

# ESTIMATING AND CATEGORISING GRID ENERGY STORAGE NEEDS

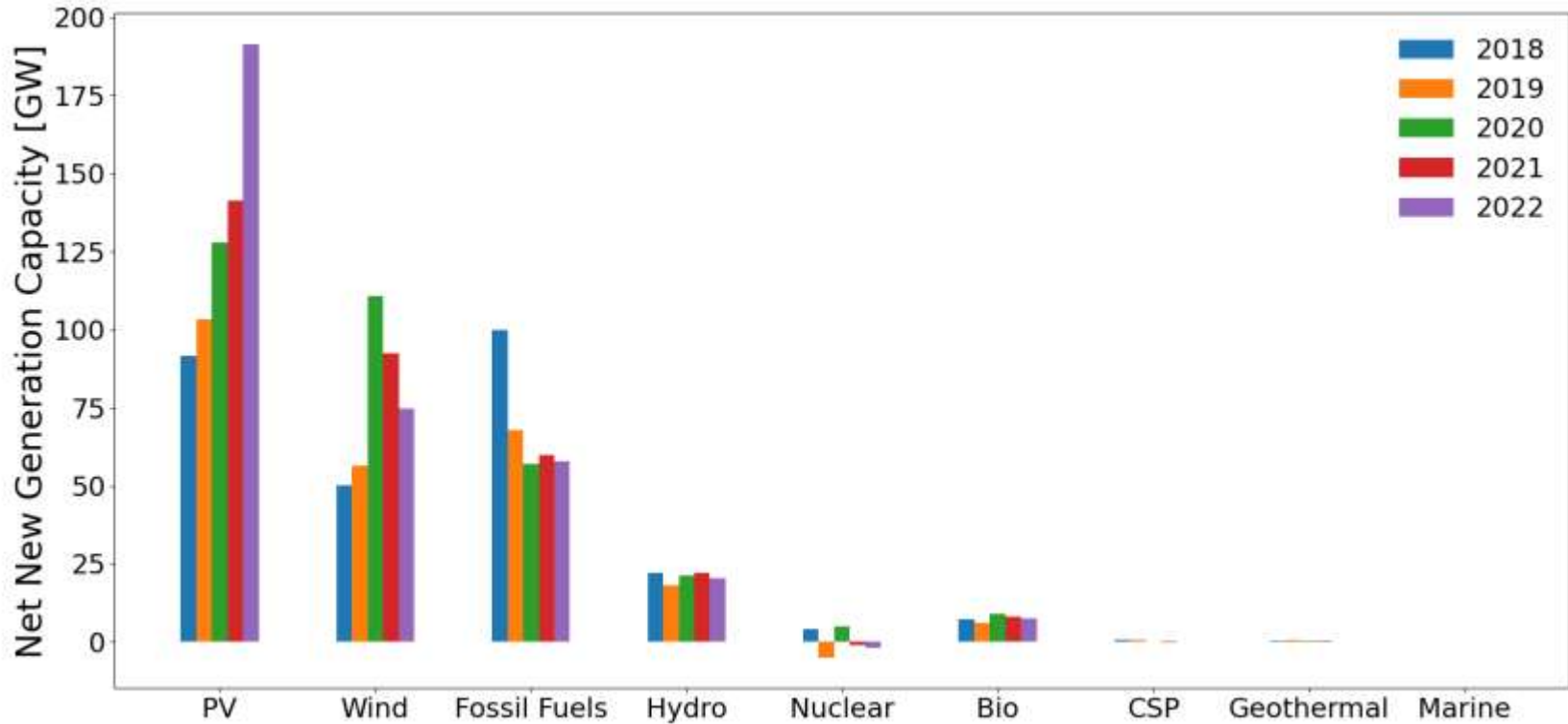
Timothy Weber  
(Research Officer)



Australian  
National  
University



# Global Solar PV and Wind Deployment



Data: IRENA, 2023a; World Nuclear Association, 2022; World Nuclear Association, 2020; World Nuclear Association, 2019; World Nuclear Association, 2023; IRENA, 2019; IRENA, 2020; IRENA, 2021; IRENA, 2022a; IRENA, 2023b



# Modelling Decarbonised Grids – FIRM Model

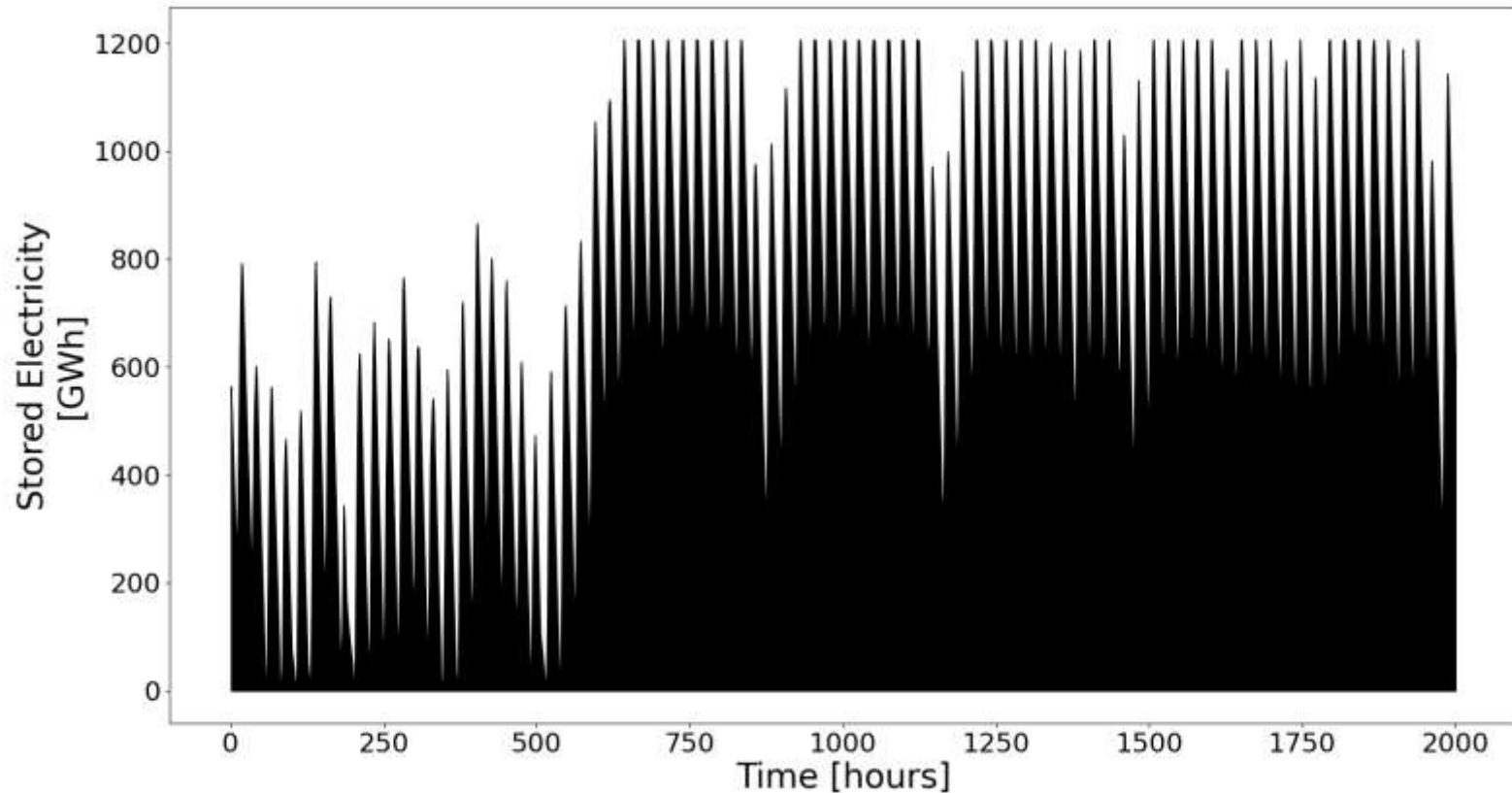


Image: <https://doi.org/10.1016/j.energy.2021.121387>, CC License

- Hourly weather and demand data over 10 years
- Existing capacity (hydro, legacy fossil fuels) + new capacity (solar PV, wind, energy storage)
- Net load energy balance model
- Finds the least-cost configuration of solar PV, wind, energy storage required to balance hourly demand over 10 years



# FIRM Output - Stored Electricity Profile



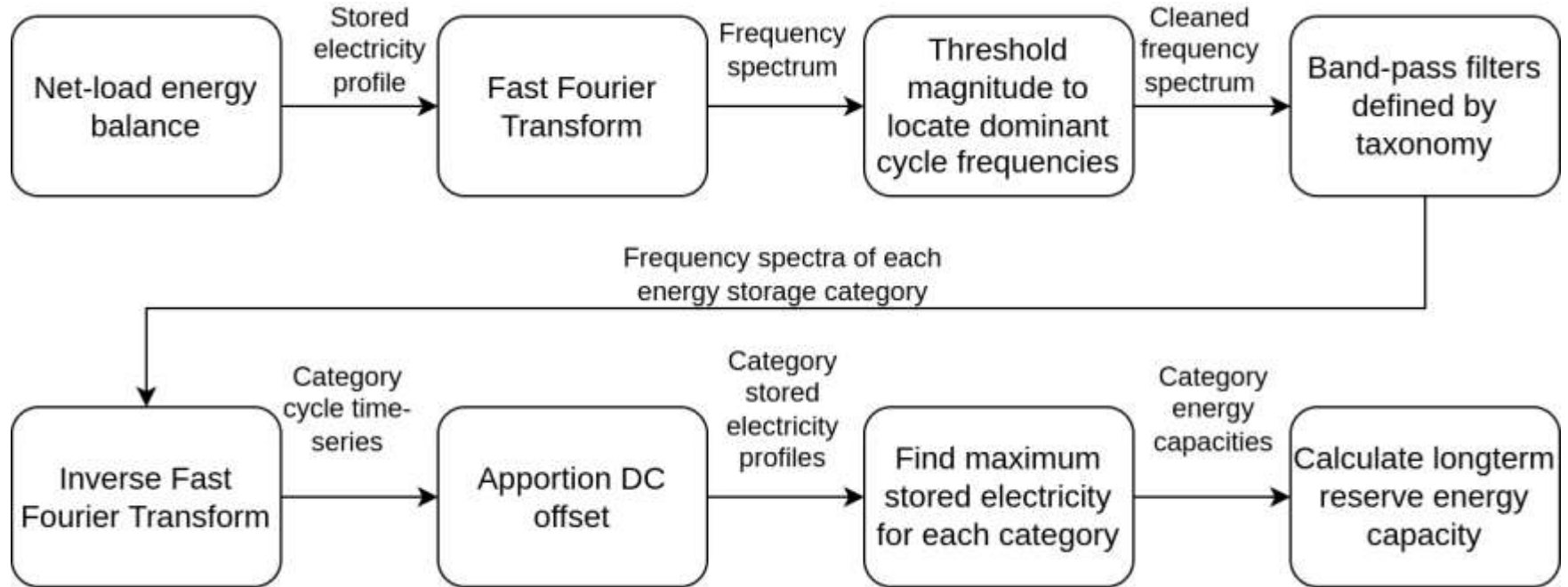
# Taxonomy of Energy Storage Systems

Category	Minimum Cycle Period	Maximum Cycle Period
Intra-day	2 hours <sup>a</sup>	20 hours
Overnight	20 hours	28 hours
Monthly	28 hours	30 days
Seasonal	30 days	1 year
Long-term	-	-

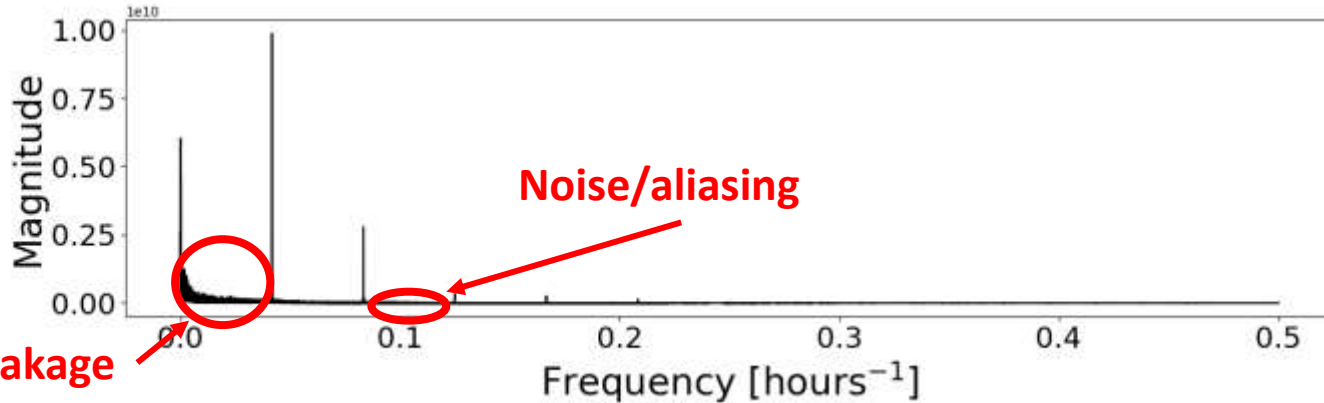
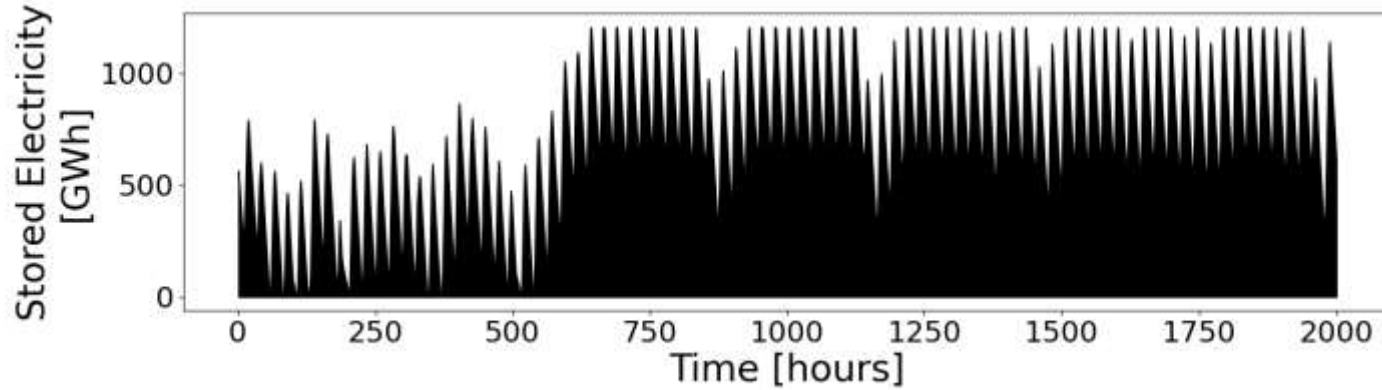
<sup>a</sup> Nyquist–Shannon sampling theorem



# Methodology for Categorising Storage



# Stored Electricity – Frequency Spectrum (FFT)

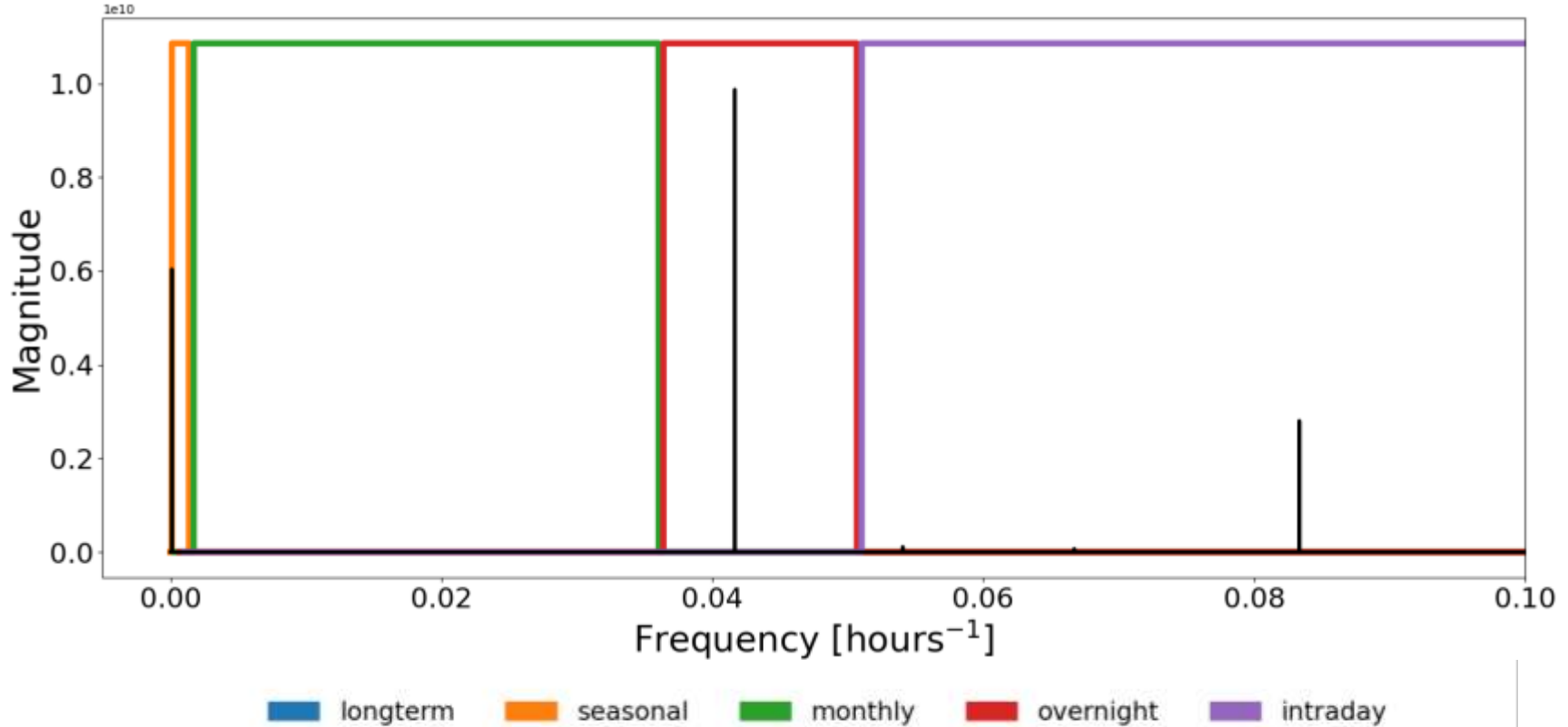


Spectral leakage

Noise/aliasing

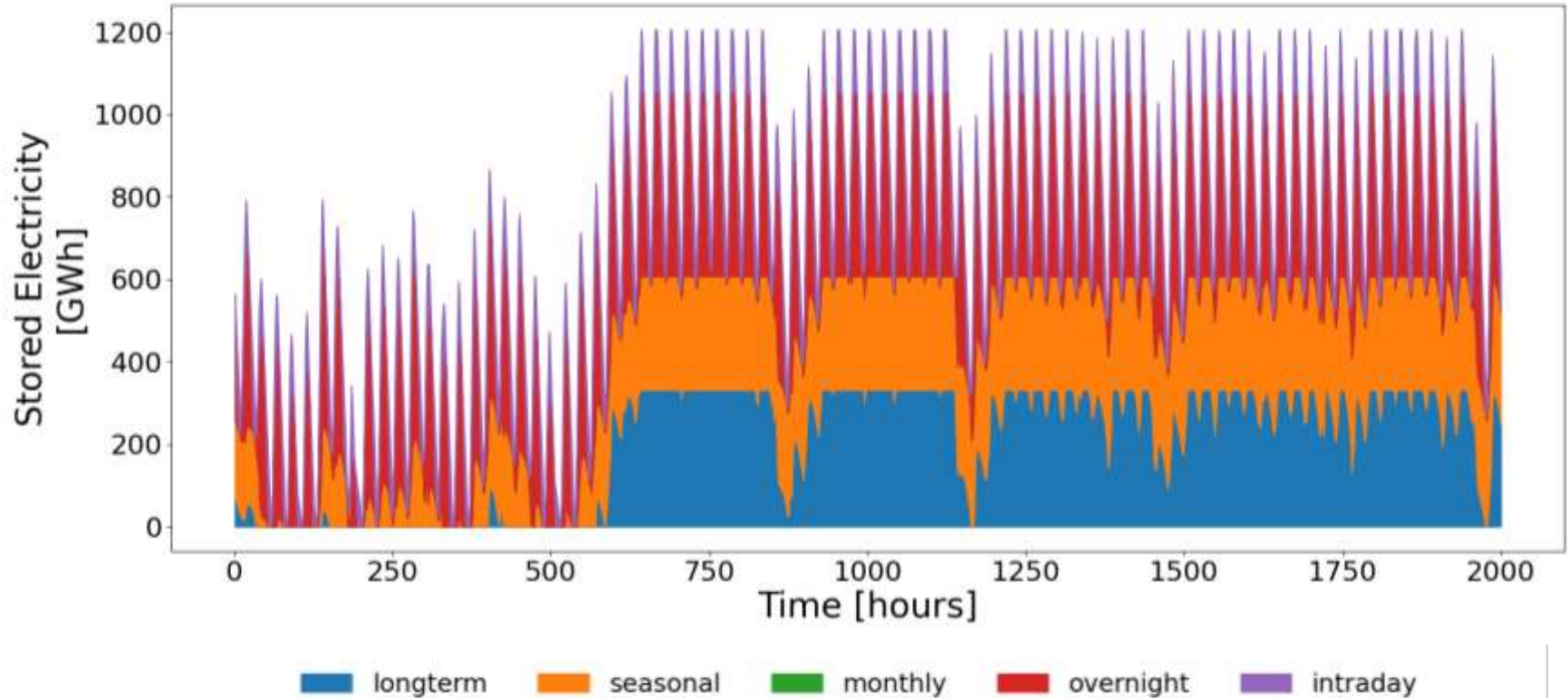


# Cleaned Frequency Spectrum w Band-pass Filters





# Categorised Stored Electricity Profiles

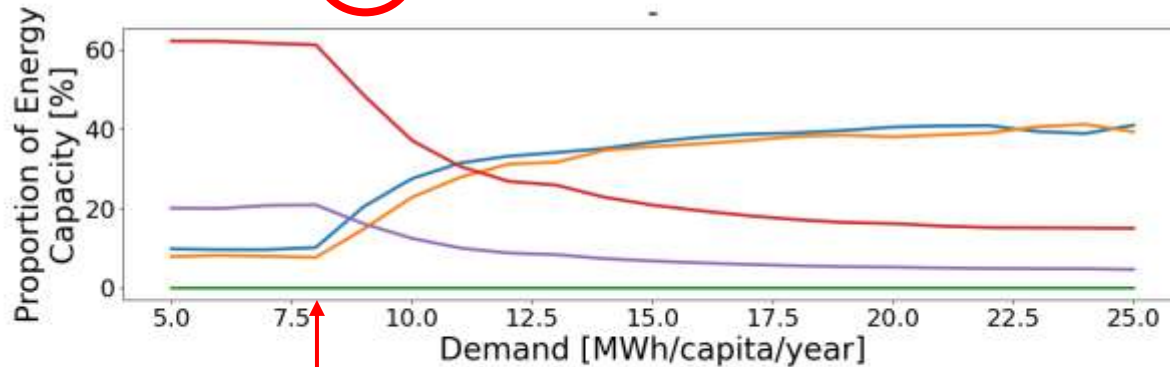


# Energy Capacity of Each Category



Seasonal + longterm needs rapidly increase

Flexible generation (hydro + legacy fossil fuels) can no longer manage all infrequent cloudy periods



— longterm — seasonal — monthly — overnight — intraday

Maximum value in time-series



# ANU Global Pumped Hydro Energy Storage Atlases



Image: <https://re100.anu.edu.au/>, Basemap: Earthstar Geographics SIO, Microsoft Corporation, 2023



# Malaysia Pumped Hydro Potential

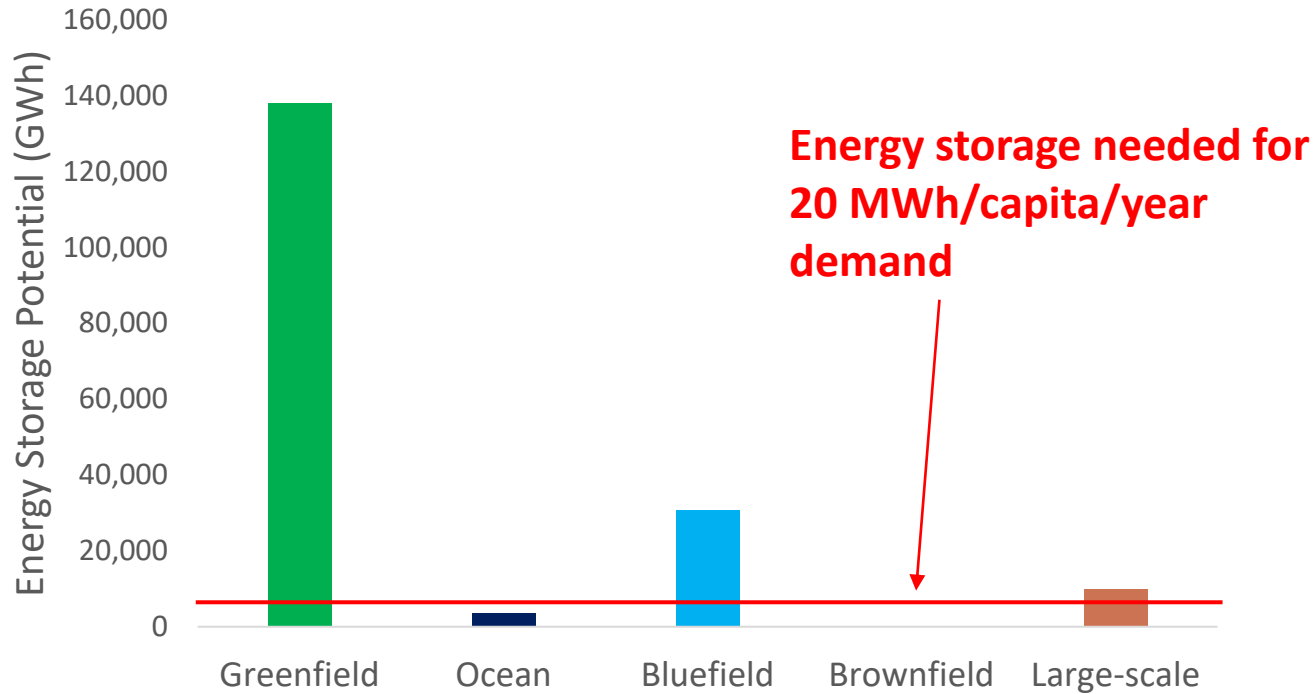


Image: Author provided



# Future Work

- Consider multi-node network for Australian National Electricity Market (NEM)
- Estimate power spectral density for stored electricity profile
  - Stochastic behaviour of differential evolution
  - Variations in weather data near each node
  - Other network configurations around least-cost solution
- Window functions to manage aliasing effects
- Effects of regional interconnection, hydrogen firming, demand management on seasonal + longterm storage needs



# THANK YOU

## Contact Us

Timothy Weber (RE100 Group)

CSIT Building (#108)  
Australian National University  
Canberra ACT 2601

E [timothy.weber@anu.edu.au](mailto:timothy.weber@anu.edu.au)



Australian  
National  
University

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