The Holy Grail in Energy Storage

Water-based Supercapacitors and Flow Batteries

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Two Problems

1

Renewable energy sources are **intermittent**

Current storage technologies are expensive, flammable, unsustainable, …

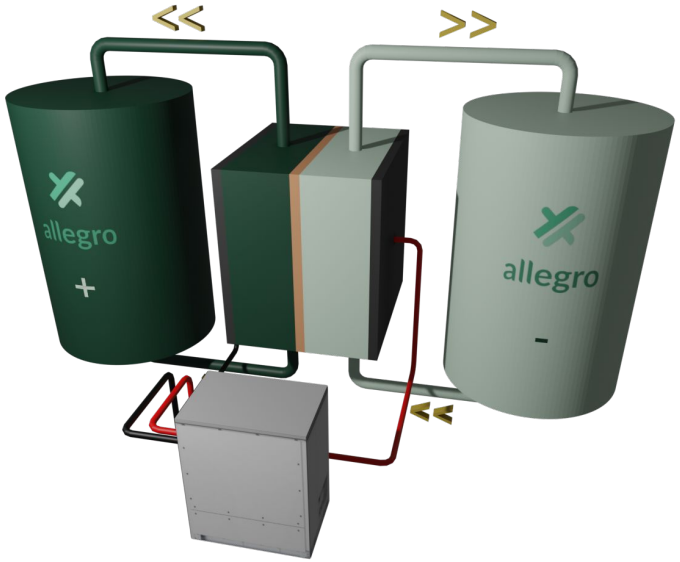
2

The Third Problem

3

Lithium ion batteries

< 4 hour duration



4 to >12 hours

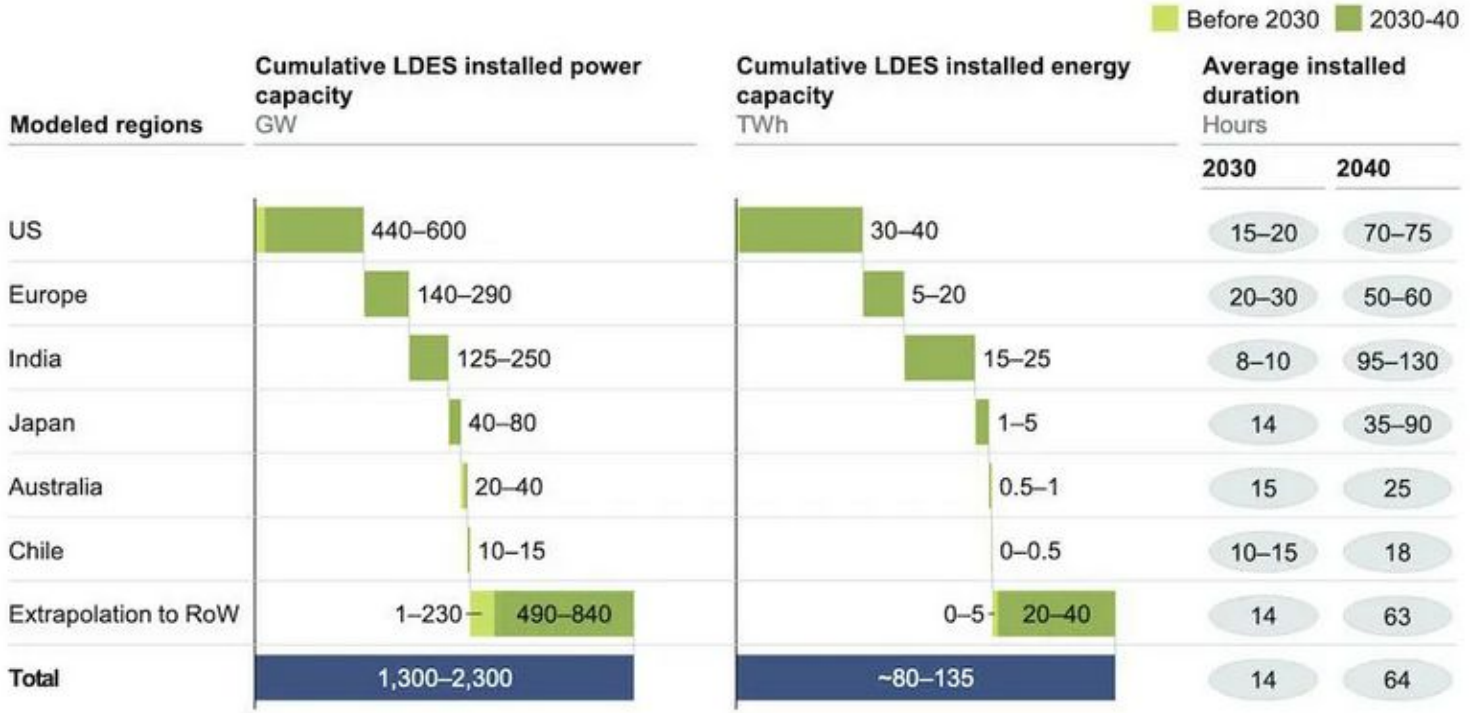
Pumped hydro

seasonal

The Size of the Problem

Long Duration Energy Storage

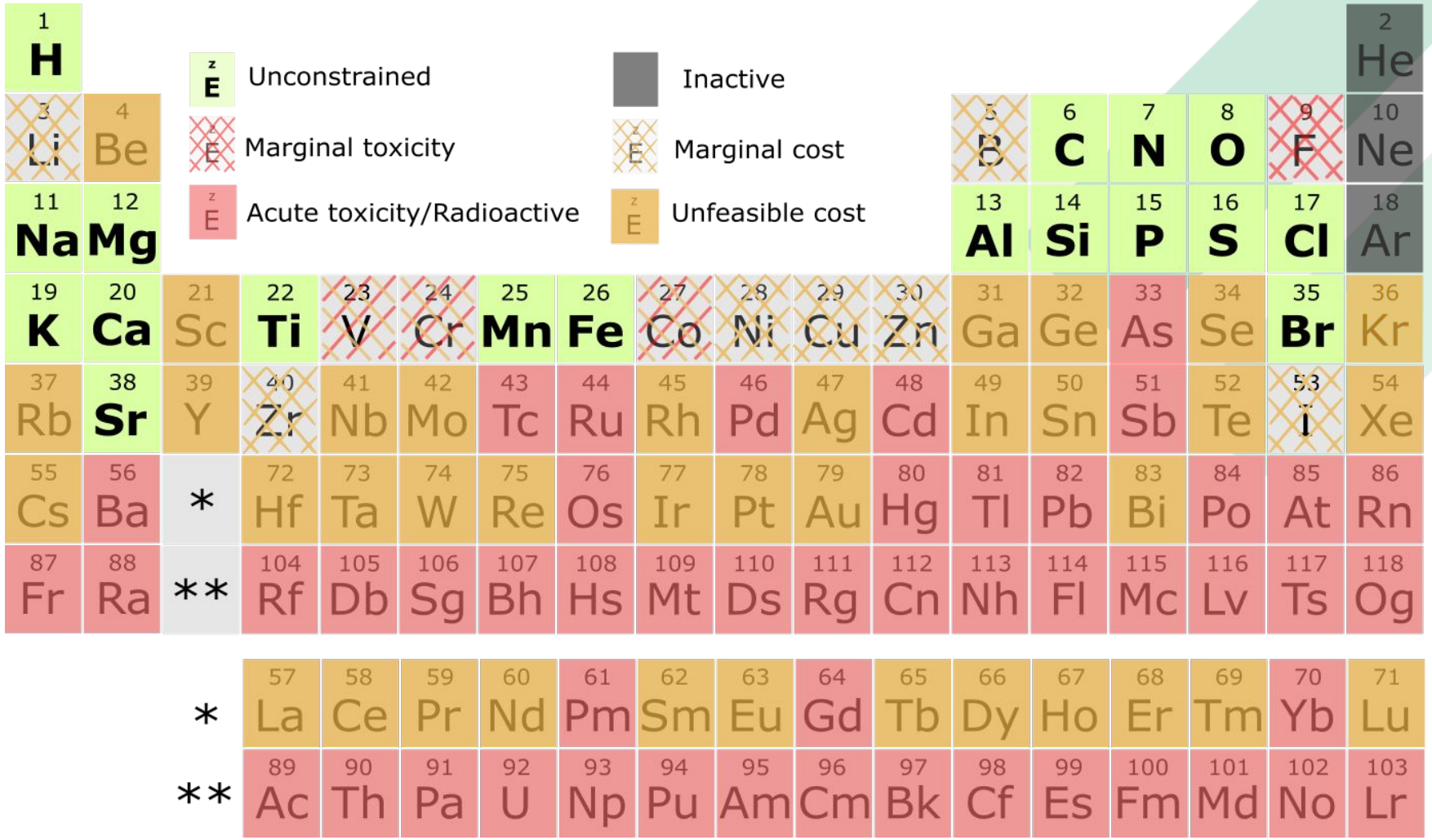
Total addressable market by modeled markets



TAM ~ US $3.5 trillion

Source: LDES Council, McKinsey & Company

The other Dilemma



Supercaps and Redox Flow Batteries

Allegro Water-based Electrolytes

Cheaper than all competing supercaps and RFBs

High **performance**

Non-corrosive, non-flammable

Strong **IP position**

Platform technology (solving many large energy storage challenges)

What are Supercapacitors?

*High **power density**;*

fast charging and discharging

Relatively low energy density;

short term - high power

The Supercapacitor Market

IoT

EVs, Hybrid vehicles

Light rail, electric buses, electric trucks

Grid Stabilisation and FFR, FCAS

Mining – process electrification

UPS

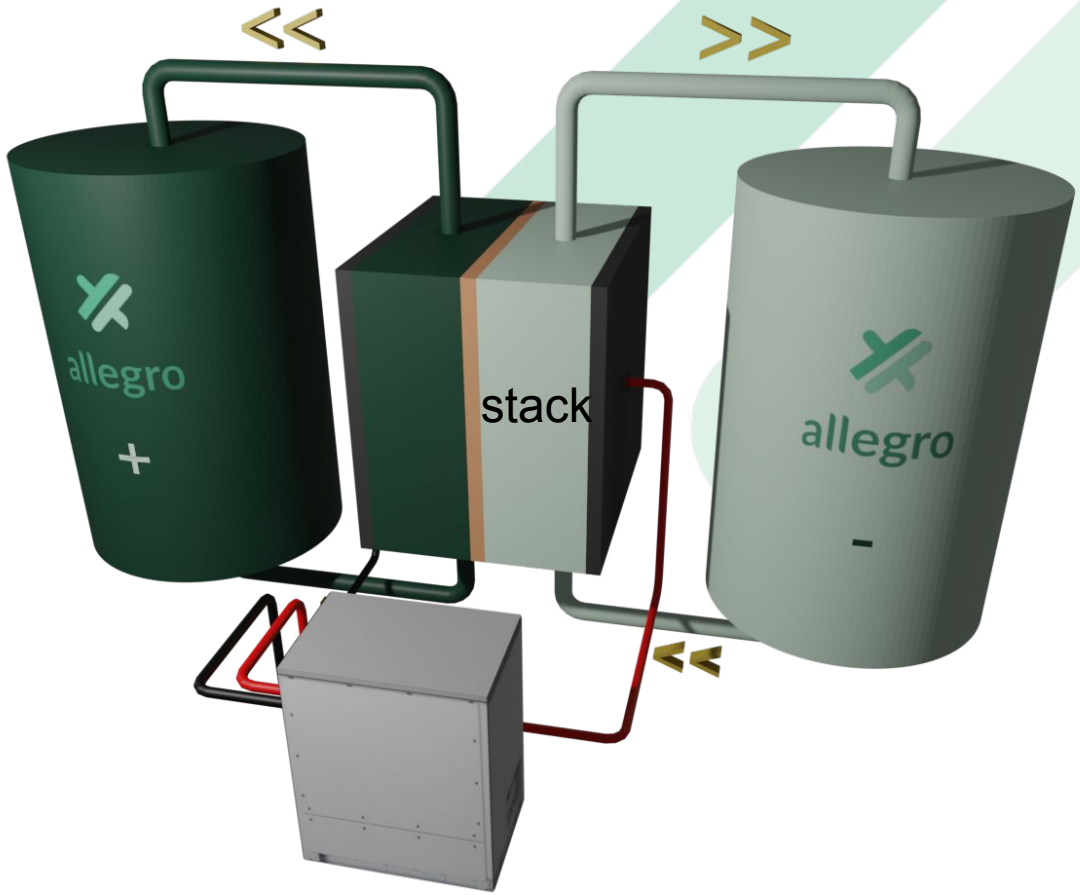
Supercapacitor Alternatives

	Allegro Supercaps	*Graphene*	*Activated carbon*	*Li-ion*
Levelised Cost of Storage - LCOS	**Substantially lower cost than all competing supercaps**	**Very expensive upfront cost**	**Expensive upfront cost**	**Expensive and low cycle life**
Cost of assembly (fixed costs)	**Very low. No need for drying or inert atmospheres**	**Strict, expensive controls required**	**Strict, expensive controls required**	**Strict, expensive controls required**
Source materials	**No rare elements, all commodity chemicals**	**Expensive, bespoke graphene, toxic electrolyte**	**Toxic and expensive electrolyte**	**Expensive, and environmentally damaging**
End-of-life processing	**100% recyclable; non-flammable; non-toxic**	**Toxic and flammable electrolyte**	**Toxic and flammable electrolyte**	**Very difficult to recycle effectively**
Response / charge time	**Charge a tram, car or e-bike in 30 seconds**	**Very high power density**	**High power density**	**Charging too fast reduces cycle life**

What are Redox Flow Batteries?

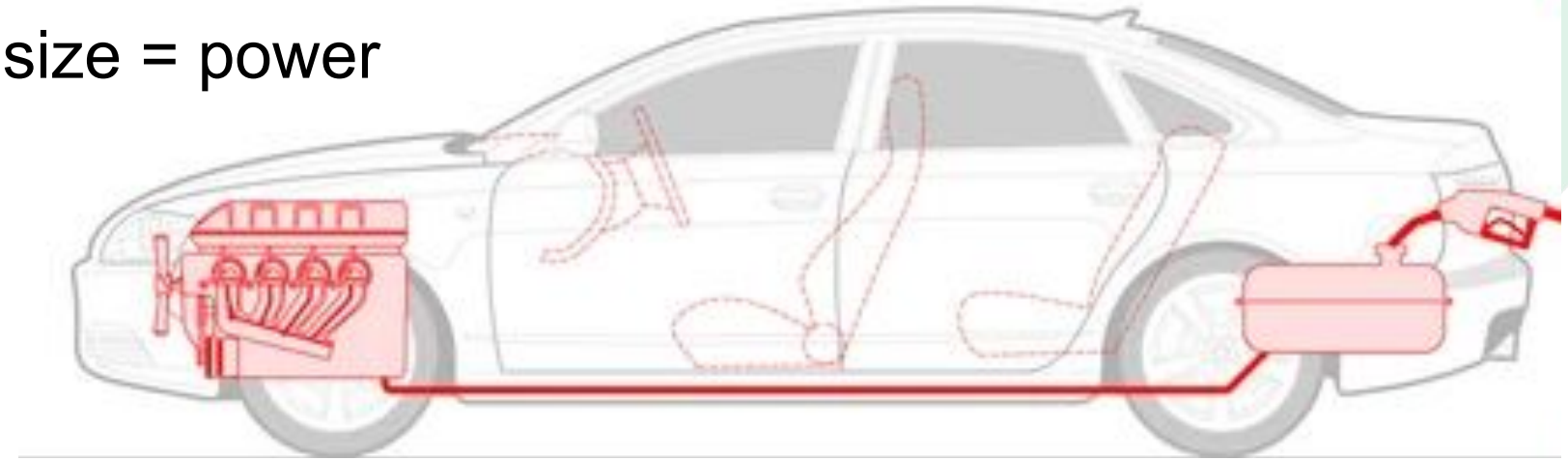
Power and ***energy*** uncoupled: both can be scaled independently - we can meet the broadest customer needs

Suitable for commercial and utility-scale storage



Decoupled Power and Energy - Petrol cars

Engine size = power



Tank size = energy

RFB State of the Market

Type	Pro	Con
Vanadium	• Well tested • Crossover mitigation easy	• Corrosive • Vanadium price fluctuation • Long term vanadium sourcing issues (75% from China and Russia) • Expensive membrane for performance
Zinc Bromide	• Cheap and available materials	• Bromine gas evolution affects both performance and safety • High cost of complexing agent
All-Iron	• Cheapest active materials	• Problematic Iron plating • Water splitting • Precipitation • Corrosive electrolyte
All-organic aqueous	• Cheap and abundant source materials	• Often corrosive electrolytes • Material degradation
All-organic non-aqueous	• High voltage and capacity	• Low power density • Flammable electrolytes • Complex degradation mechanisms • Very expensive

RFB Alternatives

	Allegro RFB	*Vanadium / Zinc-Bromide RFBs*	*All Iron / Iron-Chromium RFBs*	*Li-ion*
Levelised Cost of Storage - LCOS	**Lowest cost RFB on the market**	**Expensive catalysts**	**Cheap chemistry**	**Expensive and low cycle life**
Source materials	**No rare elements, all commodity chemicals 100% recyclable**	**Br_2 toxic and rare**	**Low cost, abundant materials**	**Expensive, and environmentally damaging**
Customisability	**Options to suit any environment or storage duration**	**Full discharge needed every 24h**	**Fixed electrolyte will not suit all environments**	**Only good at certain durations, strict temperature profile**
Efficiency	**RTE is one of the highest of any RFB technology**	**~75% RTE**	**~75% RTE**	**>95% RTE**
Footprint	**High energy density means much less space required than any competitor**	**Moderate energy density**	**Very low energy density**	**Very high energy density**

Allegro Supercapacitors & Flow Batteries

Clean, green and inexpensive: Super-fast power for FCAS / FFR / UPS combined with utility-scale energy storage

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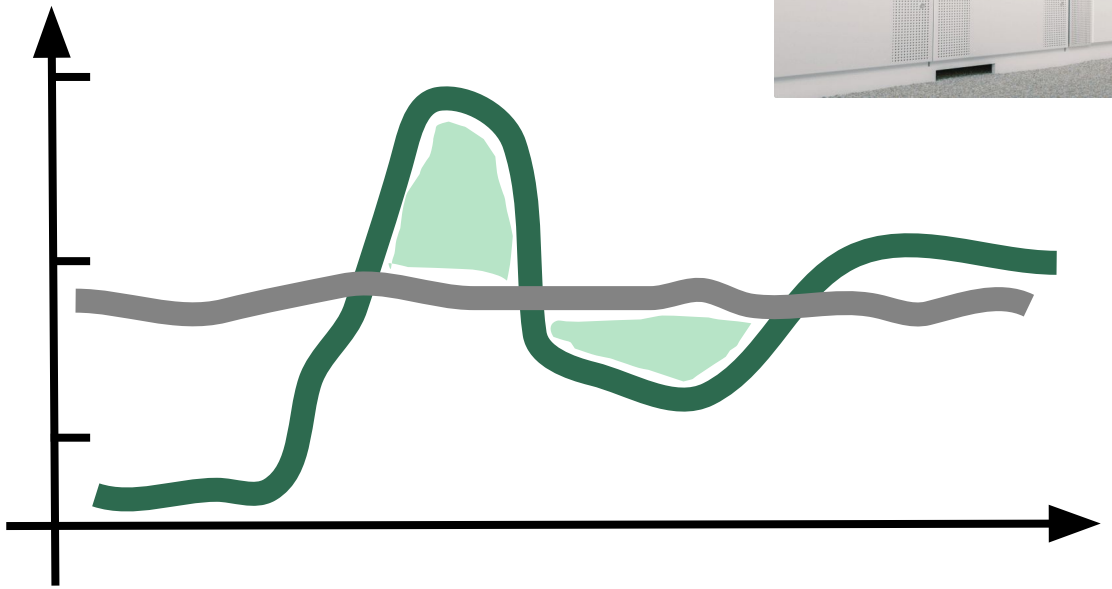
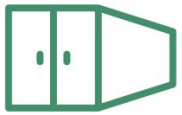


Next steps



Partner with us in pilot/lighthouse projects (RFB and supercaps)

Partner with us in scaling up manufacturing

Interested in investing? Contact me