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# Marginal vs average curtailment of renewables in Renewable Energy Zones

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# Summary

- High Variable Renewable Electricity (VRE)=> curtailment
- 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

- 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 GB future system operator on-shore?
- Australia has considered LMP and priority access (faced very strong resistance from industry and investors)

=> accepting new VRE in REZs affected by access priority

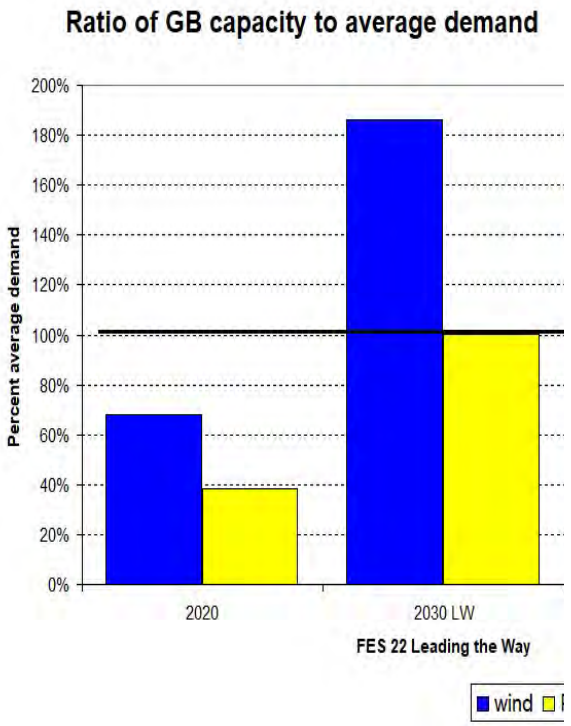
Examine case of Queensland REZs

# The high VRE problem

- VRE (i.e. wind and solar PV)
  - ratio of peak: average output 2-4:1 (wind); **5-12:1** (PV)
- Beyond some level of VRE supply > residual demand or transmission capacity

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

⇒ Marginal curtailment **3-4** times average curtailment



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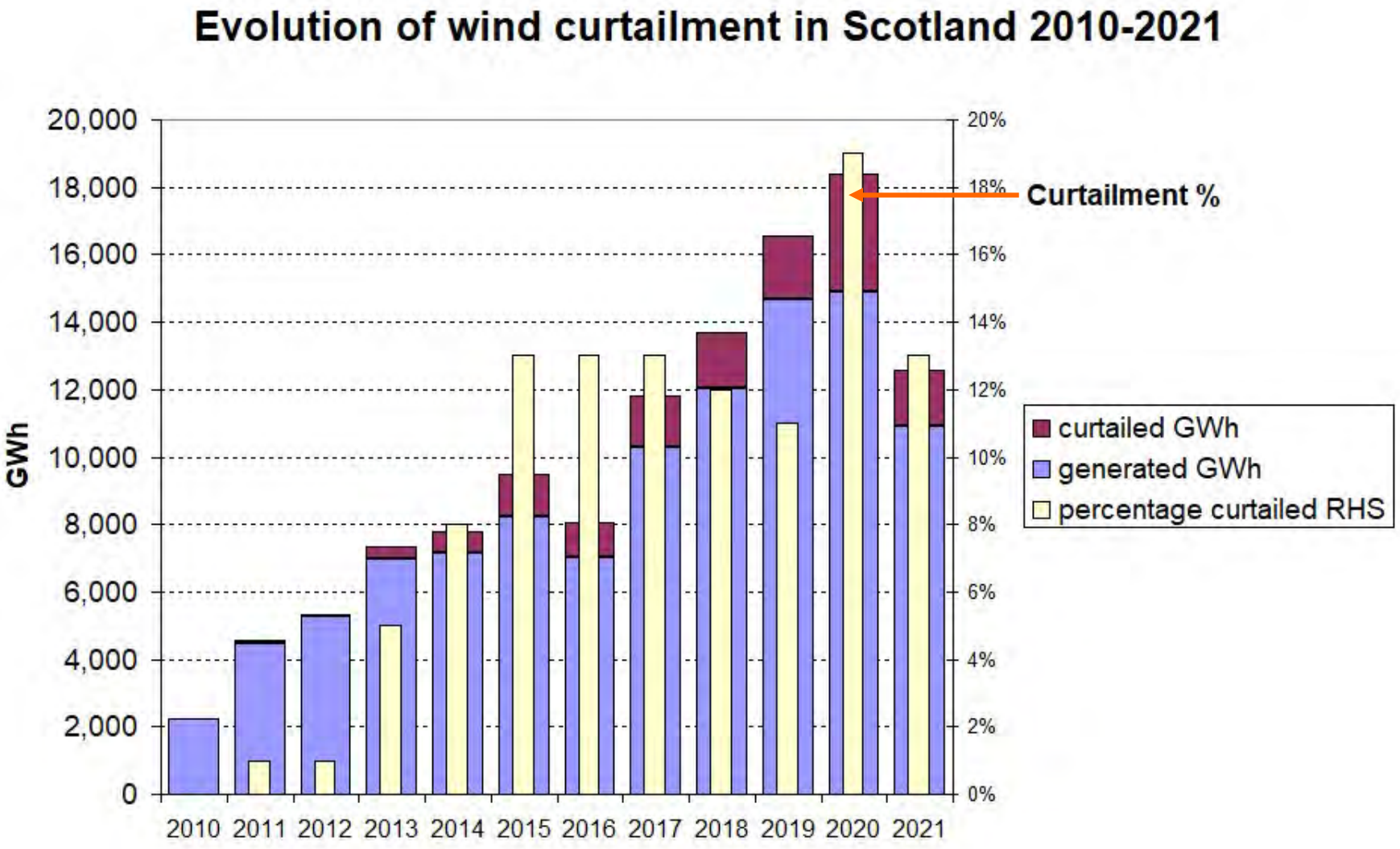
# Transmission congestion curtails Scottish wind



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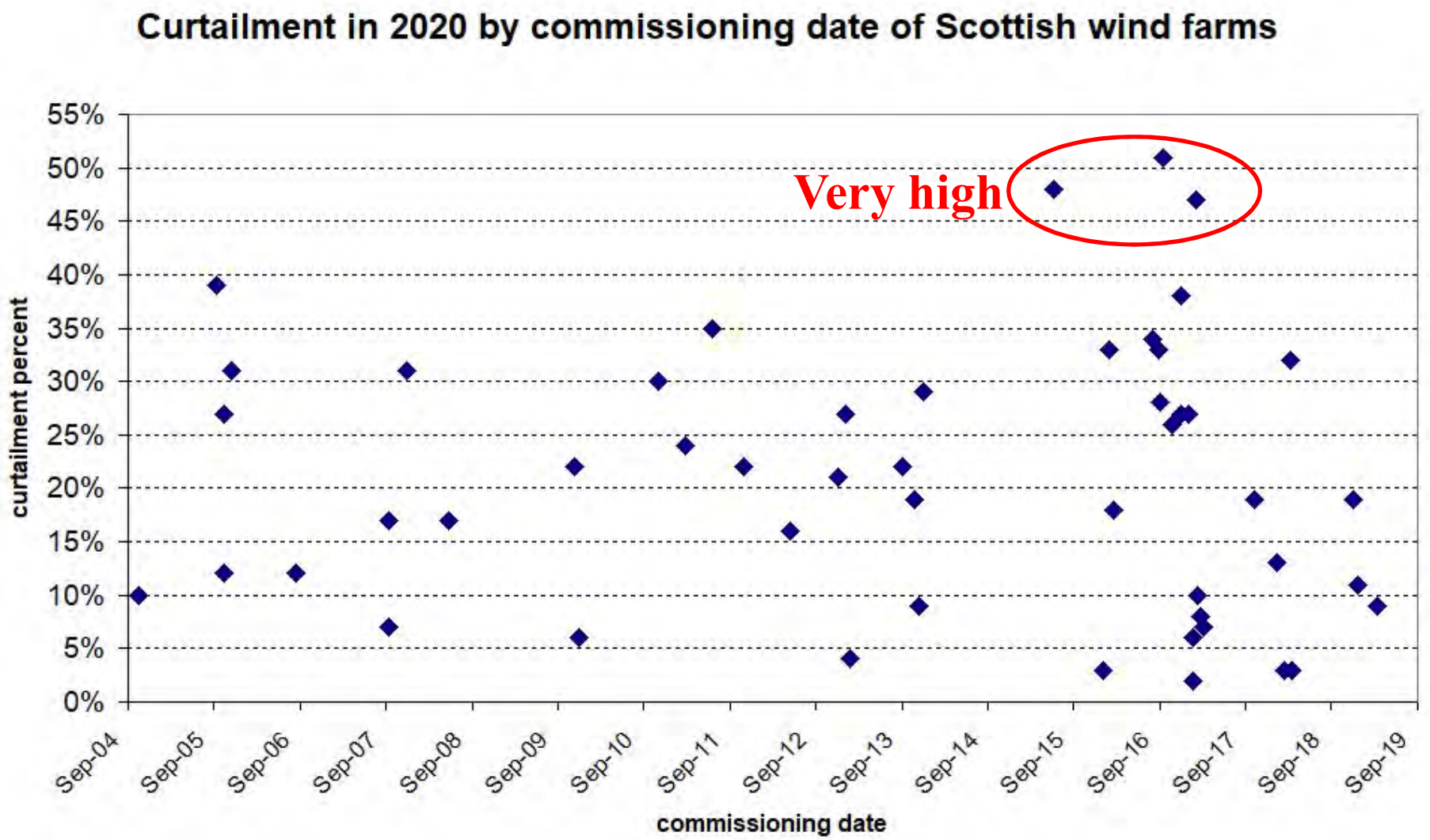
# Scotland transmission constraints already very serious



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# Queensland Fast Facts

- Population 5.3 million
  - 2.1 million households,
  - 240,000 businesses
- Electricity Demand
  - 60 TWh, 11.5GW aggregate final demand
  - 54 TWh, 10GW grid-supplied, ex rooftop solar
- Electricity Supply
  - 8GW Coal, 3GW Gas, 1GW Hydro **∑=11 GW**
  - 5.5GW rooftop solar, 5.5GW Utility Wind+Solar, 1GW Batteries
  - 19 GW near-term Connection & Access pipeline (Wind, Solar, Batteries)
  - 70+GW in the application or enquiry stage
  - Construction lags following an executed “Connection & Access Agreement” is measured in weeks, not years.

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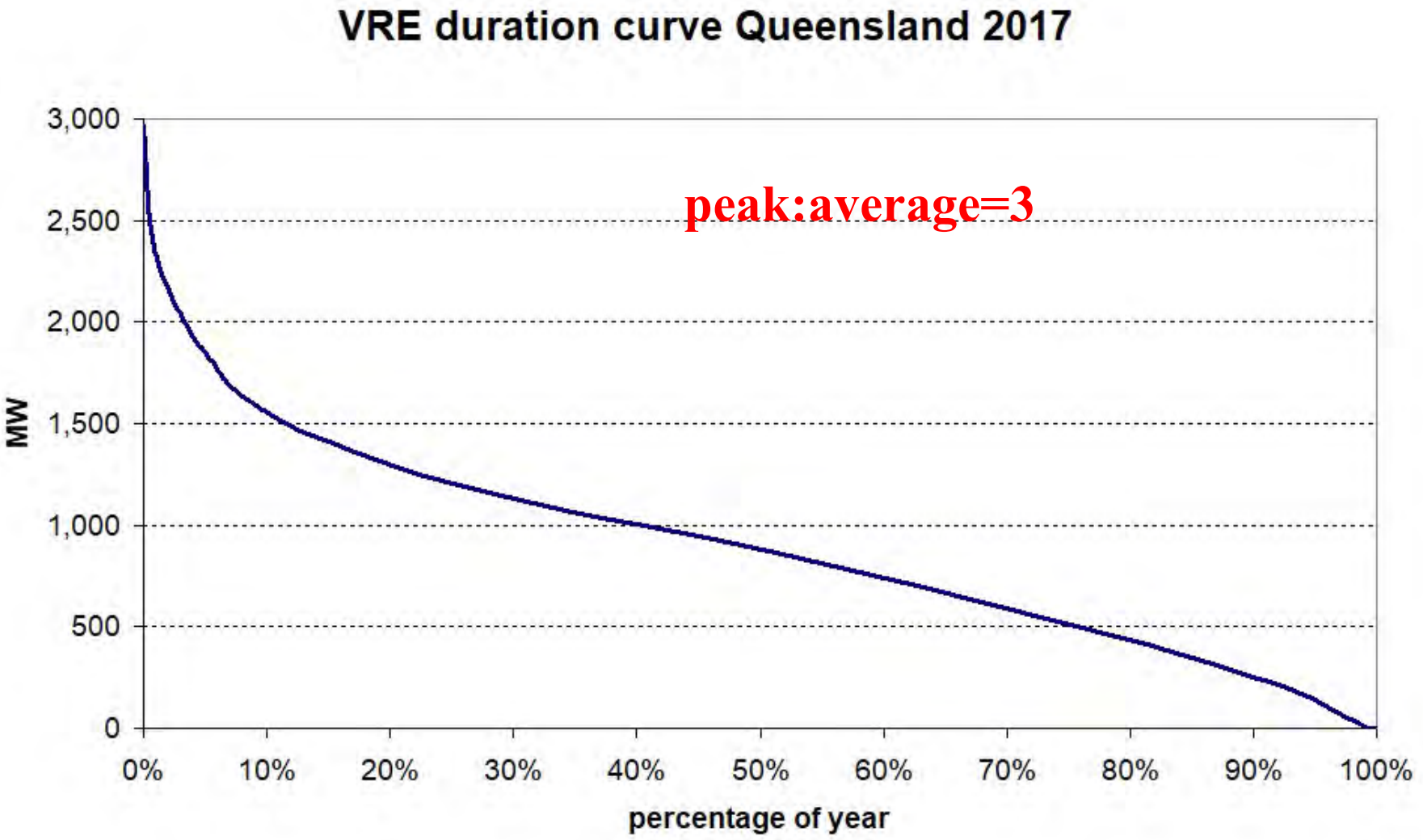
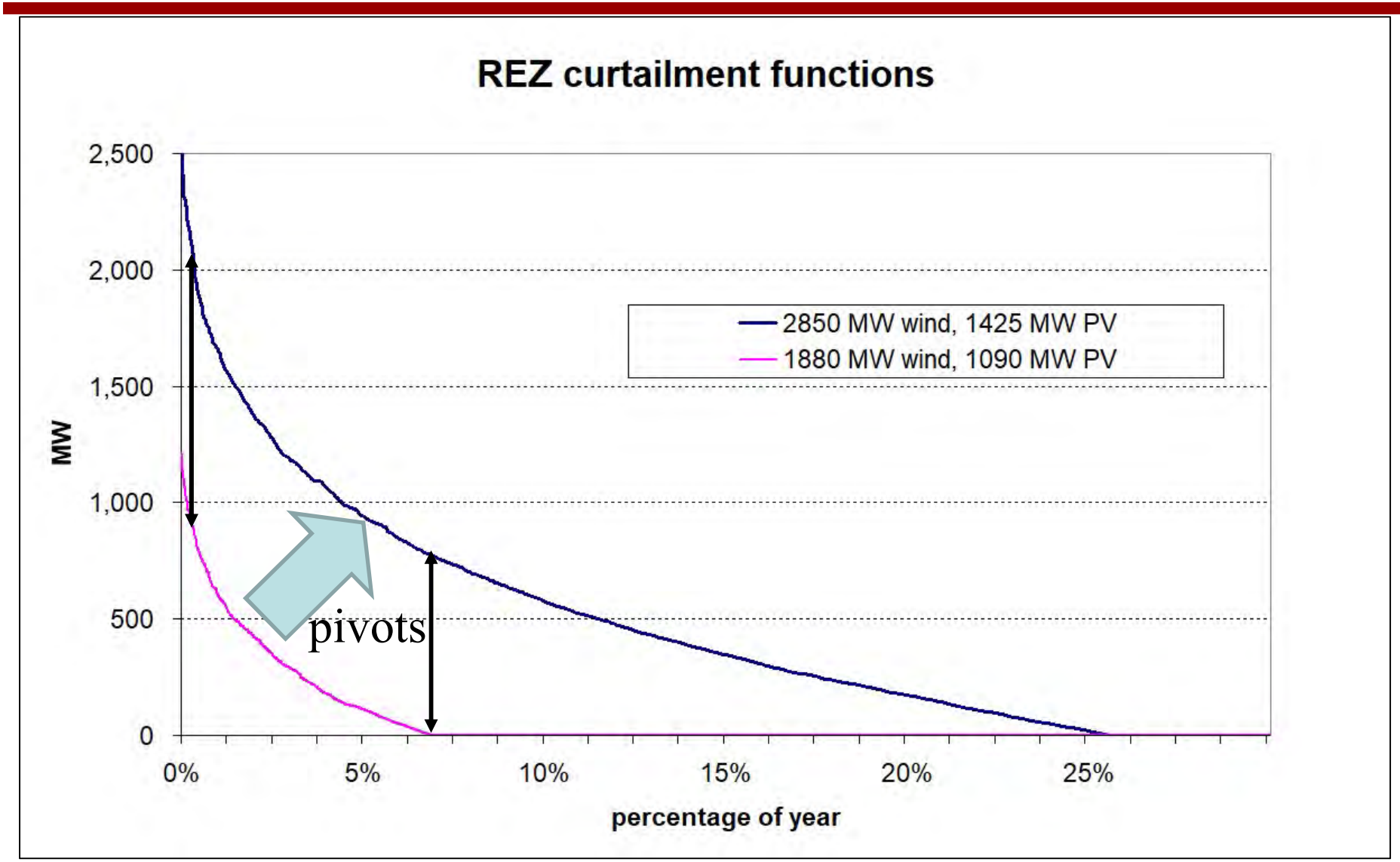
# VRE duration curve, Western Downs, 2017



# As VRE capacity increases, curtailment rises rapidly



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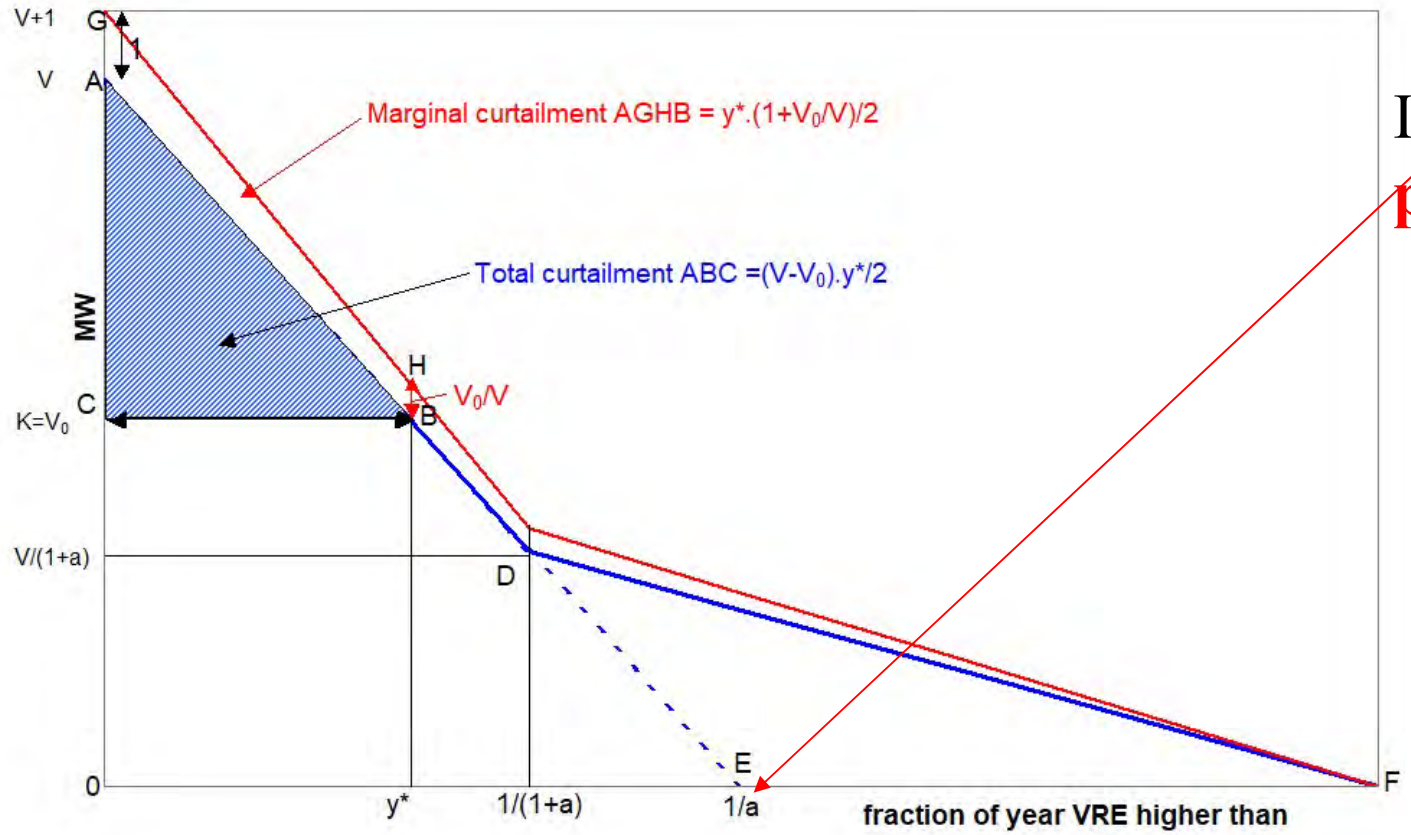
# Geometry of marginal and average curtailment




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=2$V_0$ **MC/AC=3**.

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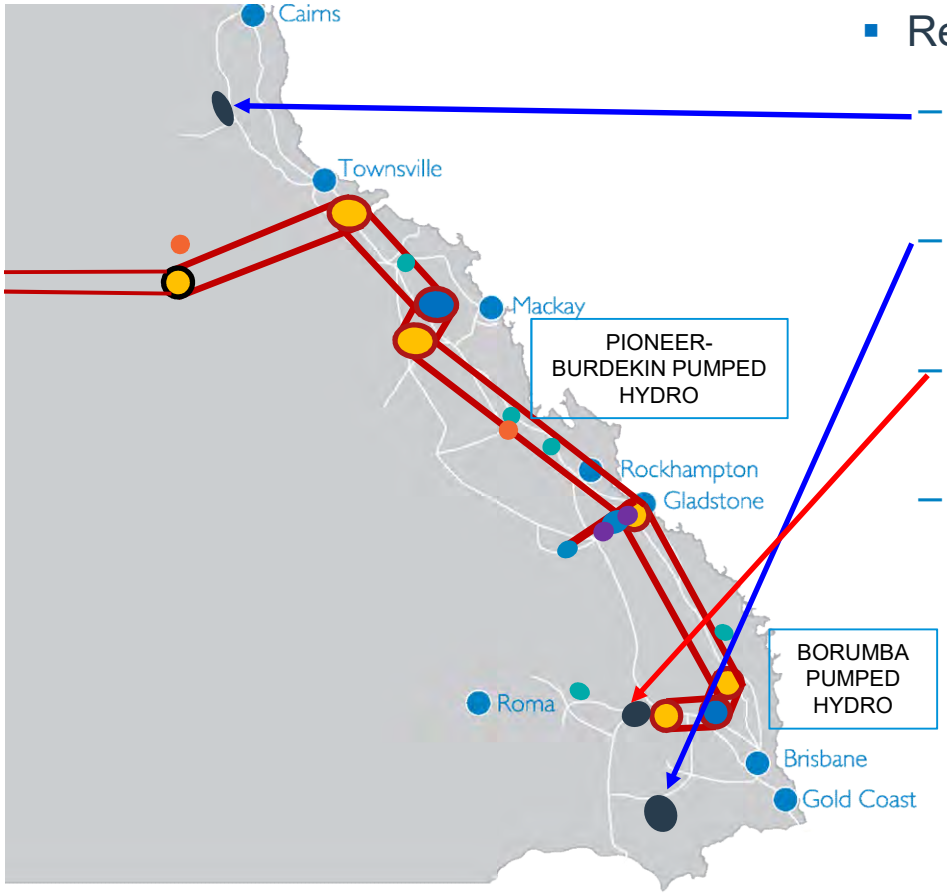
# Queensland Renewable Energy Zones

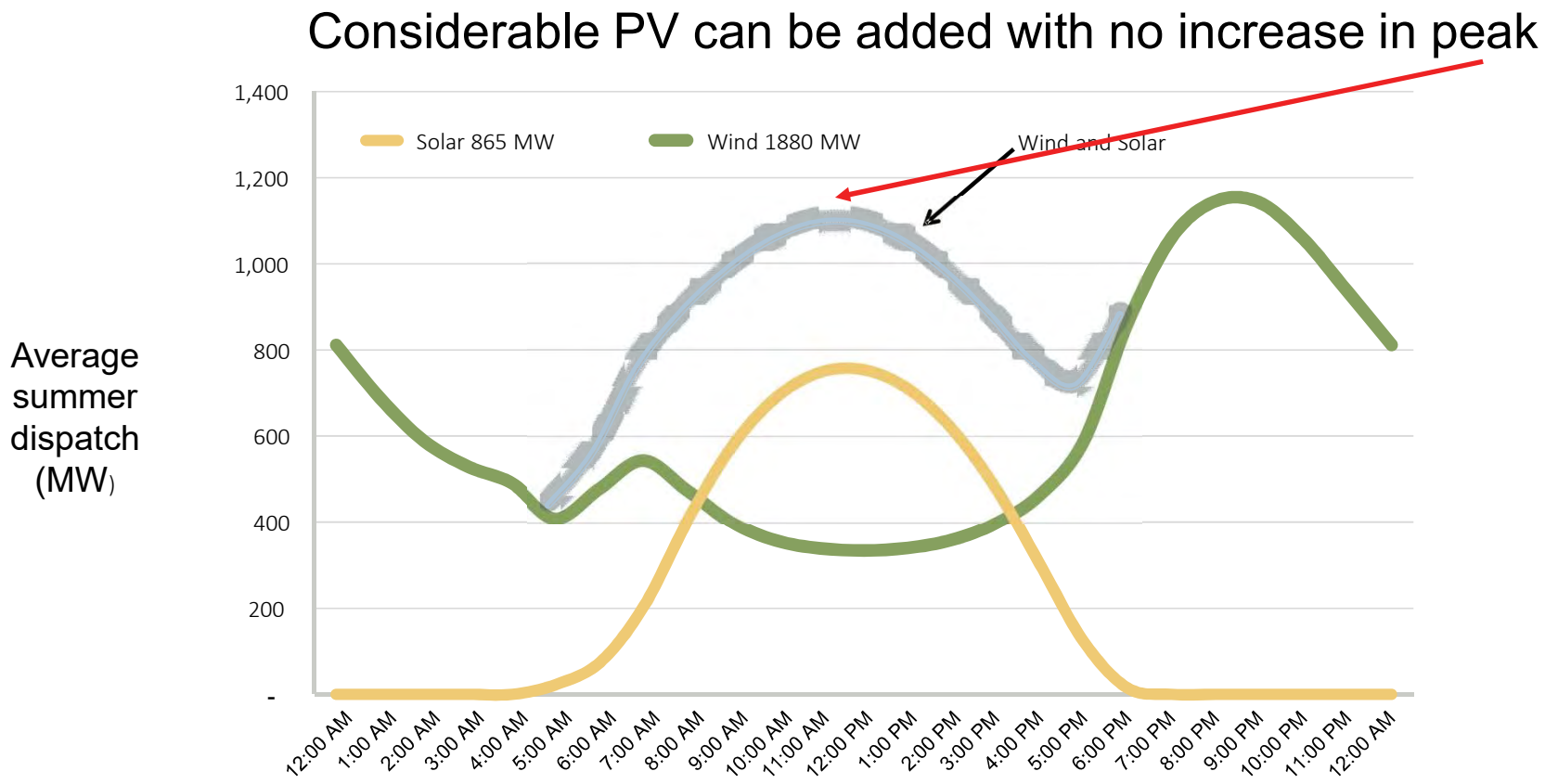
- Queensland has amazing wind and solar PV resources
- Queensland REZs are market-led and merchant
  - Merchant is fast. First 3 REZs forecast completion < 3-4 years
  - Environmental Approvals for future REZs may push this to 4-5 yrs
- Powerlink (TSO) finances the REZs as merchant investments (regulated 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 (£80) - A$250 (£130) m for each 2GW REZ
    - £40-£60/kW
  - Ensures scale-efficient REZ are built
  - There is a material difference between 2GW network capacity and the viable VRE plant capacity

# SuperGrid and Renewable Energy Zones in Queensland, Australia




- Renewable Energy Zones
  - Far North Queensland, 500 MW, Oct 2022 (A$35m, £18m
  - Southern Downs REZ, 2 GW, Dec 2023 (A$180m; £90m)
  - Western Downs REZ, 2 GW, Dec 2024 (A$160m, £80m)
  - **12 REZ in planning, 25 GW**

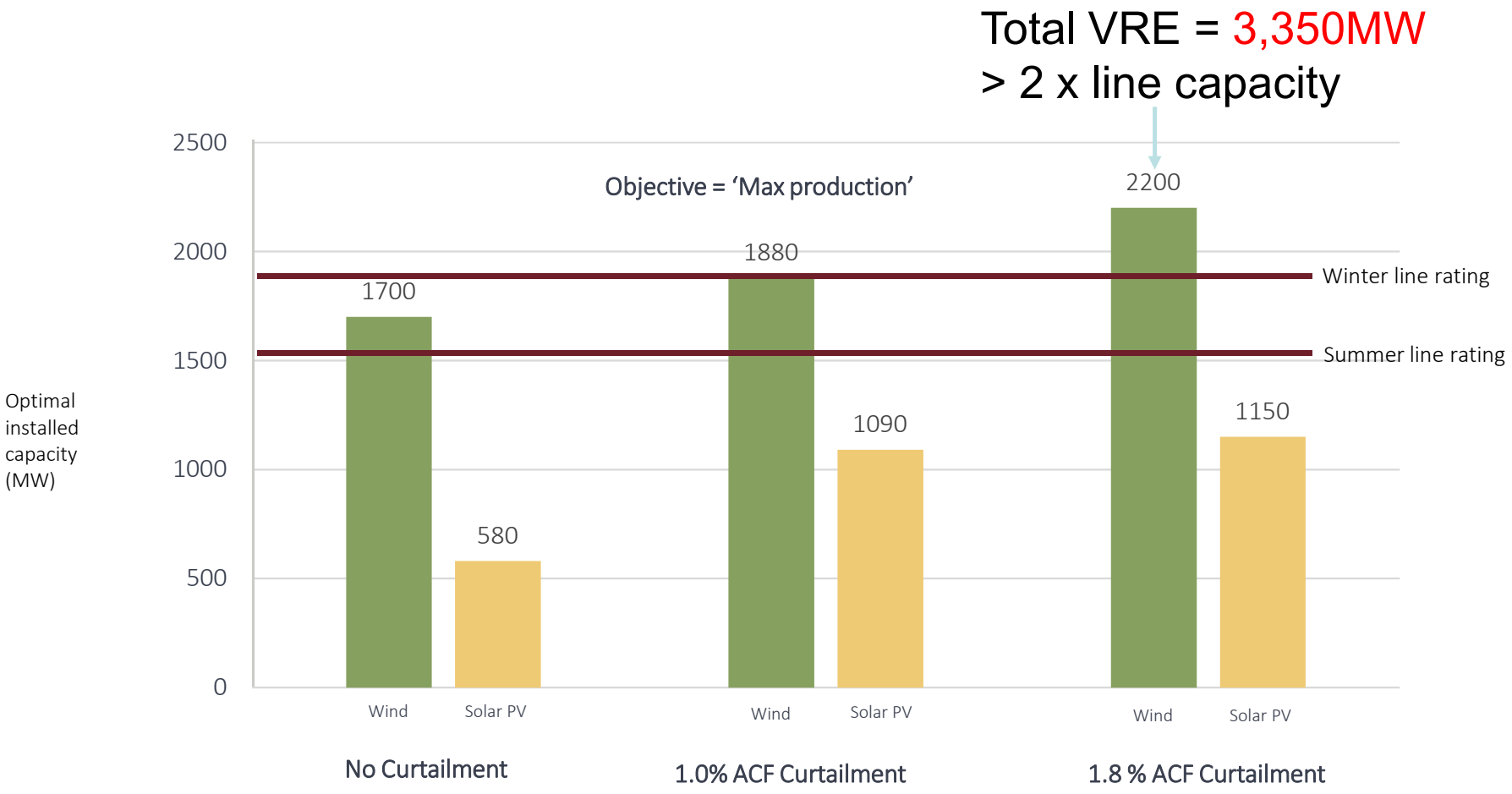
# Queensland wind and solar (Western Downs)



# 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
- Priority access forces curtailment from average to marginal

# REZ network capacity vs VRE capacity



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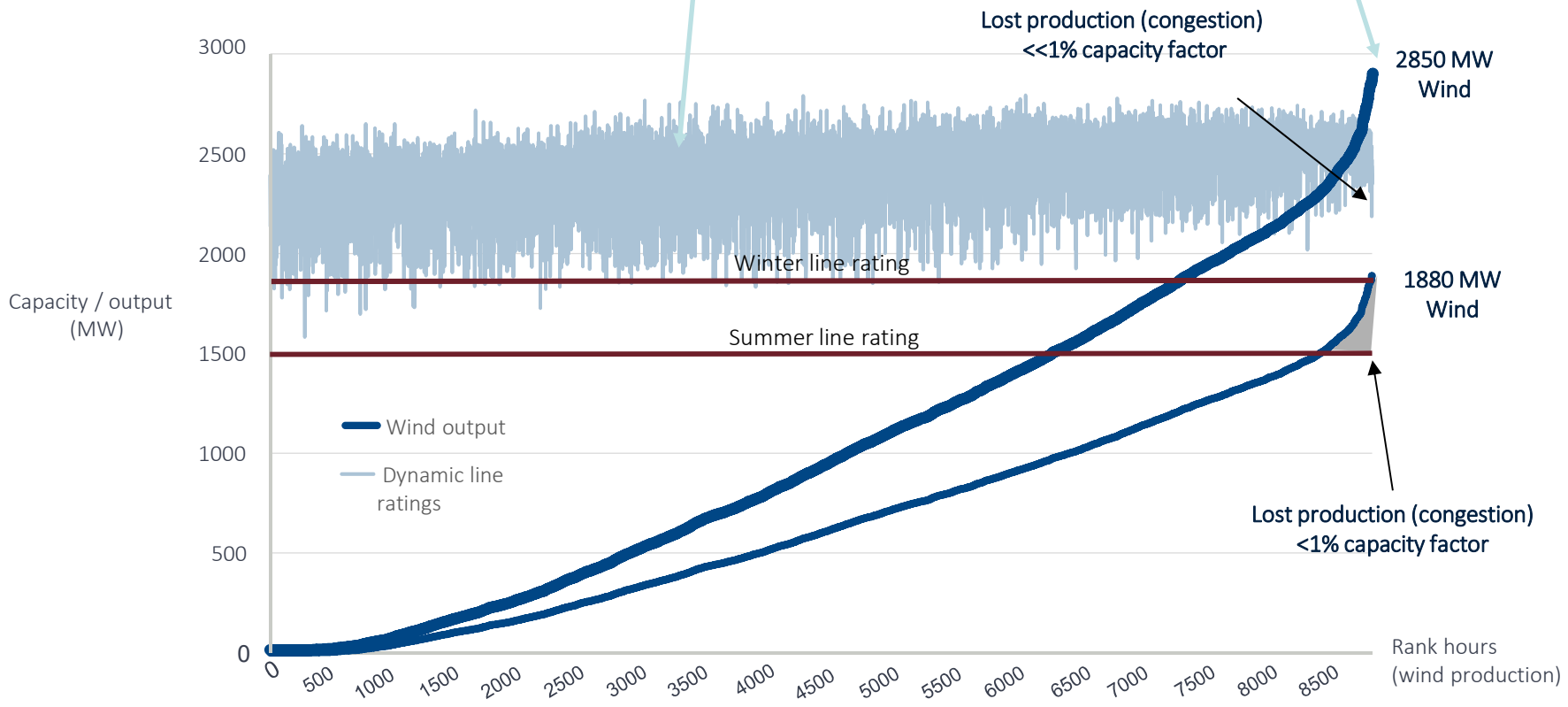
# Line ratings vs peak-to-average production:

## dynamic line rating massively increase wind capacity



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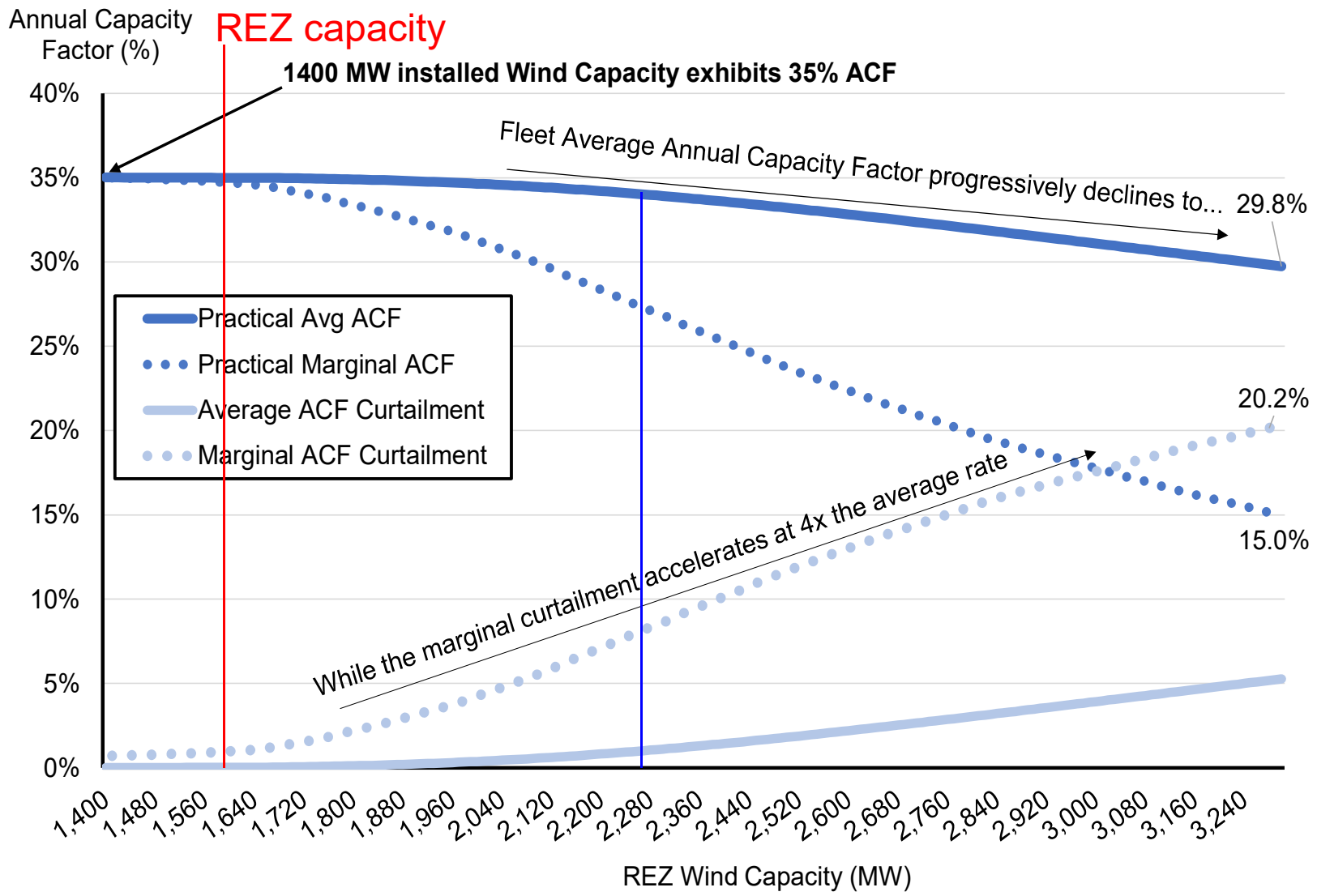
# Av. v Marginal wind curtailment rates

(PV held constant at 580MW)



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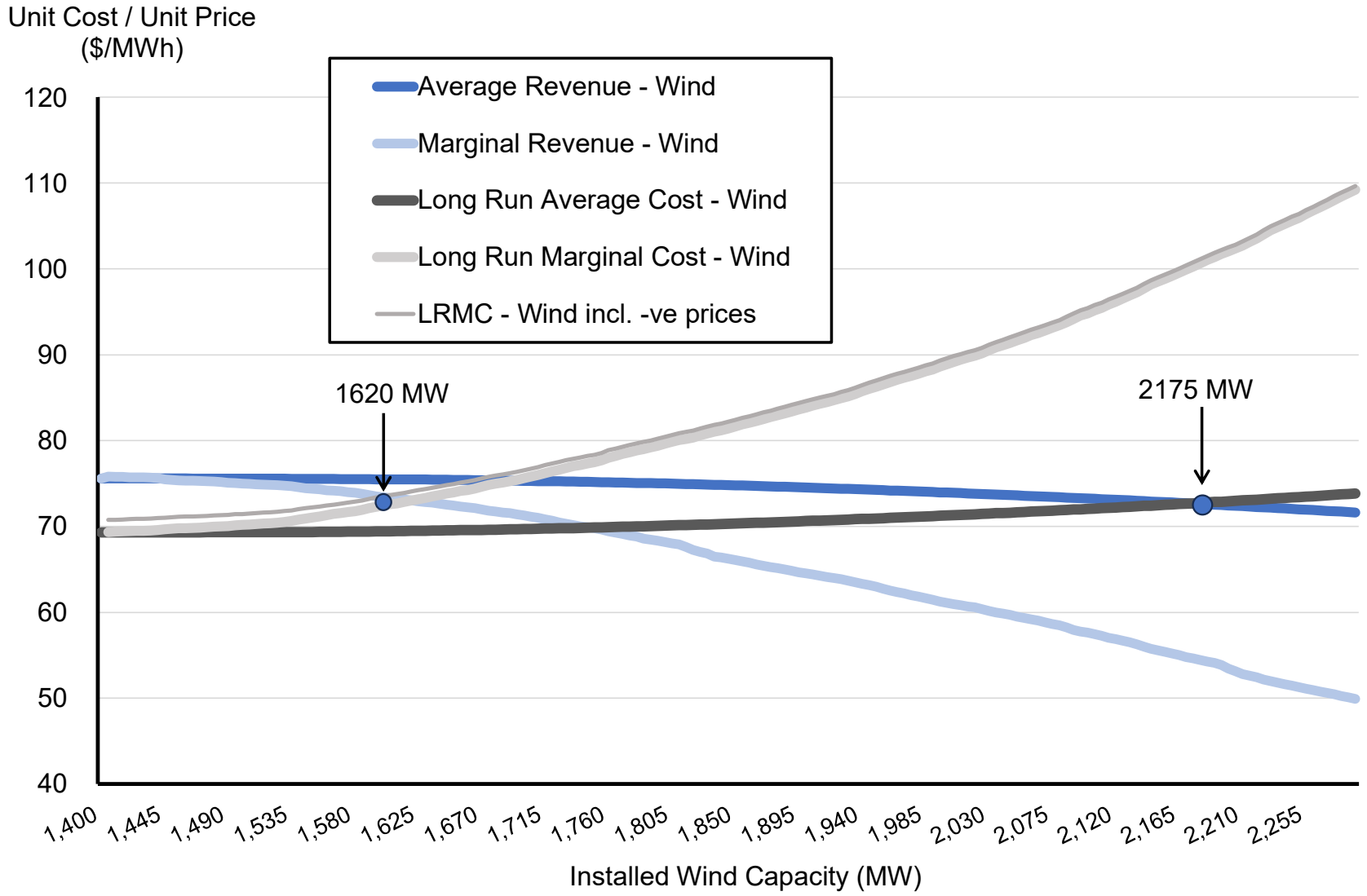
# Av. v marginal wind costs and revenues

(PV held constant at 580MW)



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# 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 can be LRMC or uniform

***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 (NEM REZ)
  - uniform charges, non-firm + priority access (**Eirgrid proposal**)
  - firm access, long-run TNUoS reset for each entrant related to expected future LMP, deemed/yardstick CfDs (tbc)

# Conclusions

- 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

**Access regime and access charges need coordination**

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