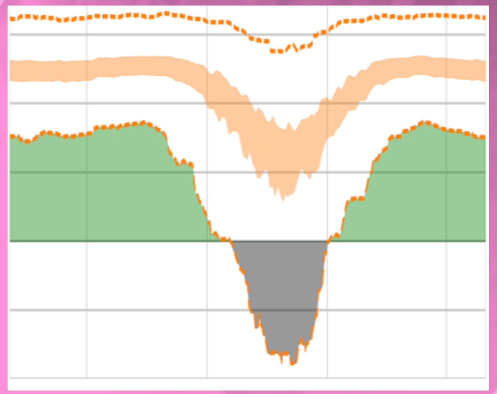
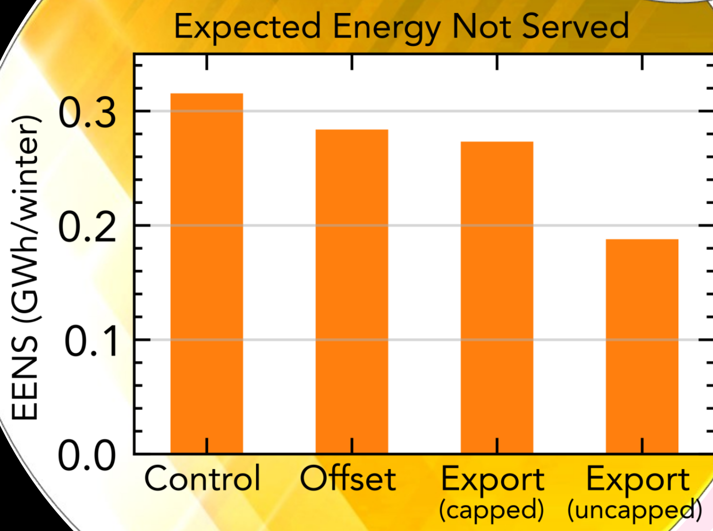
Scenario Doctoral Training Partnership | UKRI Natural Environment Research Council | University of Reading | BT Group

Utilising Reserve System Surplus to Improve Power System Adequacy





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- Prof. David Brayshaw (Reading)
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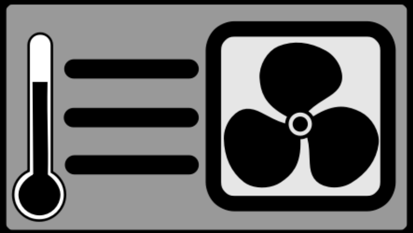
- Kjeld Jensen (BT Research)
- Louise Krug (BT Research)
- David Greenwood (Newcastle)

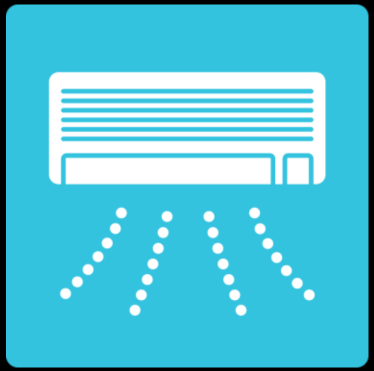
* j.fallon@pgr.reading.ac.uk

Risk and Resilience Day 12 March 2024

Power Systems are Increasingly Sensitive to Weather



- Energy electrification is increasing
  - "Electricity accounted for 20% of final energy consumption in 2023, up from 18% in 2015, though meeting the world's climate goals would require electrification to advance significantly faster in the coming years. " IEA 2024
- More generation from weather-sensitive renewables
  - In hypothetical highly renewable EU grid: "1-day extreme low energy production events are characterised by a large high pressure system" & "Atmospheric blocking can lead to [7-14 day] prolonged episodes of [energy shortfall]" van der Wiel et al. 2019
  - "32% difference between best and worst [years wind production] in GB" Bloomfield et al. 2016
- Electricity demand is more sensitive to weather
  - "Service demand for cooling is increasing by up to 5% per year in some regions [globally] due to climate change" Staffell et al. 2022
  - "41 % heat pumps would increase Great Britain's winter electricity demand by 30 TWh." & "Year-to-year variability of electricity demand increases by 37 %" Peacock et al. 2023



The Guardian
News website of the year

Energy industry

Power struggles: UK companies gear up for winter blackouts

From backup generators to empty offices on standby, bosses are preparing for worst-case scenarios

Most viewed

Cheesemaker sells firm to overcome Brexit barriers after losing £600,000 in sales

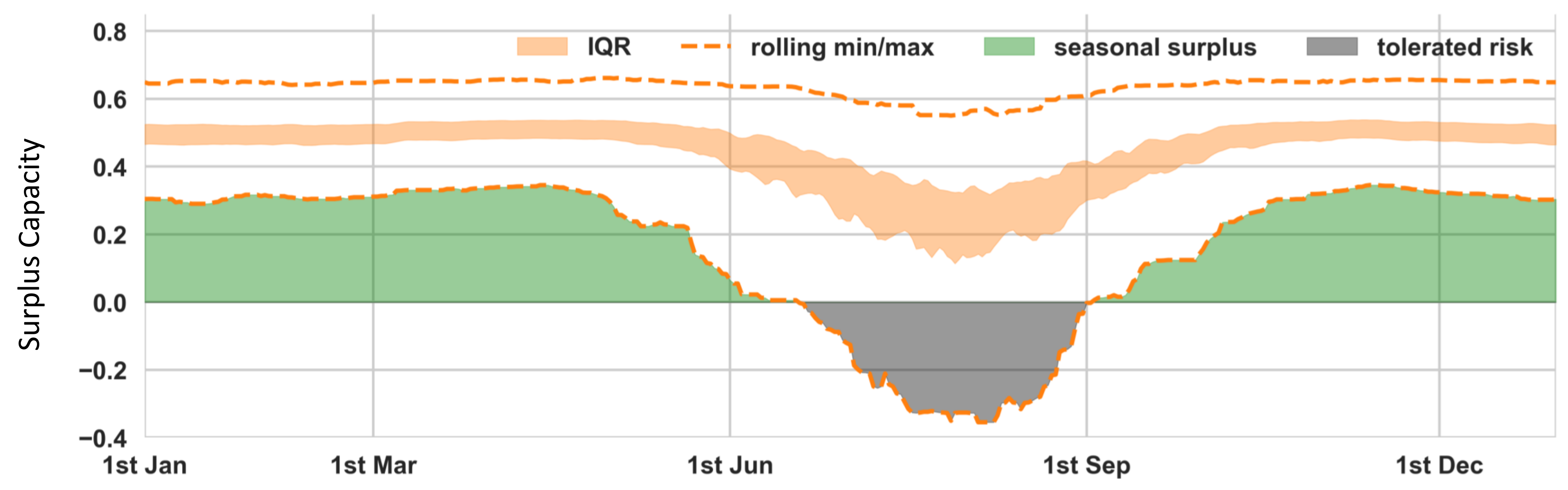
Home working will be reliant on robust telecoms, but this is an industry used to outages, typically caused by problems such as storms, and falling trees hitting overhead lines.

BT operates 6,000 UK exchanges, each of which has a backup generator. Simon Lowth, BT's chief financial officer, said this week it has held talks with the government about potentially using the generators for wider public use "to help cope with demand at peaks". Its ubiquitous green cabinets, seen on Britain's street corners, which provide broadband connections, have four hours of backup power.

the power from the guy next door, or sometimes you're literally going round

"By 2035 […] 60GW of short term flexible capacity will be needed to provide a low cost electricity system."
- National Infrastructure Commission (2023)

Idea:
Critical infrastructure energy **use varies seasonally**, and with prevailing weather –
during periods where there is a "**surplus**" in reserves, can this energy be relied upon to **help balance the grid**?



Fallon, J., Brayshaw, D., Methven, J., Jensen, K., & Krug, L. (2023). A new framework for using weather-sensitive surplus power reserves in critical infrastructure. *Meteorological Applications*, 30(6), e2158. doi:10.1002/met.2158

(from MERRA-2)

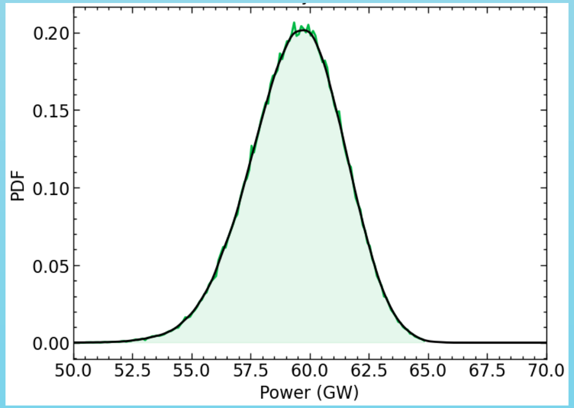
Infrastructure Electricity Demand

Fallon, J., Brayshaw, D., Methven, J., Jensen, K., & Krug, L. (2023). A new framework for using weather-sensitive surplus power reserves in critical infrastructure. Meteorological Applications 10.1002/met.2158

(from ENTSO-E)

National Electricity Generator Capacity

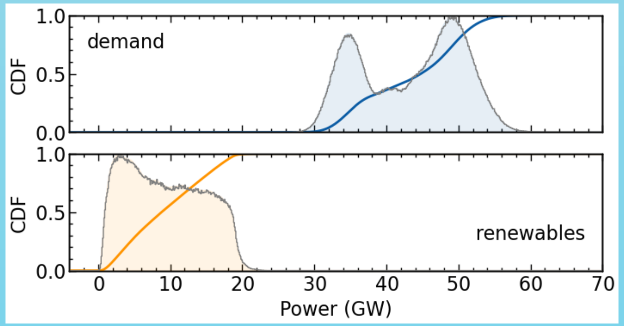
Deakin, Matthew; Greenwood, David (2022). Aggregated Generator Unavailability Data for Northwest European Countries. Newcastle University. Dataset. 10.25405/data.ncl.18393971.v1



(from ERA-5)

National Electricity Demand & Renewables

Bloomfield, H.C., Brayshaw, D.J., Deakin, M., Greenwood, D., 2022. Hourly historical and near-future weather and climate variables for energy system modelling. Earth System Science Data 14, 2749–2766. 10.5194/essd-14-2749-2022

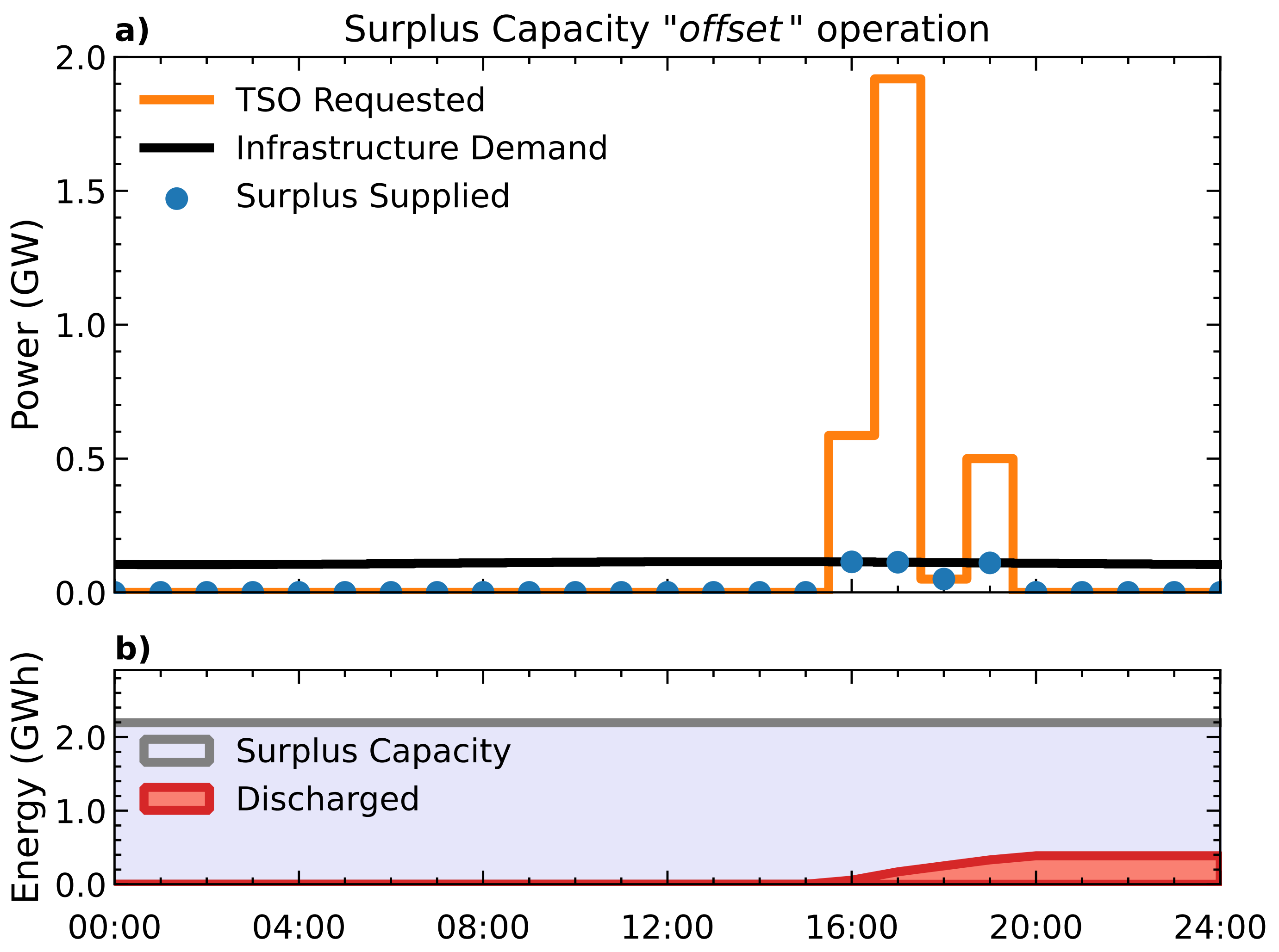


Analysis

- **Adequacy**
- **Capacity Market**
- **Balancing Service**

How to Quantify Power System Adequacy?

- **Quantity** of energy shortfall events: *Loss of Load*
- **Severity** of energy shortfall events: *Energy Not Served*



Z_t: System Margin

Z = DEMAND –
(RENEWABLES + GENERATION CAPACITY)

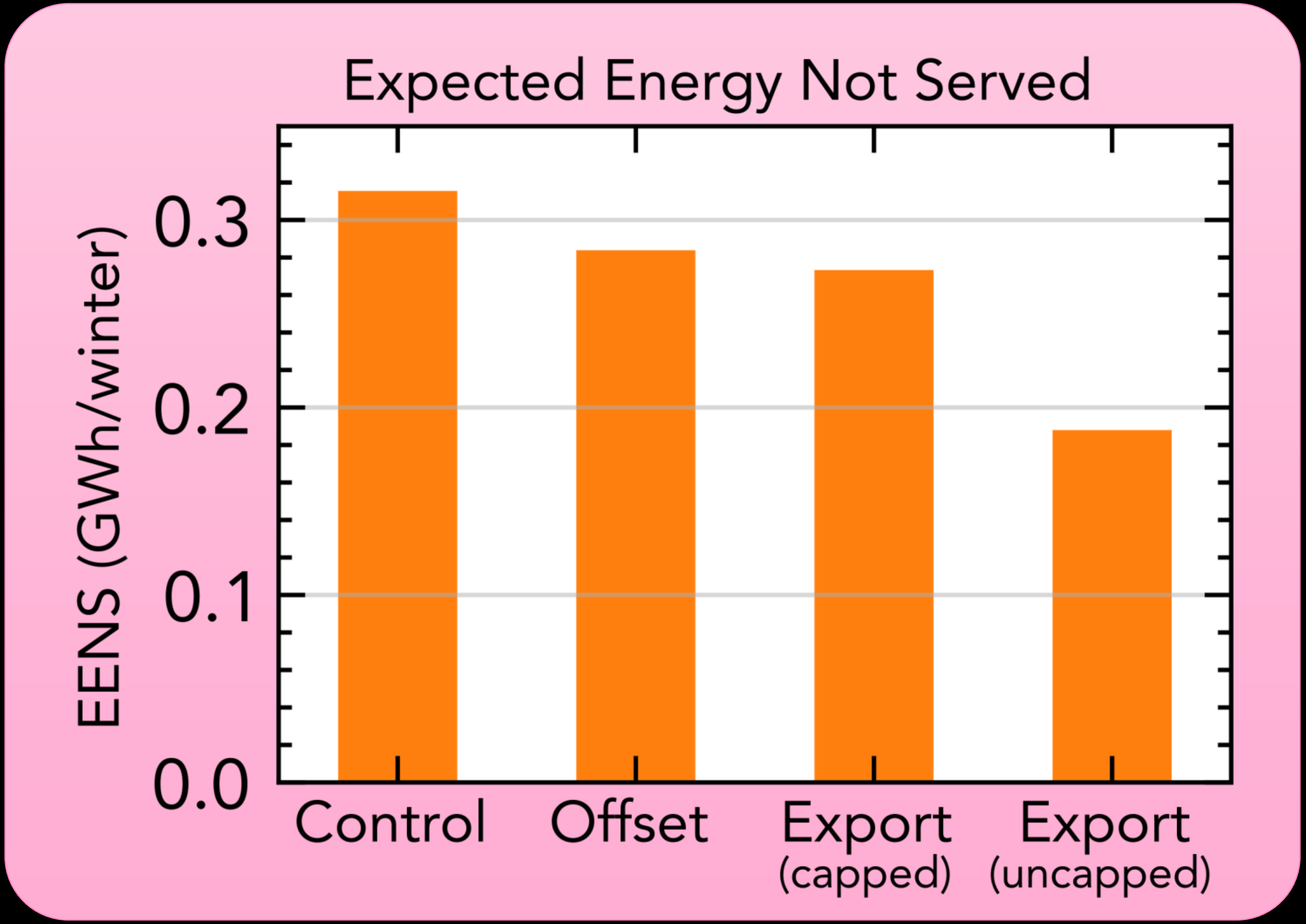
$$\text{LOLE} = \sum_{t=1}^{n} \mathbb{P}\left(Z_t < 0\right)$$

Quantity of energy shortfall events

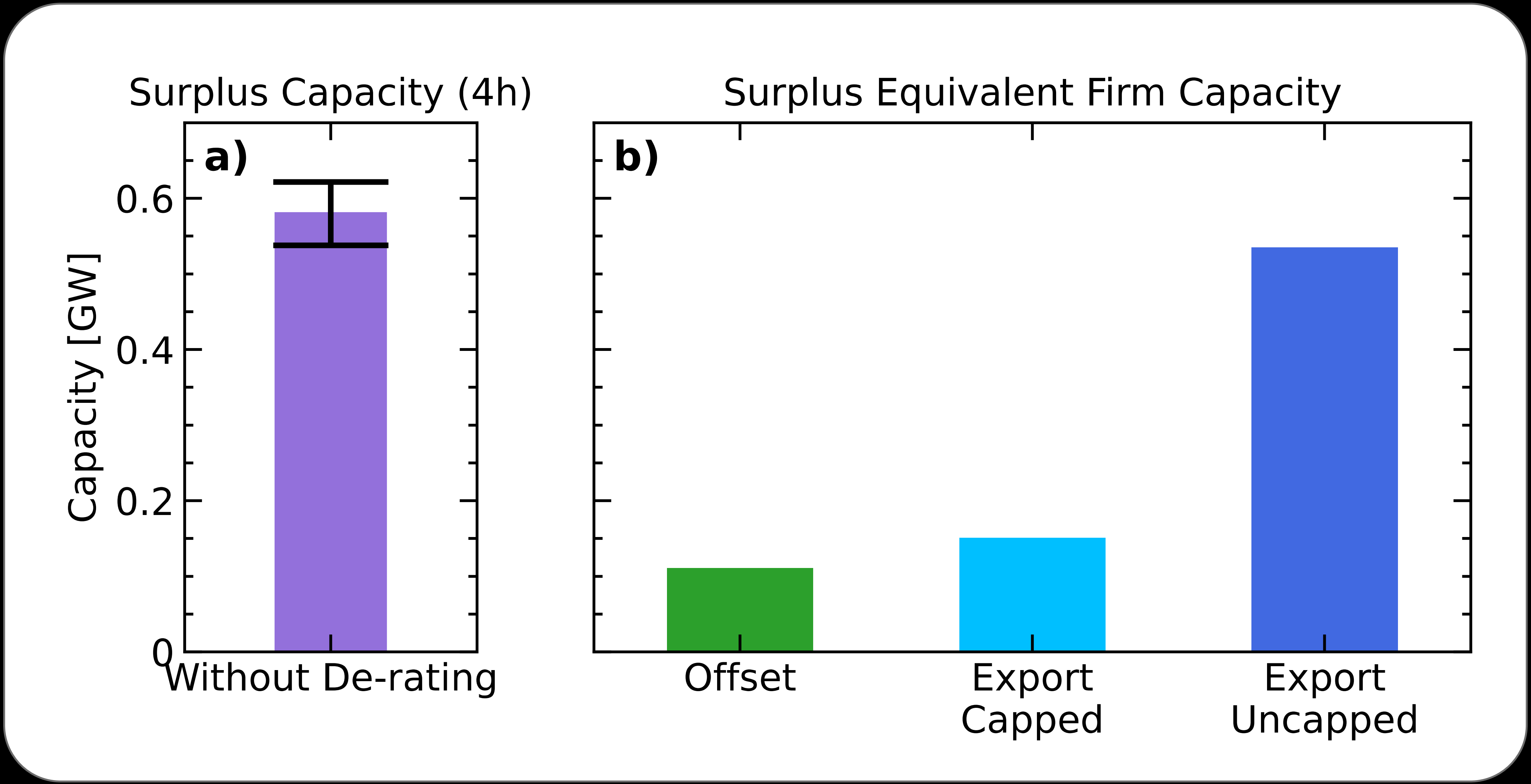
$$\text{EEU} = \sum_{t=1}^{n} \mathbb{E}\left(\max(-Z_t, 0)\right)$$

Severity of energy shortfall

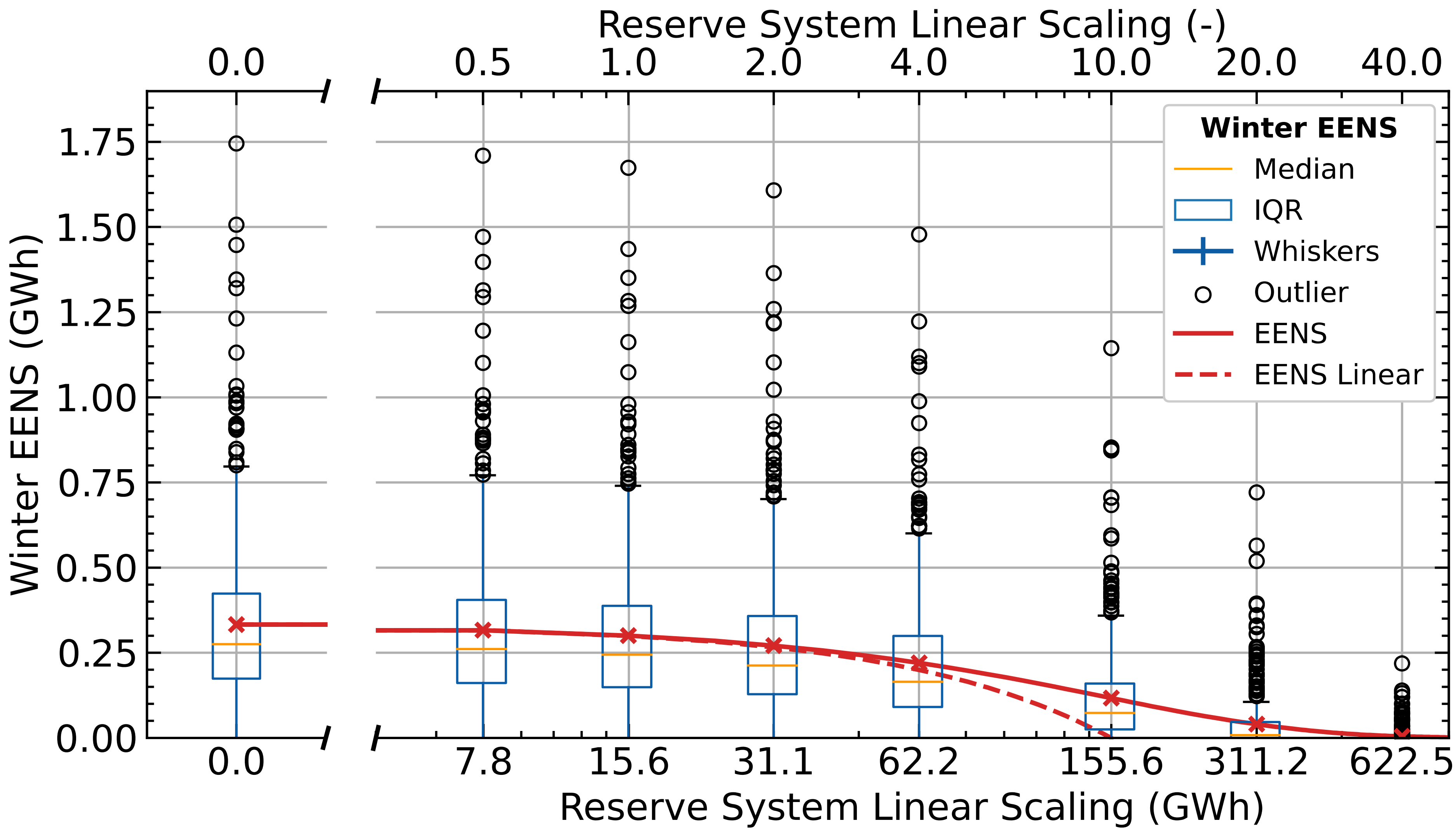
GB Energy Not Served – reduced using “Surplus”



ENS used to calculate de-rating factors



ENS change is linear with scaling the surplus



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RISK and Resilience Day 12 March 2024

- Surplus Capacity can support wider power system networks in meeting energy shortfall, and providing balancing services
- De-rating the capacity depends on adequacy (ie. EENS)
  - Investment into infrastructure (increased power export) can improve this factor
- Adequacy scaling is linear
  - ie. multiple sectors (telecoms, datacentres, health, …) can use "surplus" capacity with the same de-rating factor

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- Fallon, J., Brayshaw, D., Methven, J., Jensen, K., & Krug, L. (in review). Reserve Power Design in Future Climates: Bias Adjustment Approaches for Regional Climate Projections
- Fallon, J., Brayshaw, D., Methven, J., Greenwood, D., Jensen, K., & Krug, L. (in preparation). Revenue from Weather-Sensitive Surplus Energy Capacity of Reserve Systems