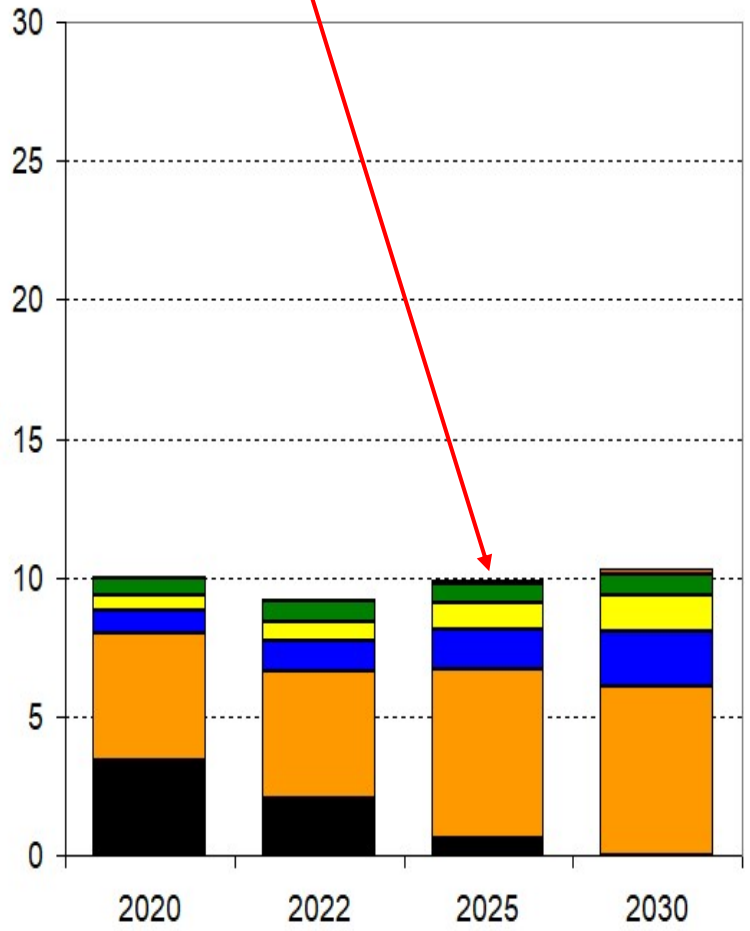
Greek renewables: double installed capacity but *potential* output lower

Installed capacity past and future

Renewable capacity nearly doubles by 2030



Effective capacity, past and future

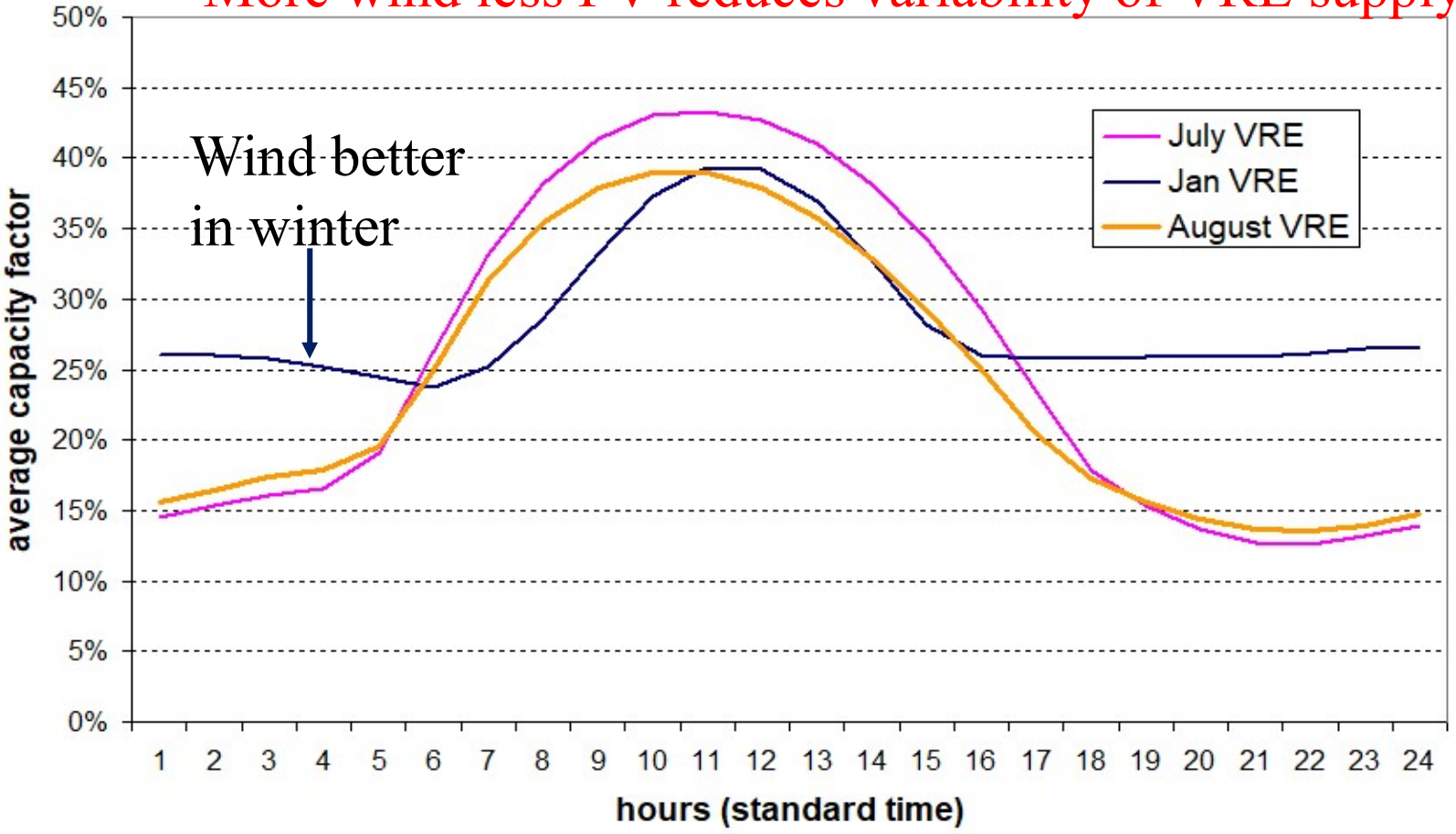


UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Greece has good PV and wind

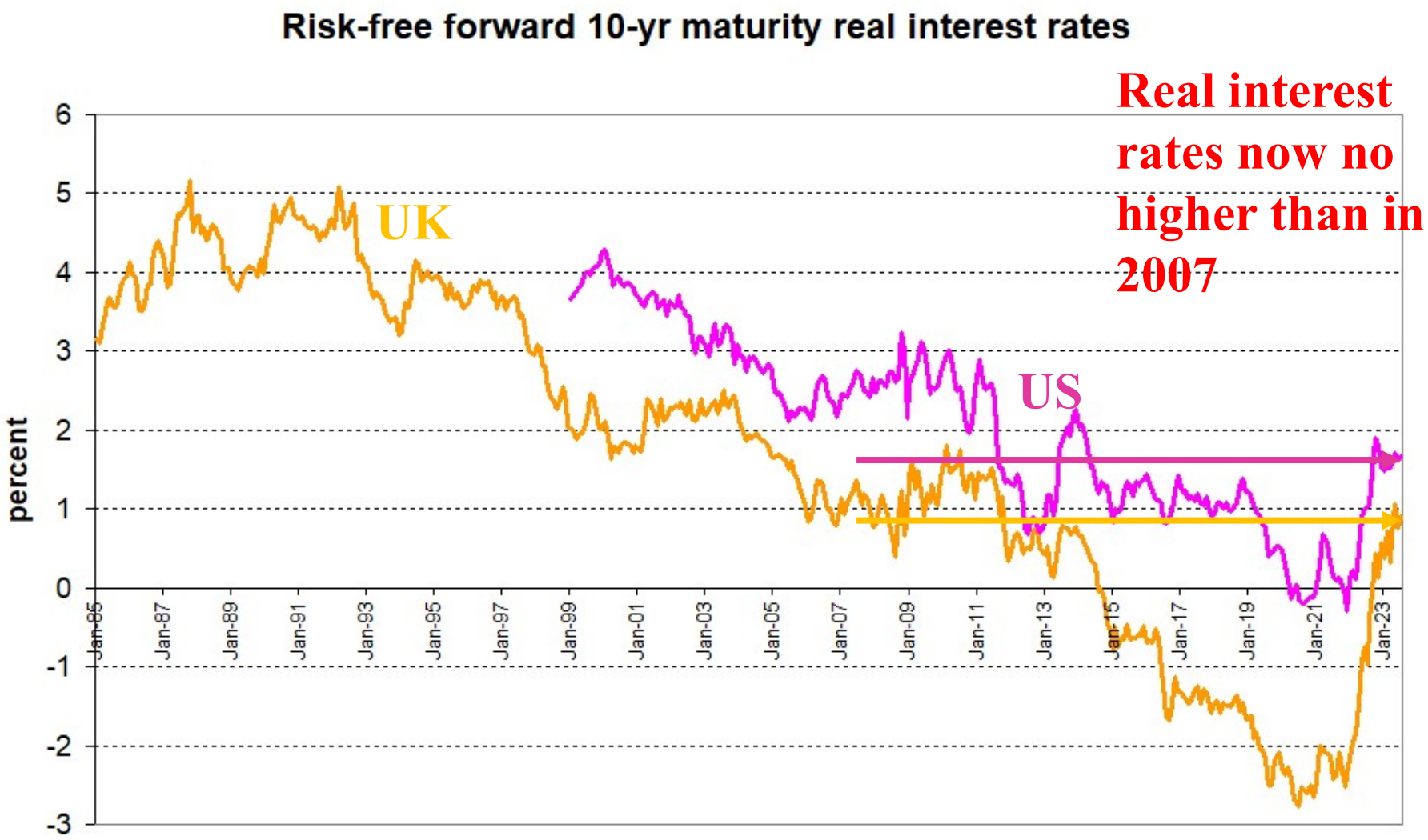
7 GW wind + 3 GW PV: monthly averages, Greece 2015

More wind less PV reduces variability of VRE supply



UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Cost of capital low



UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Net Zero messages

- Net zero requires massive investment
- Low-C is capital intensive
  - **the key to lowering cost is lowering cost of capital**

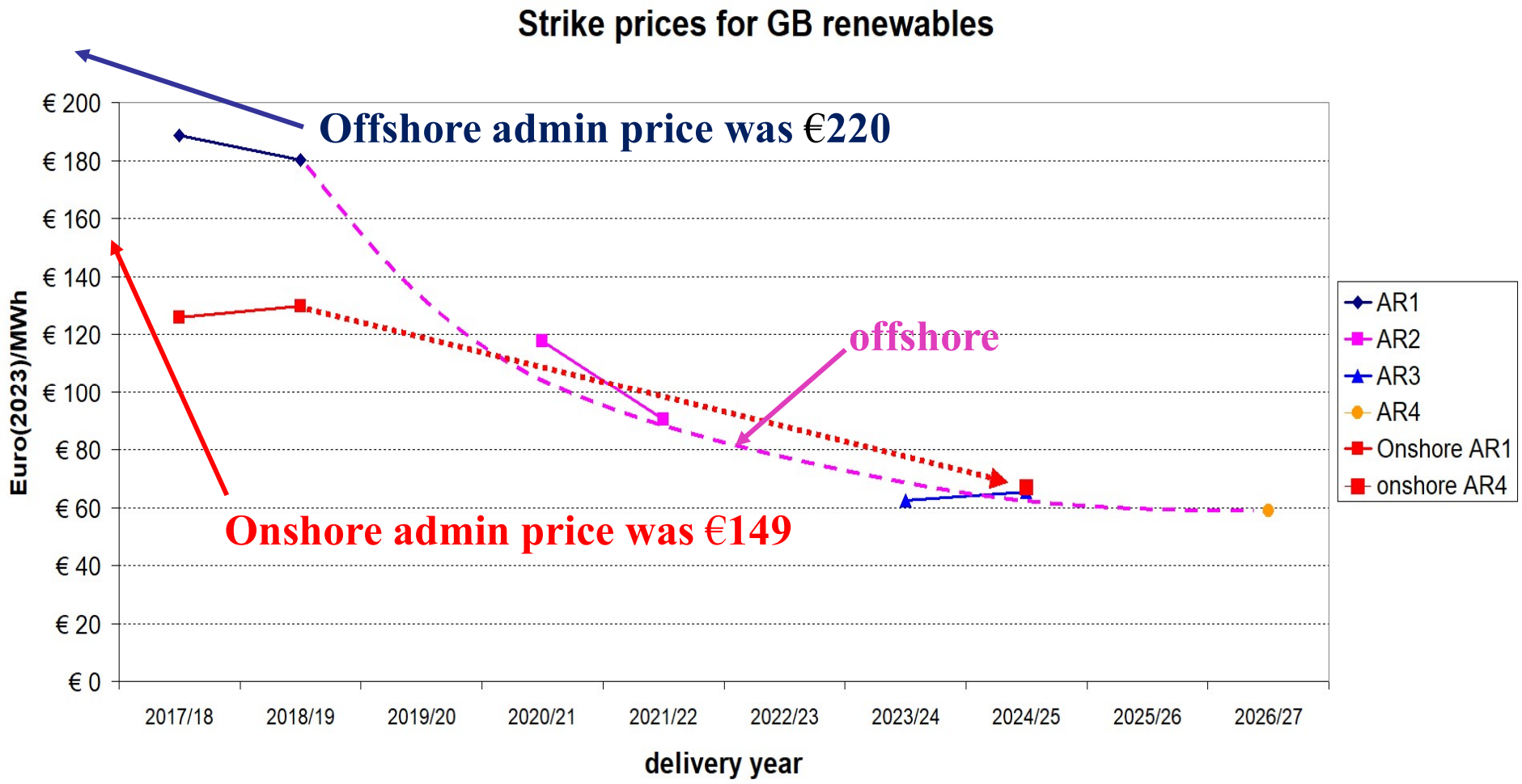
    => design good contracts to minimise risk
- Renewables – much good reform, more needed
  - Need **better hedge** against uncertain future prices
- Flexibility: capacity auction + ancillary services

  => **Hybrid markets**:
  - competition **for** the market (auction LT contracts)
  - then competition **in** the market
- Massive network investment required

  => reduce delays, coordinate location choices

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Auctions continue to deliver real GB cost reductions



UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Greek renewables support

- 2017: subsidy on top of wholesale price (Feed-in Premium)
  - Potentially excessive with wholesale price rise
- 2022 Two-sided CfD auctioned
  - average solar PV bid €47.98/MWh
  - average wind bid was €57.66/MWh
- 2023 Storage auction for 411 MW
  - average €49,748/MW/year (range €33,948 - €64,122/MWyr)
  - Further wind and PV auctions planned
- 2024 Last CfD auctions: future merchant entry? PPAs?

At present curtailment not a problem but expected to rapidly become one as VRE expands

High VRE => curtailment

- Peak:average output for wind 2-4:1
  - PV: N Europe 8-11:1, Greece 5-6:1

⇒ increasing volumes curtailed as VRE rises

⇒ exacerbated by transmission constraints

- Marginal curtailment is **3+ times average**

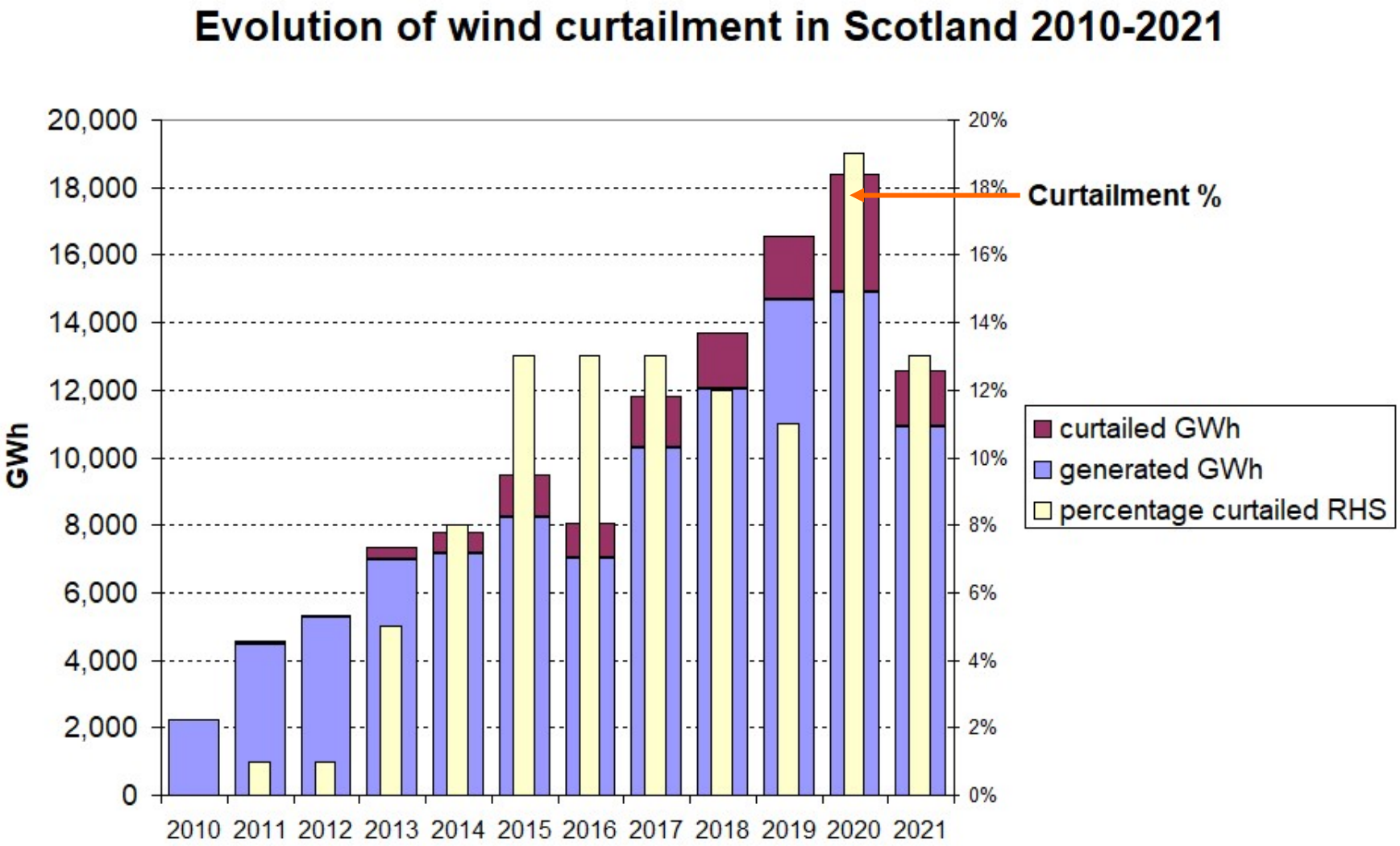
⇒ critical to locate new VRE in uncongested nodes

⇒ need strong locational connection signals

⇒ and integrated network and generation location planning

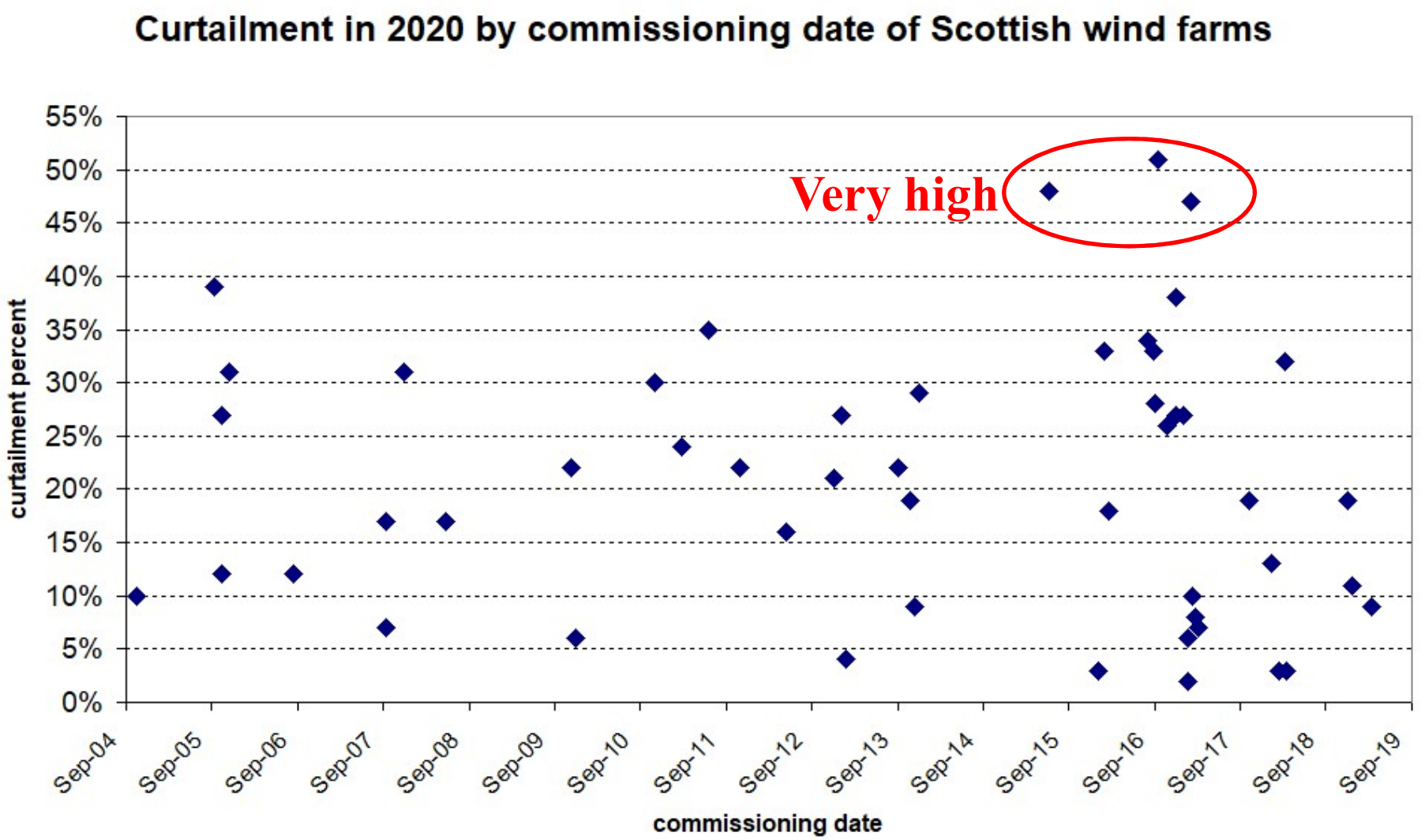
UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Transmission congestion curtails Scottish wind



UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Congestion => curtailment: marginal curtailment 3+ times average



UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

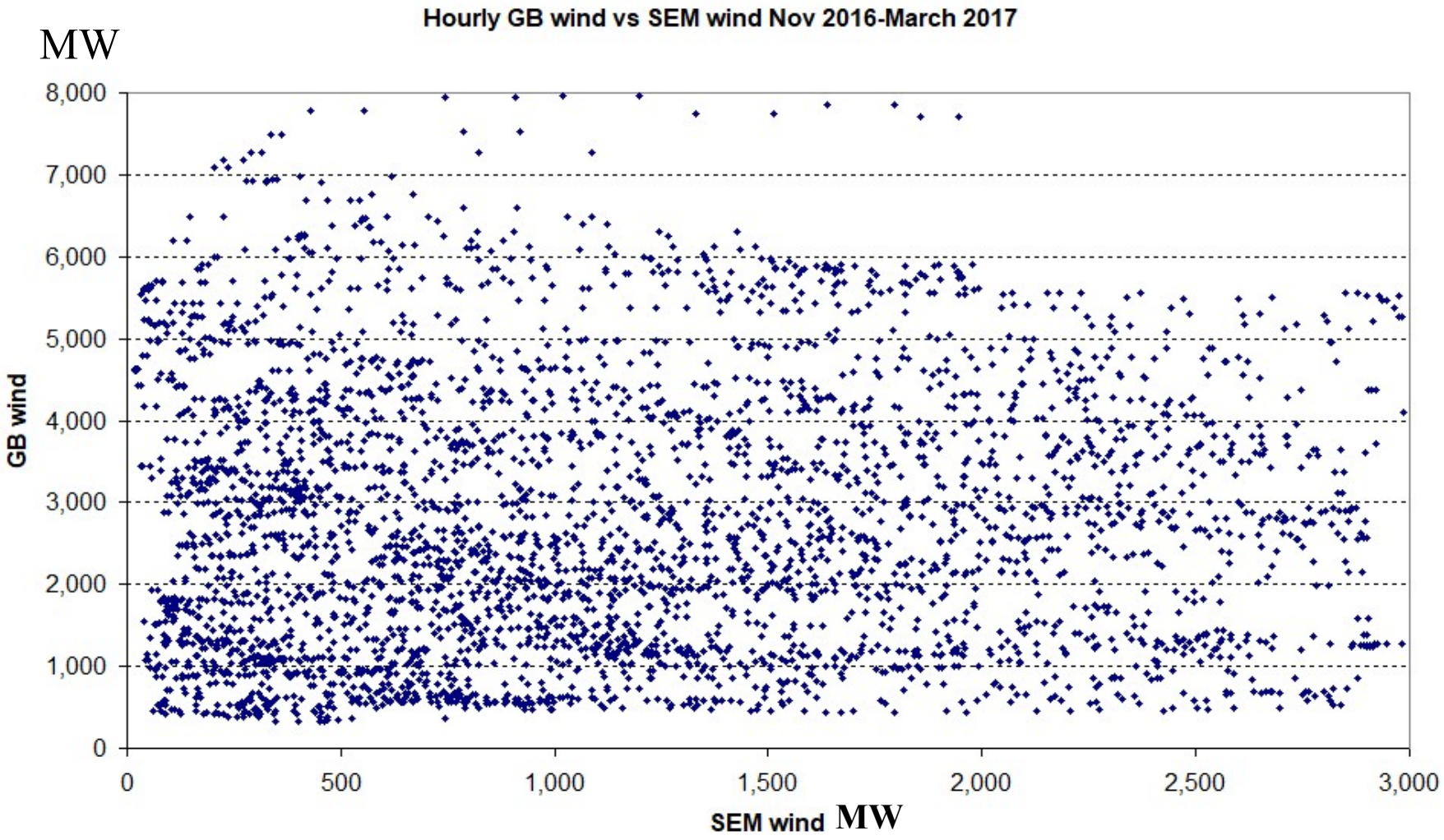
Dealing with surplus VRE

- Surplus can be shifted over time and space
- Time: by **storage** or demand side response
- Space: by **interconnecting** with uncorrelated markets
  - If wind is mainly from SW, connect **east and west**
    - Works for PV as well
- GB: Scotland could export to Norway (hydro helps)
  - but needs right price signal, zonal not GB-wide pricing
- Ireland exports to GB
  - Wind 4 hours later in GB, trade helps each country

Timely network expansion critical to accessing VRE

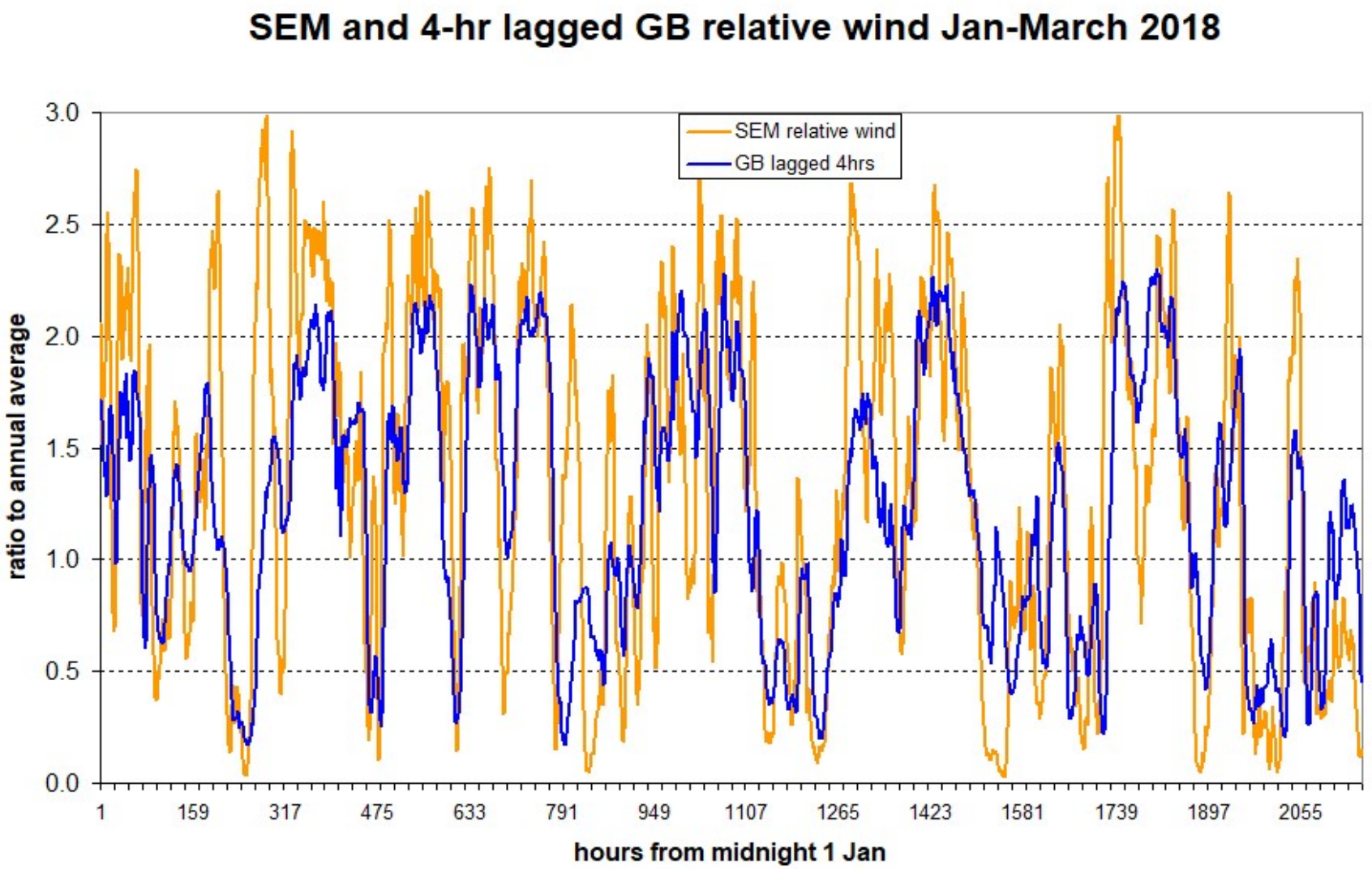
UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

SEM wind *appears* uncorrelated with GB wind – **interconnnection good?**



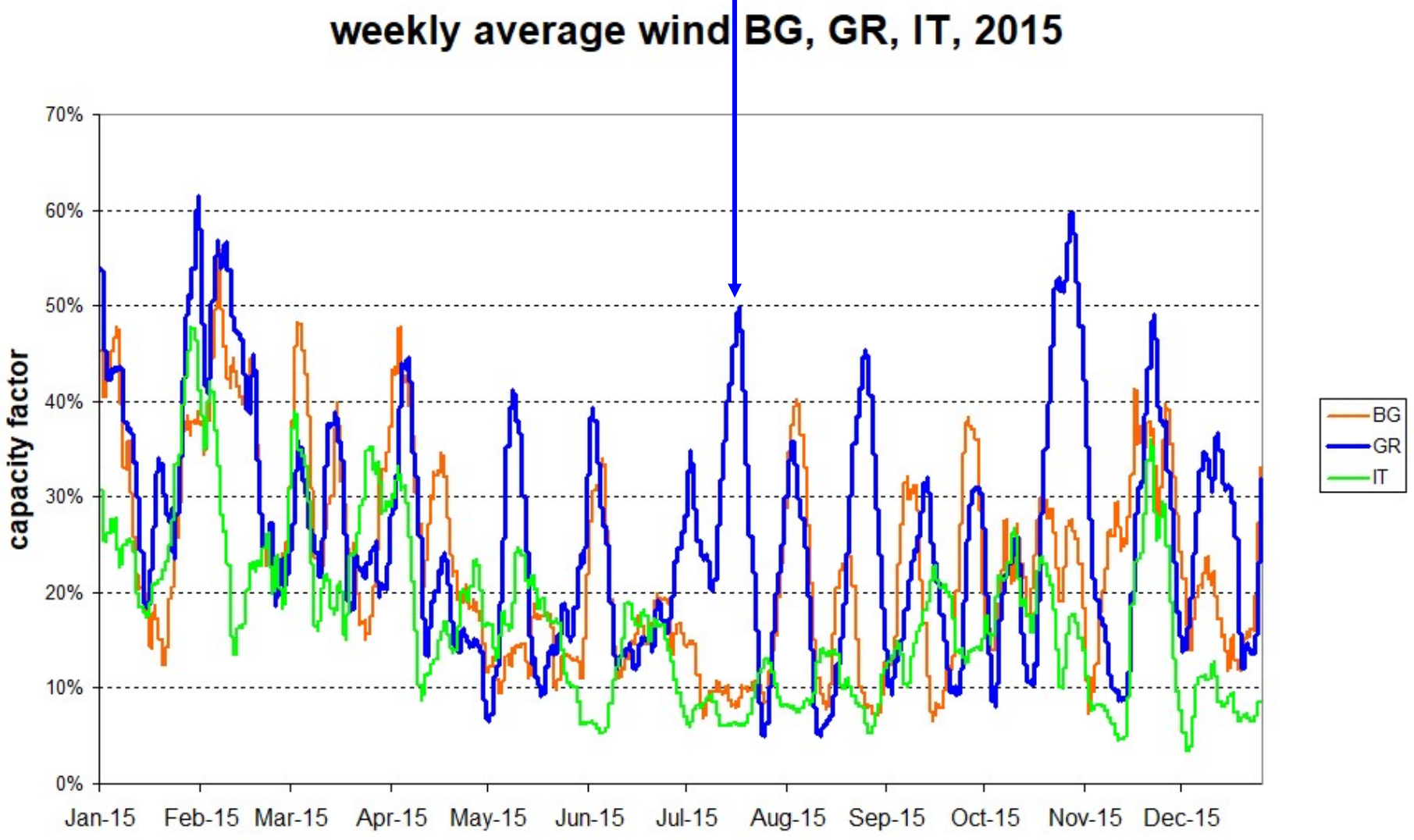
UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

GB follows SEM wind with **4-hr lag** **=> short-term benefit for each**

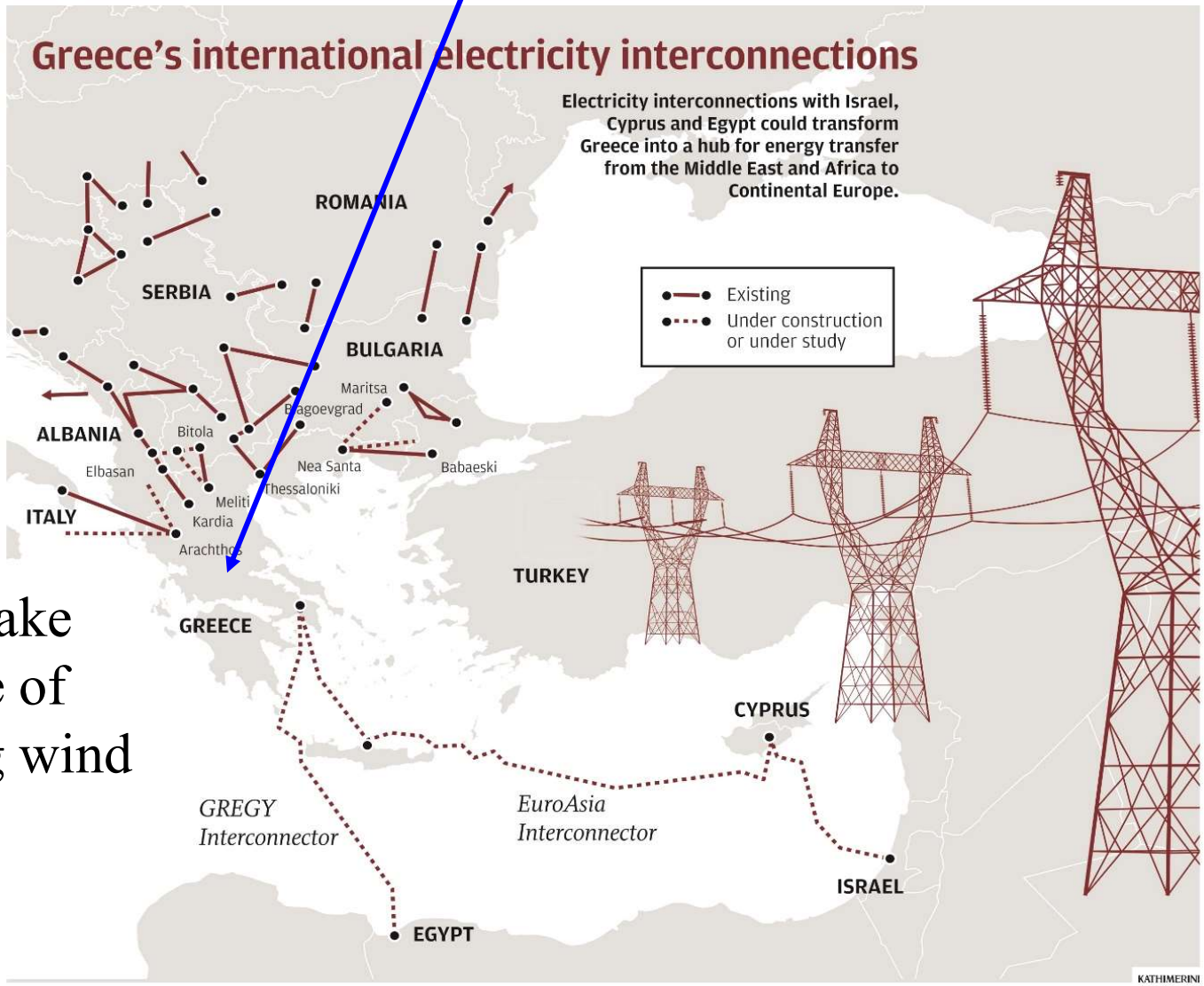


UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Summer wind in Greece can be exported to neighbours



Internal transmission will also have to be strengthened



Trade to take advantage of prevailing wind

UK *Review of Electricity Markets* Consultation 2022

- "market forces alone are currently unable to deliver our objectives"

=> Need a change in market design and network operation for the Energy Transition

- Objective – least system cost
  - Getting investment location right is most important
  - Followed by least-cost dispatch

=> reform grid locational signals

  - And VRE support schemes

=> Reform investment and dispatch signals

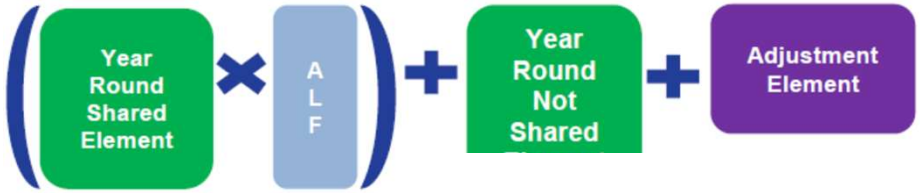
Good contract design and grandfathering solves most transitional problems

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Current GB transmission charging methodology

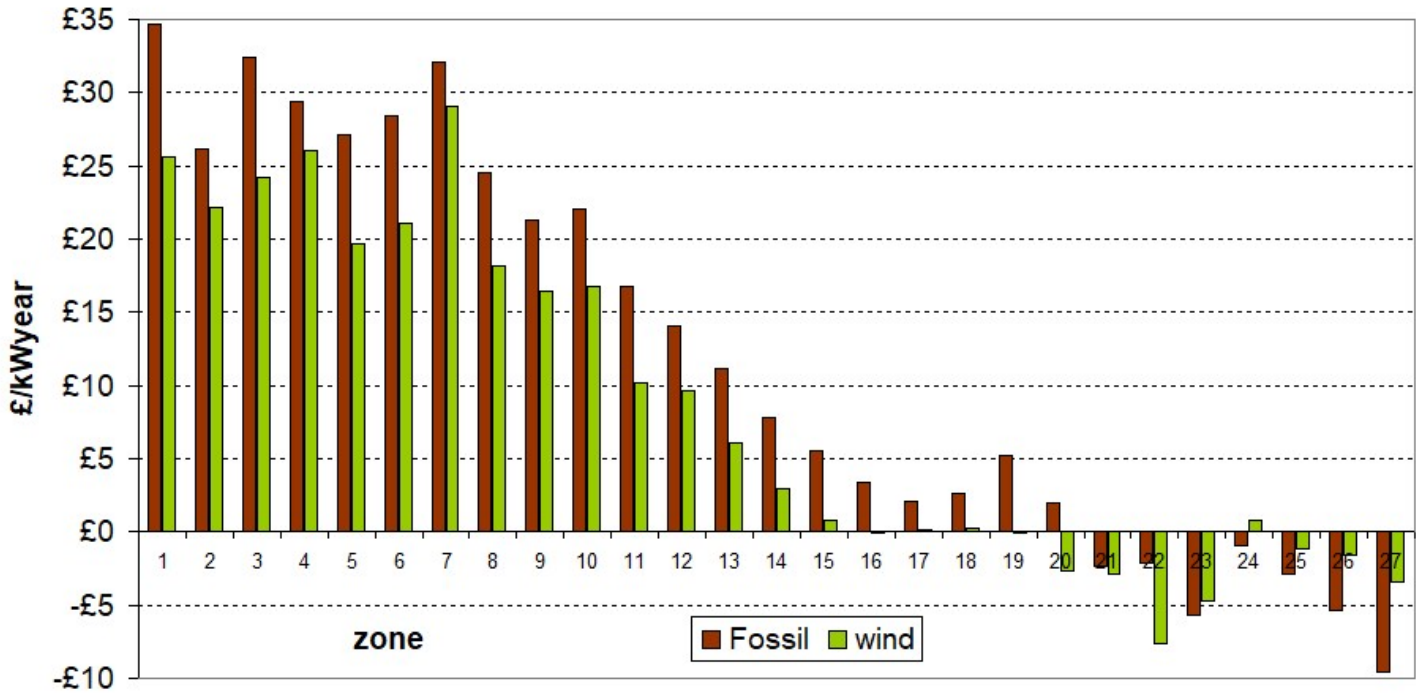
Intermittent Generators

(Wind, Wave, Tidal)



Problem: **Investment Cost Related Pricing** assumes instant incremental adjustments

Problem: charges **annually reset**, discourages substantial necessary changes



UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Guiding location decisions: different approaches

- GB set locational TNUoS to guide location
  - Now: reset annually to move towards long-run marginal cost
  - Alternative: offer **contracts to new entrants to guide location**
- Other approaches:
  - Island of Ireland proposes non-firm connection until grid expanded
  - **Greece 2022**: grid can deny grid connection for up to 6 months
- IEA *Greece 2023 Energy policy review* recommends:
  - government to identify priority locations for least system cost
  - balancing cultural social and environmental issues

Plan transmission; guide new entrants

Reforming VRE support

- Aim: minimise cost of finance while ensuring market responsiveness
- Pay for **capacity** not output for efficient technology choice
  - ⇒ Costs are up-front, running costs independent of market prices

⇒ **Efficient** market prices guide efficient investment, location and output

⇒ Or offer suitable sites for new entrants

Designing long-term low-risk VRE contract

- Current VRE contracts pay fixed price ***s*** for metered output
- Standard CfD requires specifying 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

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

Benefits of CFD reform

- Simplifies constraint payments - pay on forecast potential output that count to full operating hours
  - => pays back full expected revenue => lowers risk and cost
- Reduces excessive infra-marginal rent from high value sites
  - clearing price set by most expensive offer
  - was a serious problem with premium support schemes
  - efficient transmission charges remove much infra-marginal rent when strike prices near LRMC of VRE

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Conclusions: market design

- Zero carbon electricity: high capital cost, low variable cost
  - ⇒ Long-term hedges to lower finance cost (missing futures markets)
  - – Hedges: independent of actual output => respond to market

=> **CfD with FiT** for VRE good but can be improved

- – capacity ***not output*** support to hedge up-front costs for **low WACC**
- – **location** and **dispatch** price signals guided by **market**, not support prices
- => hedge set not by metered output but forecast output (***yardstick pricing***)
- – contract specified for *full operating* ***hours, not years***

- **Long-term transmission contracts**
  - – plus grandfathering for **smooth transition and hedging**

Concentrate on network investment, interconnectors and storage

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Secure, sustainable and affordable electricity: the challenges

David Newbery, *EPRG,*
University of Cambridge

7th GREEK-BRITISH SYMPOSIUM 2023: London

17th October 2023

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

References

- *BEIS Review of Electricity Market Arrangements: Consultation Document* at https://www.gov.uk/government/consultations/review-of-electricity-market-arrangements
- Eicke, A. & T Schittekatte, 2022. Fighting the wrong battle? A critical assessment of arguments against nodal electricity prices in the European debate, MITEI-WP-2022-01
- FTI's presentation at https://www.strommarkttreffen.org/05_Jason%20Mann%20and%20Ljubo%20Mitrasevic%20(FTI%20Consulting)_%20Cost-Benefit-Analysis%20of%20moving%20to%20zonal%20or%20nodal%20electricity%20market%20design%20in%20GB.pdf
- Newbery, D. 2021. National Energy and Climate Plans for the island of Ireland: wind curtailment, interconnectors and storage, *Energy Policy* 158, 112513, 1-11. https://doi.org/10.1016/j.enpol.2021.112513 also EPRG WP2020 at https://www.eprg.group.cam.ac.uk/eprg-working-paper-2020/.
- Newbery, D., 2021. Designing efficient Renewable Electricity Support Schemes, at https://www.eprg.group.cam.ac.uk/eprg-working-paper-2107/
- Newbery et al., 2022 Response to REMA at https://www.eprg.group.cam.ac.uk/wp-content/uploads/2022/10/REMA-consultation-questions-.pdf
- Newbery, D., 2022 Commentary on REMA at https://www.eprg.group.cam.ac.uk/wp-content/uploads/2022/10/Newbery-Response-to-REMA-.pdf
- Newbery, D., 2023. High wind and PV penetration: marginal curtailment and market failure under "subsidy-free" entry, *Energy Economics*, 126 (107011), 1-11, doi: https://doi.org/10.1016/j.eneco.2023.107011

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Acronyms

CfD:	Contract for Difference
E(F)SO	Electricity (Future) System Operator
FiT	Feed-in Tariff – sets price paid
FTR	Financial (Physical) Transmission Right
LT	Long-term
PPA	Power purchase agreement
RE	Renewable electricity
REMA:	Review of electricity market arrangements
RO(C):	Renewable obligation (certificate)
SEM	Single Electricity Market of island of Ireland
TNUoS	Transmission Network Use of System
VRE:	variable renewable electricity, i.e. wind and solar PV