Reimagining an optimised grid with abundant storage

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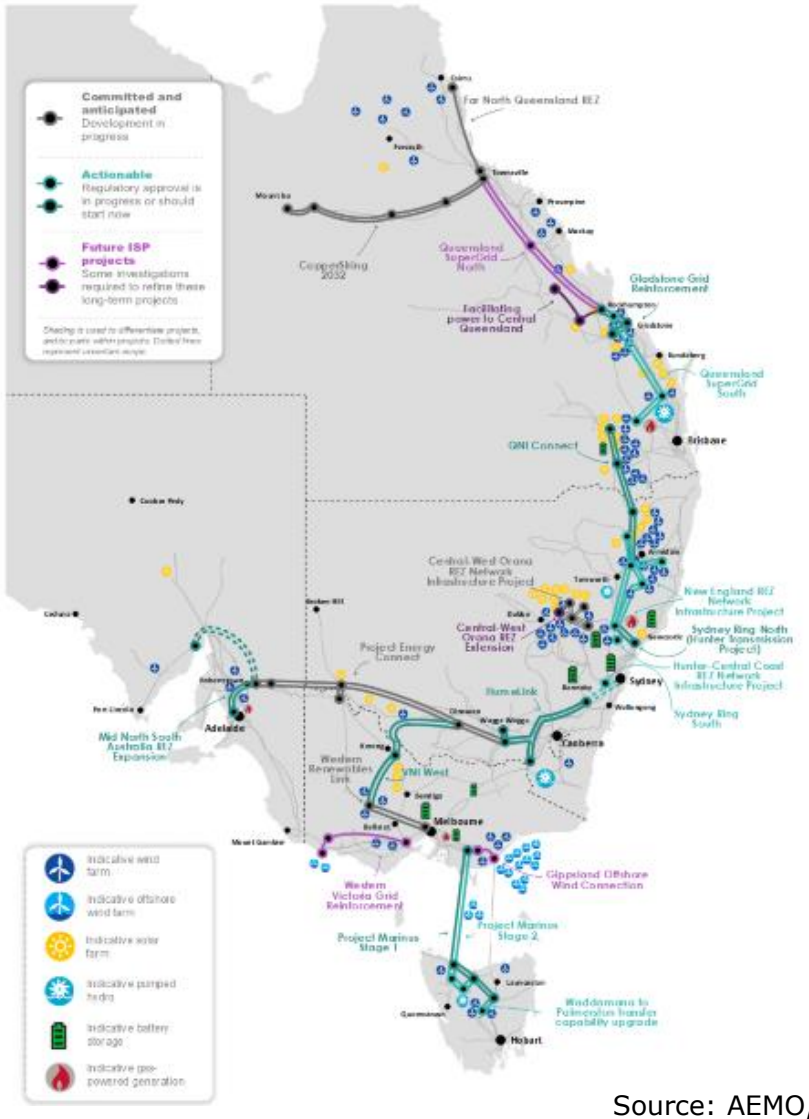
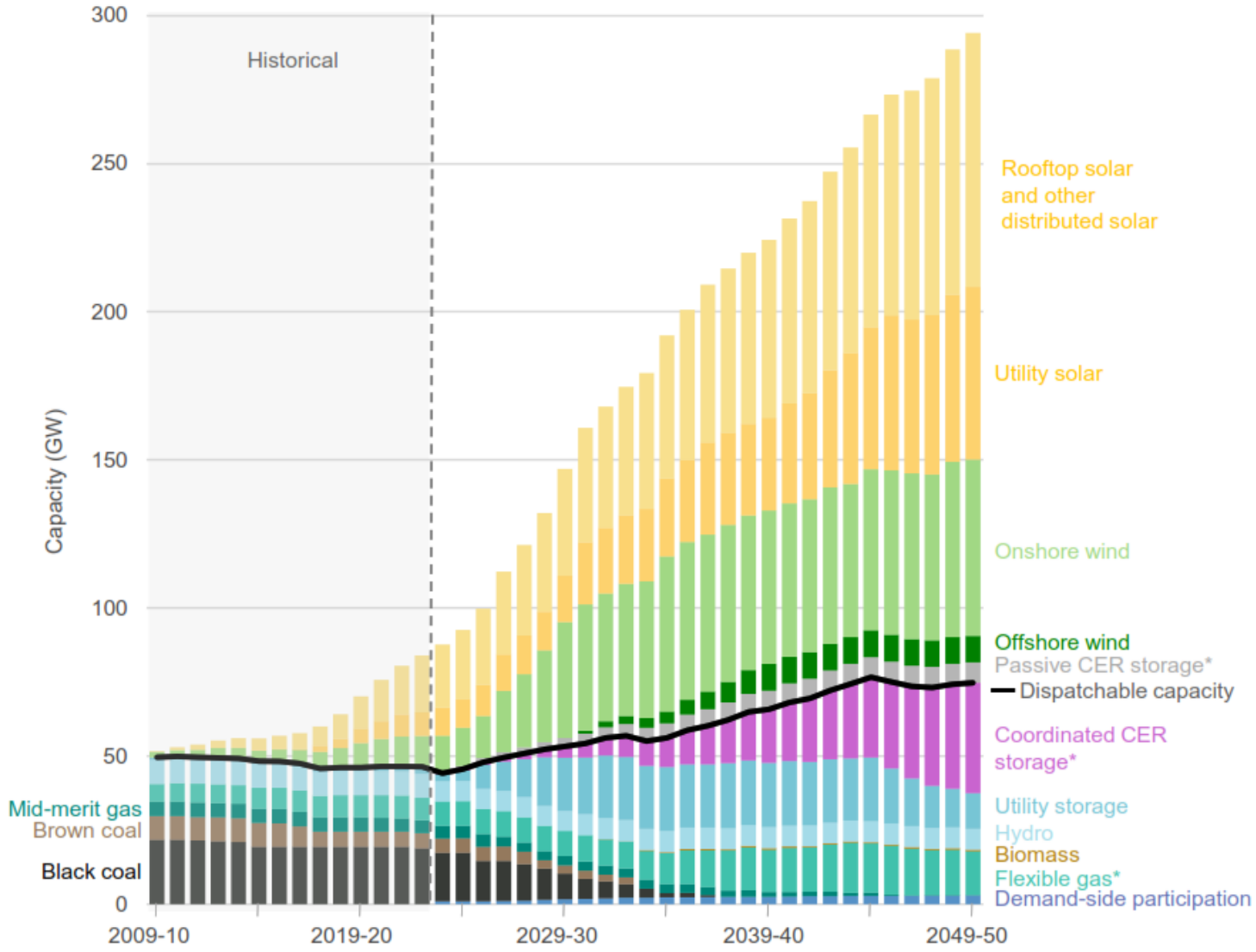
C4NET webinar, 26th February 2025

An epochal transition



Installed generation capacity, "Step change"

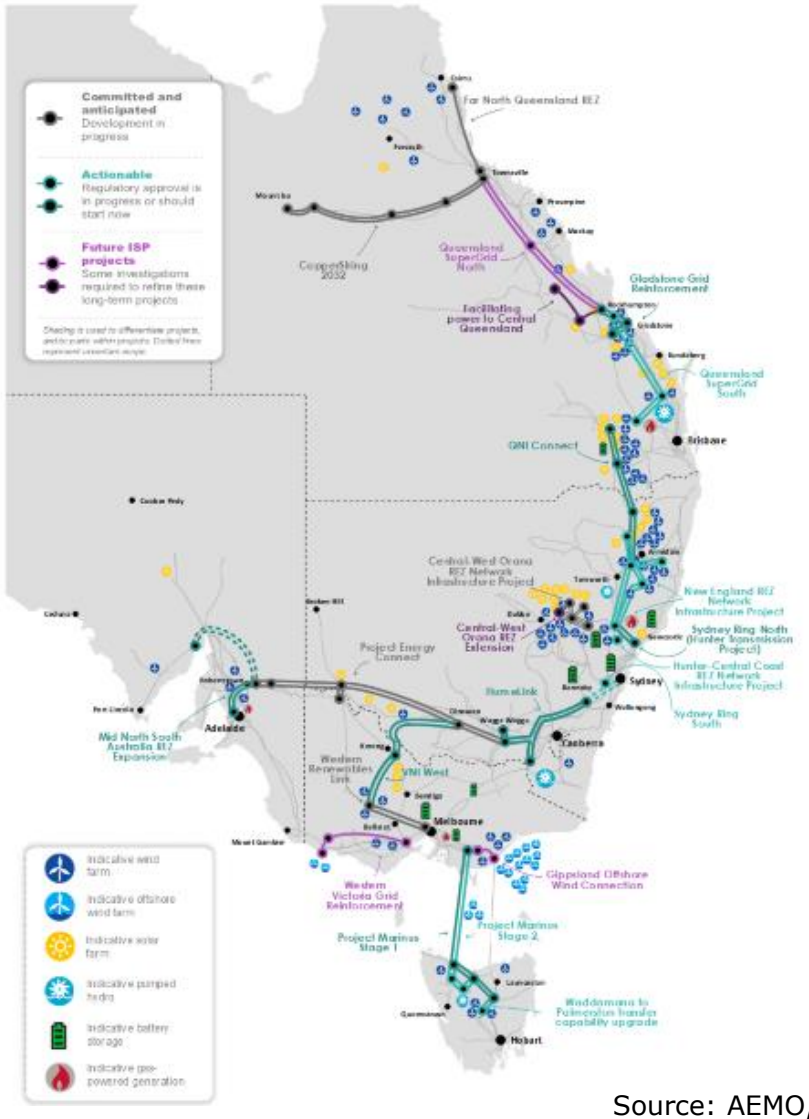


Source: AEMO, ISP 2024

A Copernican revolution for the grid

Image taken from the internet

An epochal transition & a Copernican revolution



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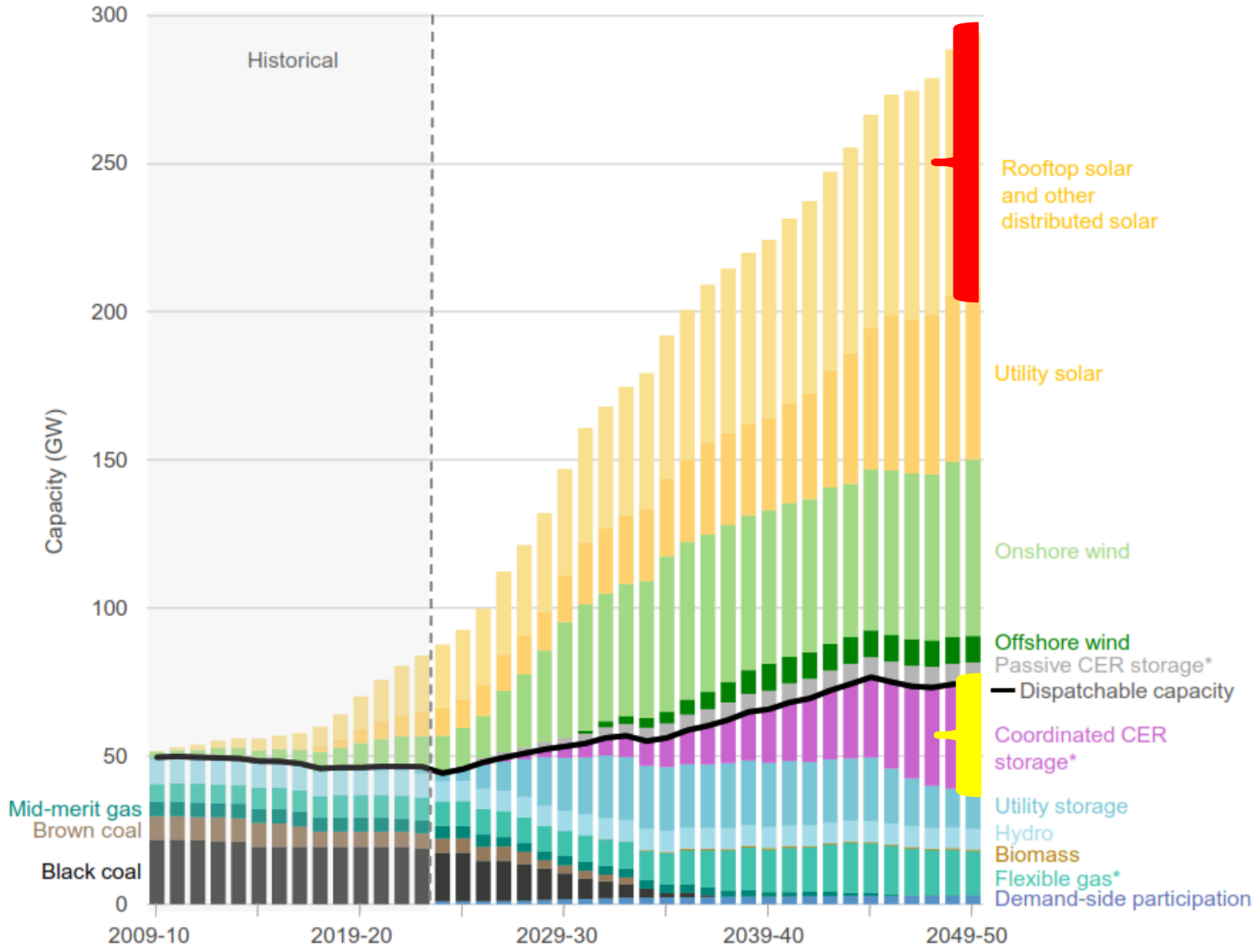


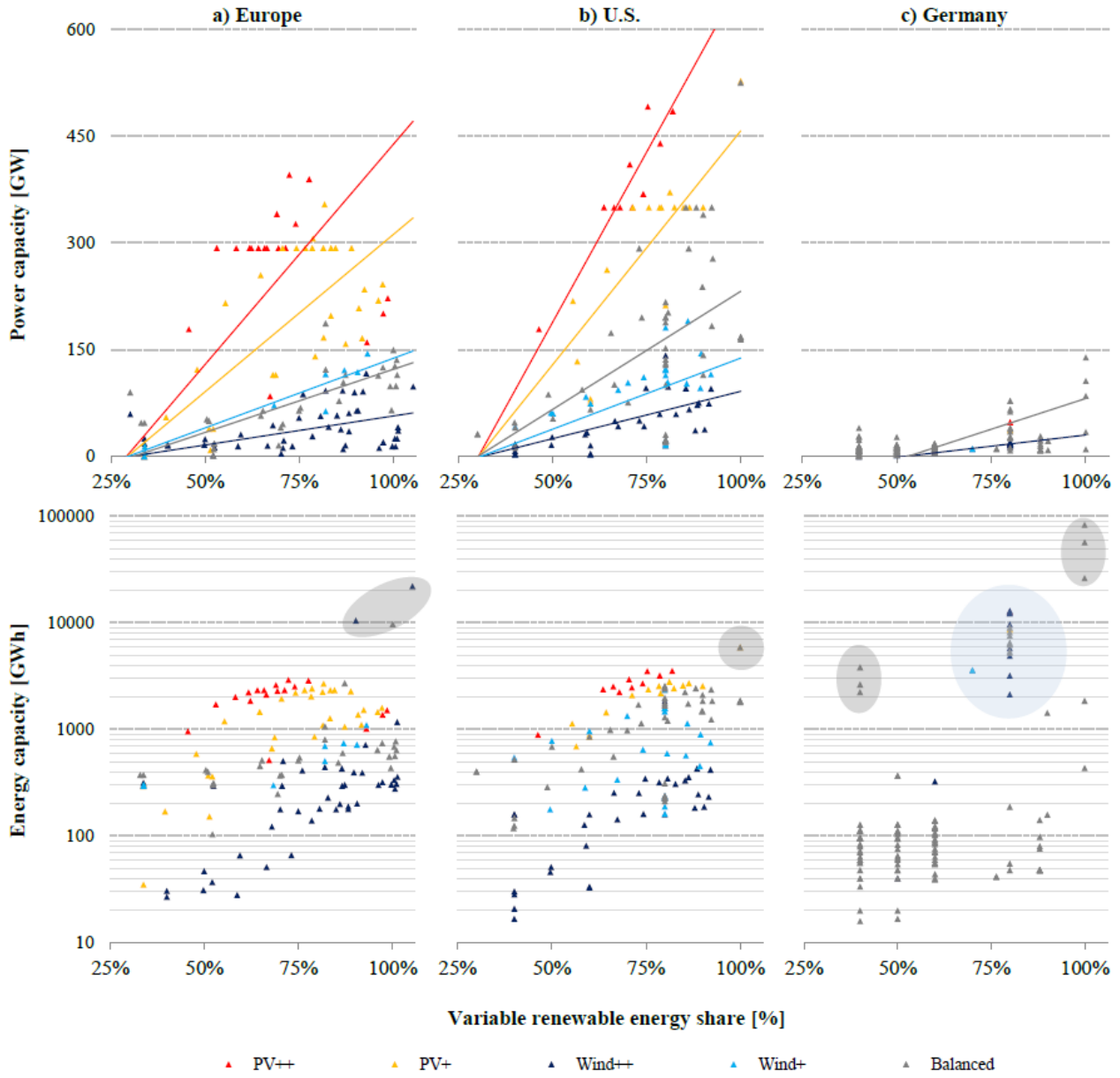
Source: AEMO, ISP 2024

How much and what storage do we need?

GW

Renewables penetration

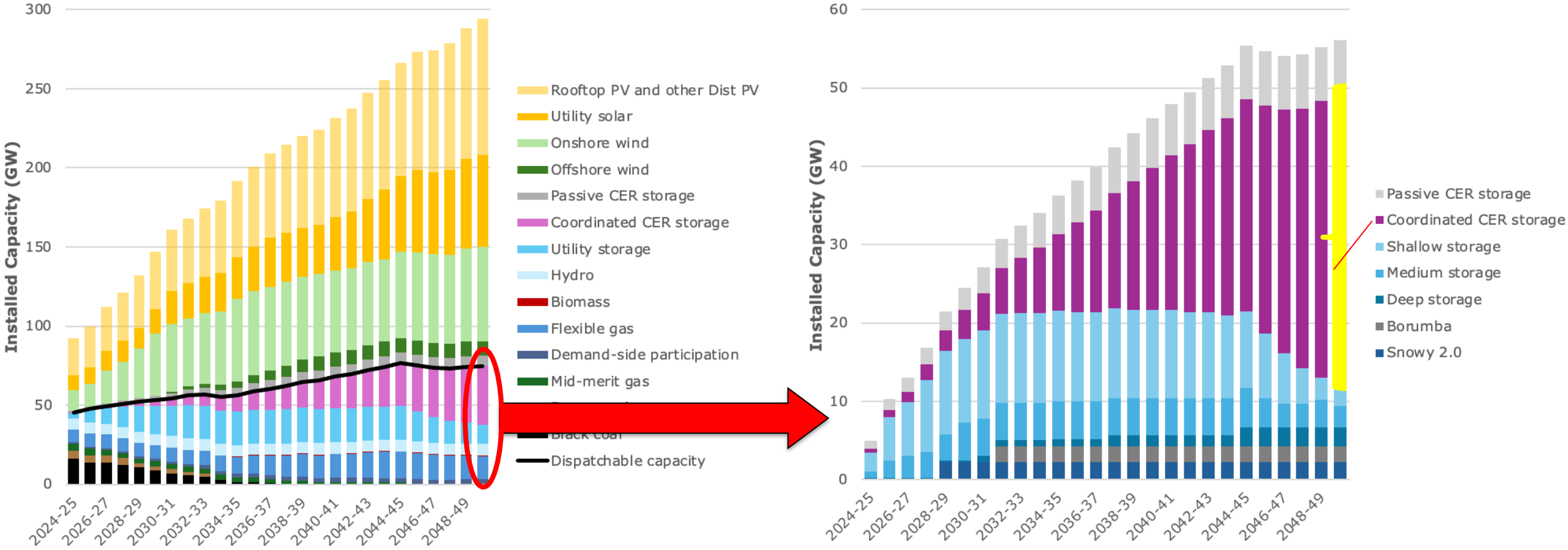
GWh



Correlation with generation type matters!

F. Cebulla, *et al.*, "How much electrical energy storage do we need?", *Journal of Cleaner Production*, Volume 181, 20 April 2018, 449-459

How much and what storage do we need?
The *NEM case*



Source: AEMO, ISP 2024

Generation capacity while transitioning to a renewables- and storage-abundant system

Peak demand = 100 GW

VOLL = €3000/MWh

ES round-trip efficiency=85%

	Peak	Base	VRE	ES
Capital (€/kW)	320	640	1,890	2,380
Variable (€/MWh)	155	103	0	0

Optimal generation capacity expansion

A. Botterud, *et al.*, "Price formation and long-term equilibrium in future electricity markets: The role of energy storage", The Oxford Institute for Energy Studies Forum, April 2024

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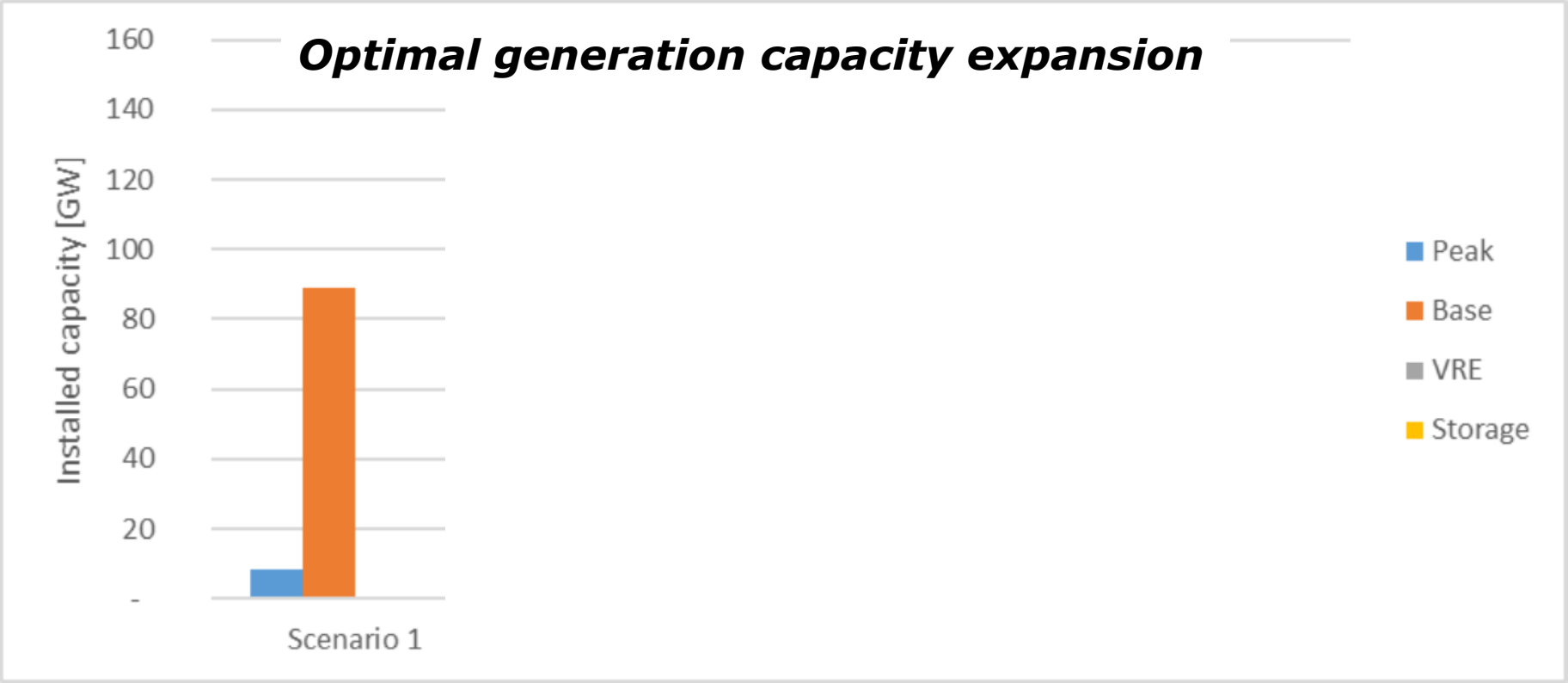

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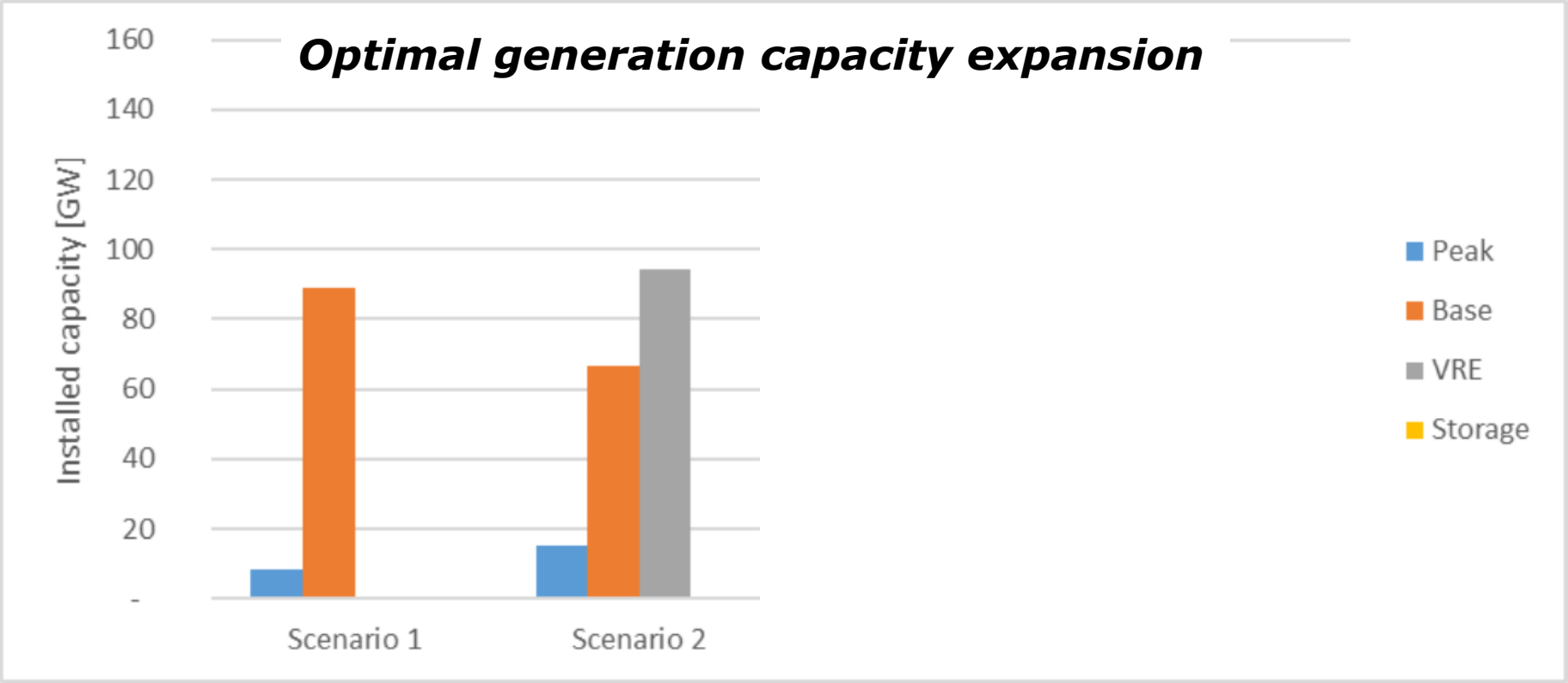

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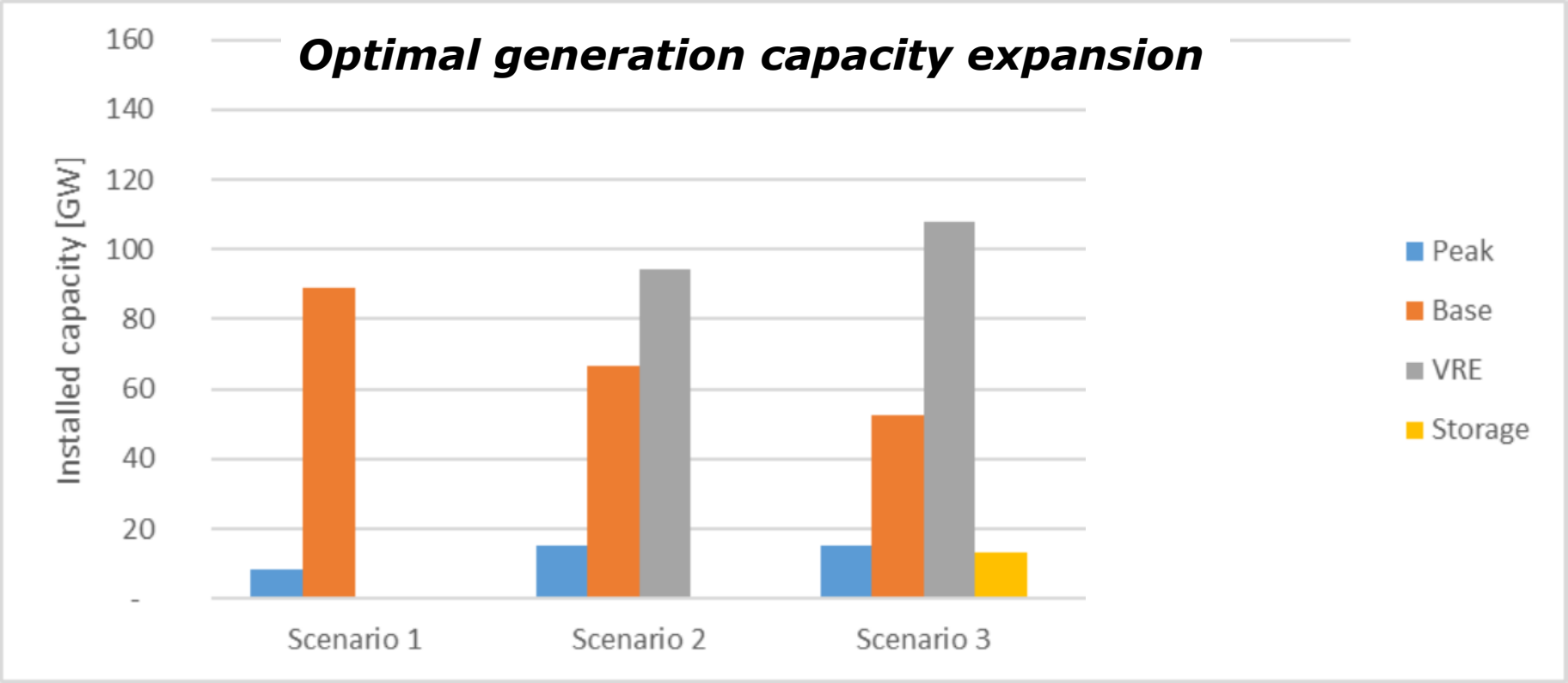

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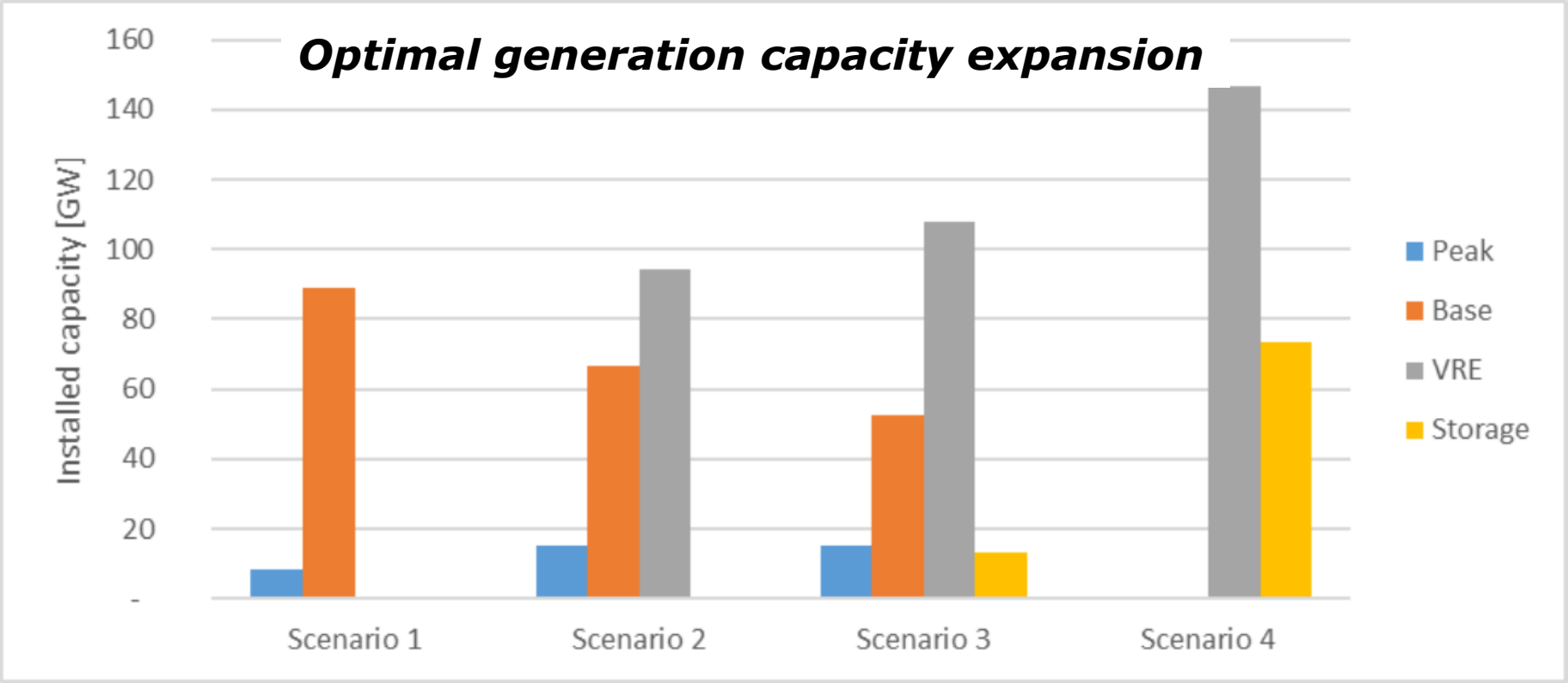

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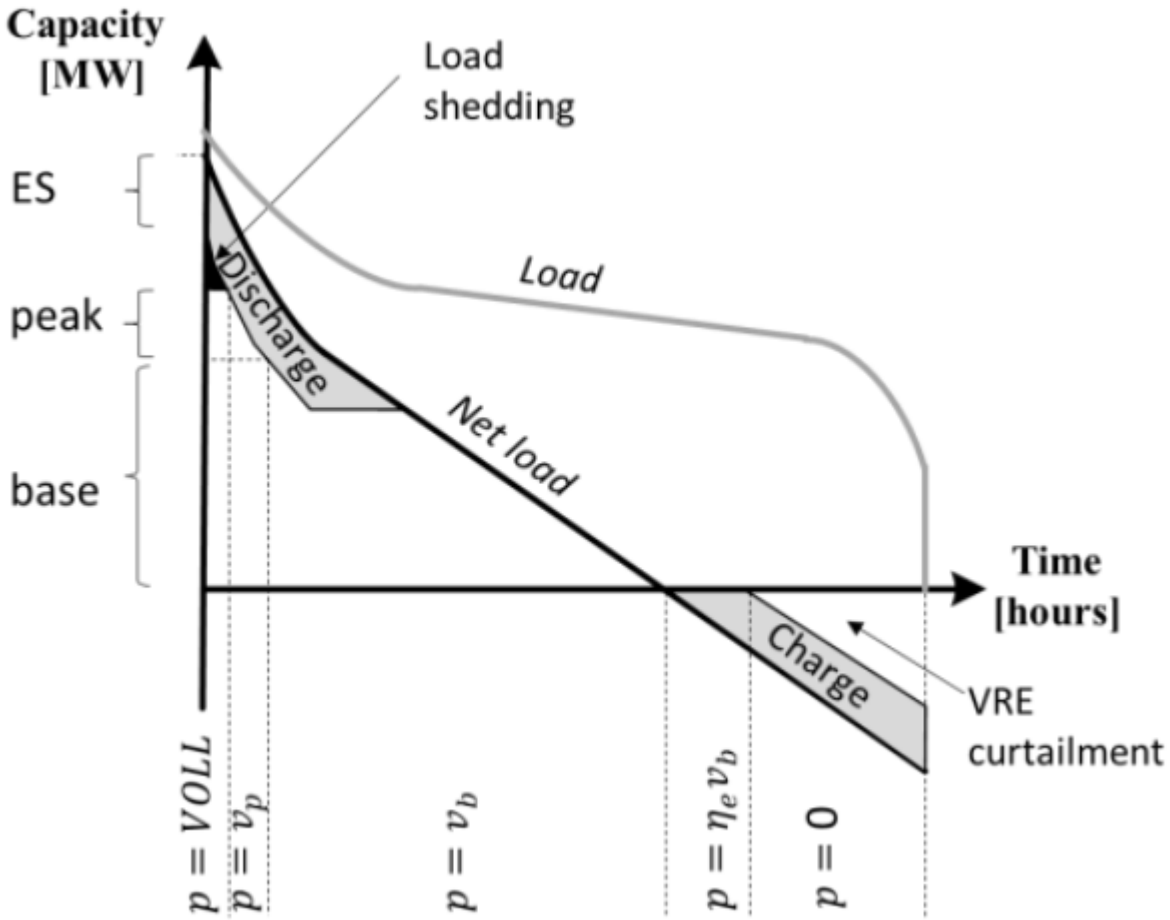
Storage, demand flexibility and market prices

Scenario 3



Prices (p) for different durations are indicated along the x axes, with *VOLL* = value of lost load, *vp* = variable cost for peak plant, *vb* = variable cost for base plant, ηe = round-trip efficiency of ES, and Λ = a functional expression which includes the capital costs for VRE and ES

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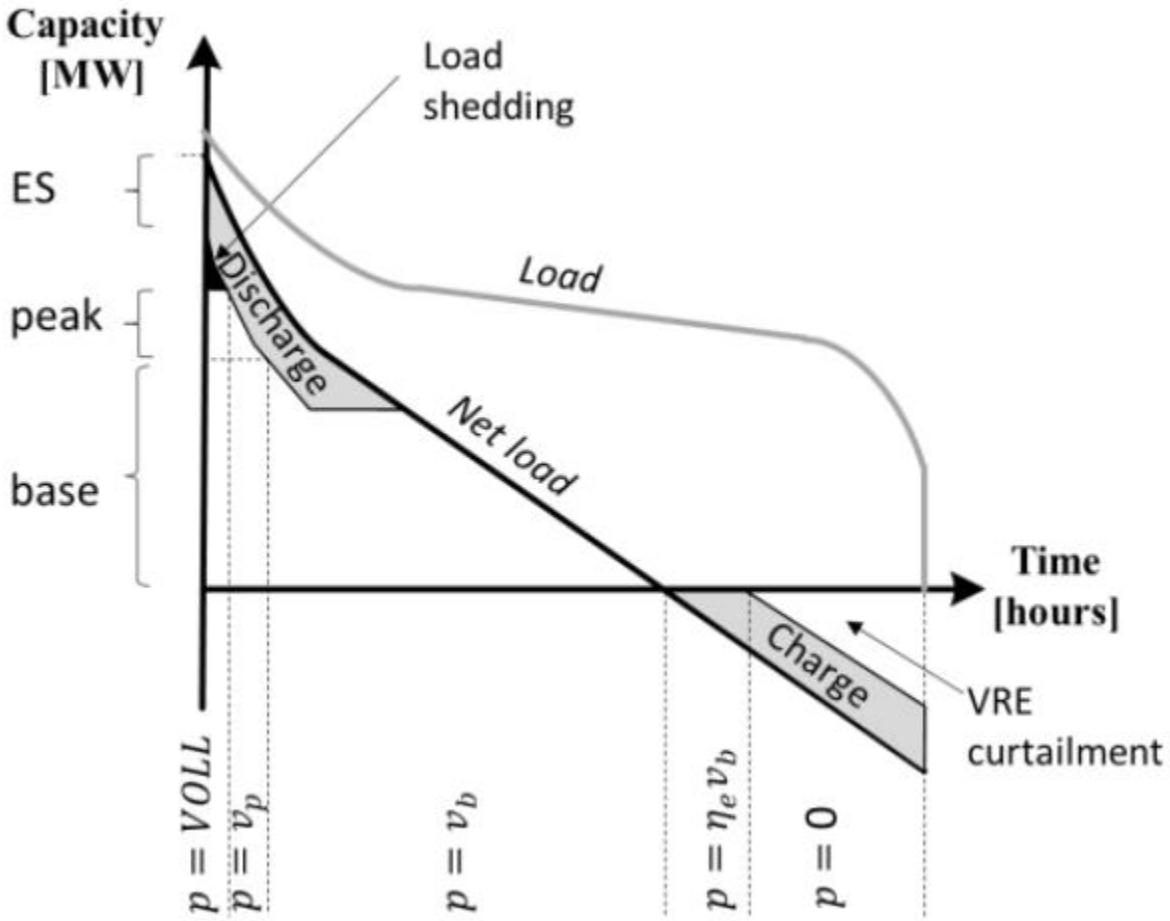
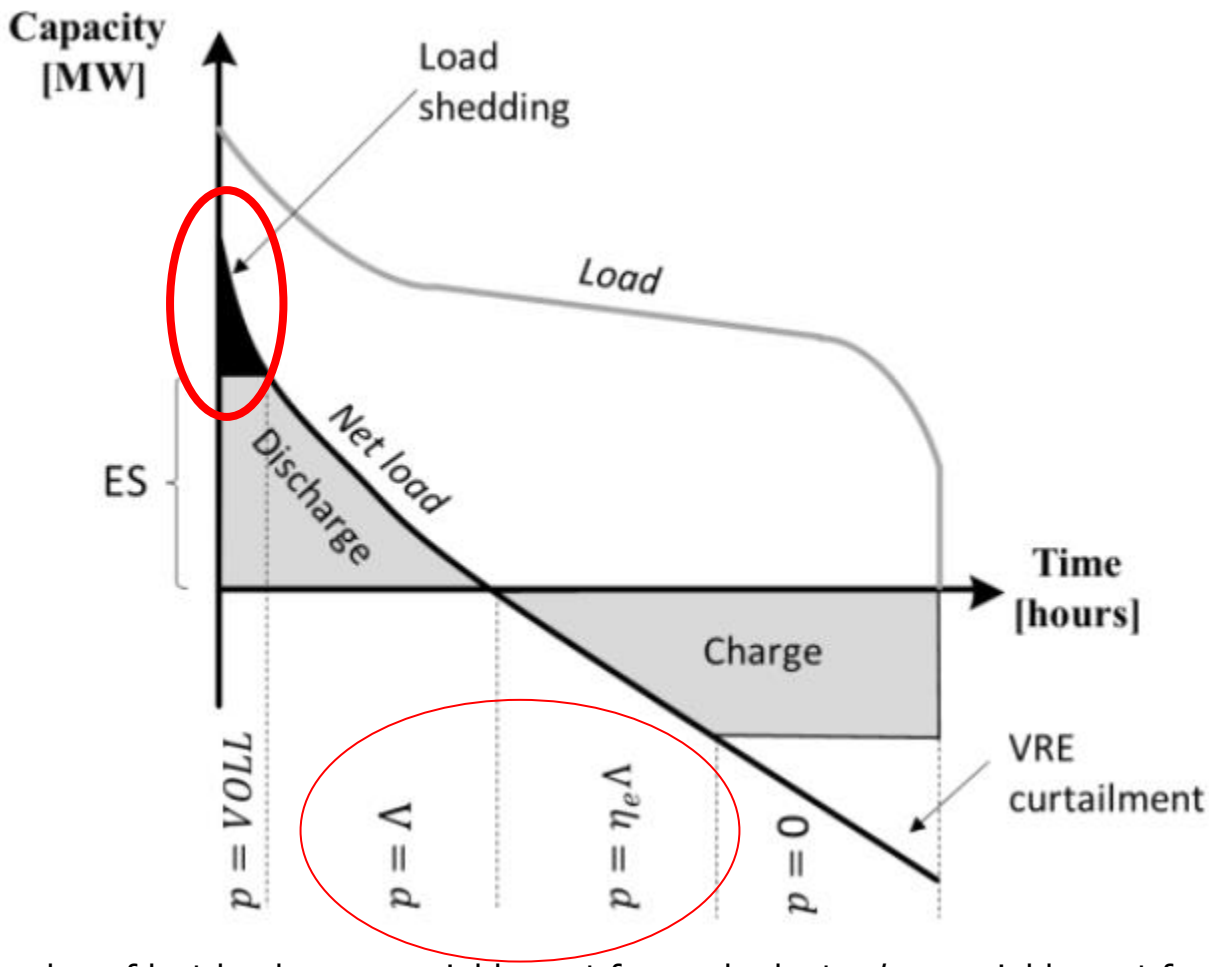


Scenario 4



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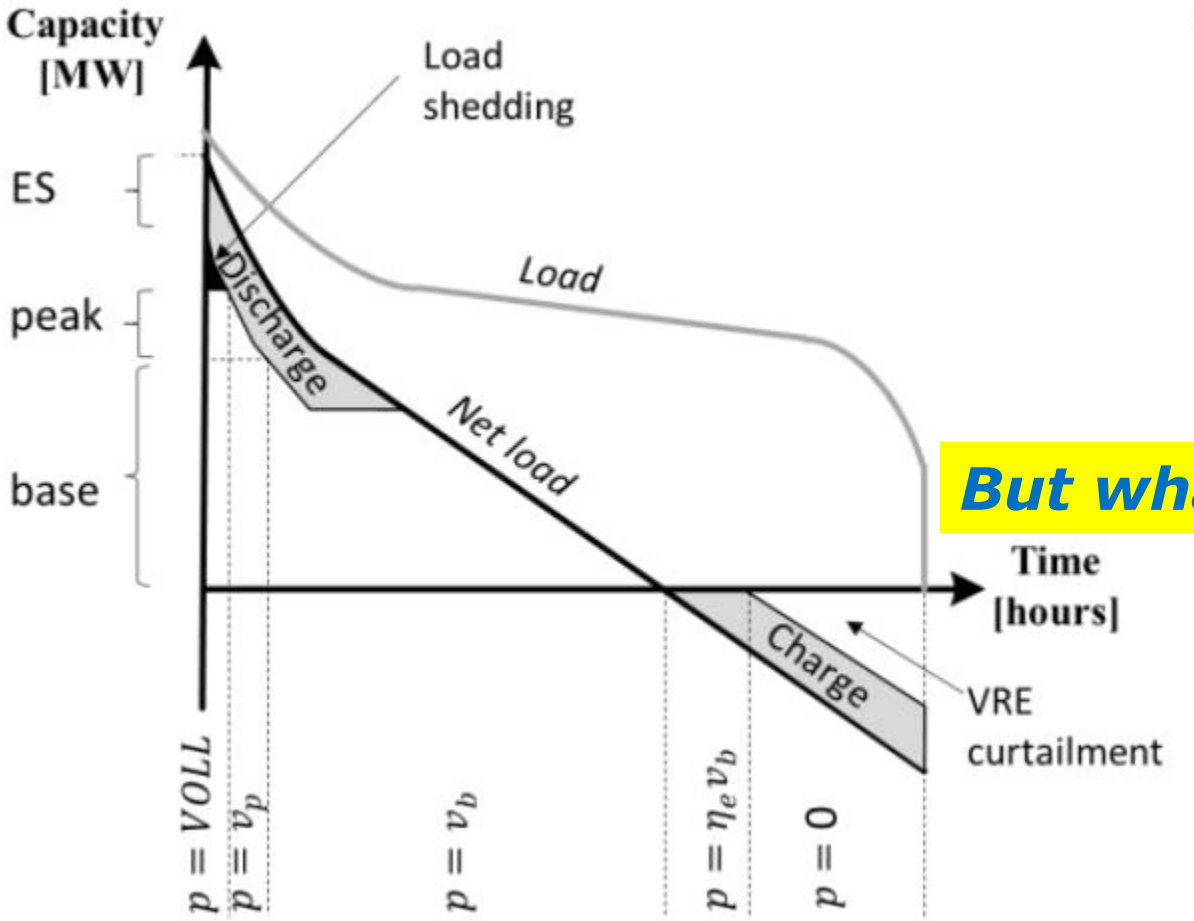

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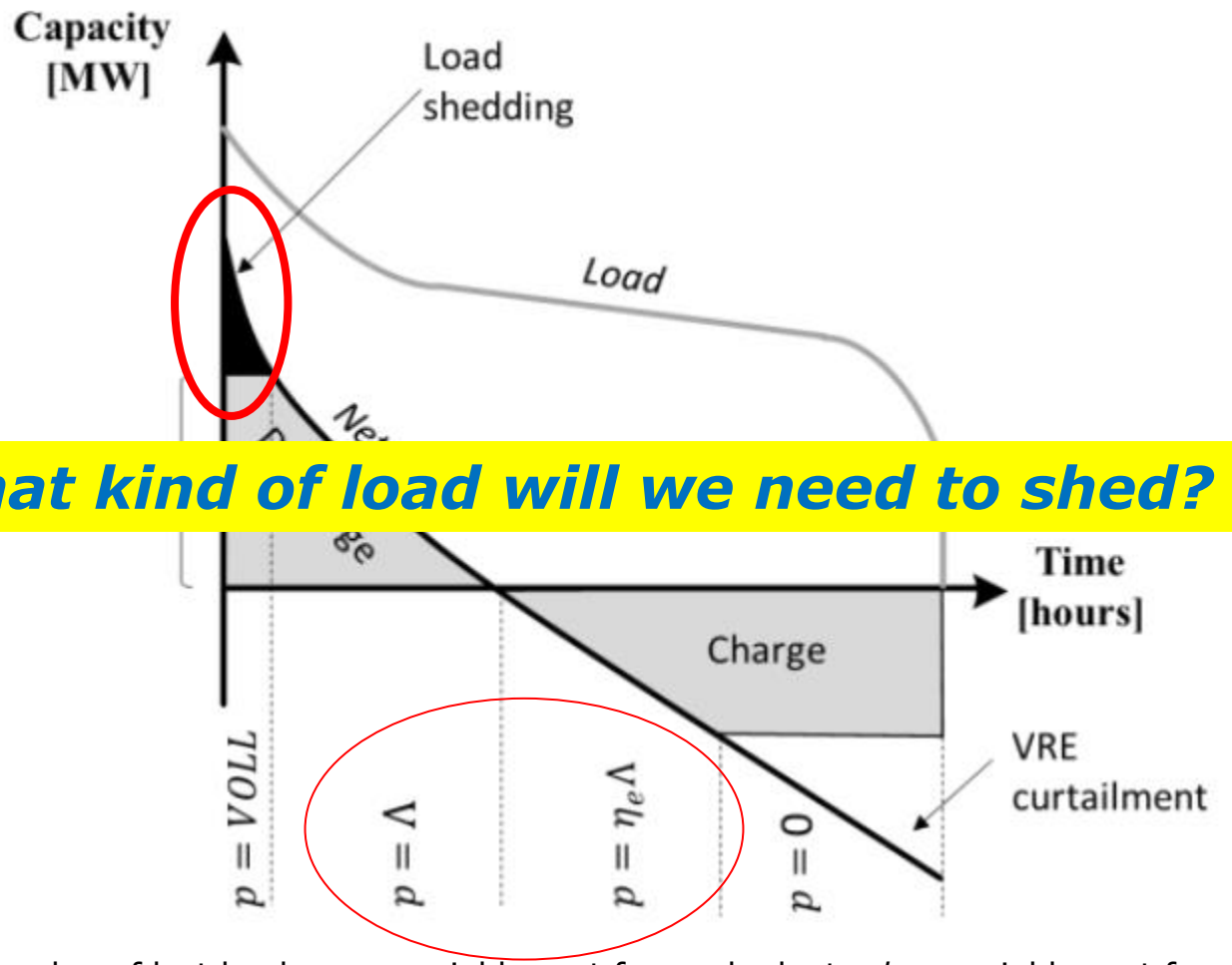

But what kind of load will we need to shed?

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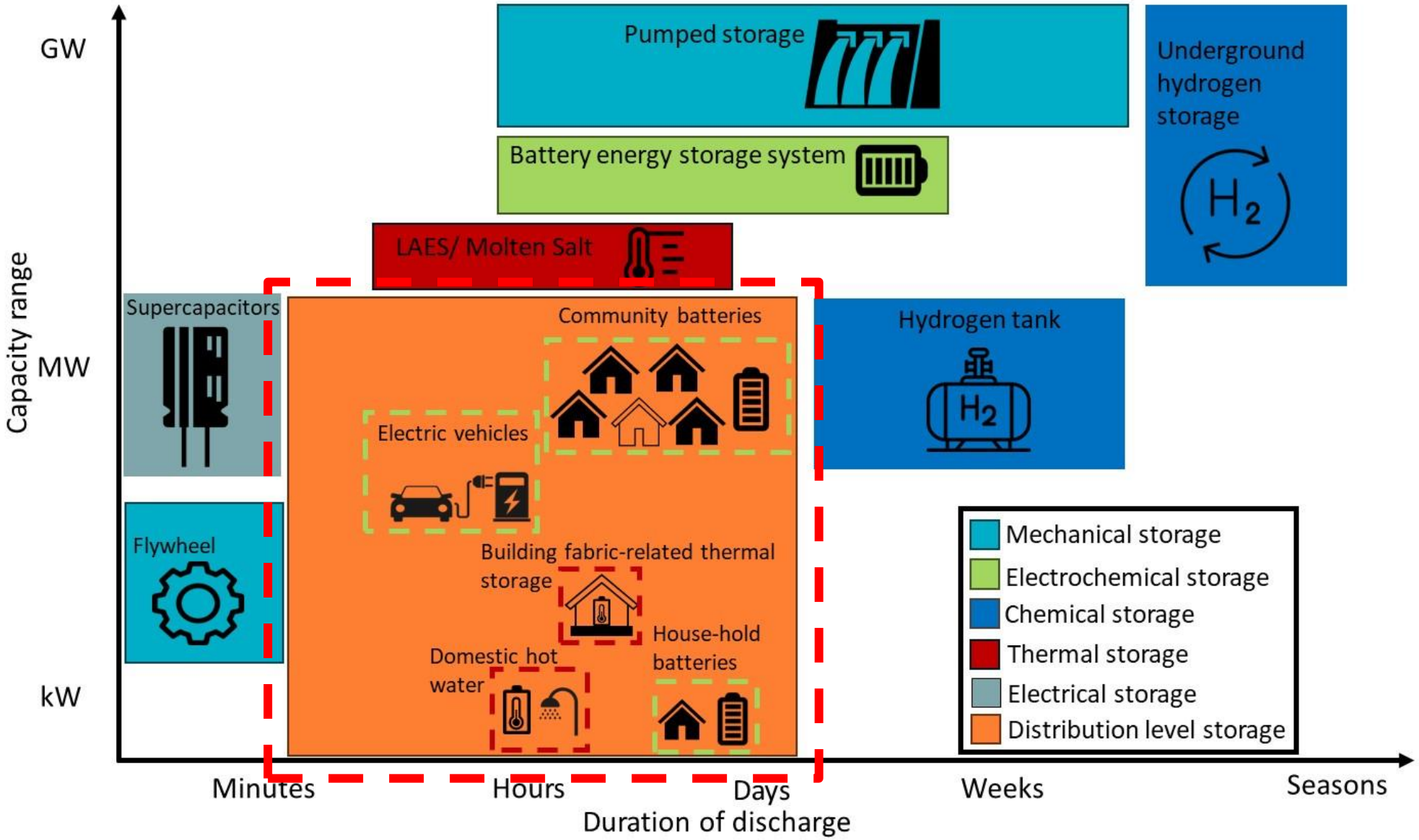
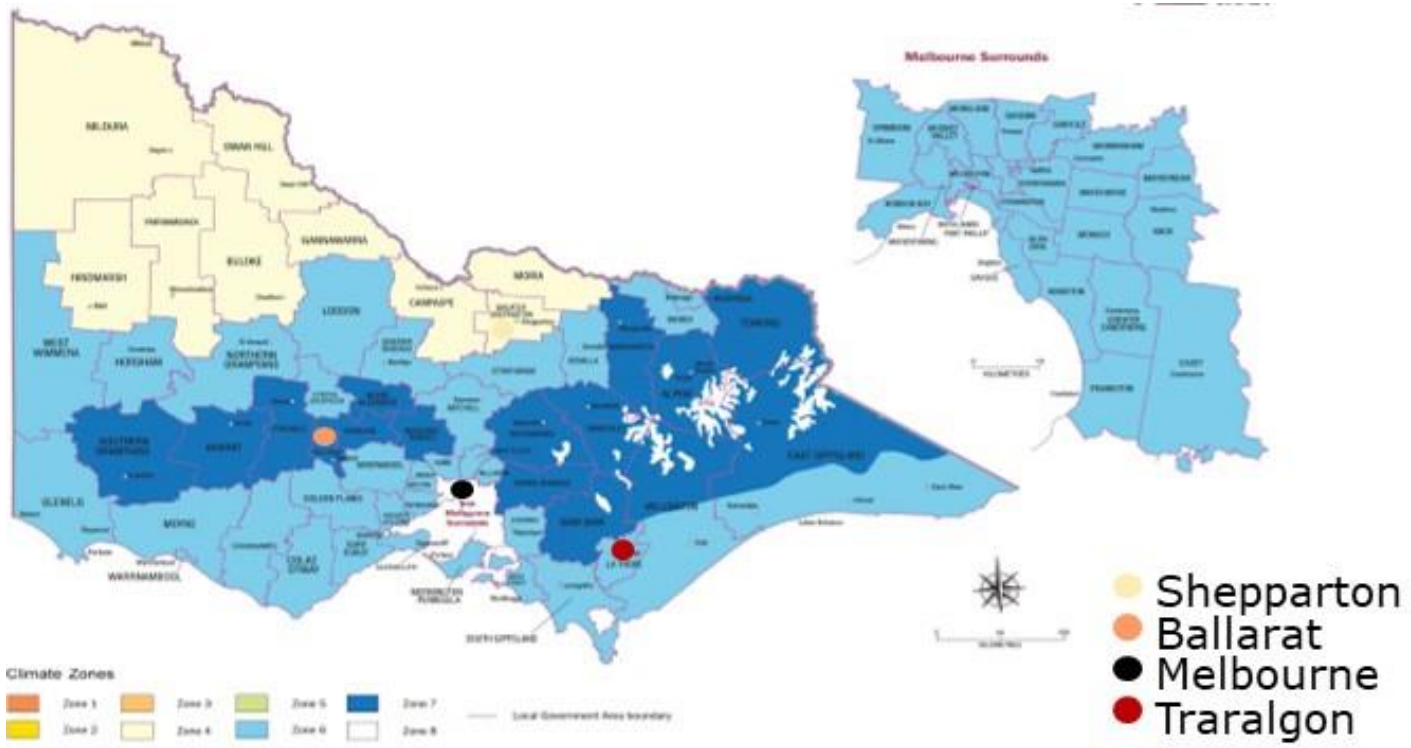
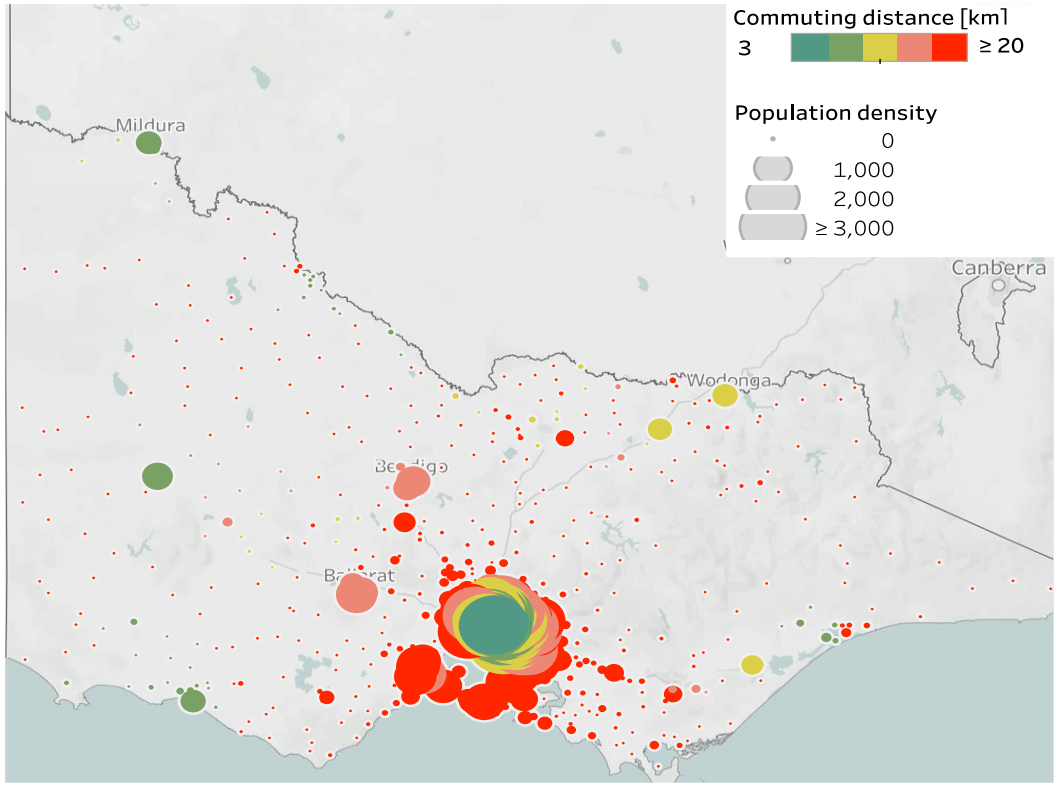
Storage and flexible demand



The C4NET ESP-V project: Impact of *demand-side electrification*



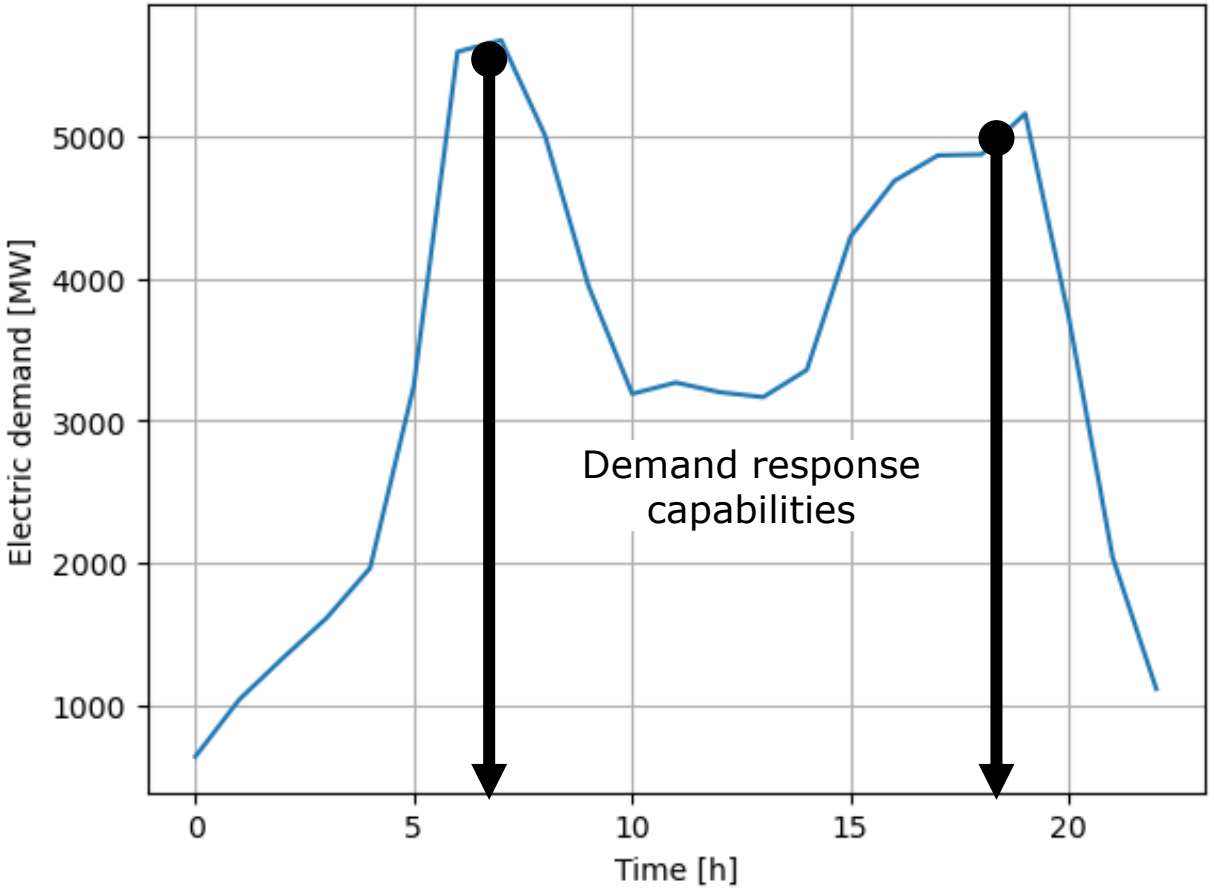


[1] ABCB and National Construction Code, Victoria Climate zone map, 2019
[2] A. De Corato, P. Mancarella - WP1.1 Technical modelling of electrification of heating (and cooling) profiles, C4NET ESP-V project, 2024

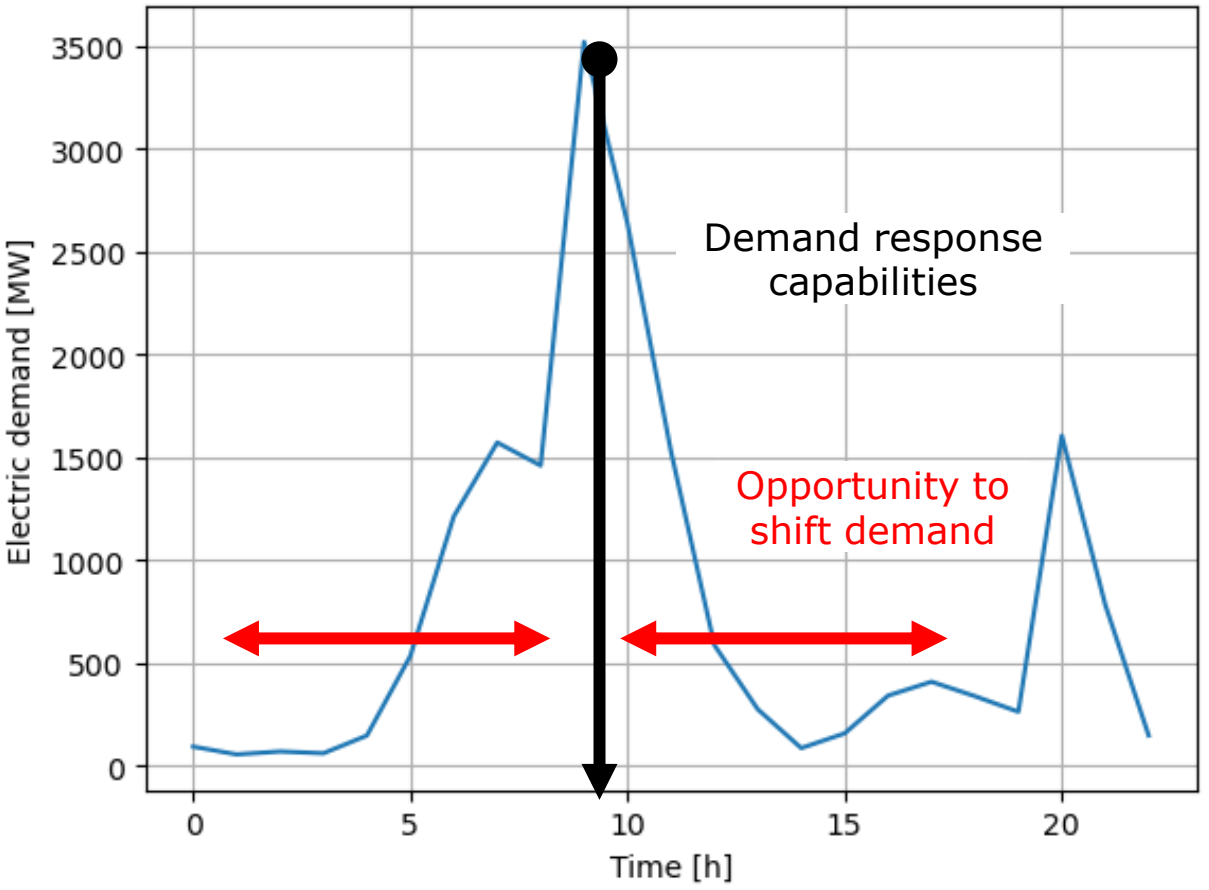
Storage in buildings and hot water

Aggregated demand in Victoria on a winter day

Space heating

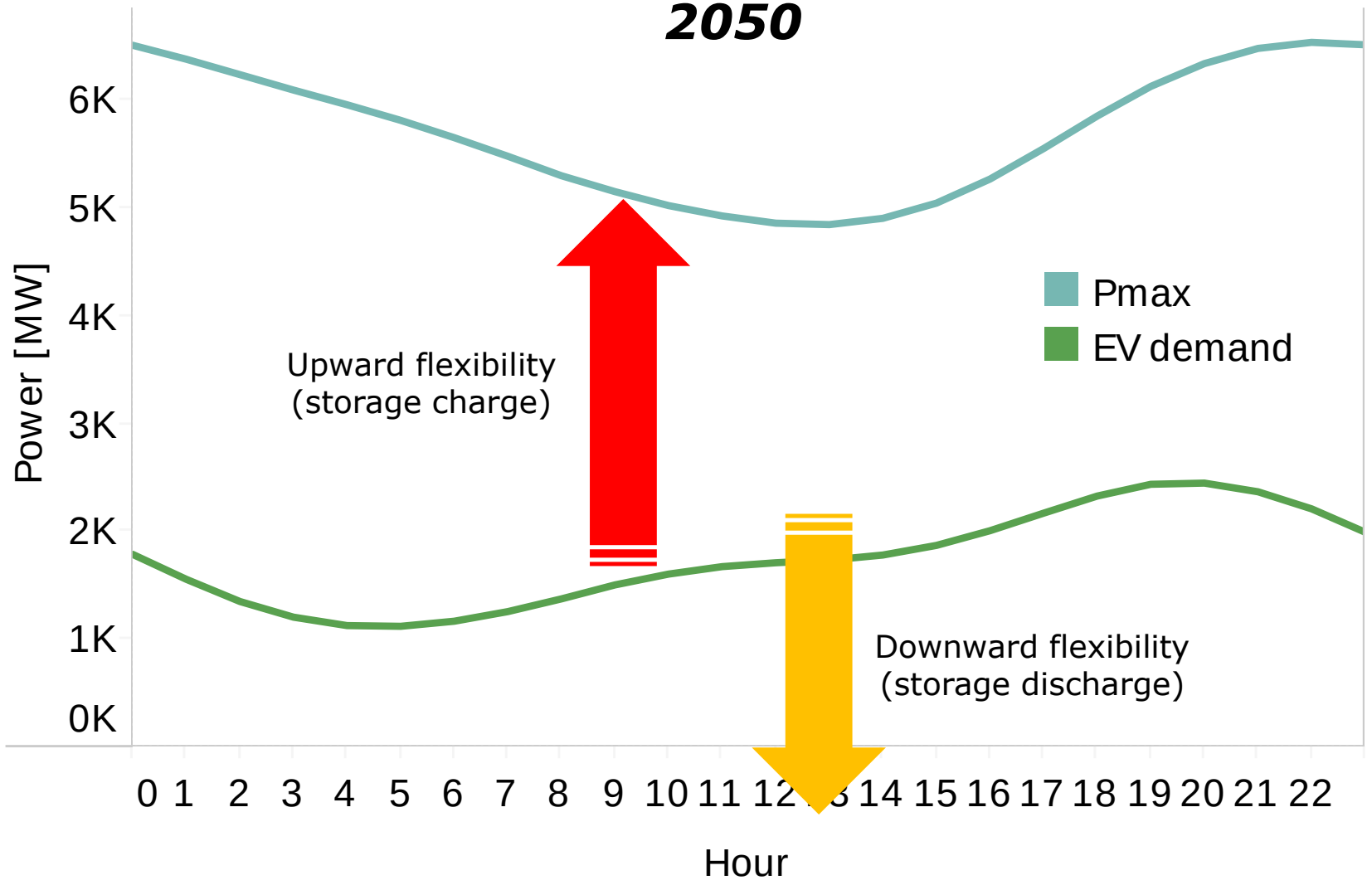


Domestic hot water

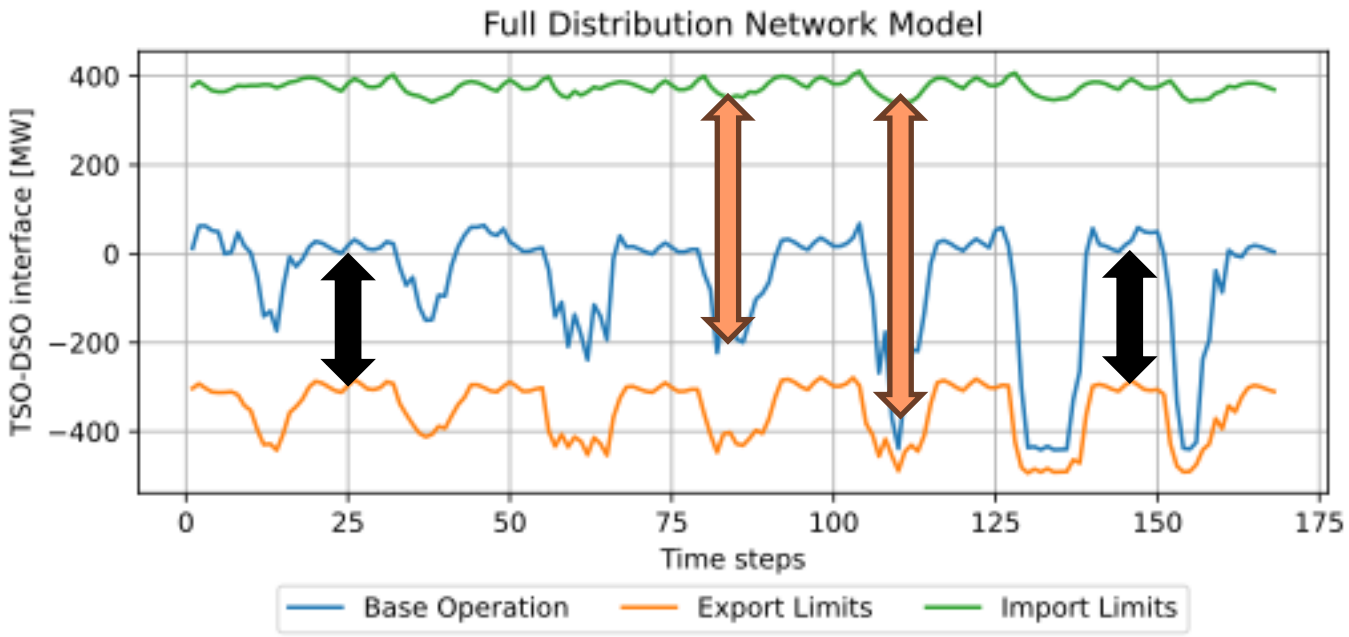


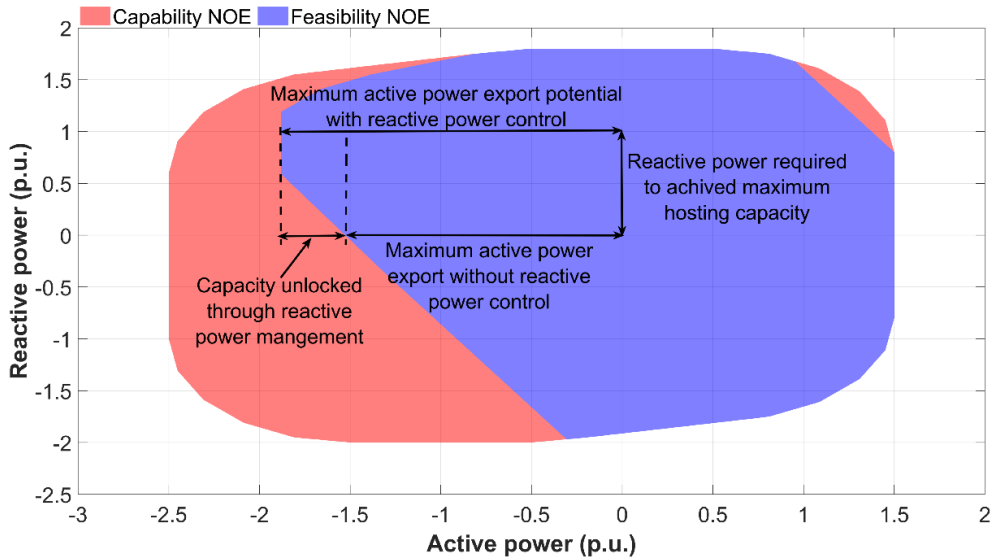
Storage in cars

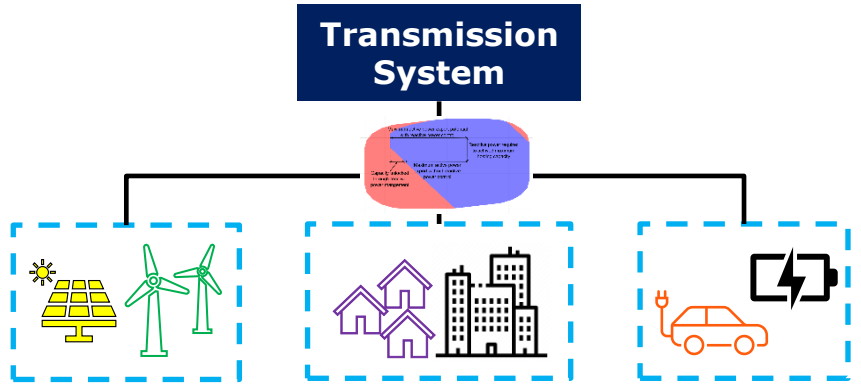
Expected EV demand and maximum available charging power in Victoria, 2050



The distribution grid as an active resource

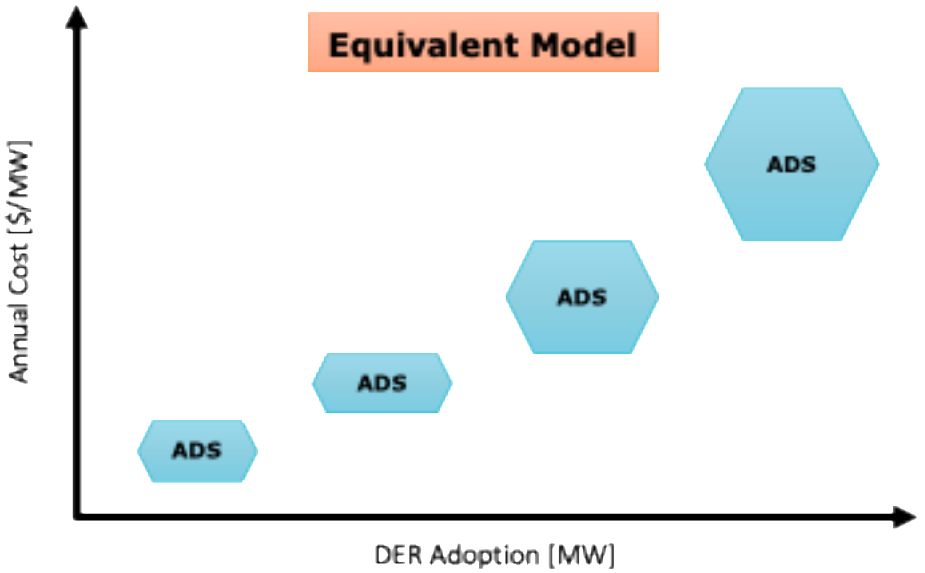


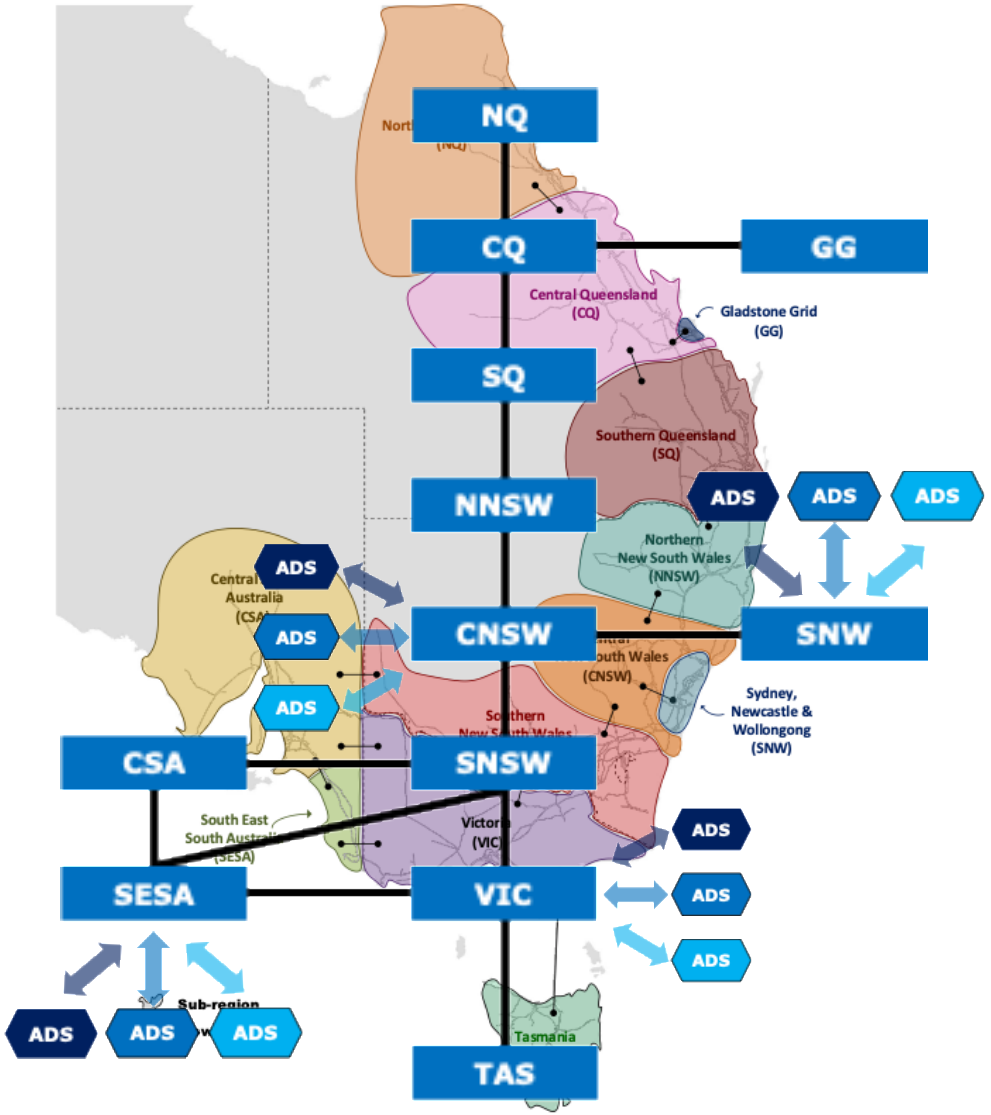




S. Riaz *et al*, "Modelling and characterisation of flexibility from distributed energy resources", *IEEE Transactions on Power Systems*, July 2021;
A. Churkin, *et al.*, "Tracing, Ranking and Valuation of Aggregated DER Flexibility in Active Distribution Networks," *IEEE Transaction on Smart Grid*, 15, 2, 2024
M. Liu *et al.*, "Grid and market services from the edge", *IEEE Power and Energy Magazine*, July/August 2021

Whole-system planning: Integrating transmission and distribution

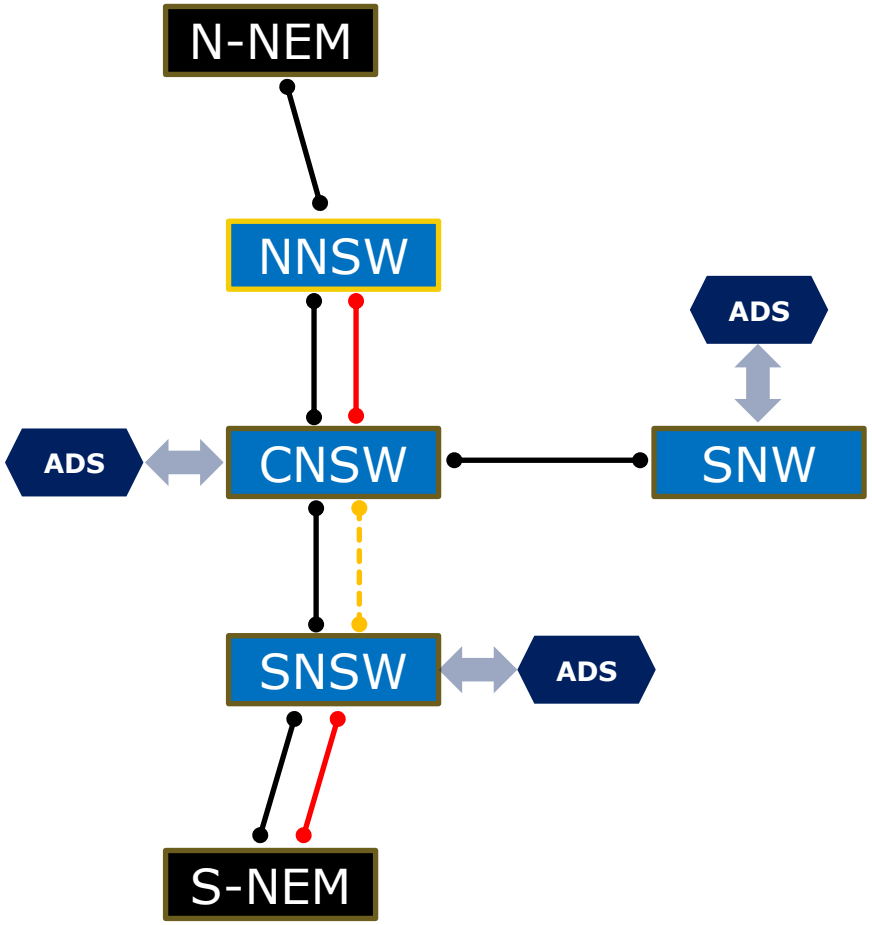




ADS = Active Distribution System

Integrated planning of transmission and distribution systems with DER

- By including active distribution systems (ADS) as "investment options" the best least-cost option with DER flexibility may lead to **shifting investments from transmission to distribution**
- **DER flexibility** and **transmission-level investment** exhibit **complementarity and synergy**
- Benefits from DER flexibility better captured when considered **planning uncertainty** and network **investment risk**
- ***DER flexibility*** may systematically **reduce** transmission-level:
  - **investment** requirements
  - **investment uncertainty** → *risk-hedge value*



P. Apablaza *et al.*, "Assessing the Impact of DER in the Expansion of Low-Carbon Power Systems Under Deep Uncertainty", *Electric Power System Research*, 2024

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This is work in progress, stay tuned!

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Acknowledgements

- C4NET for the *"ESP-V"* project
- CSIRO and AEMO for the ongoing support on the topic of "*Planning*" as part of the GPST consortium
- All my team!

Thank you!
Any question?

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