

# **CAREC High Technology Roadmap - Battery Technology**

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# Introduction

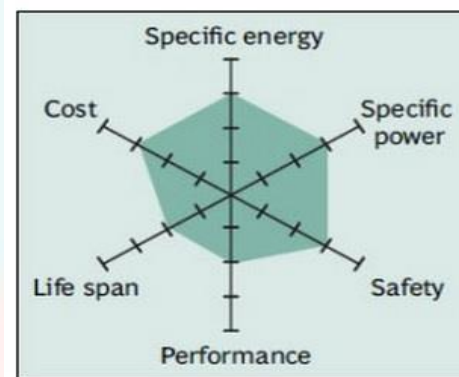
- Rapid advancements in battery technology and reductions in costs leading to increased uptake
- Numerous applications across the electricity sector
- Highly disruptive technology – leapfrogging technology change
- Demand and supply side opportunities for CAREC countries

# Battery Applications

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

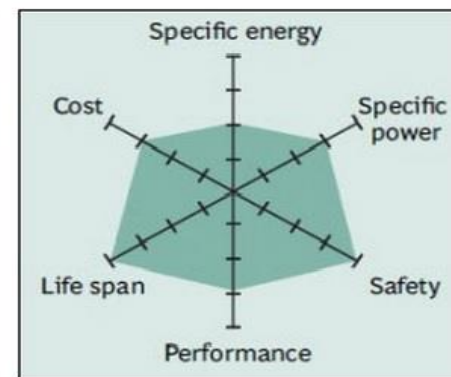
# Battery Technologies

- Lead-acid most common throughout 20<sup>th</sup> 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



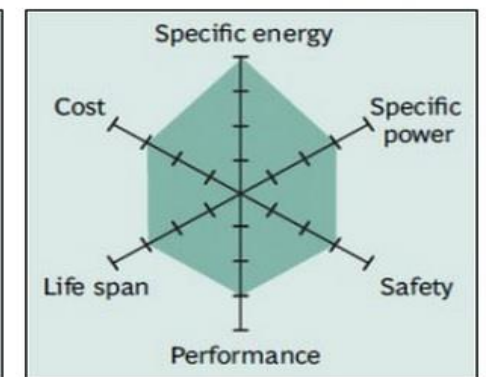
(LiMn<sub>2</sub>O<sub>4</sub>)

LMO



(LiFePO<sub>4</sub>)

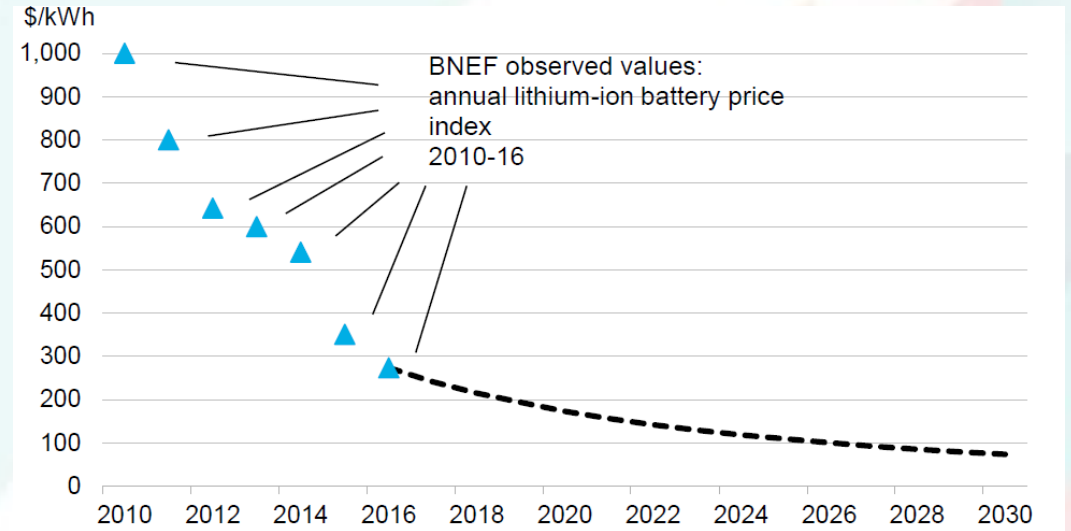
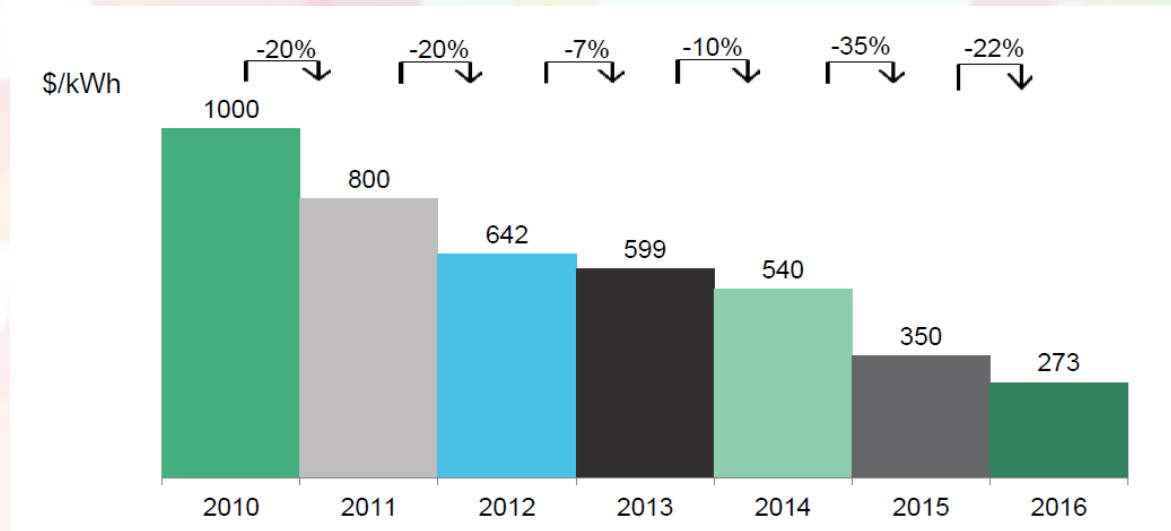
LFP



(LiNiMnCoO<sub>2</sub>)

NMC

# Price trends



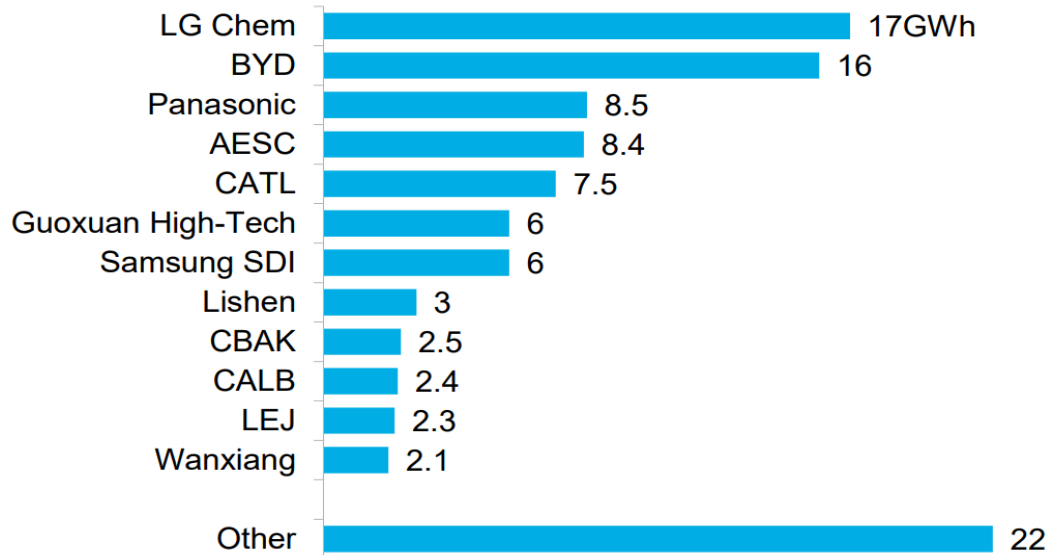
BNEF suggests that battery cell prices reached \$200/kWh in 2017

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

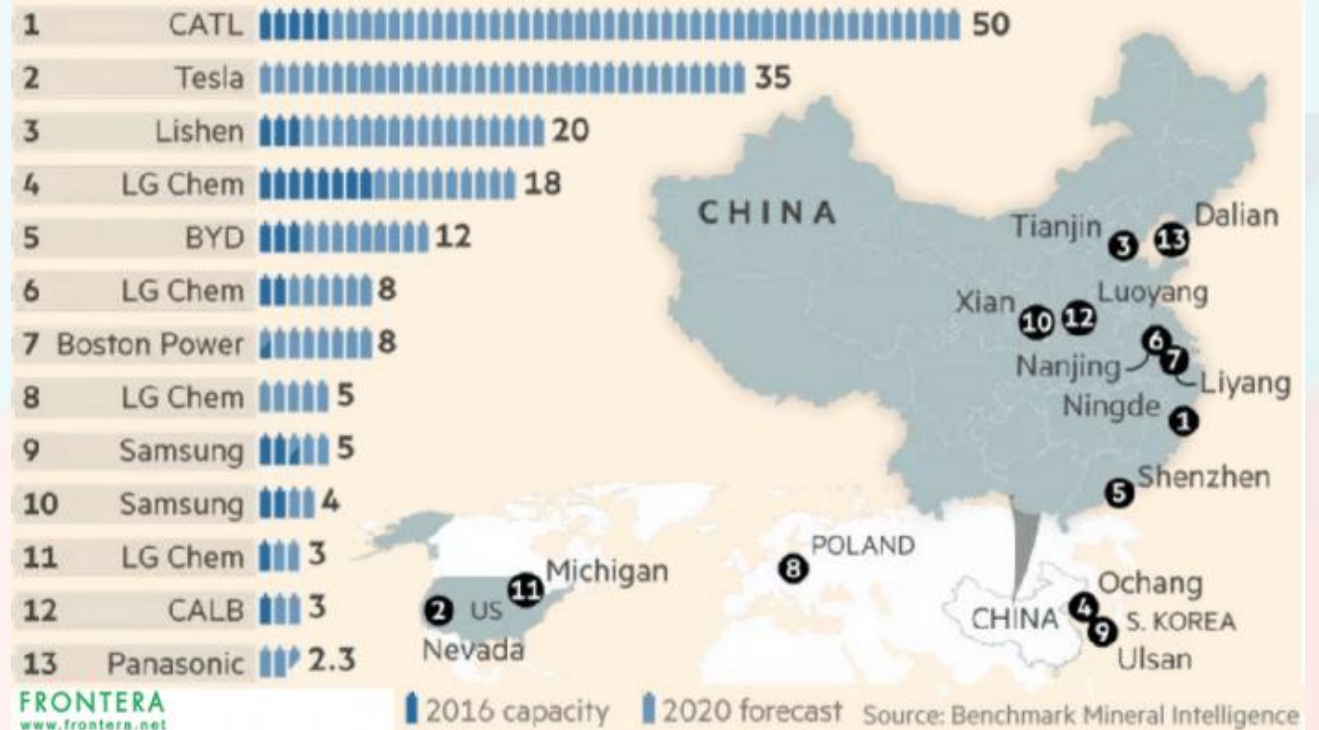
# Battery Manufactures

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

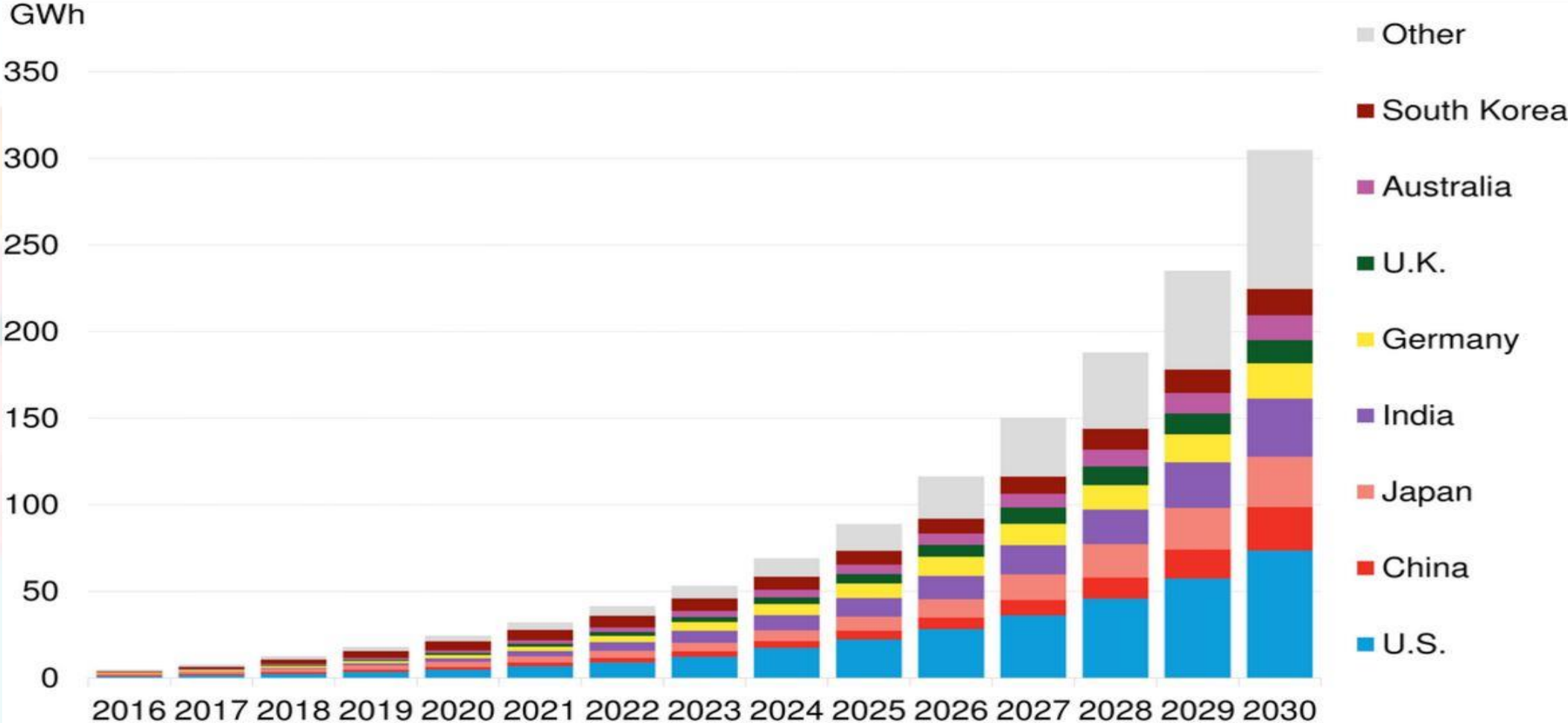
Total: 103 GWh



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



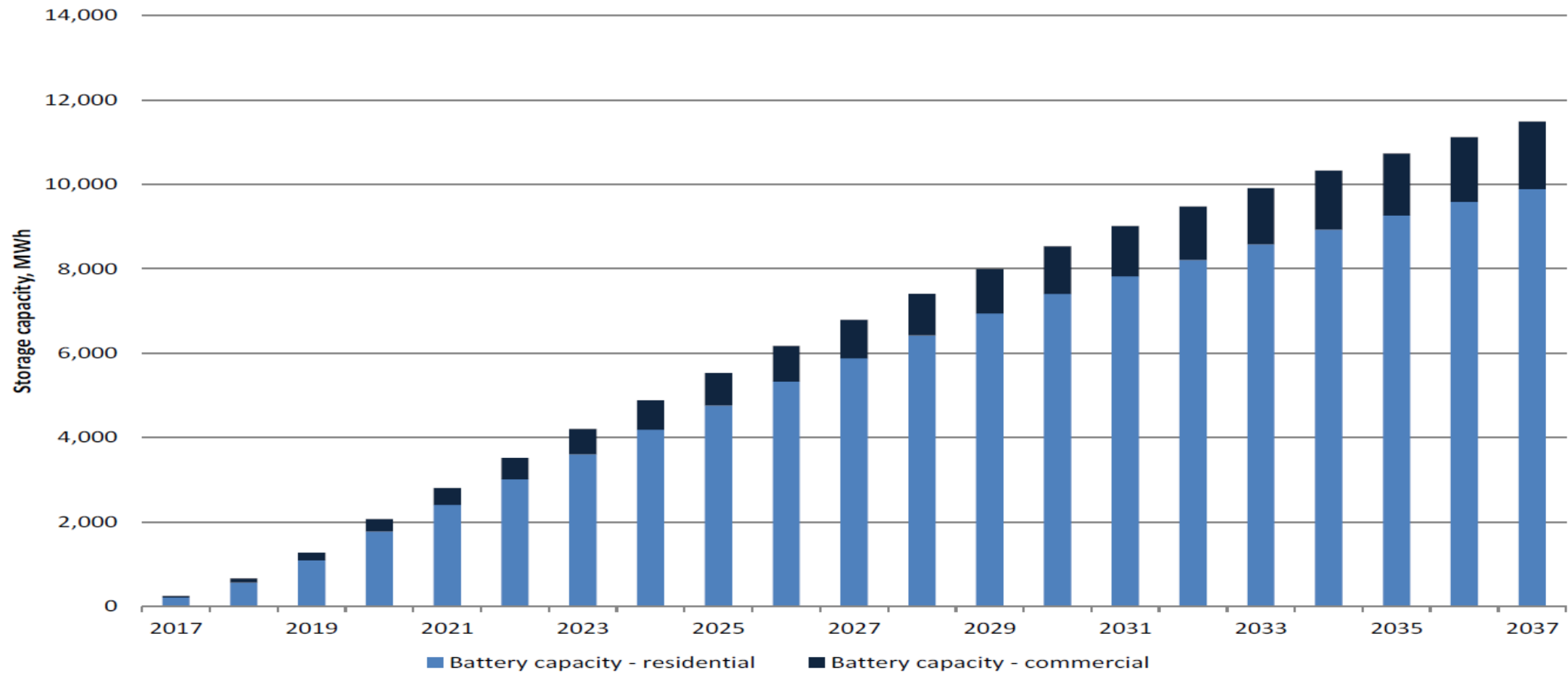
# Battery Uptake



Source: Bloomberg New Energy Finance (BNEF)

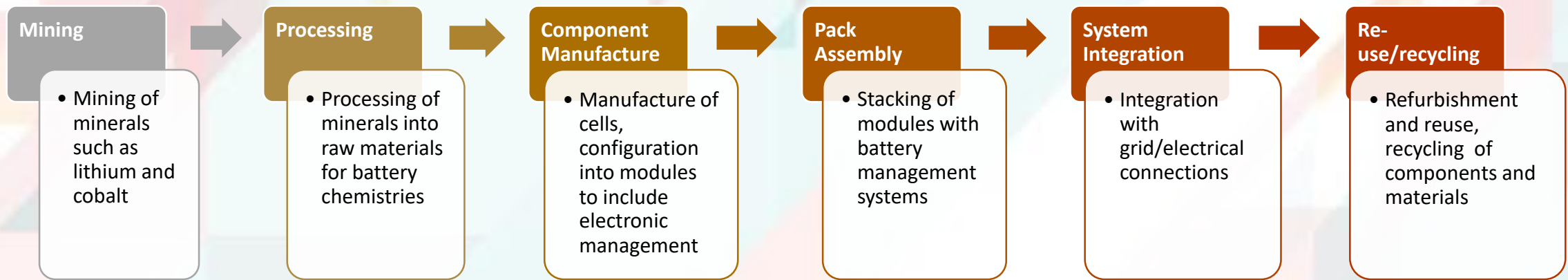
# Battery Uptake - Australia

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.

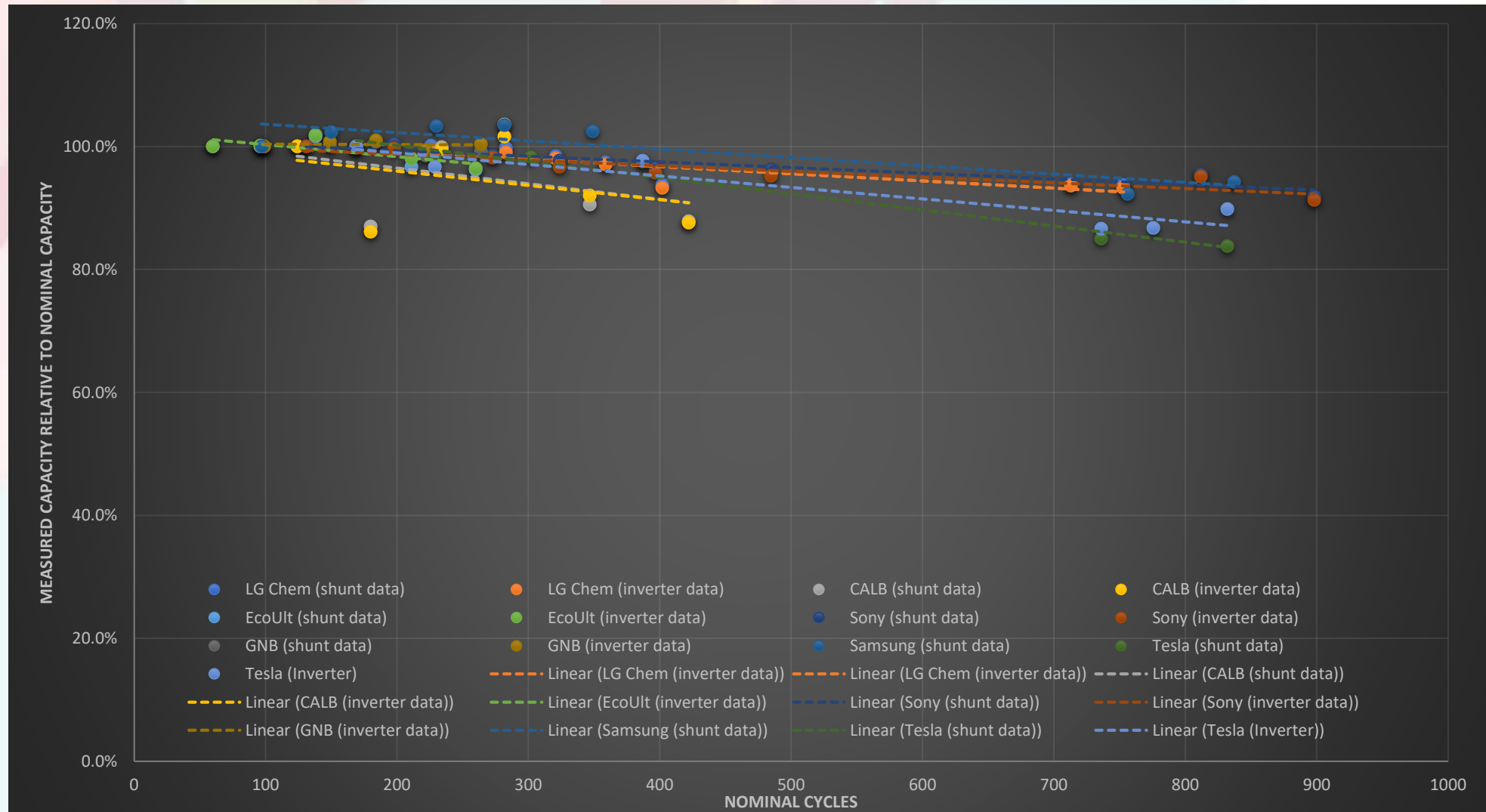
# Opportunities for CAREC

- 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

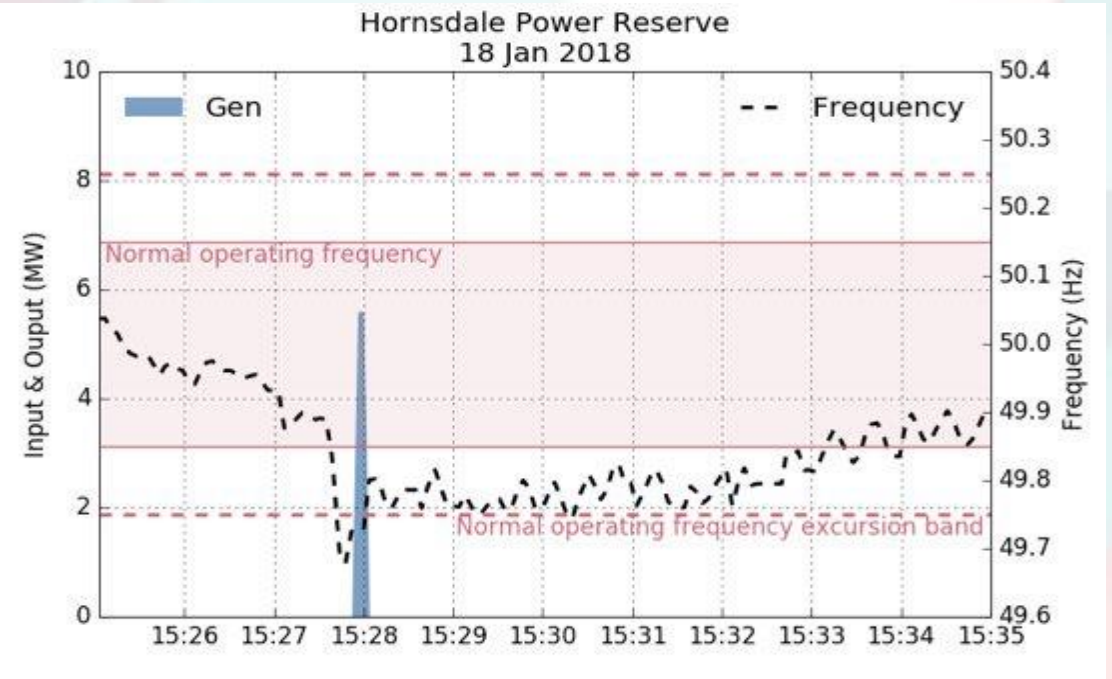
# Best available Technology - Testing

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

# Best available Technology – Testing Results



# Hornsedale 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?