What Does It Take To Go Deep Tech in High Tech?

Energy Storage – Opportunities and Challenges

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Key Points for Discussion

$$\text{Transformation} = \frac{\text{Vision x Competence}}{\text{Anxiety}}$$

Motivation:

- Need for storage
- Types of storage

Technology:

- Not just one type of chemistry
- Not just one type of storage mechanism

Opportunities:

- R&D only
- Manufacture

Challenges:

- Timelines
- Investment volume
- Supply chain
- Production Ecosystem

Pace of Change – Hard to Predict and Consistently Underestimated

1903

1913

New York City

Source: Robert Morgan CEO, Energy Storage Renewable Hybrids GE Renewable Energy

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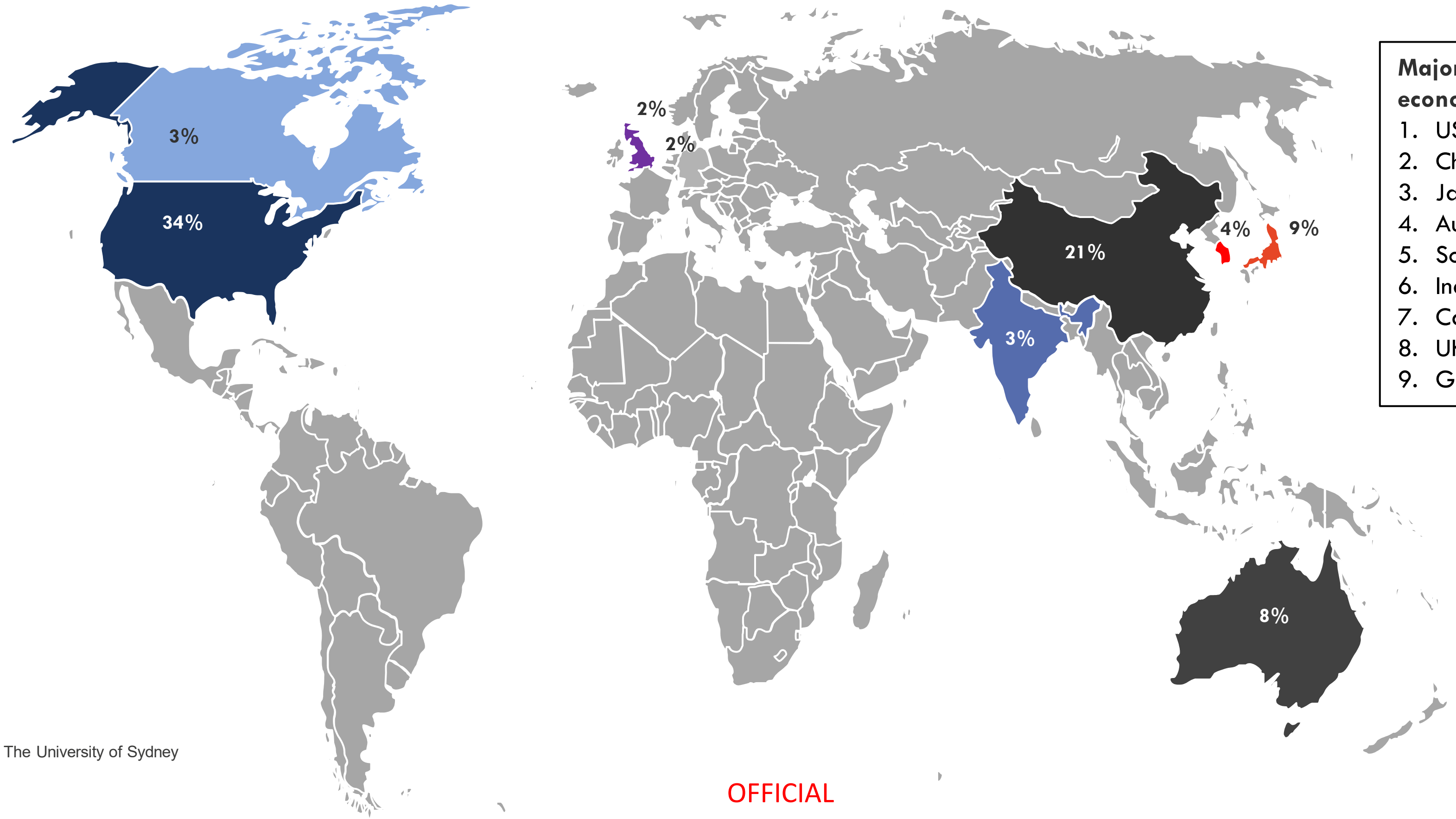
IEA Prediction: Global Stationary Battery Storage Capacity 2024: 158 GWh



Major economies

1. USA
2. China
3. Japan
4. Australia
5. South Korea
6. India
7. Canada
8. UK
9. Germany

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Motivation – Need and Types of Power and Storage

- **Wind and Solar Power:**
  - 1,500 GW (2020)
  - 4,000 GW (2030)
- **Fossil Fuel Power:**
  - 4,000 GW (2020)
  - 4,400 GW (2030)
- **Green buffering power:**
  - ~ 175 GW (2020, ~11%)
  - ~ 600 GW (2030, ~15%)
- **Green buffering capacity:**
  - 1,530 TWh (2020)
  - 5,250 TWh (2030)

*John Wood, World Energy Storage day 2022

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Motivation – Need and Types of Storage

- At least 5,250 TWh needed by 2030
- China's 2023 battery production capacity per annum: 900 GWh = 77% of global capacity, but only 0.02% of buffering needs
- Many technologies needed:
  - Pumped hydro (capacity good / power poor)
  - Batteries
  - Green hydrogen/ammonia
  - Bioenergy

- **Green electricity production is running way ahead** of the ability to implement unless there is a **huge uplift in storage capability** with good power characteristics
- We need to transition to green power to meet climate goals
- Increasing energy density leverages production capacity => key strategic target

Technology (just a selection)

- Lithium (anodes):
  - Li-ion
  - Li-metal (solid state)

- Lithium (cathodes):
  - NMC
  - Iron Phosphate
  - Titanate
  - Sulfur

- Sodium-ion ("rinse and repeat", but)
  - Different carbons (hard)
  - Different cathodes (ferrous cyanides) and electrolytes

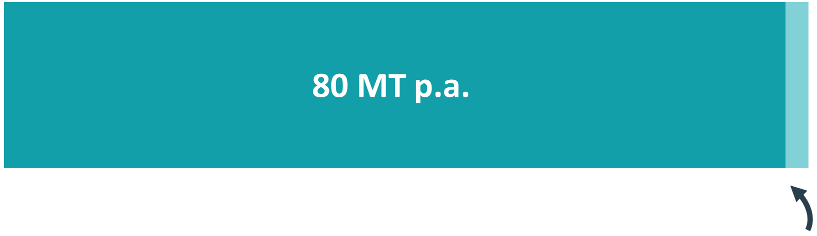
Flow batteries:
- Vanadium redox flow
- Zinc bromide
- Iron/Iron
- Organic redox couples

- Ultra(super)capacitors (**very high power**):
  - EDLC
    - Fast, millions of cycles
  - Hybrid (battery-like)
    - Tens of thousands of cycles
    - Moderate energy density

Supply chain benefit – changing from critical metals (NMC) to sulfur

Global sulfur supply chain

Total global sulfur production (waste product from oil refining)



Just 1% is enough to replace all battery cathodes

- Replacement with sulfur, the 5th most abundant element on earth by mass.[1]
- Removal of cobalt from the NMC cathode reduces reliance on inputs with ethical concerns.
- Sulfur sources are "almost limitless"; supply chain stability is expected.[1]
- All Li-ion cathodes (2.7 TWh by 2030)[2] could be replaced with sulfur using just 1.1% sulfur supply.

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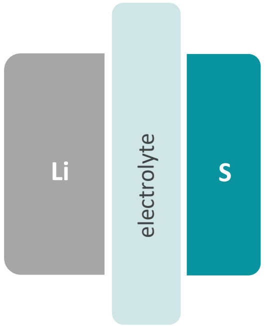
[1]Mineral Commodity Summaries, U.S. Geological Survey, 2022
[2]BNEF, Long-term Electric Vehicle Outlook 2021

Complexity – more than one pathway in Lithium Sulfur: Li-ion/LiSi/Li-metal

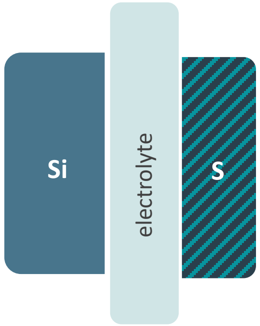
1 Electric flight, EVs, and tools

Li-S
ultra-high capacity

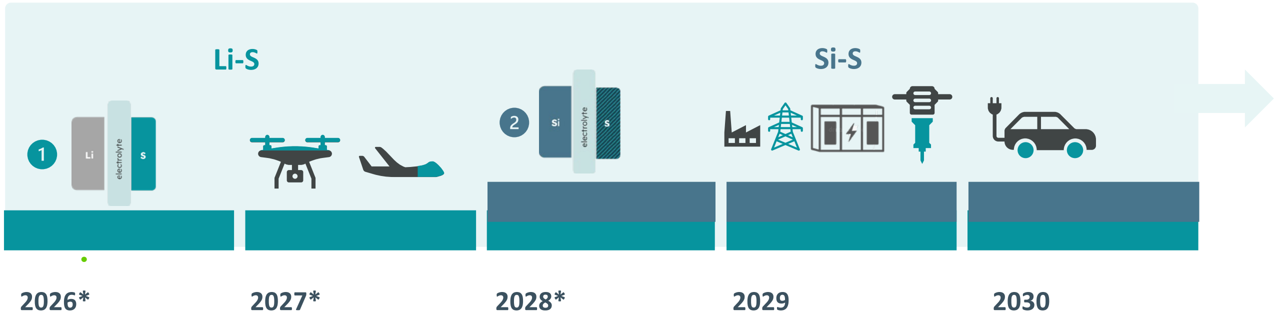


2 Stationary storage and EVs

Si-S
long cycle, high capacity



Smart market entry balances lower risk development and faster market presence



*technology progresses through sampling, small high value quantities, to volume applications in later years

gelion

Opportunities

- **R&D only, or also Manufacture** ?
  - Manufacturing is a strategic move requiring a large commitment
    - Is it worth doing?

1. **Battery tech will determine product performance** (cars, grid)

2. **Access to the latest technology** – not that from three generations ago (enshrines structural disadvantage)

3. Be increasingly a part of the supply chain, **harvesting value at each step**

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Opportunities:

- Supply Chain and Production Ecosystem

    - Some of Australia's advantages:
        - large raw materials base
        - huge renewable resources
        - highly skilled R&D workforce
        - very substantial internal markets (e.g. decarbonization of mining sector)

Challenges:

- **Production workforce**, manufacturing capability, logistics, etc.
- Lack of a bi-partisan, dependable array of policy settings
- Compare with USA (DoE-lead energy storage strategy), EU (‘Green deal’ initiatives)

- Timelines:
  - Energy transition – last fossil-oil-based infrastructure took ~150 years to build
  - Strategic positioning across multiple decades needed, like defense
  - After 150 years only less than 10 battery techs at scale

- Investment volume:
  - 1 GWh/y = US$130m for fully optimised, off-the-shelf technology
  - many TWh needed => trillions of investment across the supply chain

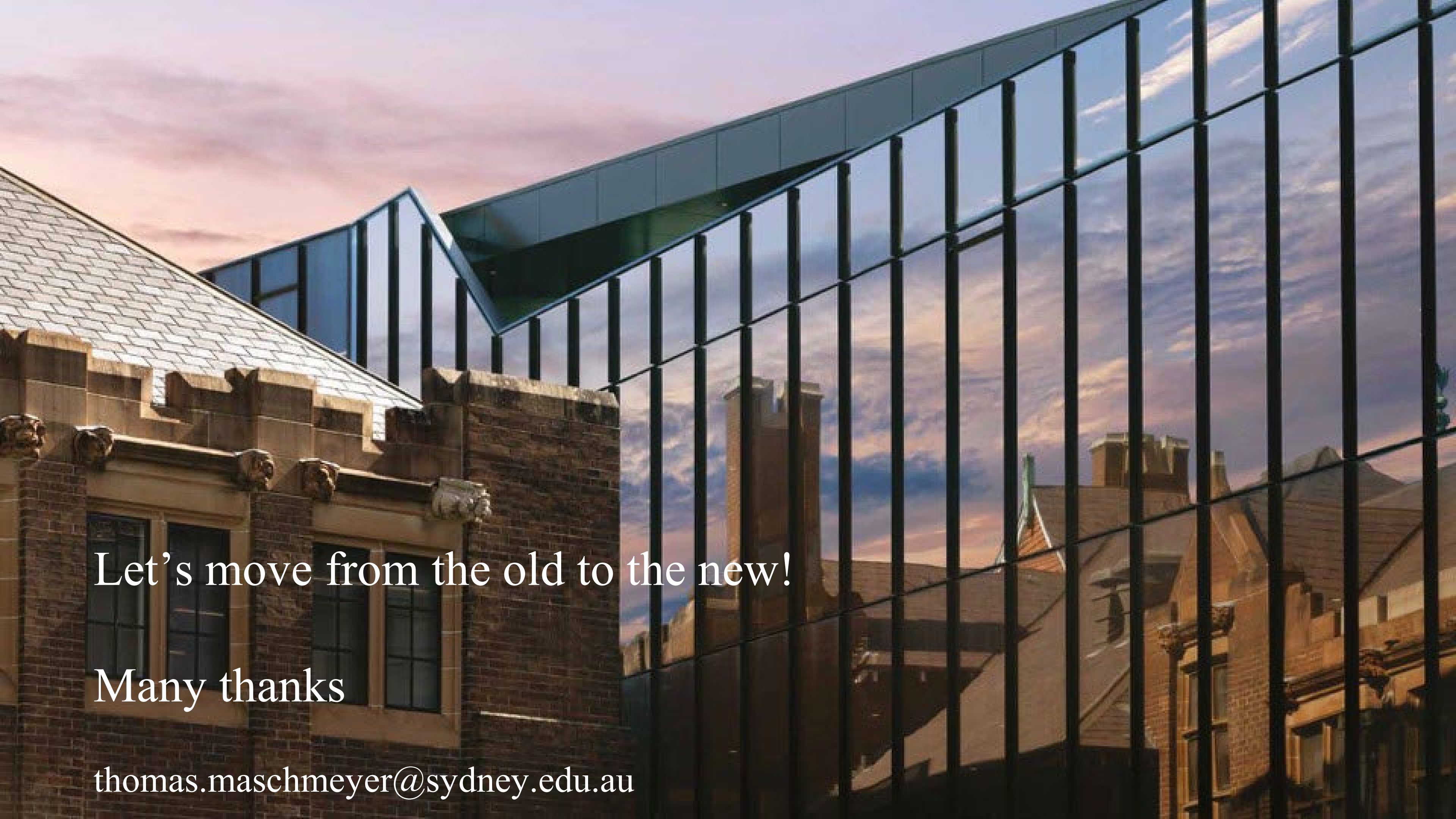
Why should we bother, aren’t other countries way ahead?

- Yes, but not in the **latest battery technology** – there is still room to be at the top for NEW technologies

- Australia is scientifically leading in many battery fields

- **Connecting access to resources with co-investment into the growth of new battery technology capability can position Australia as a global high and deep tech player**

- Examples: Indonesia (Nickel), China (access to internal market)



Let’s move from the old to the new!

Many thanks

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