

CAREC High Technology Roadmap - Battery Technology

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Introduction

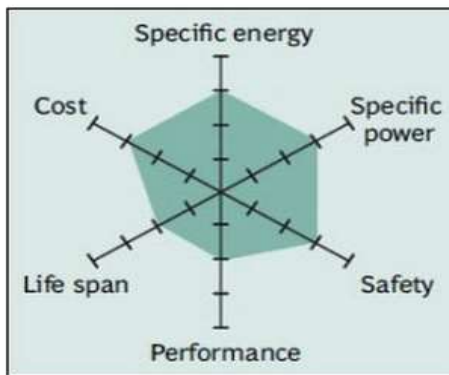
- Rapid advancements in battery technology and reductions in costs leading to increased uptake
- Numerous applications across the electricity sector
- Highly disruptive technology – leapfrogging technology change
- Demand and supply side opportunities for CAREC countries

Battery Applications

Sector	Typical Battery Size	Battery configuration	Examples
Utility Scale			
- Generation Support	> 10 MWh	Higher power, frequency control	Tesla 100 MW battery, SA
- Transmission Support	> 10 MWh	Higher power, frequency control	Tesla 100 MW battery, SA
- Distribution Support	> 1 MWh	Higher power, voltage regulation, peak load reduction	1.4MW/5.3MWh Lakeland Solar and Storage Project
Medium Scale			
- Mini/micro grids	0.5 - 10 MWh	High energy, energy shifting, islanding, V/Hz reg	1.5 MW/3.5 MWh battery for mini-grid, Niue
- Commercial buildings	0.5 - 10 MWh	High energy, peak load reduction	
Small Scale			
- Domestic applications	5 – 20 kWh	High energy, energy shifting, grid support	Endeavour Energy battery trial

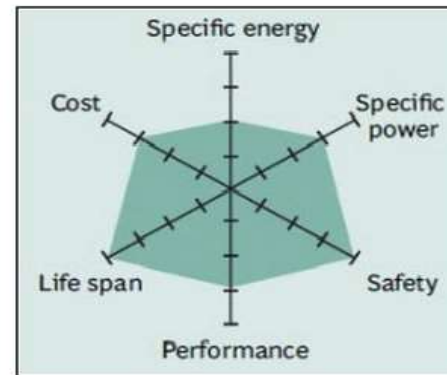
Battery Technologies

- Lead-acid most common throughout 20th century
- Li-ion 80% of new deployment
- New technologies include
 - Flow batteries (Zinc Bromine and Vanadium Redox)
 - Aqueous hybrid ion ('salt water') batteries
 - Liquid metal batteries
 - Sodium batteries



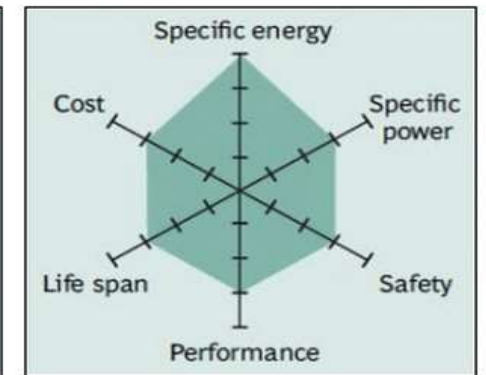
(LiMn₂O₄)

LMO



(LiFePO₄)

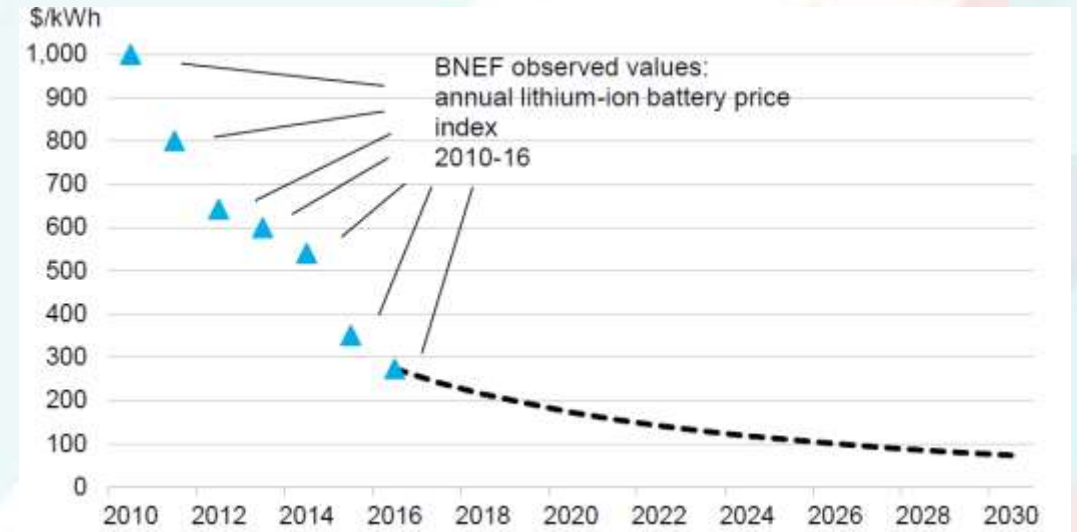
LFP



(LiNiMnCoO₂)

NMC

Price trends

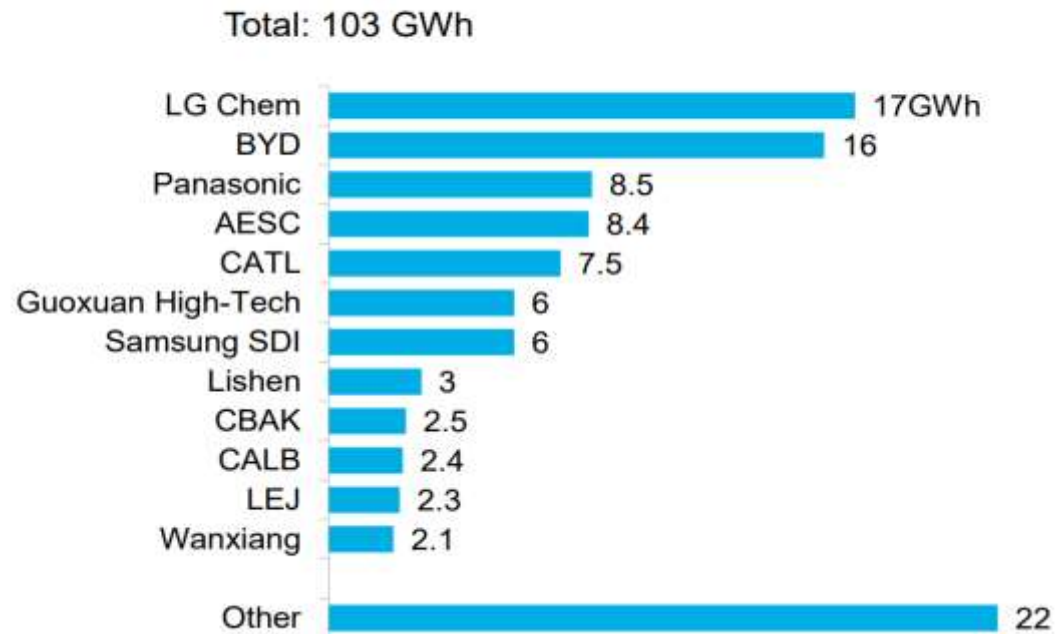


BNEF suggests that battery cell prices reached \$200/kWh in 2017

In 2030 battery requirement for 1 house will be \$642.00 or < 6 cents over the life of the battery

Battery Manufactures

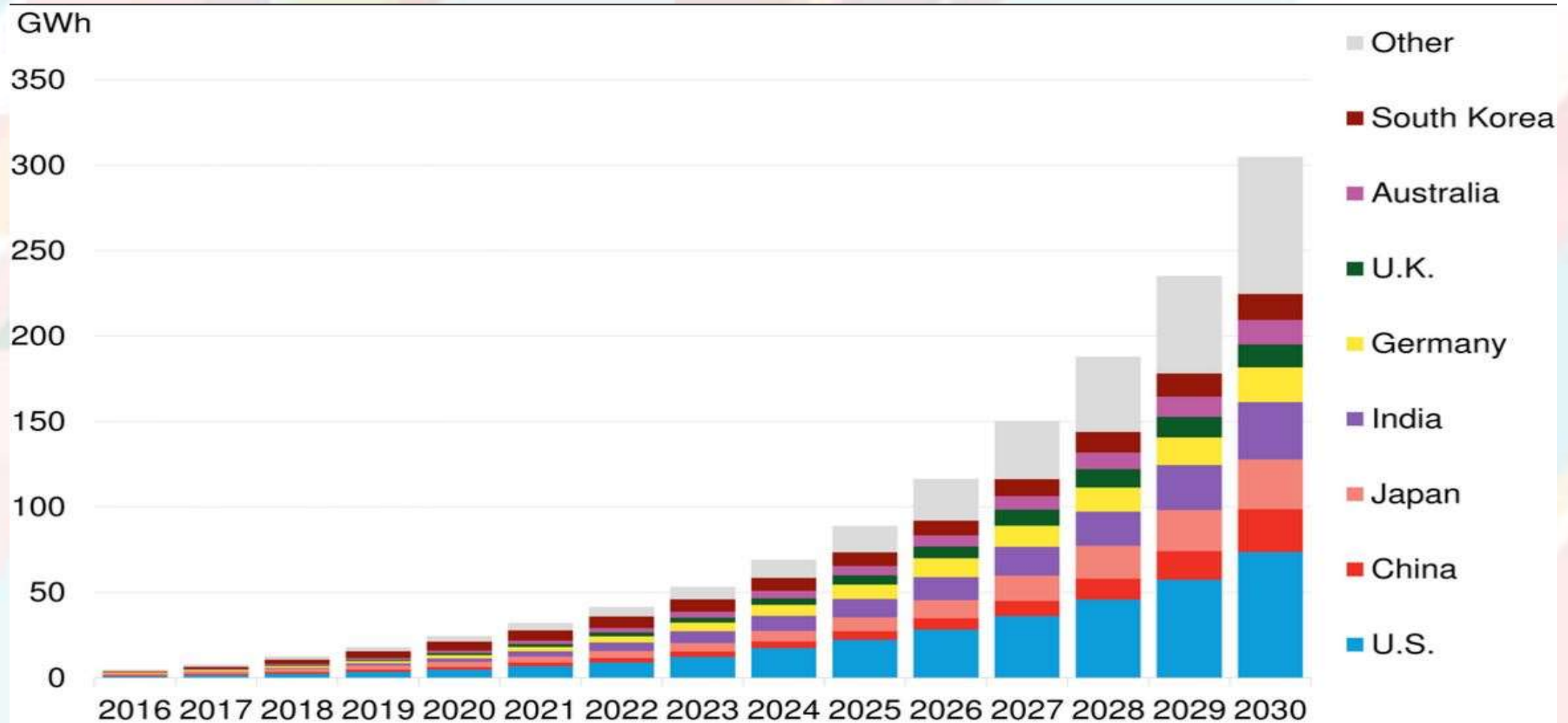
Installed lithium-ion battery manufacturing capacity, Q1 2017 (GWh)



Lithium-Ion Battery Production Targets As Set By Major Battery Manufacturers (in GWh)



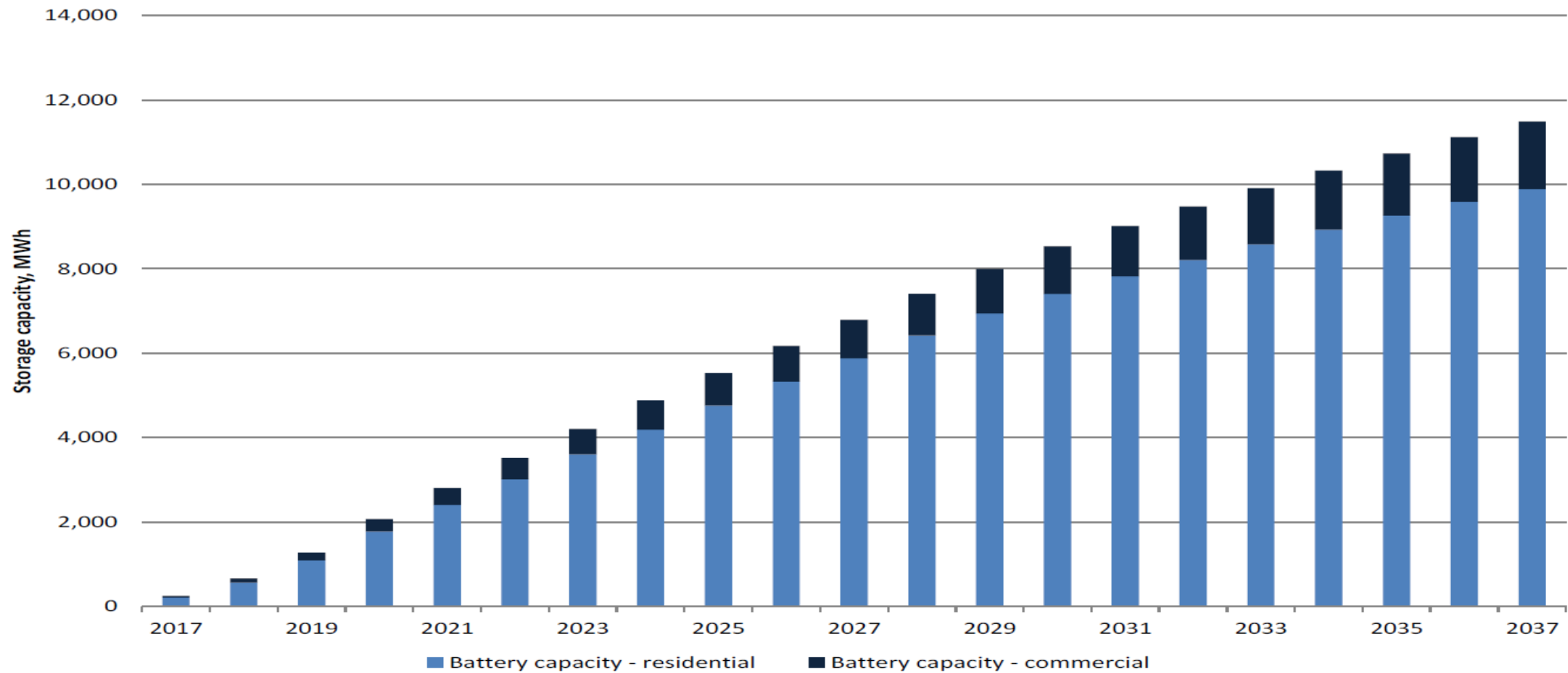
Battery Uptake



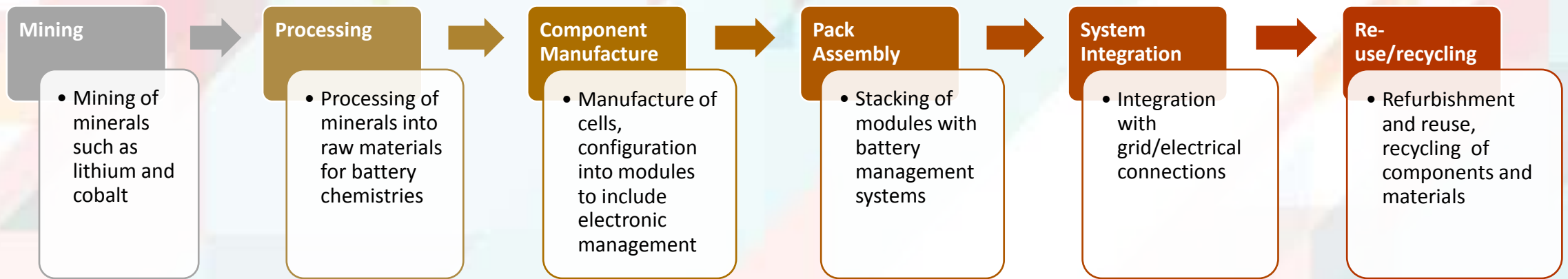
Source: Bloomberg New Energy Finance (BNEF)

Battery Uptake - Australia

Figure 16: Total installed battery storage capacity, Neutral scenario



Supply Chain



Complex supply chain, key materials including lithium, graphite, nickel, cobalt, manganese, aluminium, and iron phosphate.

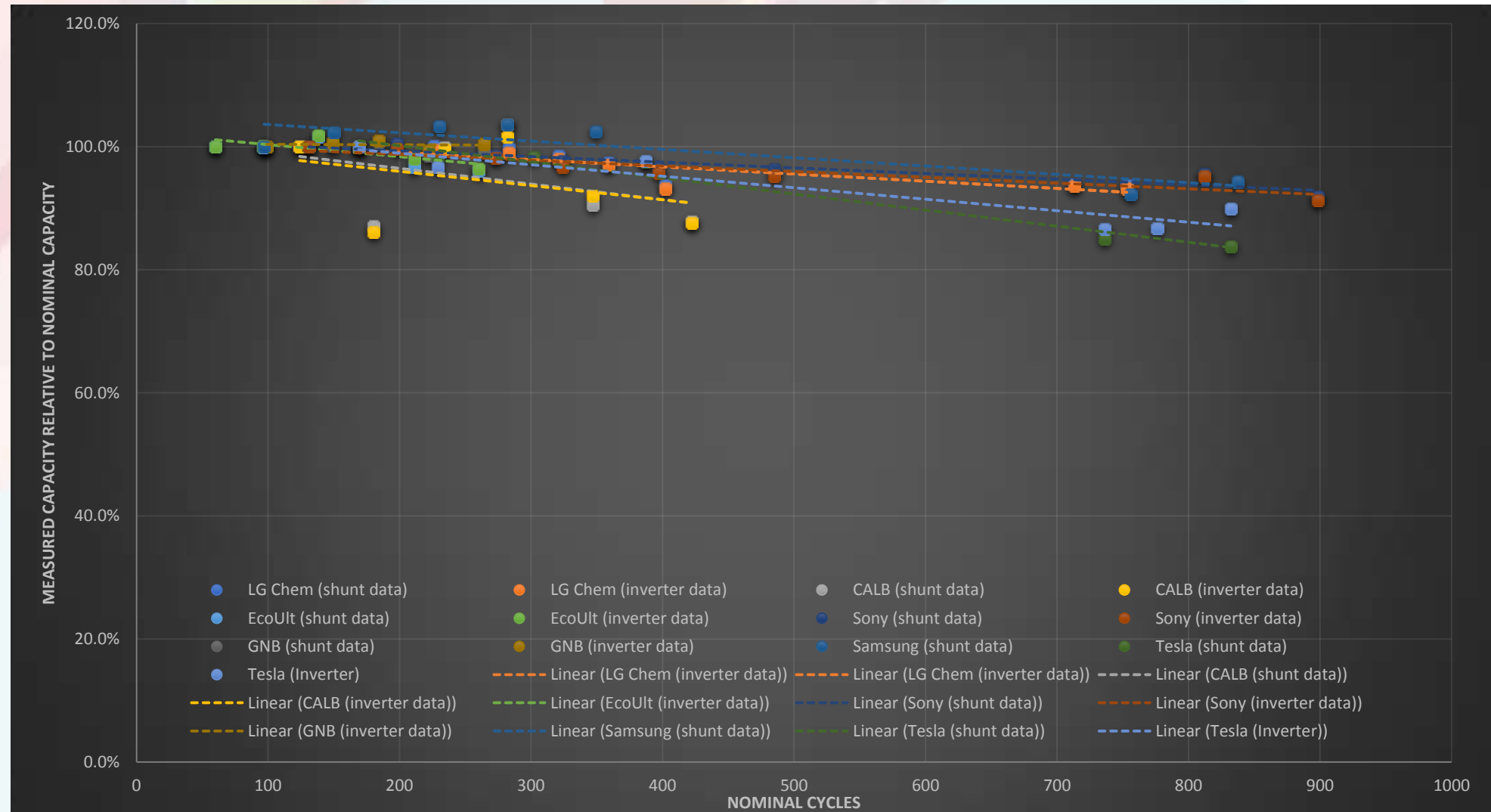
Opportunities for CAREC

- Manufacturing
- Raw mineral supply
 - E.g. Afghanistan - lithium, cobalt, nickel and graphite
- Minerals processing
- Second life batteries
- Demand side
 - Integration of renewable energy
 - Grid support
 - Electrification
 - Smart grids

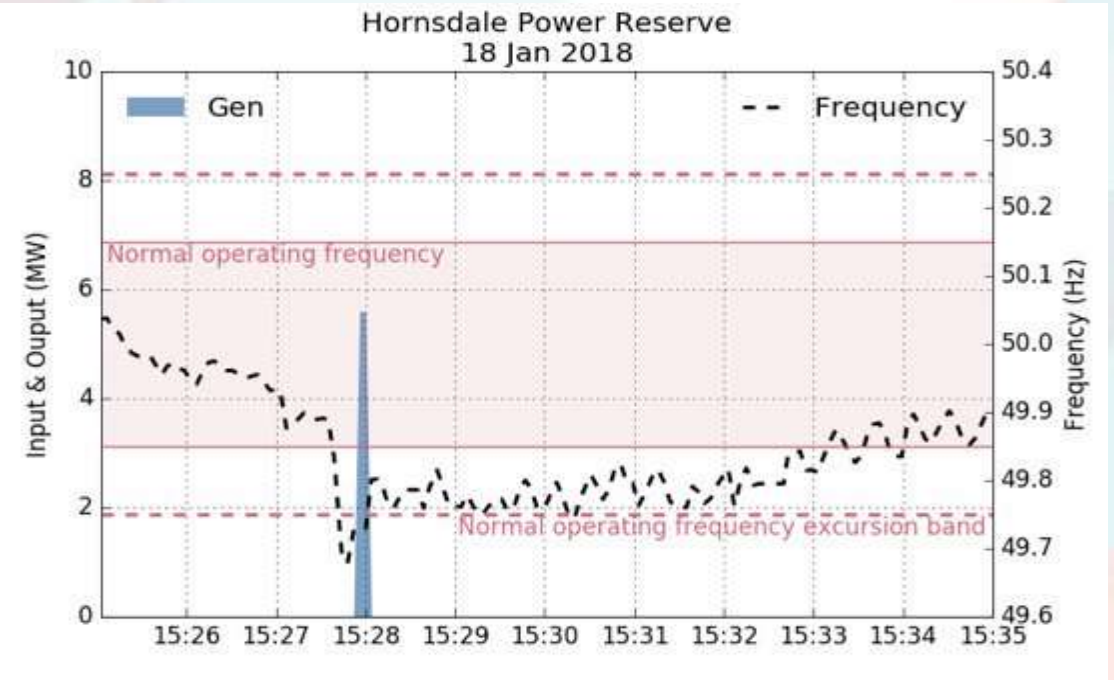
Best available Technology - Testing

Phase one batteries	Battery Chemistry	Phase two batteries	Battery Chemistry
LG Chem RESU	Nickel Manganese Cobalt	Redflow Z-Cell	Zinc Bromide Flow battery
Kokam Storaxe	Nickel Manganese Cobalt	Alpha M48100	Lithium Iron Phosphate
CALB CA100	Lithium Iron Phosphate	BYD B-Box	Lithium Iron Phosphate
Sony Fortellion	Lithium Iron Phosphate	LG Chem RESU HV	Nickel Manganese Cobalt
Tesla Powerwall 1	Nickel Manganese Cobalt	Tesla Powerwall 2	Nickel Manganese Cobalt
Samsung all in one 12.8	Nickel Manganese Cobalt	Aquion	Salt Water battery
GNB Sonnenchein	Lead Acid	Pylontech	Nickel Manganese Cobalt
Ecoult Ultraflex	Lead Carbon Ultra battery	Ampetus	Lithium Iron Phosphate
		SimpliPhi	Lithium Iron Phosphate
		GNB Lithium @ home	Lithium Iron Phosphate

Best available Technology – Testing Results



Hornsdale Power Reserve - 100MW battery



- Commissioned in December 2017 the battery has already provided frequency support to the South Australian Grid

Endeavour Energy Virtual Power Plant

- 40 residential batteries installed behind the meter
- 2kW / 10 kWh
- Utility pays 75% of battery cost
- Utility controls batteries as required



CSIRO Off-grid Battery



- Load 860 kW, with slight daily/seasonal variations.
- 2 MW diesel capacity
- 2MWp PV capacity
- 1.2 MW grid-forming inverter, 2.5 MWh battery



Questions?