Designing efficient contracts and access regimes for Variable Renewable Electricity

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Summary

- EU now mandates CfDs for Variable Renewable Electricity
  - Design matters for efficient dispatch: metered or yardstick cover?
- Marginal curtailment = 3+ times average curtailment
  - If average curtailment = 14% an additional MW is curtailed 50% of the time

⇒ Location to avoid transmission constraints vital in GB

⇒ What kind of connection contract for VRE?

- Australian model of Renewable Energy Zones (REZs)
  - TSO procures sites and builds link to grid
  - similar to GB off-shore wind regime
  - useful model for future VRE connection contracts?
- Australia and GB considered LMP; SEM priority access

=> accepting new VRE in REZs affected by LMP and access priority

Examine case of REZs and yardstick CfDs

The high VRE problem

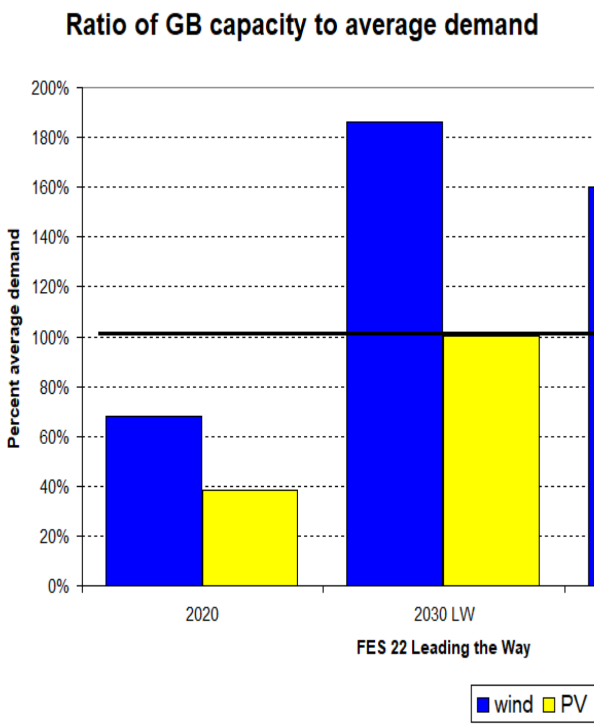
- VRE (i.e. wind and solar PV)
  - – ratio of peak: average output 2-4:1 (wind); **4-12:1** (PV) – low in Australia, high in N Europe
- Beyond some level of VRE supply > residual demand or transmission capacity

⇒ surplus VRE export, store and then **curtail**

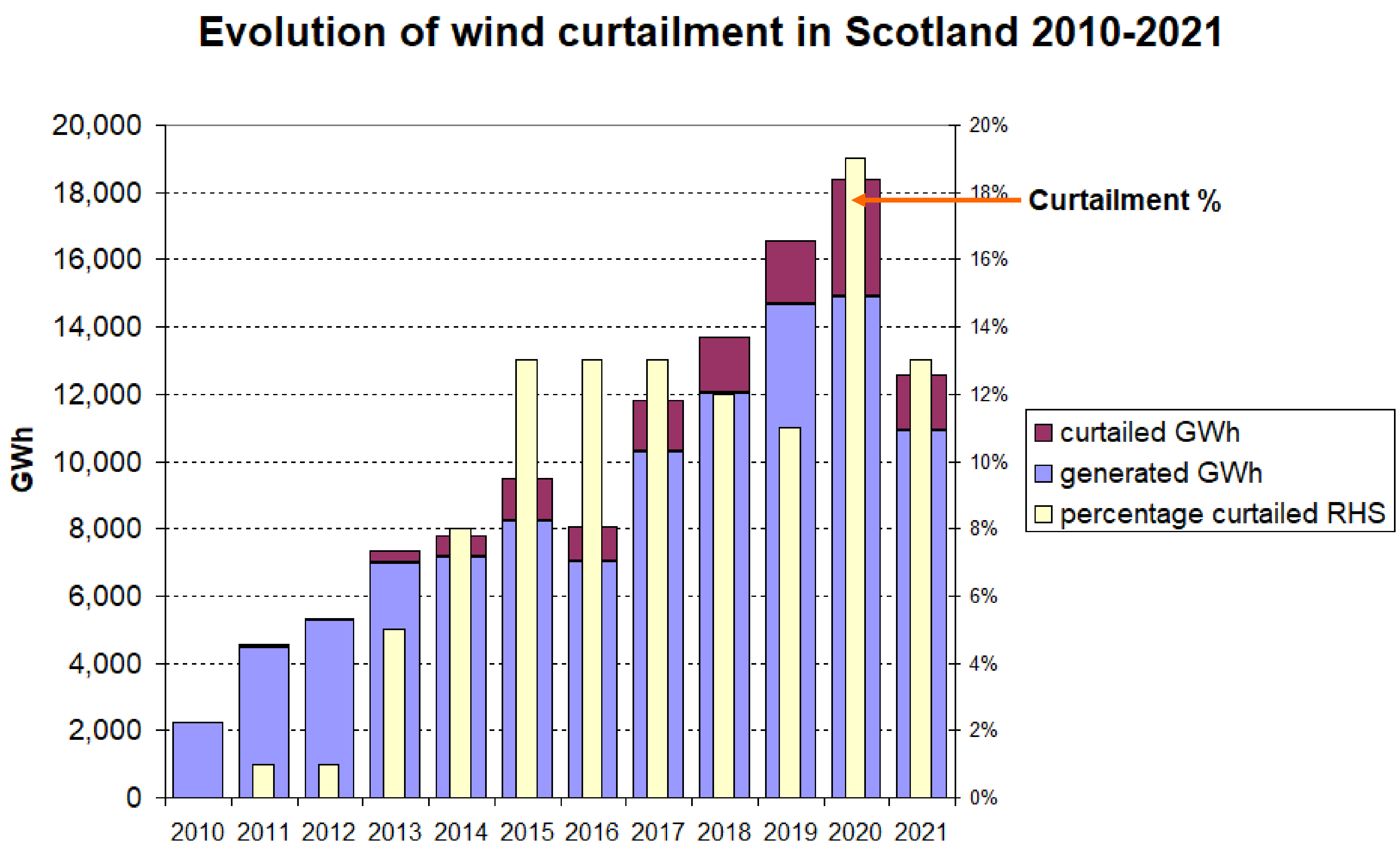
⇒ Curtailment rises rapidly with penetration

⇒ **What is the marginal curtailment?**

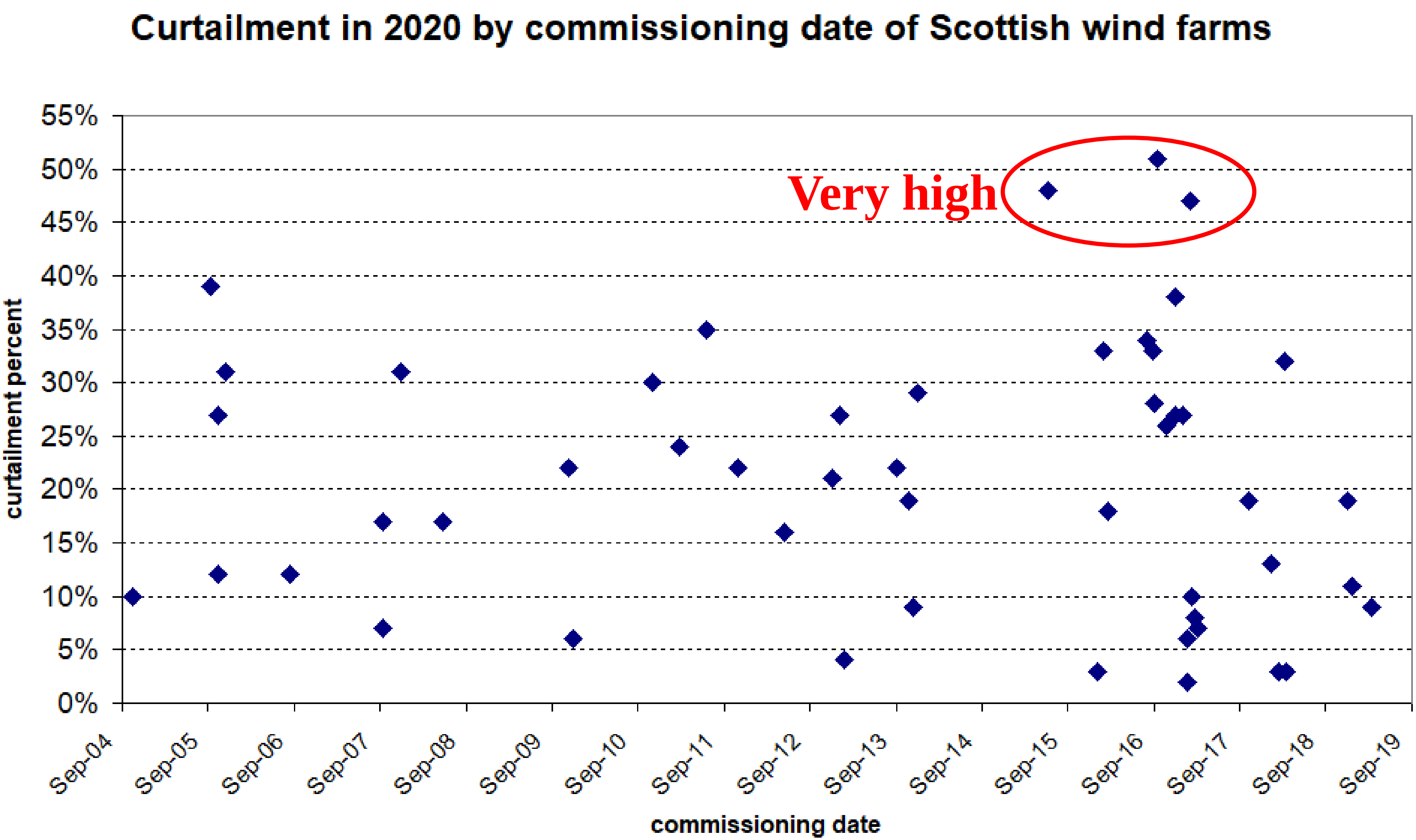
⇒ ***How to signal efficient entry***



Transmission congestion curtails Scottish wind



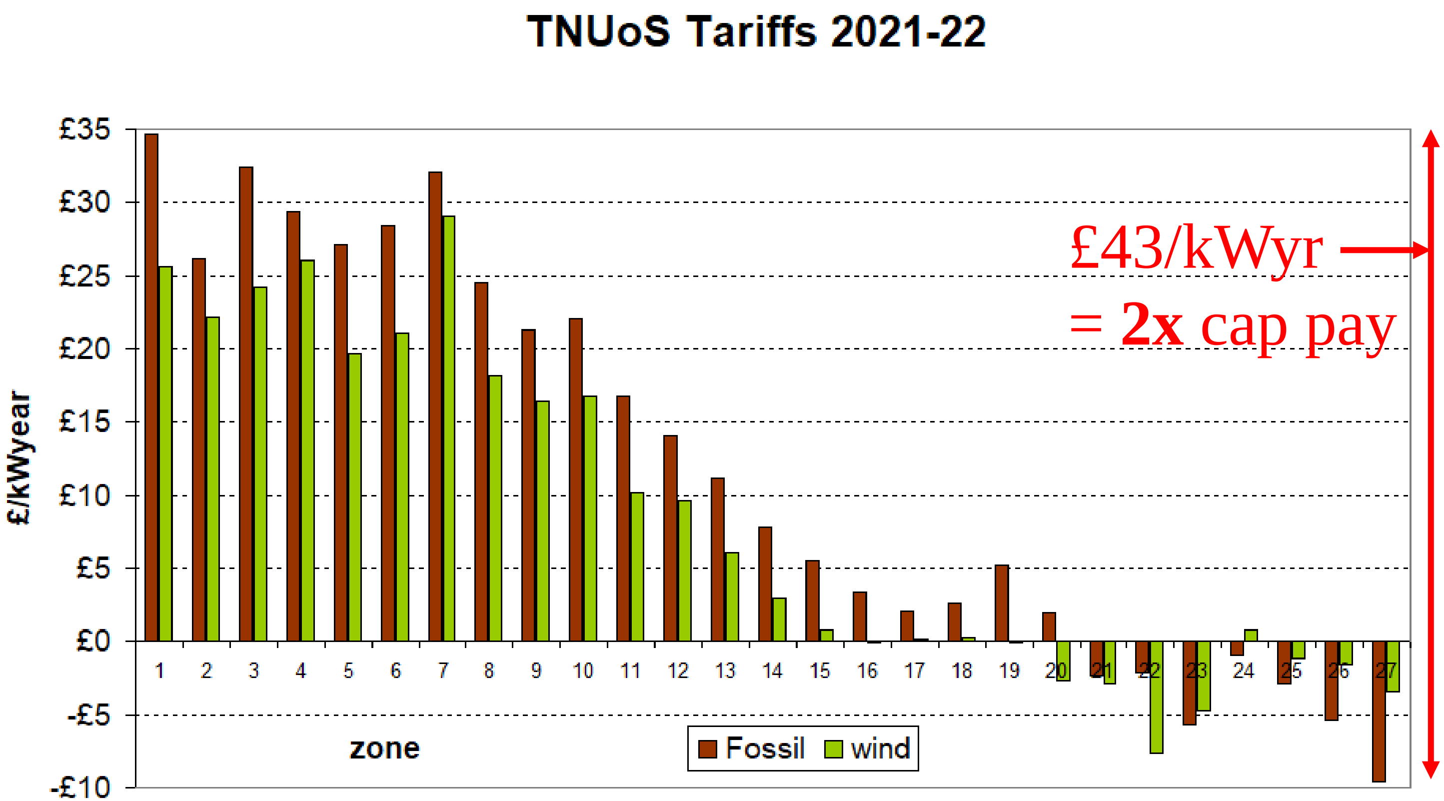
Scotland transmission constraints already very serious



Guiding investment location
Transmission Network Use of System

Problem: **TNUoS=LRMC** assumes instant incremental adjustments charges **annually reset**, discourages substantial necessary changes

Solution: grandfather existing TNUoS, entrants face forward-looking TNUoS



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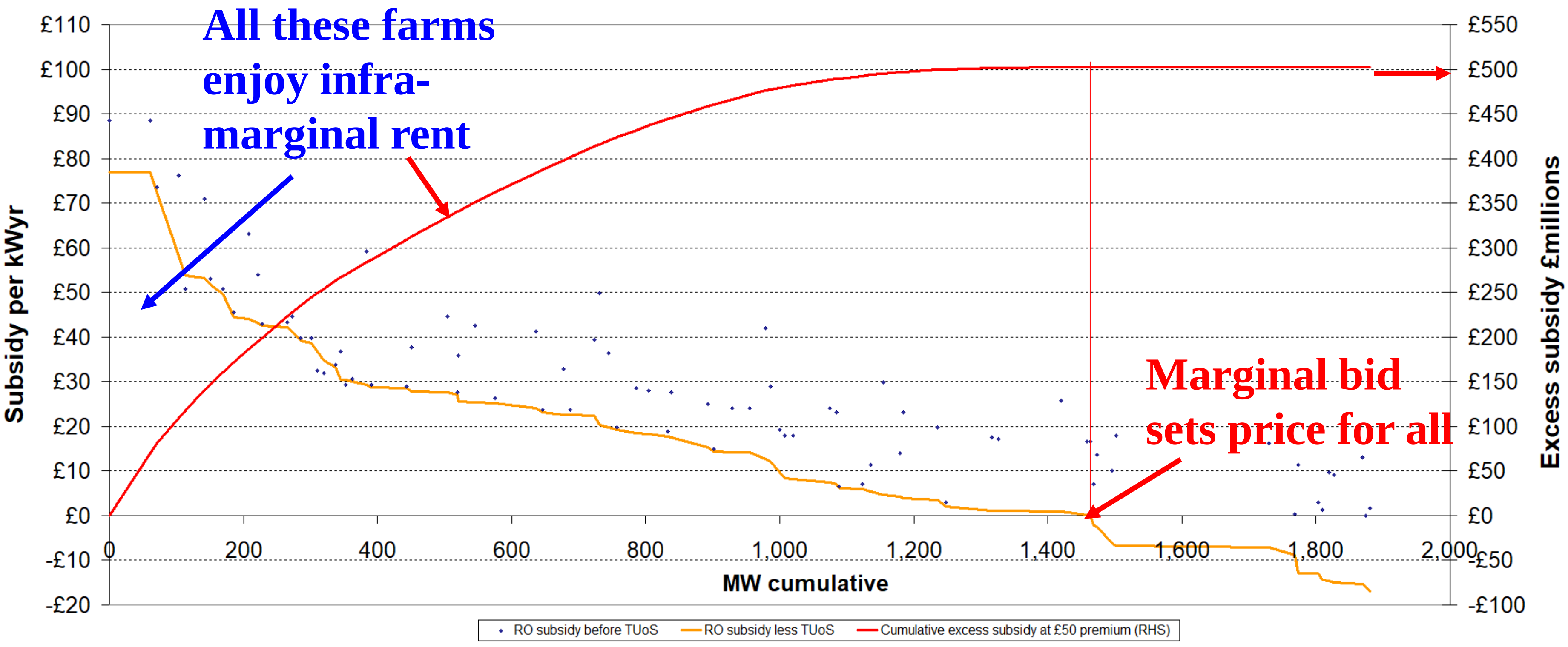
Cumulative excess subsidy from a time-based contract

Subsidy calculated from rolling capacity factors
Auction clears at 25% CF and £50/MWh subsidy for 15yr contract



Reforming VRE support

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

⇒ **Efficient** network access charges guide efficient location

- ⇒ Efficient spot prices guide output
- ⇒ good hedging contracts **reduce risk and cost**

Designing long-term low-risk VRE contract

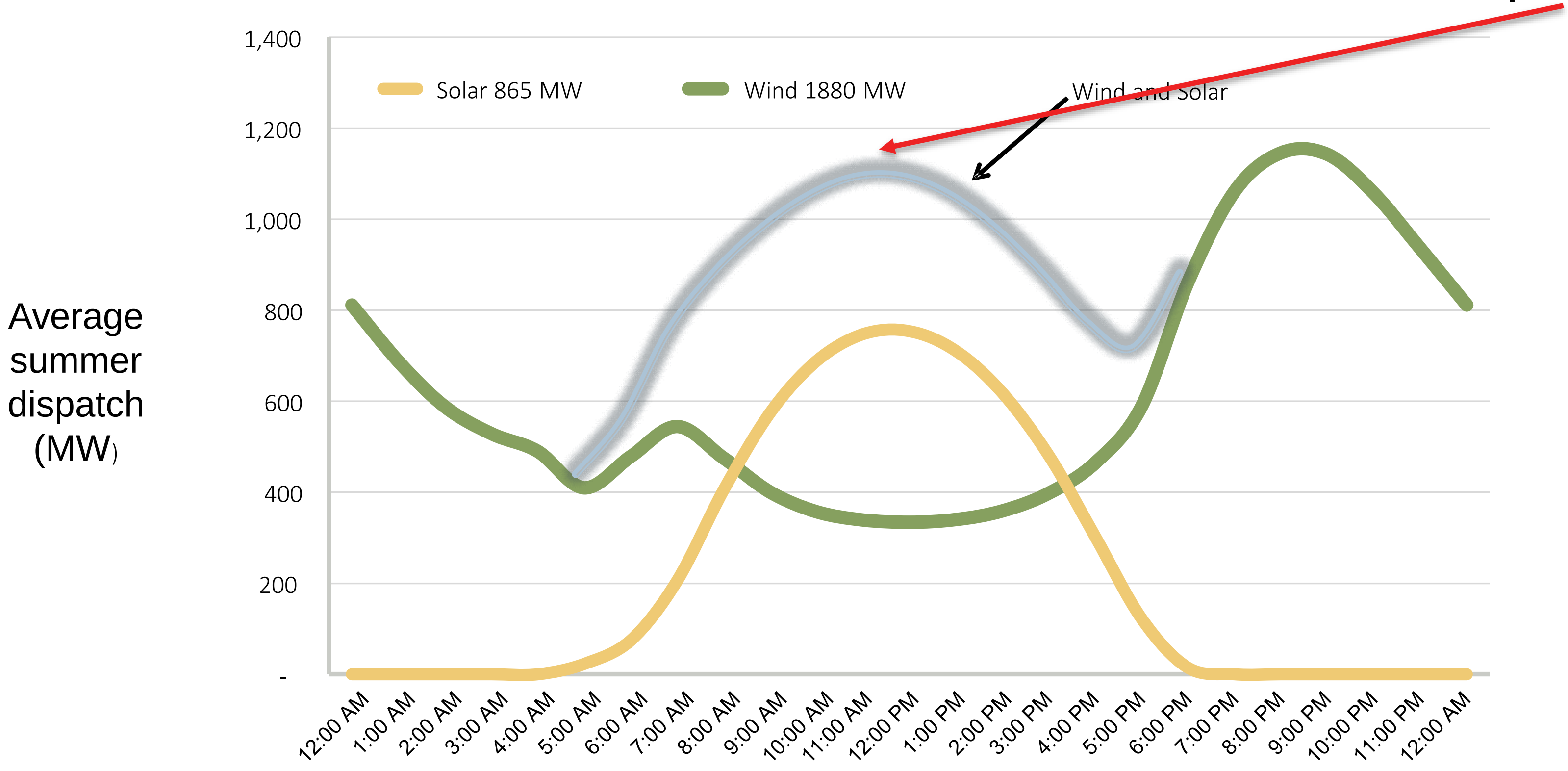
- Current VRE CfDs pay fixed price ***s*** for metered output
- Standard CfD independent of output
  - => Generate if **price>variable cost**, not if not (buy cheaper from the market)

=> 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 with efficient TNUoS contract charge
  - Efficient price when curtailed makes generating unprofitable – but strike price on forecast output keeps contract whole
- **Auction** to determine strike price ***s*** for new contracts

Queensland wind and solar (Western Downs)

Considerable PV can be added with no increase in peak



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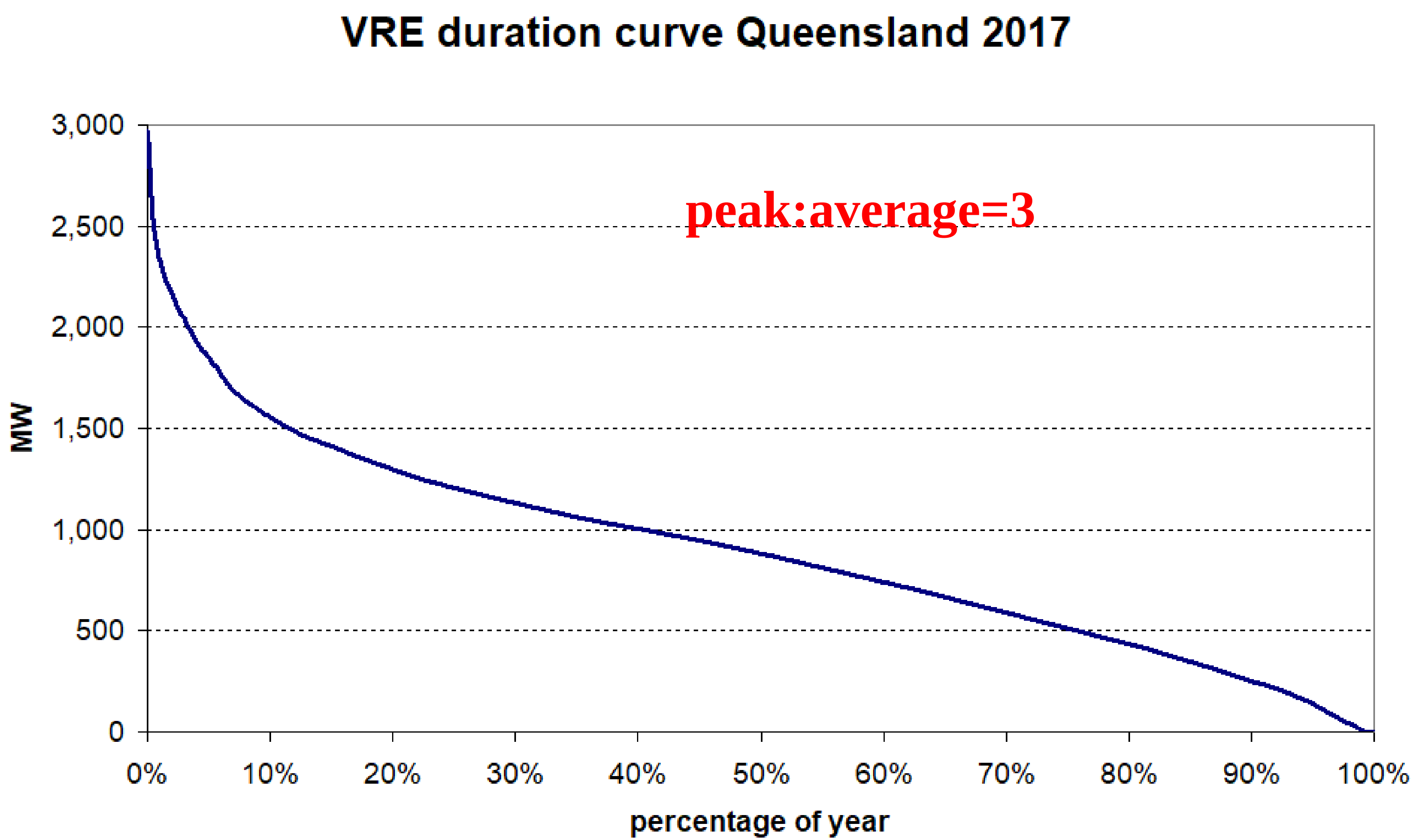
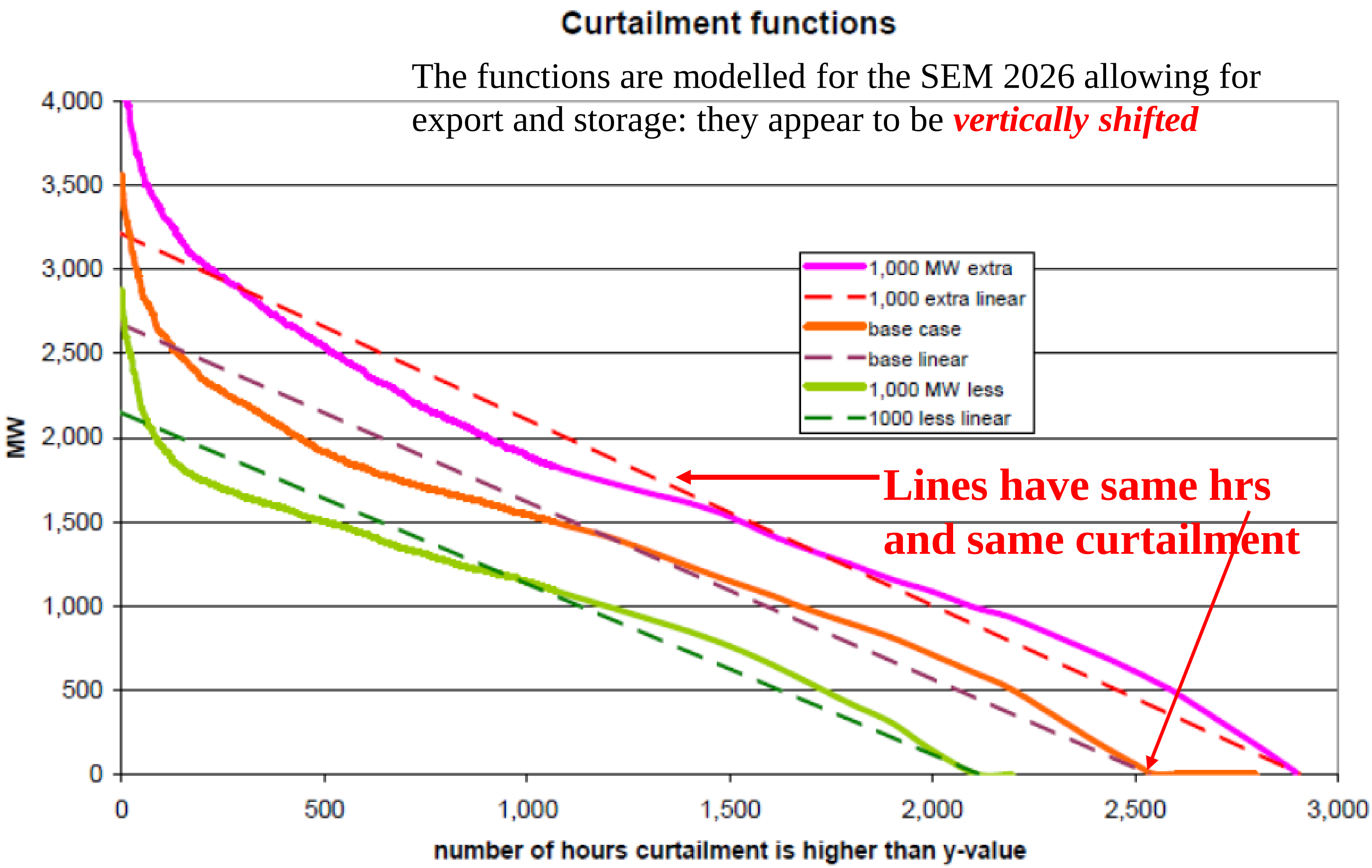
VRE duration curve, Western Downs, 2017



Linearizing allows simple algebraic curtailment model*



The functions are modelled for the SEM 2026 allowing for export and storage: they appear to be ***vertically shifted***

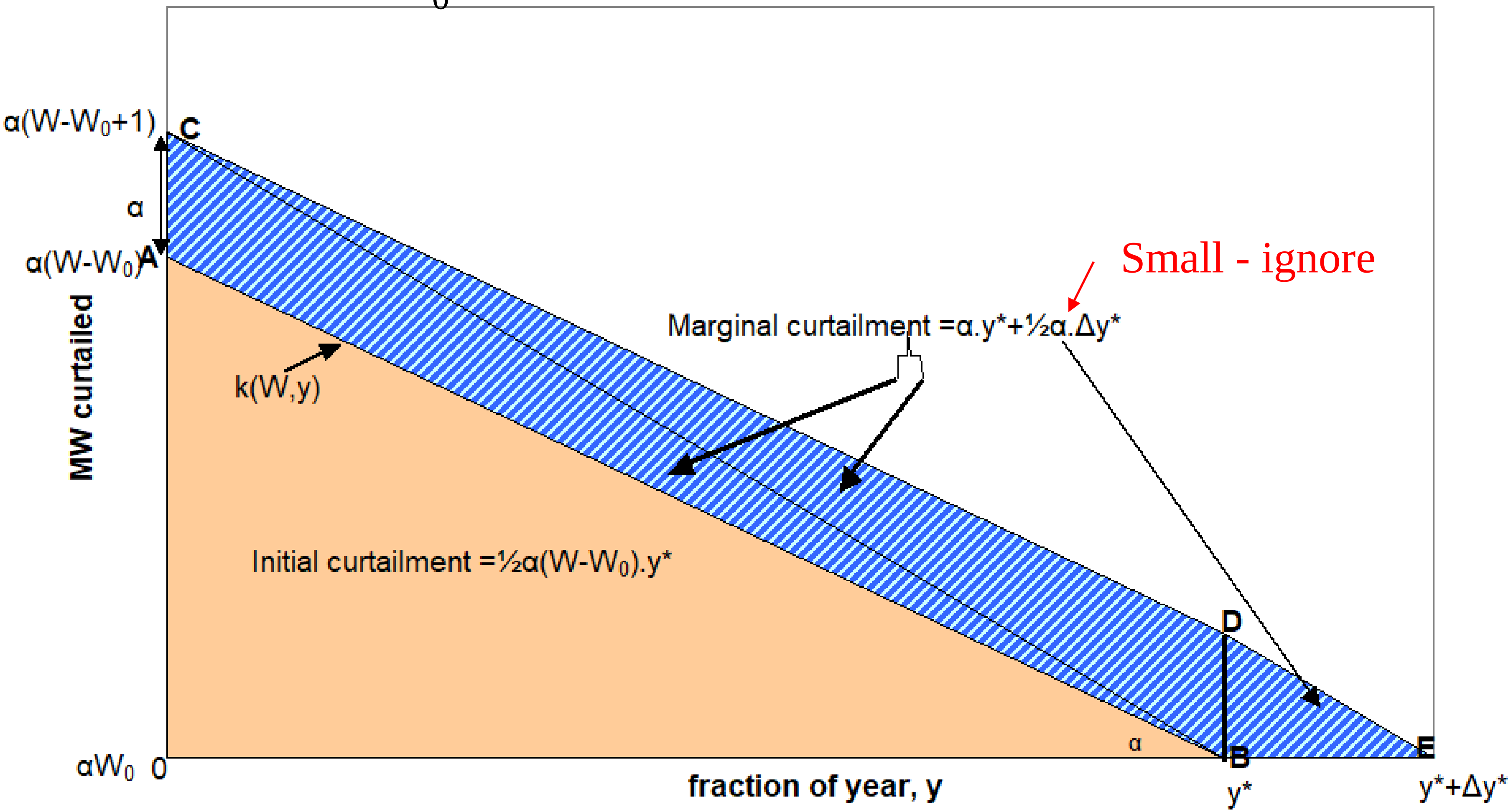
Lines have same hrs and same curtailment

* See https://www.eprg.group.cam.ac.uk/wp-content/uploads/2020/12/2036-Text_UPD1.pdf

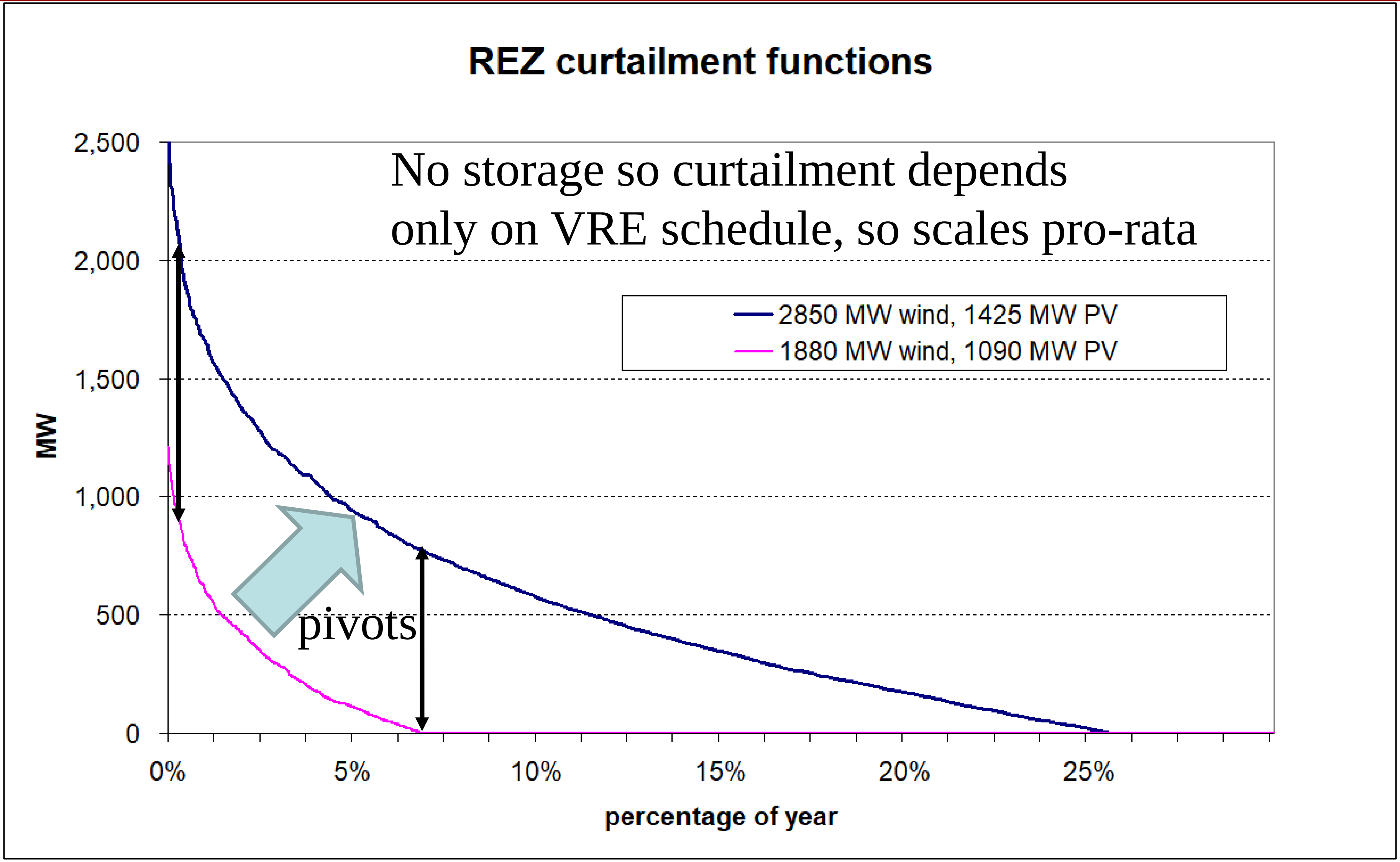
Ratio of marginal to average curtailment

MC= ½αy*; AC = ½α $(W-W_0)$y*/W, **MC/AC= $2W/(W-W_0)$**

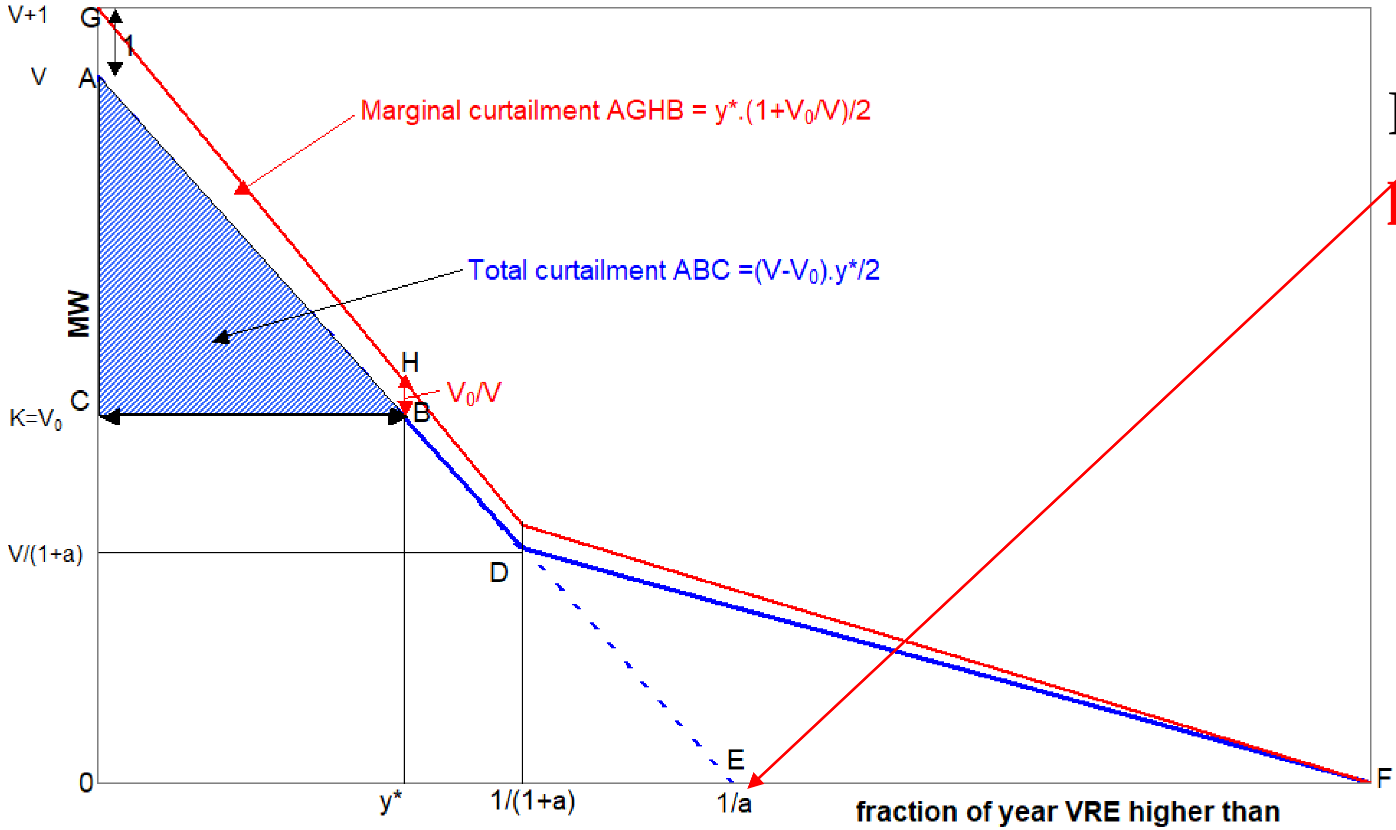
So if $W=2W_0$ **MC/AC=4**.



Queensland REZ example: scaling VRE => *scaled* curtailment



Geometry of marginal and average curtailment



If **a** = 2,
peak:average=3

MC= ½ y*(1+V_0/V); AC = ½ (V-V_0)y*/V,
MC/AC= (V+V_0)/(V-V_0) So if V=2V_0 **MC/AC=3**.

Queensland Renewable Energy Zones

- Queensland has amazing wind and solar PV resources
- Queensland REZs are market-led and merchant
  - Merchant is fast. First 3 REZs forecast completion < 3-4 years
- Powerlink (TSO) finances the REZs as merchant investments (regulated consumers do not pay)
  - Generator charges are broadly proportional to share of exit capacity
  - early entrants are not penalised with total REZ cost
- Powerlink takes on subscription risk
  - Low cost. A$160 (€100) - A$250 (€150) m for each 2GW REZ
    - **€50-€75/kW**
  - Ensures scale-efficient REZ are built
  - Viable VRE capacity >> than 2GW network capacity

REZs: lead **enabler** of VRE

- Three critical drivers:
  - **Complementarity** of wind and solar in Queensland REZs
  - Peak-to-average wind ratios 3:1; solar PV 4:1
  - The NEM's non-firm access regime

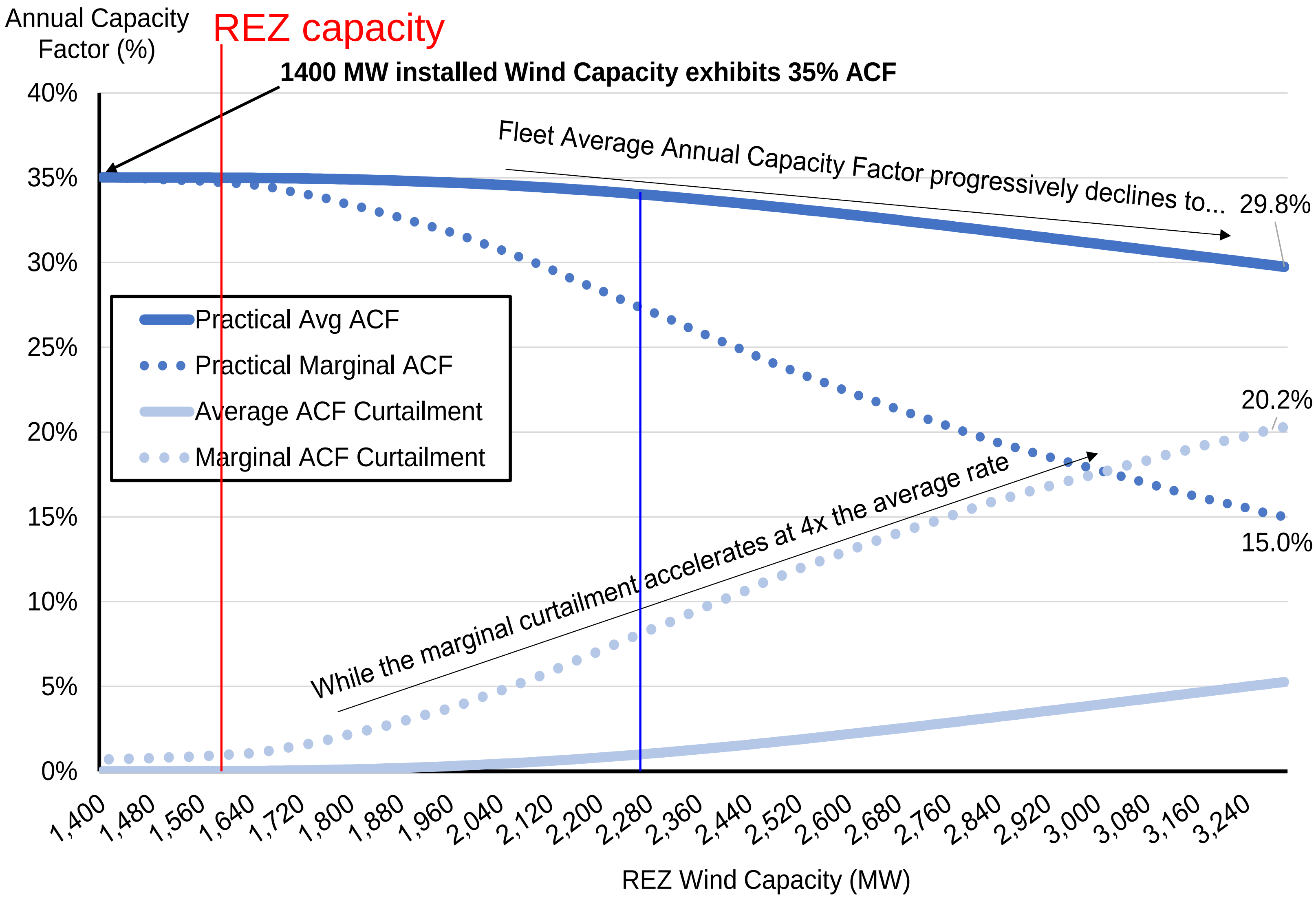
- Non-firm access means congestion is shared

  => average curtailment

- Priority access forces curtailment from average to marginal

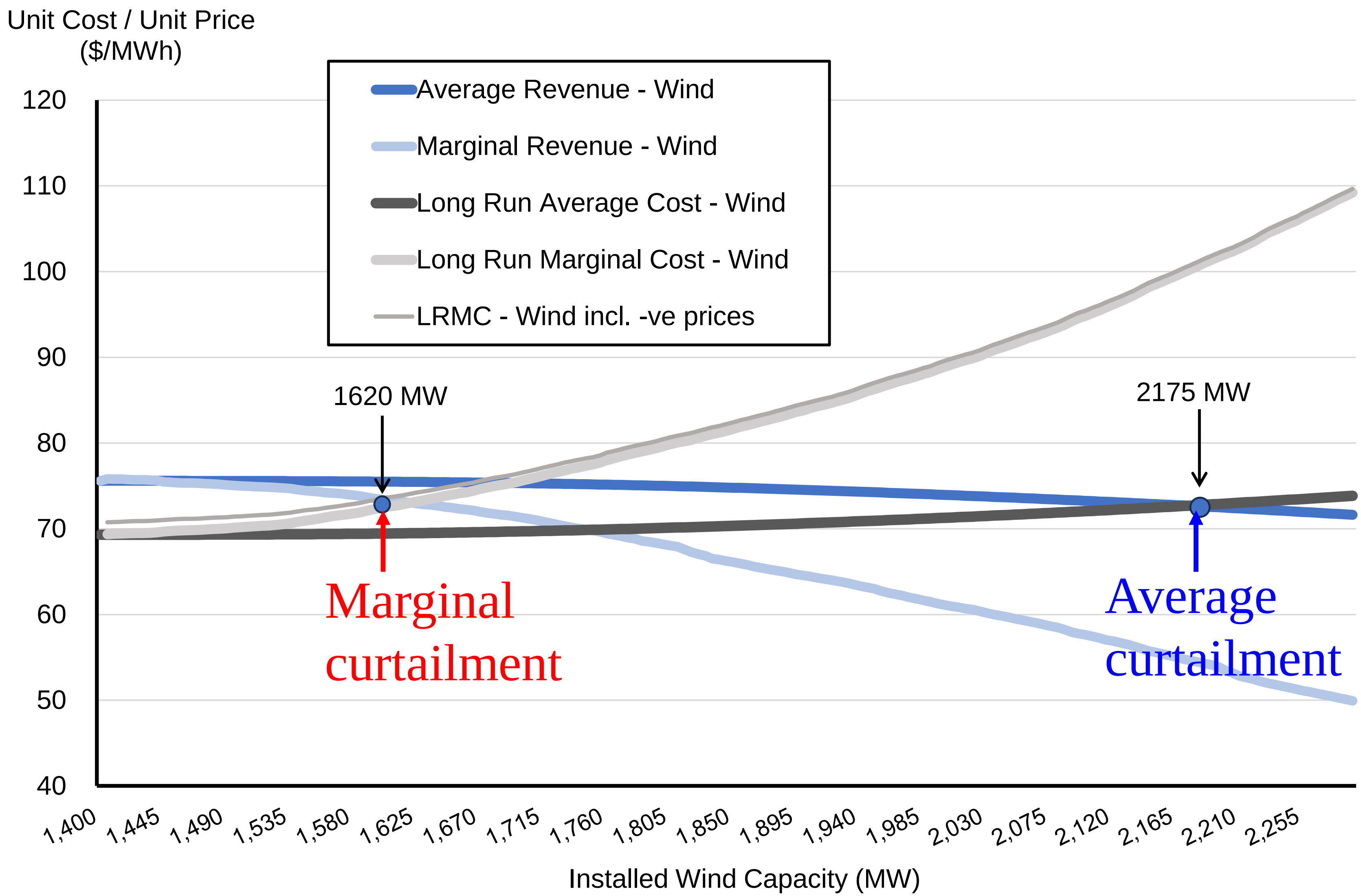
Av. v Marginal wind curtailment rates

(PV held constant at 580MW)



Av. v marginal wind costs and revenues

(PV held constant at 580MW)



Access and pricing options for export-constrained zones

- Access rights can be firm or non-firm
- Curtailment can be pro-rata or priority (last in first out)
- Access charges: LRMC (GB) or uniform country-wide (EU)
  - Queensland REZ = AC ≈ LRMC

What combination gives efficient VRE entry signals?

- **The worst**: firm access + uniform access charges (EU)
- **Efficient** (assuming no other distortions):
  - shared REZ charges, non-firm access + pro-rata curtailment (QLD)
  - uniform charges, non-firm + priority access (**Eirgrid proposal**)
  - firm access, forward looking long-run TNUoS, yardstick CfDs?

Conclusions on market design

- Key point: **marginal curtailment 3-4 x average**
- REZ concept: shared connection costs and pro-rata curtailment => entry guided by average curtailment
  - – average exit cost + average curtailment = efficient entry
  - – same result with REZ LMP if allocate FTRs pro-rata
  - – useful model for TSO who procures sites and links
- Without zonal pricing/LMP, need priority access
  - ⇒ Entry driven by marginal curtailment is efficient
  - ⇒ entry driven by average curtailment => “excess” entry
  - – Or limit access at each node for VRE

Access regime and access charges need coordination

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References

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