Batteries – Your Achilles Heel?

Selecting the wrong battery may sabotage your corporate ESG strategy

DATA CENTER WORLD

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Navigating ESG - Battery & Supply Chain Perspective

Starts with ESG

We will review the foundational elements.

- Environment
- Sustainability
- Governance

Exploring Batteries – more than energy storage

- Chemistries
- Characteristics
- Material composition
- Material sourcing
- Supply chain implications
- CO2 implications

Choices

Summary, Q&A

We only have one

Environment – What is it, why do we care?

Environment

The environmental factor in the ESG equation focuses on how a company performs as a steward of nature. It considers how a company uses natural resources and how their operations impact the environment. It includes not only a company's direct operations, but also all activities across their supply chains.

Climate Change

- Reducing CO2, GHG
- Decarbonization

Natural Resources

- Land, water, wildlife conservation
- Biodiversity, ecosystems

Pollution & Waste

- Reducing waste, toxic emissions, water/air/land pollution

Environmental Opportunities

- Energy efficiency

Batteries – Think Differently

#1 – No such thing as a Perfect Battery!

- Only the best one for your application, today
- Innovation & material science improving all the time
- Your battery options will increase over time

The Good:

- Batteries can, will, and are enabling a new future world

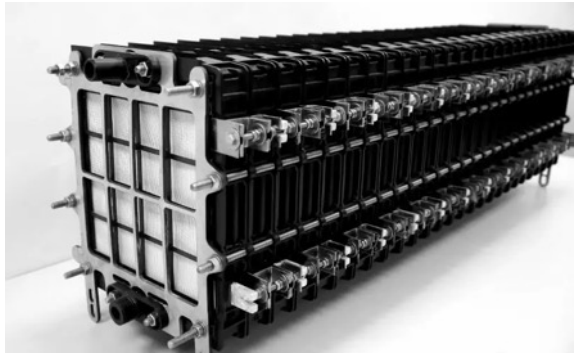
The Bad:

- Batteries can, will, and are destroying the environment, cultures, polluting our air and water, and creating unnecessary fire, explosion, unnecessary risks to life and property

Chemistry Class from A to Z (thankfully no quiz, today)

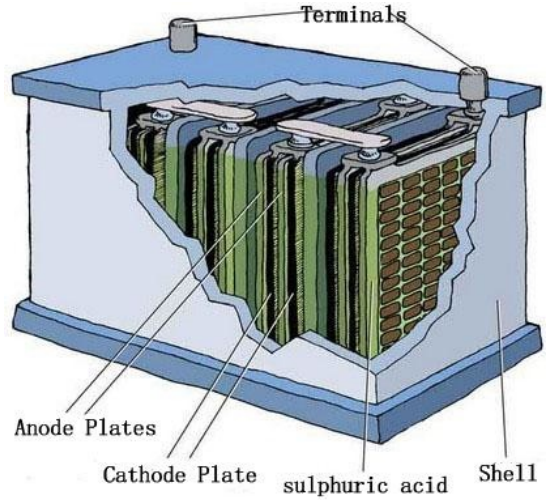
Focusing on rechargeable batteries

- Aluminum
- Lead
- Lithium-ion, (alphabet soup)
- NiCd
- NiZn
- NiMh
- Na-ion



Flow batteries

- Vanadium
- Iron-oxide



Ok – so there is a quick quiz – no right answer

What do you see?

Well this is what I see

Time to think differently

EV to UPS Handy Converter Guide

EV Batteries rated at 1 C rate

UPS Batteries rated at ~10 C rate

500kW – 1MW

2.5MW – 4MW

50MW – 100MW

The Global EV industry is devouring supply chain

Starts with raw materials

- Lithium
- Cobalt
- Nickel
- Steel
- Semiconductors
- Poly insulation

Accelerates with:

- Personnel
- R & D technicians
- Scientists
- Factory space, workers
- Energy

And who's phone call do the suppliers take first?

Batteries and RE Systems / PPAs impact your ESG

Understanding your RE eco-system is vital

- Storage?
- Most likely lithium, from China
- Susceptible to catastrophic events
  - Potential environmental hazards

Owned, Leased, PPA

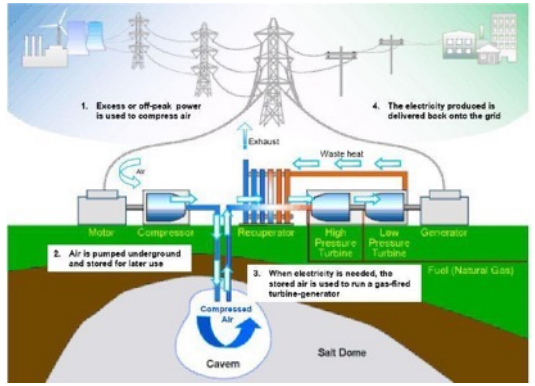
- There will be a carbon reporting requirement
- Anticipate WRI, Greenpeace, other NGO engagements
  - Environmental impacts of supply chain
  - Societal impacts of supply chain
  - Governance impacts of supply chain

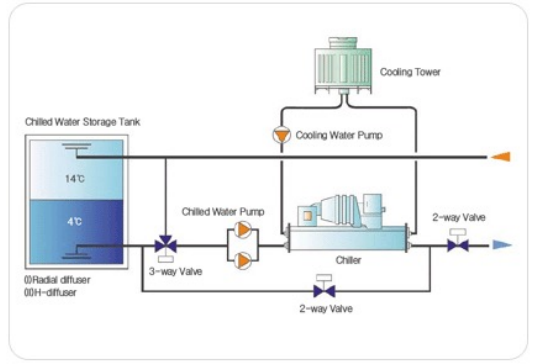
The only ‘Green’ energy is the NegaWatt

- Thank you Amory Lovins & RMI, circa 1990
- Expanded and applied to Data Centers via Energy Logic

Energy Storage Everywhere – pick one, some

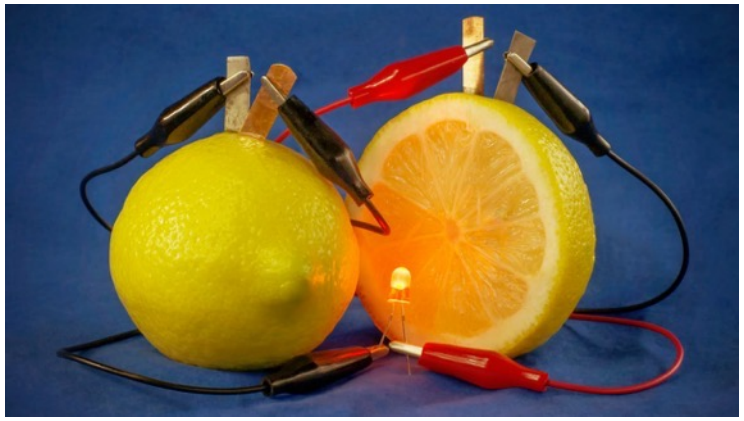
ESS Platform of the Week





Big Fan of Thermal Energy Storage

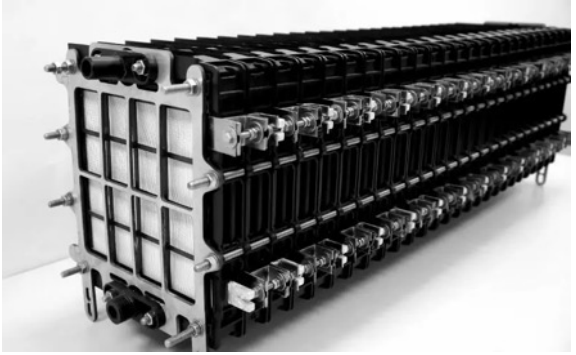
Let’s Talk Batteries!



Aluminum

Technically not rechargeable

- Aluminum, abundant resource
- Energy intense refining & processing
- China #1 source raw materials 40M mt
- India #2 source raw materials 4M mt
  - Both extremely high CO2 emitters, coal-fired plants
- Highly recycled material – potential cost / environmental benefits
- GHG contributions, perfluorocarbons 9,200X more powerful than CO2
- Refuellable battery? Perhaps. Recycled Aluminum negates many of the less palatable environmental impacts.
- Long carbon and/or hydro intense supply chain
  - Recycled material sourcing improve CO2 and logistics



Aluminum Mine or Tar Sands?

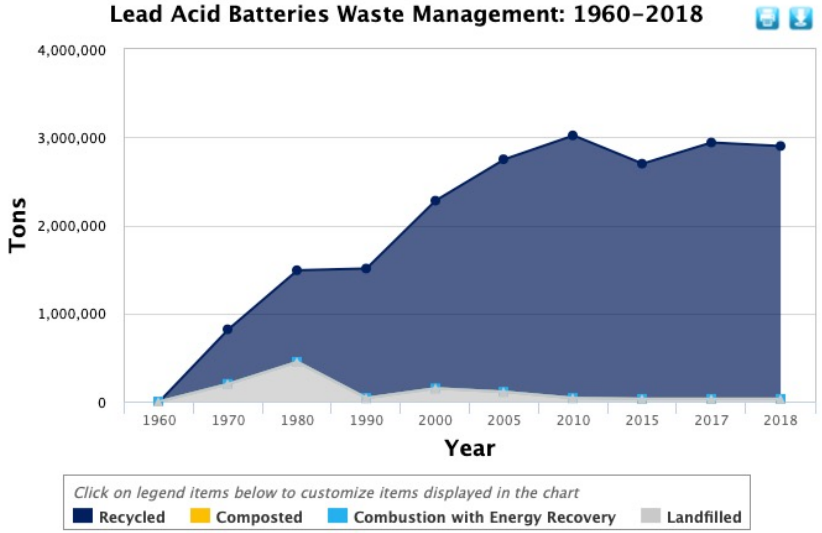
Lead – A long way from Dead!

The poster child for recycling, usually

- Lead, extremely toxic, exactly why most markets excel at recycling
  - Note: most is far from ALL! Tragic working conditions and environmental nightmares exist in many locations around the globe.
  - Low-cost labor, poor/no government oversight lead to abuses
- Know your waste management / recycling providers
  - Document, third-party certify
- China #1 source raw materials, Australia #2, USA #3

Lead the one we know but don't love

- Used in mission critical applications since day one
- Still the primary go-to battery
  - Best first costs
  - Known performance & operational characteristics
- Requires hazard / safety mitigation
  - Spill containment, H2, fire suppression, thermal runaway
- Generally a regionalized / local supply chain when sourced via recycling

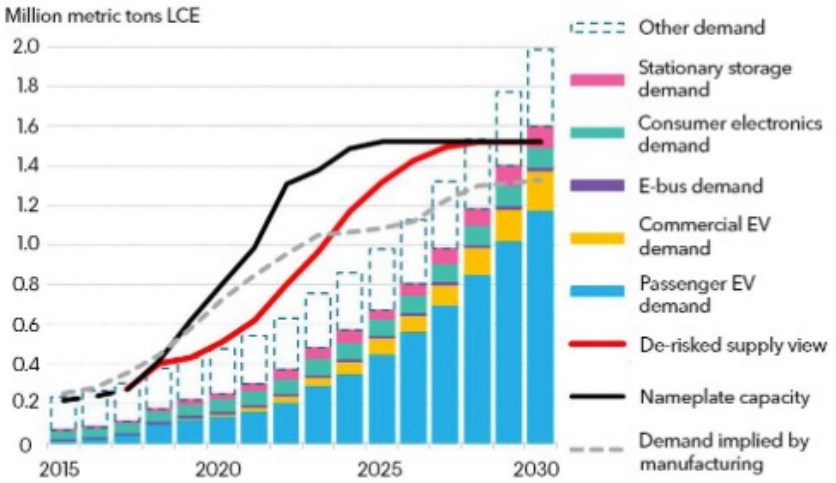


Lithium – Square Peg, Round Hole

Fifty+ years in the making, thanks NASA

- Energy density champion (today) darling of the mobility industries
  - Consumer electronics
  - EVs
  - Grid-scale ESS (questionable use!)
- Lithium, inherently toxic
  - Have not solved recycling issues
  - Chemical soup – think Bhopal accident on steroids
- Inherently unsafe – all chemistries capable of thermal runaway
  - NFPA 855 – Not a Pass/Fail test, read the unredacted cell level test data
  - Permitting, transportation, issues abound, every AHJ has an opinion
  - Mitigation strategies available, are the worth the cost & risk?
- ESG Nightmare! No chemistry is immune
  - Lithium sourcing
    - Displacing indigenous peoples
    - Destroying eco-systems
  - Other rare earth minerals – tragic working, environmental conditions
  - Long, carbon intense supply chain

Figure 1: Global lithium supply and demand forecast, comparing methodologies



Source: BloombergNEF, Avicenne.

Cobalt is mined by children in the Democratic Republic of Congo (UNICEF)

Nickel to the Rescue? NiCd, NiZn, NiMh

Over 100-years in the making, thank you Jungner (NiFe)

- Nickel – relatively abundant but consumed heavily by steel industry
  - Nickel Super Alloys – aircraft, turbines, power generation
  - Construction, population growth, EV infrastructure drive Nickel demand
  - Becoming supply constrained for battery use
- Numerous chemistries enabling unique operating characteristics
  - Early EV platform
  - Portable devices, medical, telecom, data center
  - Some have a memory
- Can be fire / life safe: read the unredacted NFPA 855 tests
- Energy intense refining & processing
- Questionable mining environmental impact
  - Strip mines, water contamination
  - Deforestation
- Indigenous People displacement – Indonesia
- Long carbon intense supply chain

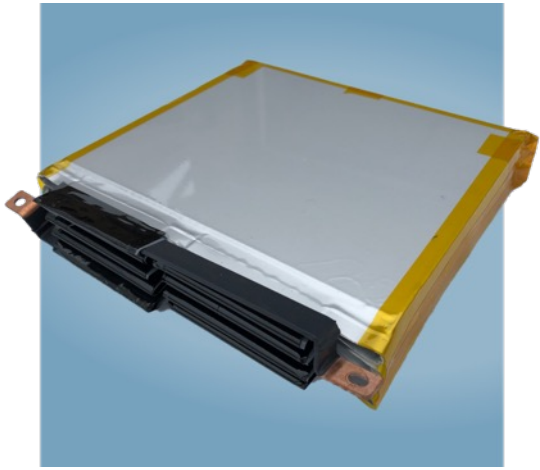
Nomadic Hongana Manyawa group in the Halmahera rainforest. The Hongana Manyawa get all they need from the forest and have lived there for thousands of years © AMAN

Nickel Mine or Tar Sands?

Sodium-ion, a little Salt with your Batteries?

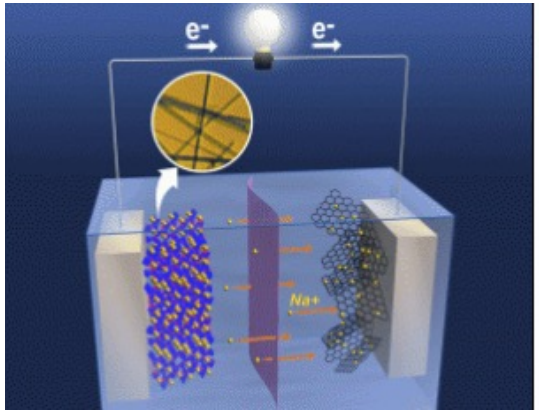
Focusing on Sodium-ion not high-temp Sodium metal

- Discovered early 1800's resurgence circa 2000
- Numerous chemistries enabling unique operating characteristics
  - PBA derivatives – high peak power, long cycle-life >100,000 cycles
  - PWA/PGA derivatives – energy density ~LFP
  - Ceramic derivatives – long autonomy
  - Near future – energy cells, energy density & >10,000 cycles
- No rare earth minerals
- No EV, Steel industry high-demand materials (Ni, Li, Cu)



Safety advantages

- PBA derivatives can be inherently nonflammable, no thermal runaway
  - Read unredacted NFPA reports
  - PWA/PGA – Carbon Cathode behave ~LFP slightly better



Early stages of commercialization

- Limited availability as global production capacity scales
- Gigafactory, chemistry advancements may achieve near LFP price parity
- Locally sourced supply chains, low CO2 intensity manufacturing

Flow Batteries

Vanadium and Iron-oxide (others and new developments)

- Typically designed for long-duration discharge
- Long-life, provided proper electrolyte maintenance

- Low C rate discharge and charge
- Typically large footprint, high volume liquid systems
- Low-speed response
  - 30-seconds to 8-minutes to full power
  - Require super cap or high C rate, high cycle rate battery front end
- Hazardous material containment
- May include a caustic, toxic chemical soup
- Lower RTE ~70%

Where in the World did My Battery Come From?

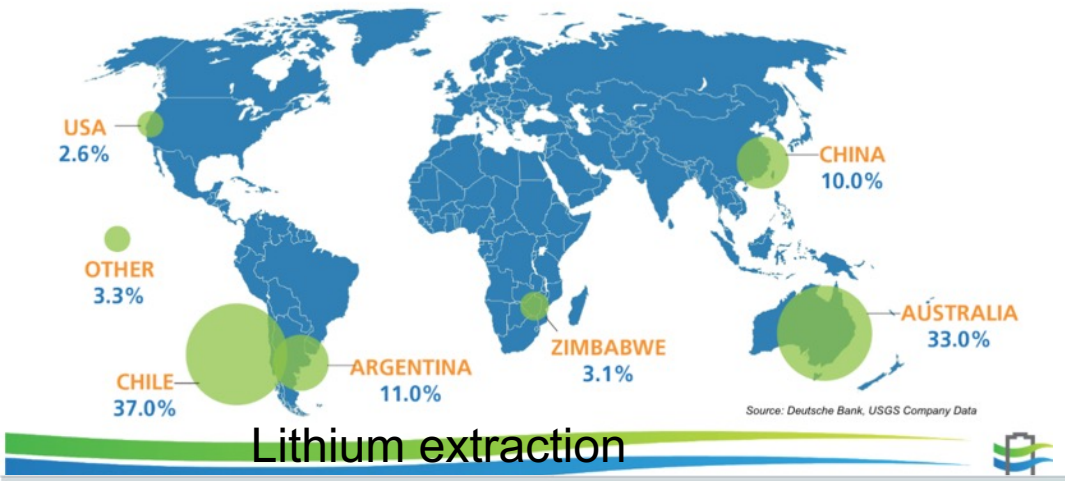
We aren’t there yet as an industry

- Raw material sourcing maps
- Material processing and refining maps
- Manufacturing and supply chain maps
- Final assembly, integration, testing, sales location

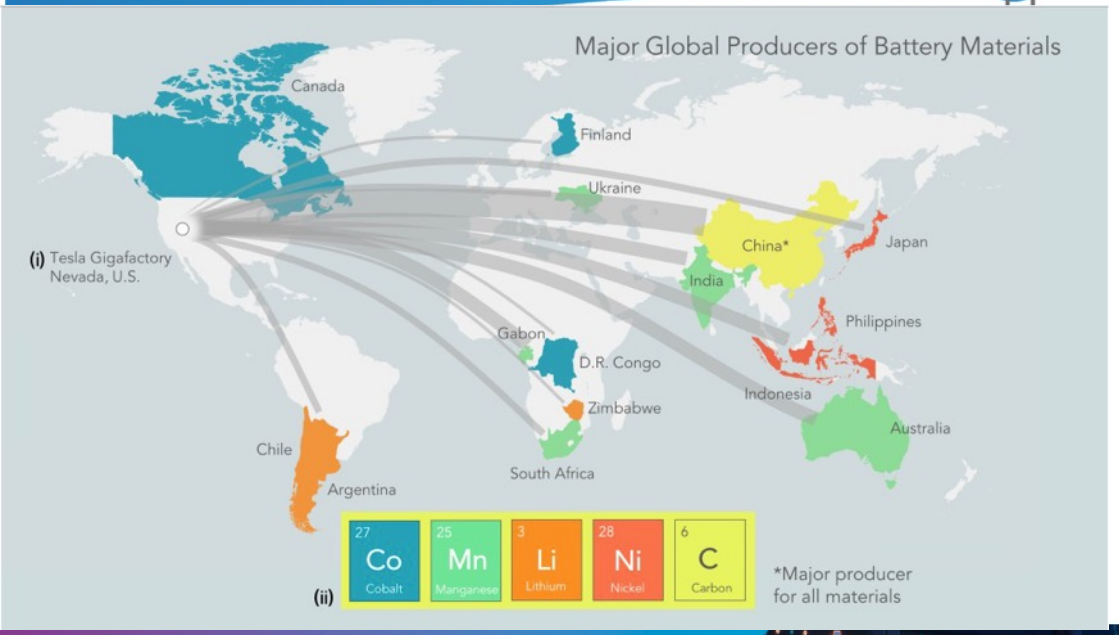
Thank you Schneider

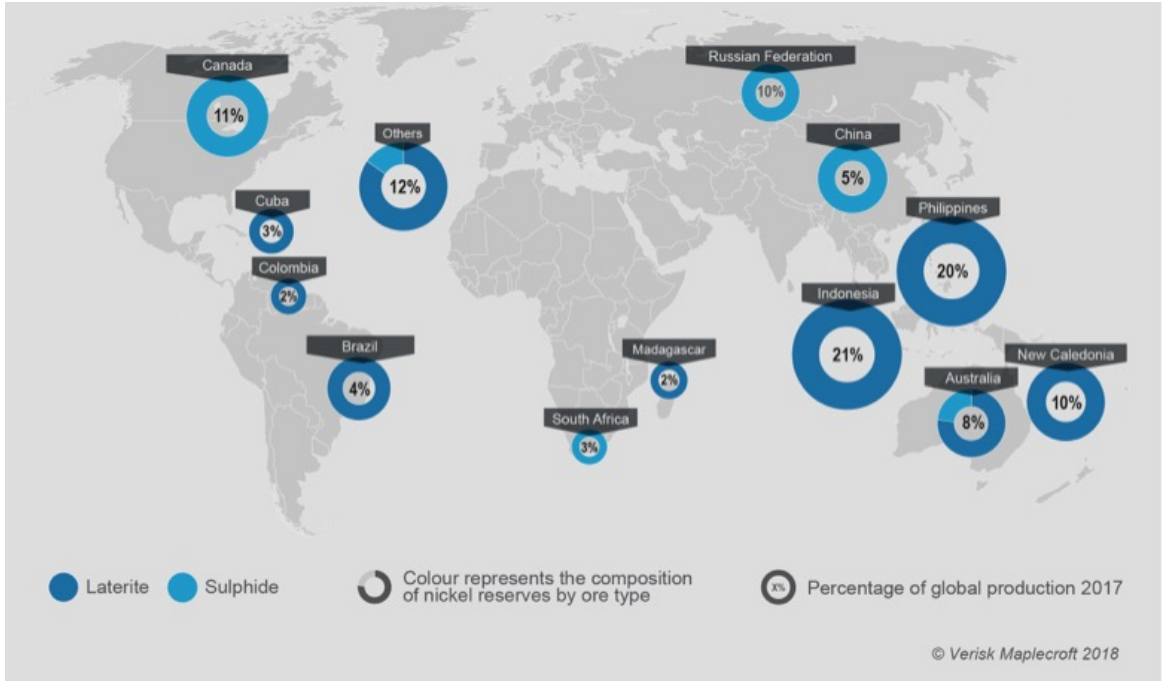
How digital traceability can work Image: Schneider Electric/Global Supply Chain Vision

Where in the World did My Battery Come From?



Lithium extraction





Nickel

Every battery has core material sourcing requirements
Some travel a long way before hitting your receiving bay!

My Battery has CO2?

Yes, we have a long way to go to accurate reporting

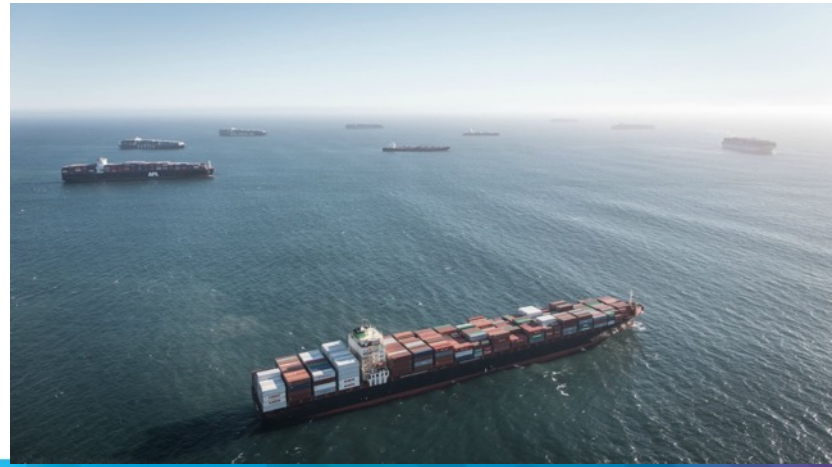
CARBON TRUST
The carbon footprint of this product has been measured and certified
CERTIFIED

GREENHOUSE GAS PROTOCOL

Logic dictates:

- Closer is better
- Transportation & logistics = CO2, delays
- Energy intensity matters
  - 500 tons of dirt = 1 Tesla pack = 1 250kVA UPS battery
  - Similar metrics Ni, Al, etc.

Do your homework before Greenpeace does!



Considerations before derailing your ESG program

Chemistry	Environment	Sustainability	Safety	Density	CO2	Availability
Aluminum	3	3	3	2	4	4
Lead	4	4	4	3	2	1
Lithium	5	5	5	1	5	2
Nickel	2	2	2	3	3	3
Sodium	1	1	1	3	1	5

Your ratings may vary. Do your research.

Summary

There is no such thing as a perfect battery!

Every Chemistry has unique Pros and Cons
Every Chemistry has some environmental impact
Every Chemistry has some embedded CO2
Every Chemistry involves some amount of logistics
Some have societal/cultural implications
Some involve child labor / labor abuses
Some involve deforestation
Some involve less ideal trade / governance
Some are not safe
Some last longer than others
Some cycle more often and faster than others
Some are more efficient than others >98% RTE

Do your homework – TCO and Beyond to ESG

Batteries – the Achilles Heel of Your ESG / RE Strategy

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