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2

Webinar

Overview of Battery Energy Storage Systems

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Overview

1. Intro to BESS Technology
2. Technical Parameters
3. BESS Designs
4. Quality & Assurances
5. Investment Costs
6. Commercials
7. Current Markets & Future of BESS
8. Wrapping Up, Q&As

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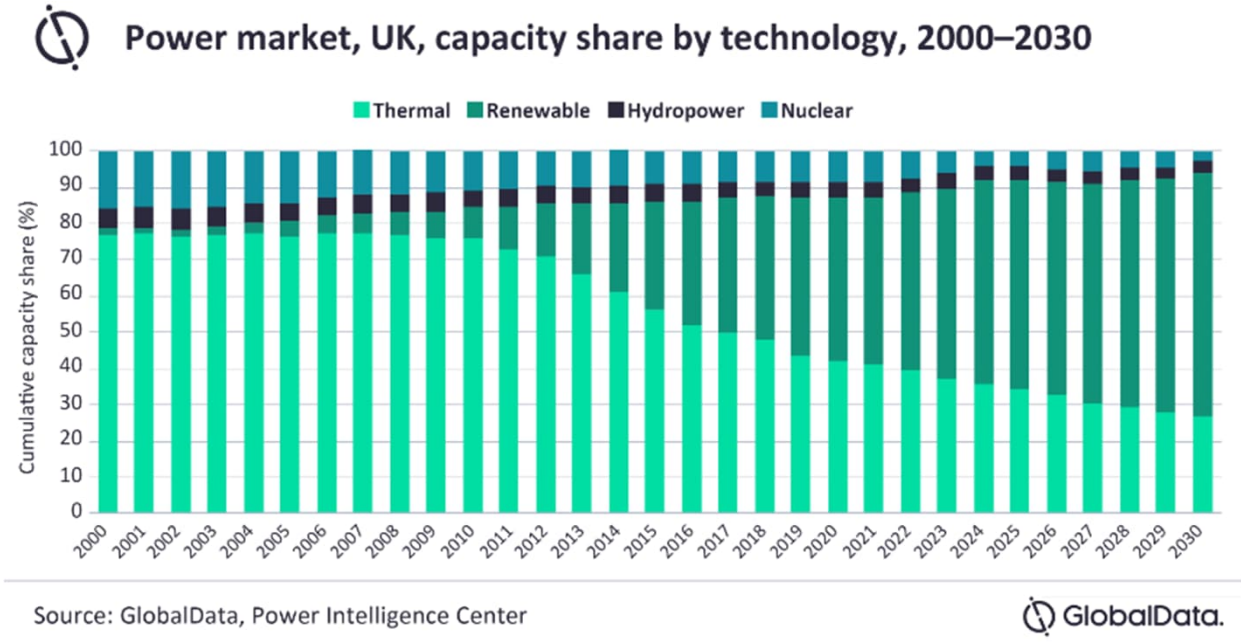
BESS INTRO & TECH. PARAMETERS

The Need for Energy Storage

- Conventional thermal plant retirement and larger penetration of renewable energy systems both at the distribution and transmission levels

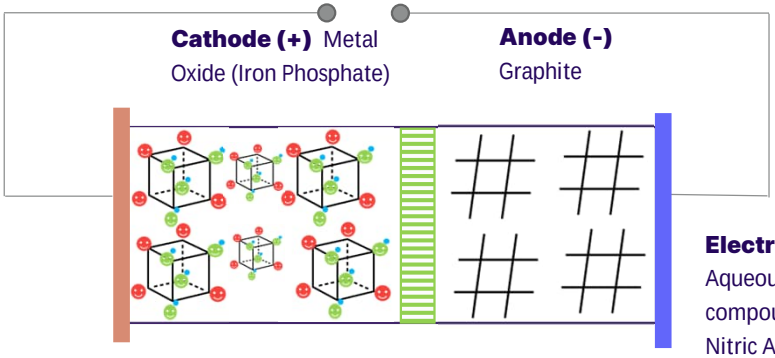


Stanley Whittingham. Sir John Goodenough & Akira Yoshino 1983

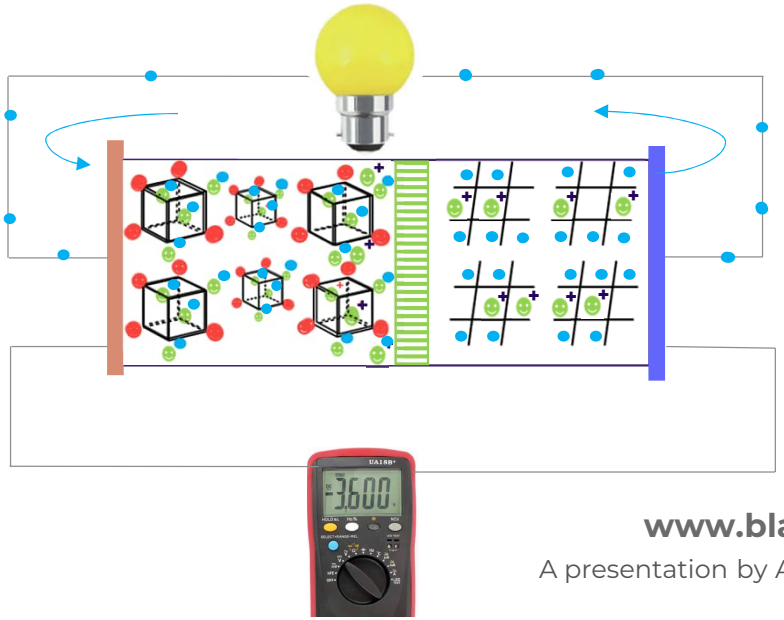
BESS Chemistry (LiFePO4)

Lithium (Li)

- Alkali Metal (Group 1 or the Lithium Family in the periodic table). Highly nuclear unstable
- Atomic number $1s^2 2s^1$
- Abundant but finite resource. Mainly in **Chile, Argentina, and Bolivia.** The Lithium triangle. Also, Australia, **Uruguay, the Republic of Congo and the Deep Sea.**

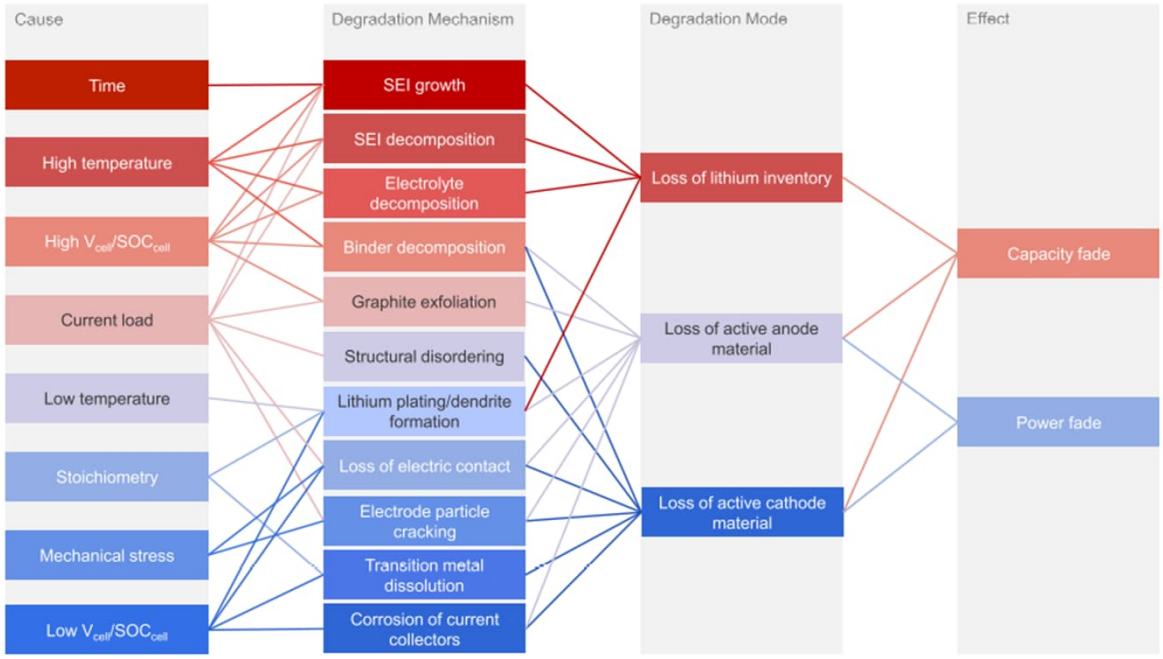


Electrolyte
Aqueous solution. Chemical compounds Sodium Chloride, Nitric Acid to name fewv



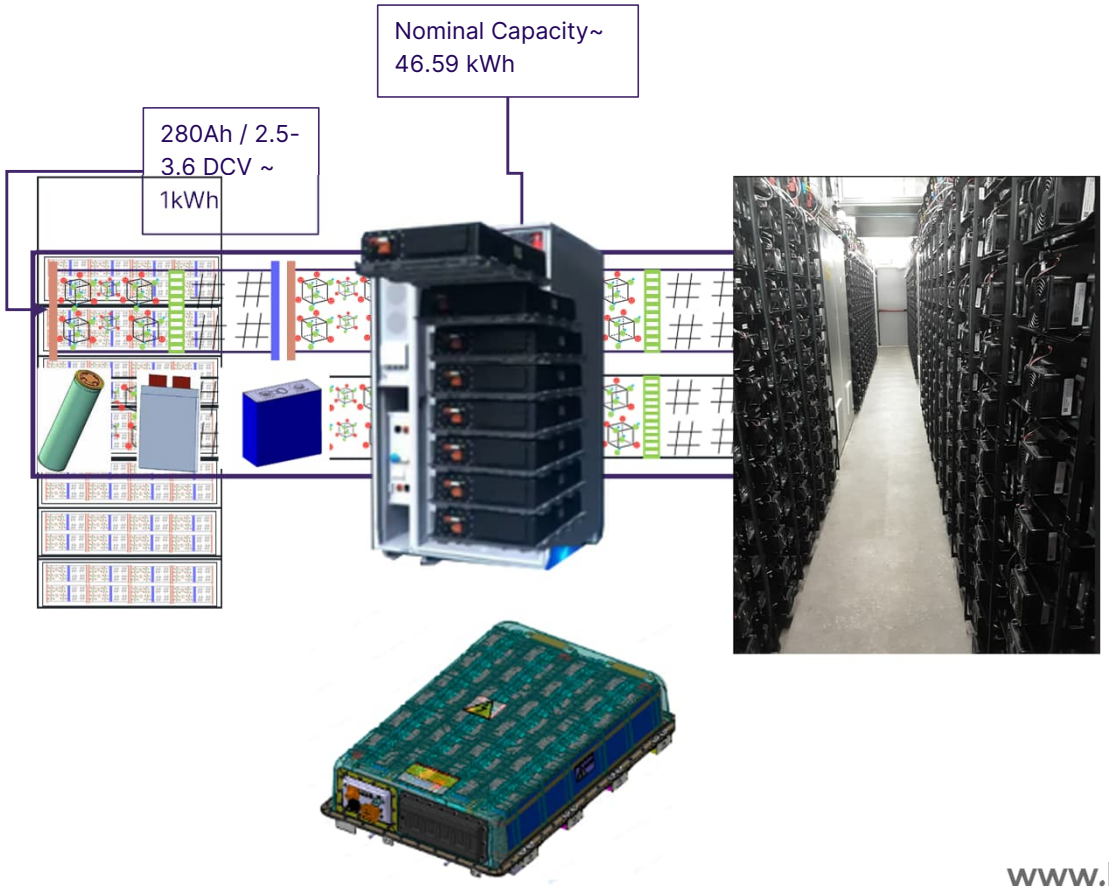
BESS Chemistry (LiFePO4)

Degradation (Solid-Electrolyte Interface –SEI-)



BESS Composition

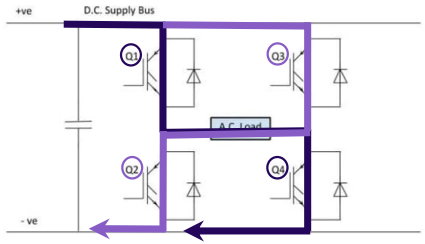
- Battery Cells, Battery Modules, and Battery Racks



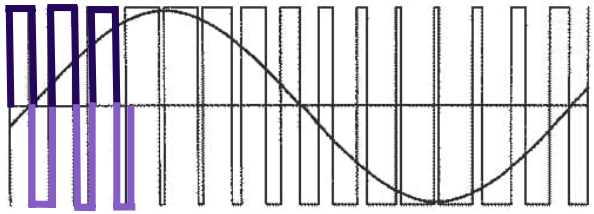
BESS Composition

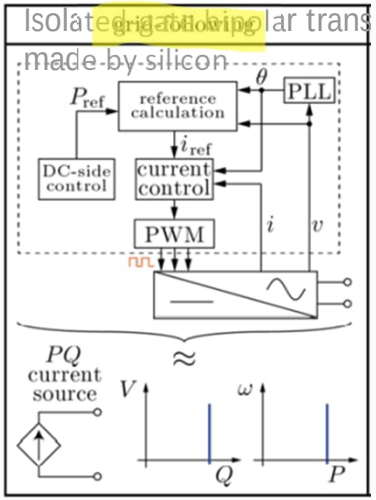
- Battery Cells, Battery Modules, and Battery Racks
- Power Conversion System (PCS)

Two-Level Converters



Oscilloscope

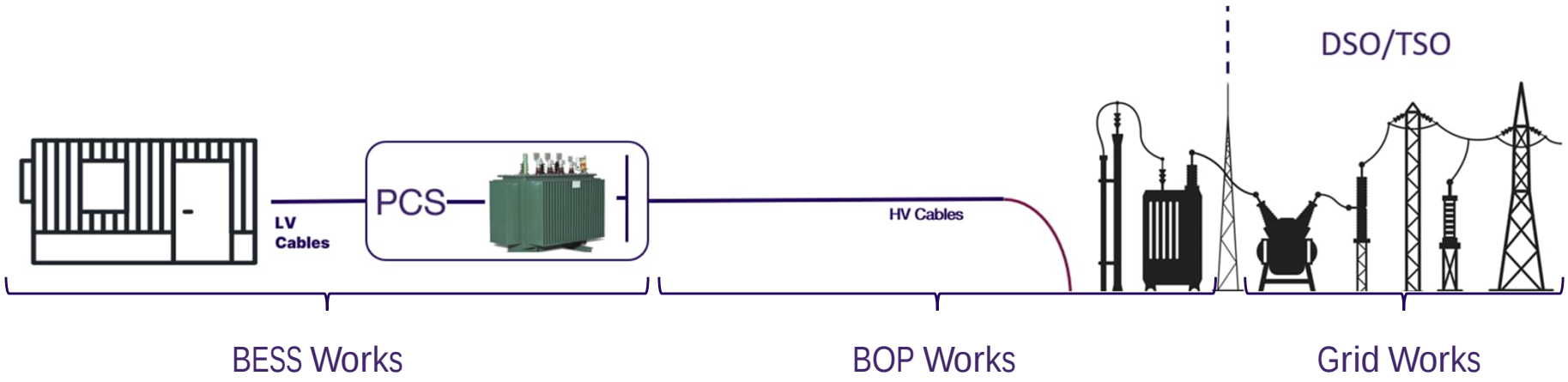




https://www.nrel.gov/docs/fy21osti/73476.pdf

BESS Composition

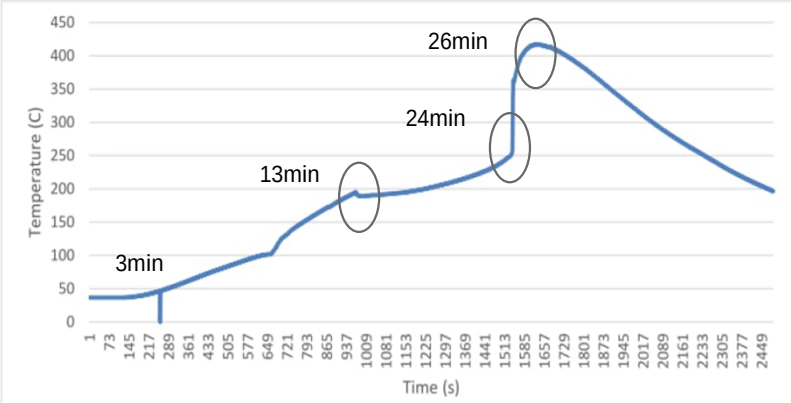
- Battery Cells, Battery Modules, and Battery Racks
- Power Conversion Systems (PCS)
- BESS, BOP & Grid Works



Fire & Explosion Issues

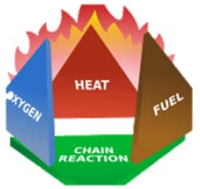
Fire & Explosion Issues

- Thermal Runway & Fire



Abuse
Electrical
Mechanical
Thermal

-Internal Short
-External Short Circuit



1. The solid-electrolyte interface (SEI) decomposes in an exothermic reaction. Can occur at 90 °C with a temperature increase of 0.001670 °C/s

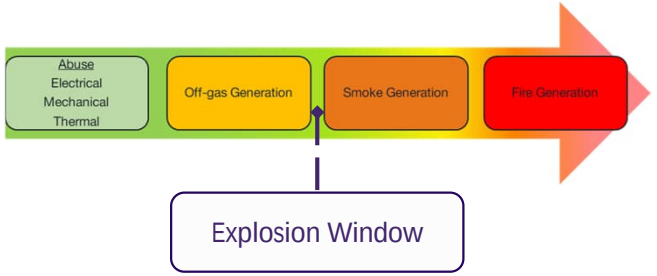
2. An exothermic reaction between the intercalated Li-ions and the electrolyte starts. Can occur at 130 °C with a temperature increase of 0.40 °C/s

3. An exothermic reaction between the positive material and the electrolyte takes place. Can occur at temperatures above 200 °C with a temperature increase of 1.7 - 17.0 °C/s

Thermal Runway

Fire & Explosion Issues

- Thermal Runway & Fire
- Explosion

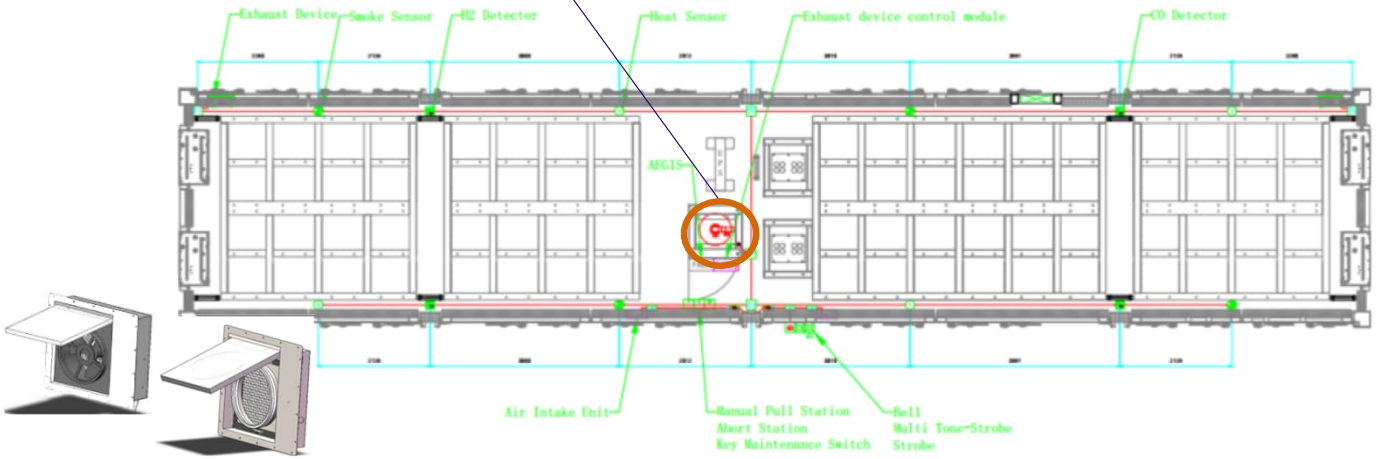


Inert gases (Nitrogen)

Fire extinguisher (compressed aerosol- Mix of gas & Potassium salt)

Off Gas

Heat & Smoke



Fire & Explosion Issues

- Thermal Runway & Fire
- Explosion
- Key standards

Thermal Runaway Test

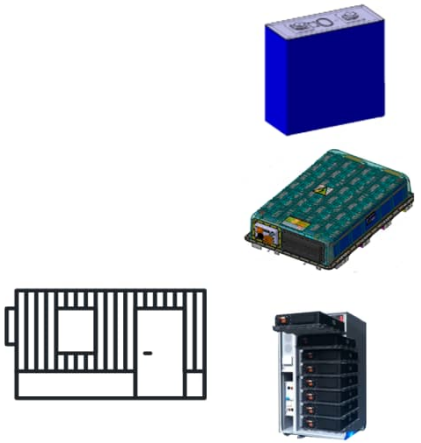
SAFETY TEST:
- Construction, electrical & mechanical

NFPA 855, 68 & 69 Fire & explosion safety and guidance for BESS

UL9540A & **UL9540** Battery Energy Storage System (ESS) Test Method

UL1973 Batteries for Use in Light Electric Rail (LER) and Stationary Applications (Any BESS type)

UN38.3 Transportation Testing for Lithium Batteries and Cells



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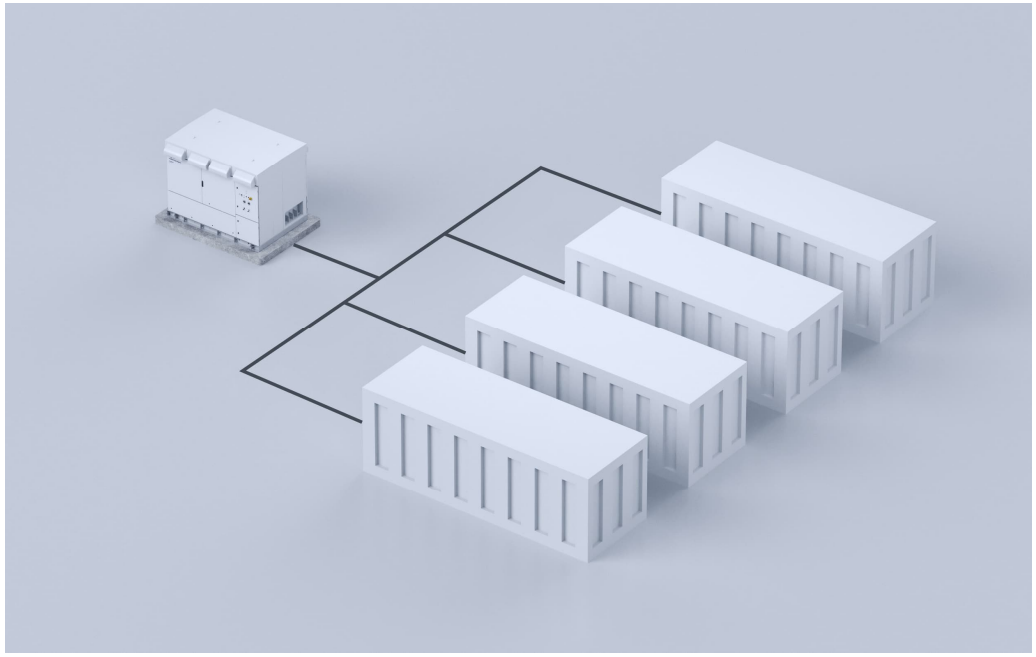
BESS DESIGNS, QA & COMMERCIAL POINTS

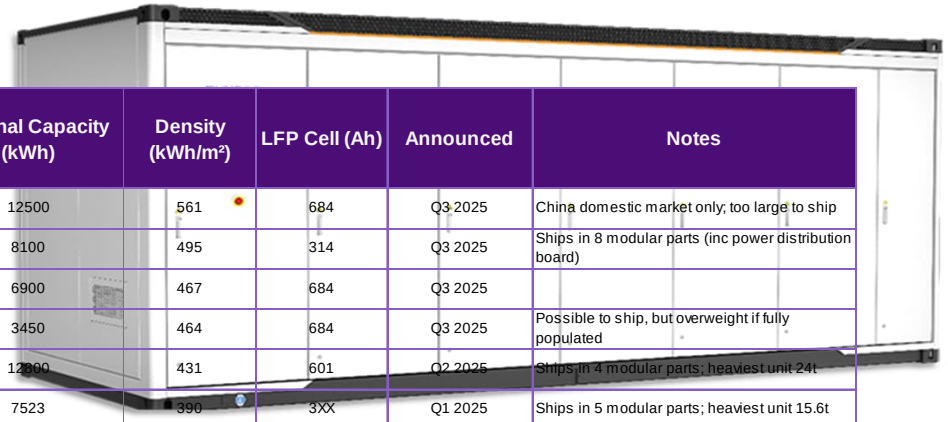
BESS Configurations

- DC block



BESS Configurations

- DC block
- AC block



No	Supplier	AC Block Product	L (mm)	W (mm)	H (mm)	Area (m²)	Weight (t)	Nominal Capacity (kWh)	Density (kWh/m²)	LFP Cell (Ah)	Announced	Notes
1	Sungrow	Power Titan 3.0 Plus 30ft*	9144	2438	2896	223	1,005	12500	561	684	Q3 2025	China domestic market only; too large to ship
2	IPS	Exeron X-BESS 8	6712	2436	2873	164	64	8100	495	314	Q3 2025	Ships in 8 modular parts (inc power distribution board)
3	Sungrow	Power Titan 3.0 Class 20ft*	6058	2438	2896	148	67	6900	467	684	Q3 2025	
4	Sungrow	Power Titan 3.0 Flex 10ft*	3048	2438	2896	74	335	3450	464	684	Q3 2025	Possible to ship, but overweight if fully populated
5	Hyperstrong	Hyperblock M	12192	2438	2896	297	96	12800	431	601	Q2 2025	Ships in 4 modular parts; heaviest unit 24t
6	Fluence	Smartstack	7376	2618	4135	193	739	7523	390	3XX	Q1 2025	Ships in 5 modular parts; heaviest unit 15.6t
7	Hyperstrong	Hyperblock III	6058	2438	2896	148	43	5016	340	314	Q2 2024	AC and DC block variants available
8	Sungrow	Power Titan 2.0	6058	2438	2896	148	42	5015	340	314	Q4 2023	
9	Wartsila	Quantum3	6410	2440	2890	156	44	5016	321	314	Q4 2024	
10	Rimac	Sinestack	2150	1420	2650	31	83	868	284	314	Q4 2023	
11	Tesla	Megapack 2XL	8800	1650	2785	145	381	3916	270	156	Q1 2023**	

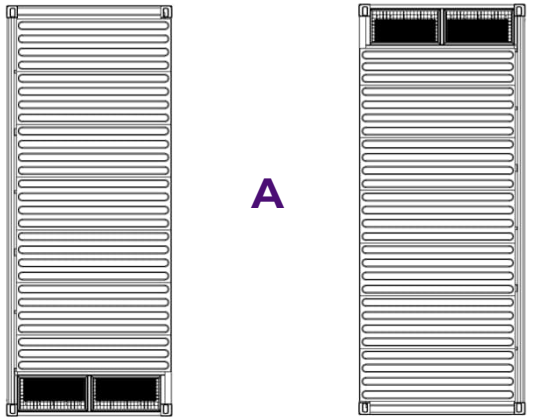
Notes:
For reference, standard ISO high-top dimensions are (L x W x H): 6058 mm x 2438 mm x 2591 mm
* Includes estimated parameters in **orange** in absence of datasheet: subject to change or update; **No official announcement, believe to be introduced early 2023 to replaced Megapack 2

Image source: https://www.linkedin.com/posts/mlkubik_energystorage-batteries-activity-7351917211445301248-REC9

BESS Configurations

- DC block
- AC block
- Separation distances

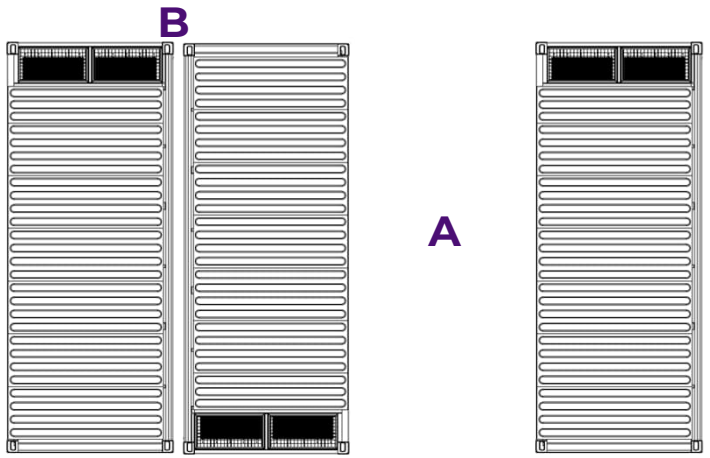
Letter	Distance (m)
A	3.1
B	
C	
D	



BESS Configurations

- DC block
- AC block
- Separation distances

Letter	Distance (m)
A	3.1
B	0.15 *
C	
D	

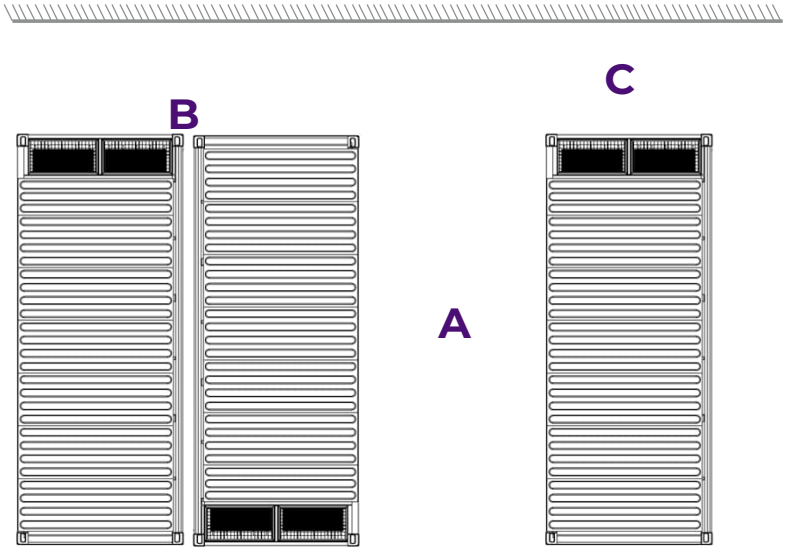


*We recommend as per the Original Equipment Manufacturer's installation manual, but this value is determined from our previous experience.

BESS Configurations

- DC block
- AC block
- Separation distances

Letter	Distance (m)
A	3.1
B	0.15 *
C	2.5 *
D	

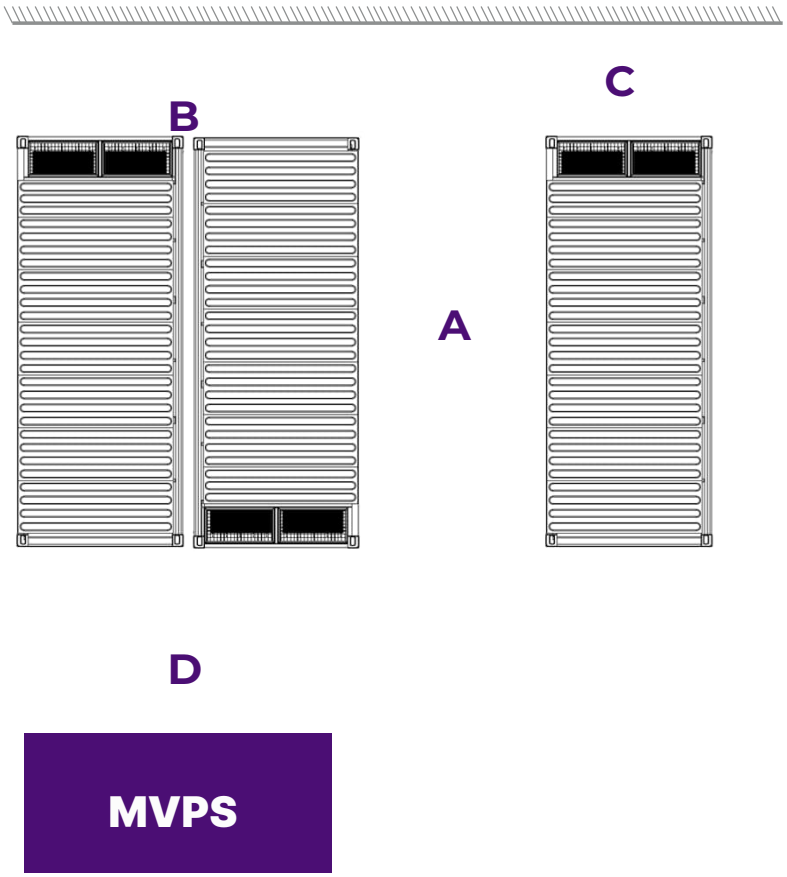


*We recommend as per the Original Equipment Manufacturer's installation manual, but this value is determined from our previous experience.

BESS Configurations

- DC block
- AC block
- Separation distances

Letter	Distance (m)
A	3.1
B	0.15 *
C	2.5 *
D	5



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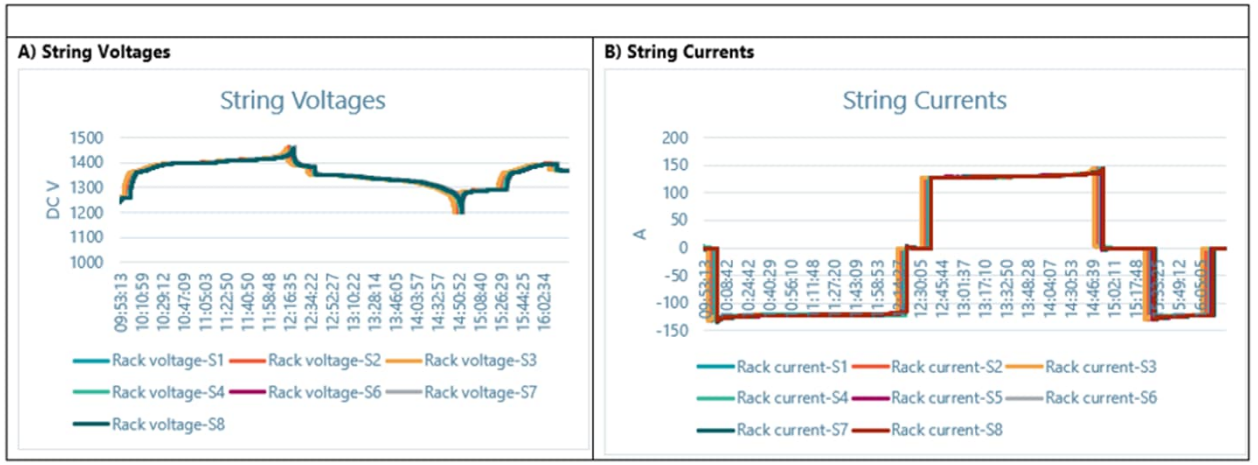
Quality & Assurance

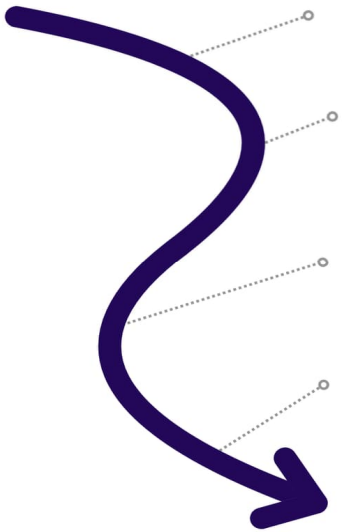
BESS Testing

FACTORY ACCEPTANCE TESTS

Figure 2-3: String Voltages and Currents



BESS Testing



FACTORY ACCEPTANCE TESTS

DELIVERY ACCEPTANCE TESTS

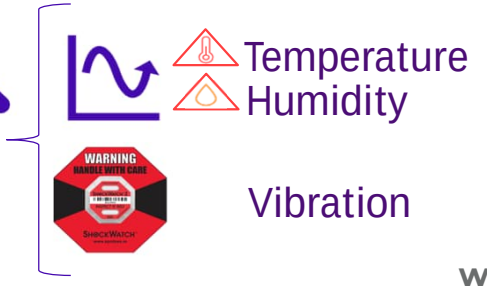


Image source: https://www.linkedin.com/posts/bydenergystorage_exciting-news-byd-energy-storage-begins-activity-7324743154966888448-1gM7?utm_source=share&utm_medium=member_desktop&rcm=ACoAACnBbQIBzjg2-y1k10_S4NWDx-oAHmuvZHA

BESS Testing

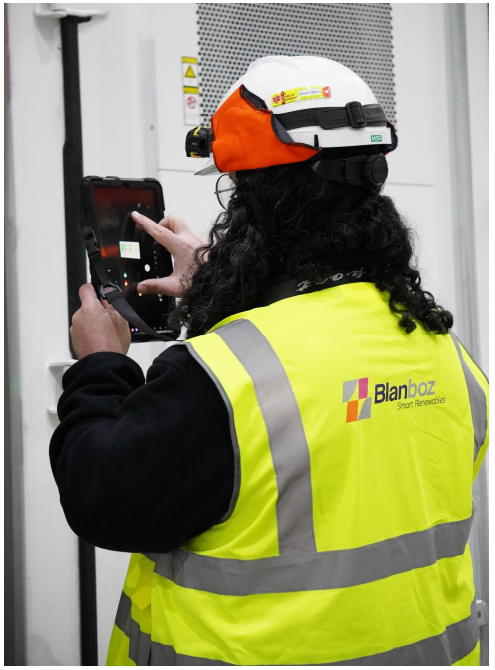
TESTS ON COMPLETION

- Clear pass/fail criteria
- Clear rejection criteria

FACTORY ACCEPTANCE TESTS

DELIVERY ACCEPTANCE TESTS

COMMISSIONING &
PERFORMANCE TESTS ON COMPLETION



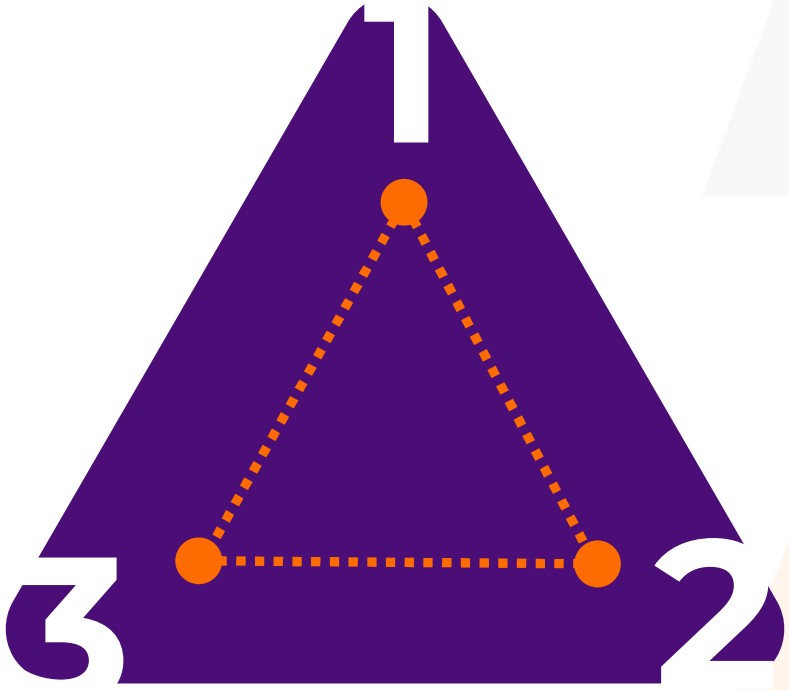
Guaranteed ≤ Actual

BESS Testing

- FACTORY ACCEPTANCE TESTS
- DELIVERY ACCEPTANCE TESTS
- COMMISSIONING & PERFORMANCE TESTS ON COMPLETION
- OPERATIONAL PHASE TESTING

Guaranteed ≤ Actual

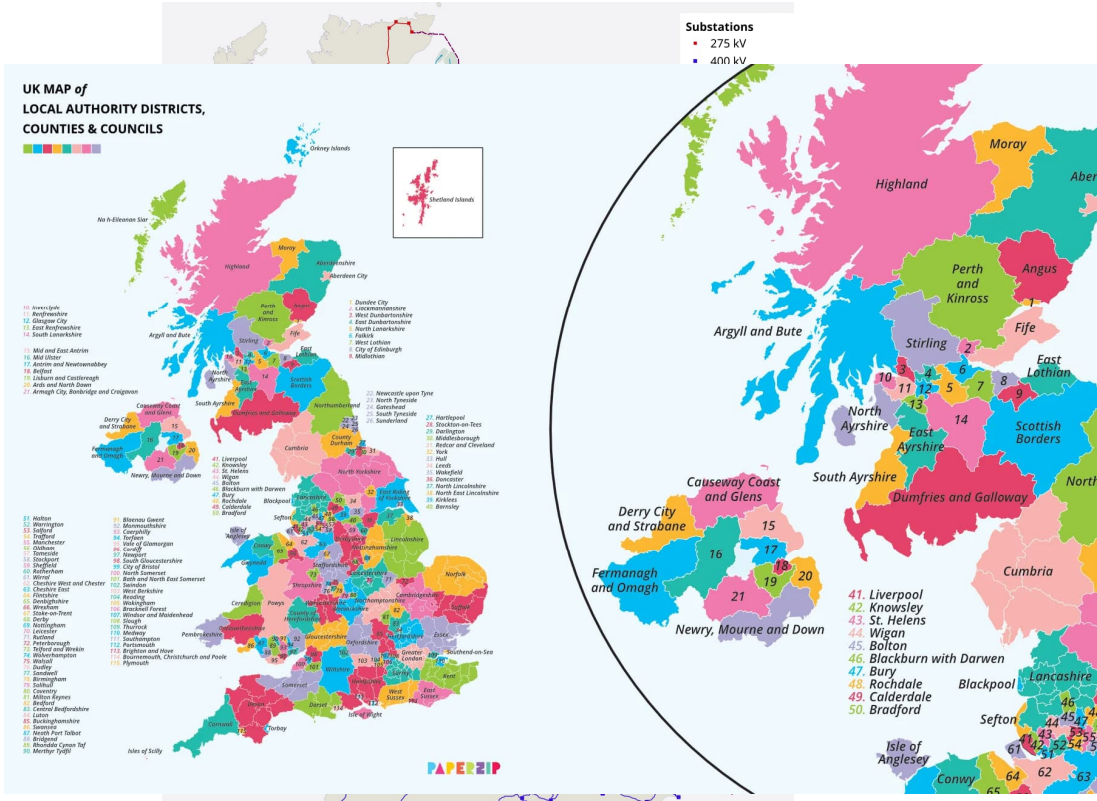
Investment for BESS



5. Investment Cost

DEVEX

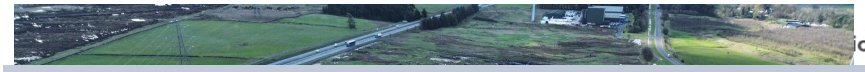
- Planning Permission – Local Planning Authority
- Grid Connection Agreement – Network Operator
- Land Rights – Land Owner
- Construction Ready

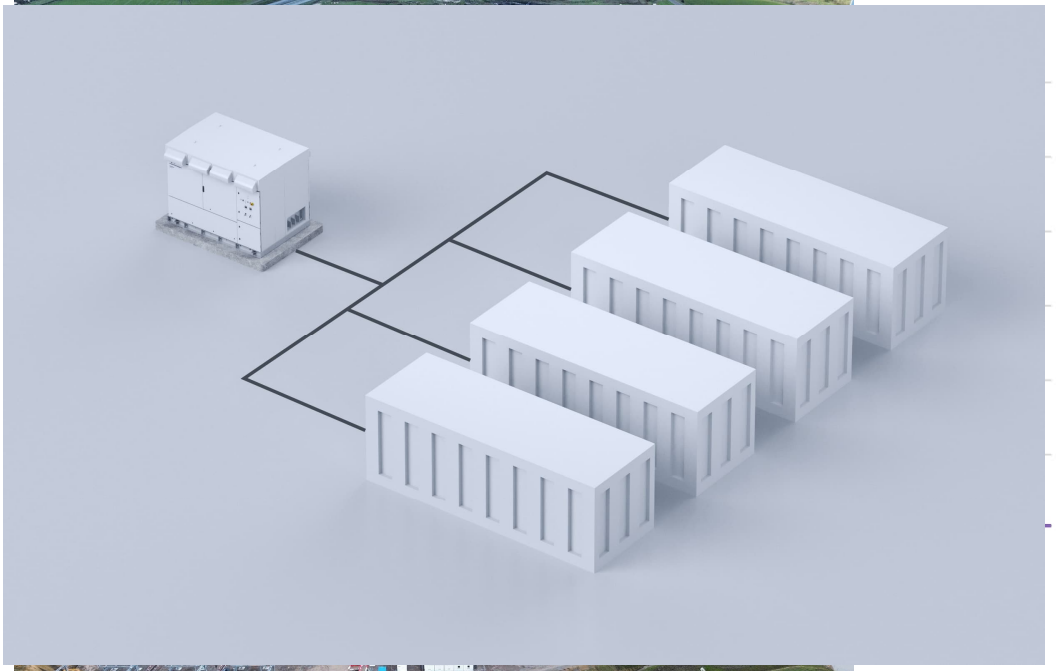


5. Investment Cost

CAPEX

- Equipment – Supply and delivery
- Civil and electrical balance of plant
- Equipment installation & commissioning
- Other take-over conditions – Training, spare parts and initial warranty





icing in China

Notes
h pricing (3GW/3GWh)
h pricing (6GW/12GWh)
h pricing (2.5GW/10GWh)

Image source: https://www.linkedin.com/posts/mlkubik_energystorage-batteries-renewables-activity-7345349000927084544-bfQ4

5. Investment Cost

OPEX

- Long term service agreements
- Augmentation
- Asset Management

State of Health (%)

Project Year	Total OPEX Costs (A+B+C+D+E)	A - Annual LTSA Fee	B - Equipment Warranties	C - Operations & Maintenance	D - Performance Guarantees	E - Other OPEX (Please specify)
Year 0 (COD)	$487,000.00			$ 267,000.00	$ 220,000.00	
Year 1	$487,000.00			$ 267,000.00	$ 220,000.00	
Year 2	$487,000.00			$ 267,000.00	$ 220,000.00	
Year 3	$832,000.00	$ 65,000.00	$ 260,000.00	$ 267,000.00	$ 240,000.00	
Year 4	$832,000.00	$ 65,000.00	$ 260,000.00	$ 267,000.00	$ 240,000.00	
Year 5	$1,017,000.00	$ 65,000.00	$ 420,000.00	$ 267,000.00	$ 240,000.00	$ 25,000.00
Year 6	$1,020,000.00	$ 68,000.00	$ 420,000.00	$ 267,000.00	$ 240,000.00	$ 25,000.00
Year 7	$1,020,000.00	$ 68,000.00	$ 420,000.00	$ 267,000.00	$ 240,000.00	$ 25,000.00
Year 8	$1,024,000.00	$ 72,000.00	$ 420,000.00	$ 267,000.00	$ 240,000.00	$ 25,000.00
Year 9	$1,032,000.00	$ 72,000.00	$ 428,000.00	$ 267,000.00	$ 240,000.00	$ 25,000.00
Year 10	$1,032,000.00	$ 72,000.00	$ 428,000.00	$ 267,000.00	$ 240,000.00	$ 25,000.00
Year 11	$1,079,000.00	$ 72,000.00	$ 440,000.00	$ 267,000.00	$ 250,000.00	$ 50,000.00
Year 12	$1,079,000.00	$ 72,000.00	$ 440,000.00	$ 267,000.00	$ 250,000.00	$ 50,000.00
Year 13	$1,088,000.00	$ 81,000.00	$ 440,000.00	$ 267,000.00	$ 250,000.00	$ 50,000.00
Year 14	$1,088,000.00	$ 81,000.00	$ 440,000.00	$ 267,000.00	$ 250,000.00	$ 50,000.00
Year 15	$1,123,000.00	$ 81,000.00	$ 475,000.00	$ 267,000.00	$ 250,000.00	$ 50,000.00
Year 16	$1,155,000.00	$ 88,000.00	$ 475,000.00	$ 267,000.00	$ 250,000.00	$ 75,000.00
Year 17	$1,155,000.00	$ 88,000.00	$ 475,000.00	$ 267,000.00	$ 250,000.00	$ 75,000.00
Year 18	$1,180,000.00	$ 88,000.00	$ 500,000.00	$ 267,000.00	$ 250,000.00	$ 75,000.00
Year 19	$1,180,000.00	$ 88,000.00	$ 500,000.00	$ 267,000.00	$ 250,000.00	$ 75,000.00
Year 20	$1,213,000.00	$ 91,000.00	$ 500,000.00	$ 267,000.00	$ 255,000.00	$ 100,000.00
Total	$20,610,000.00	$1,377,000.00	$7,741,000.00	$5,607,000.00	$5,085,000.00	$800,000.00

Eliminating and Reducing Commercial Risks

- Detailed and concise technical specifications
- Detailed division of responsibilities
- Incoterms
- Payment Terms

DOR or RACI Matrix

R	A	C	I
	BESS	GRID	
	BOP	EMP	

Responsible
Accountable
Consulted
Informed

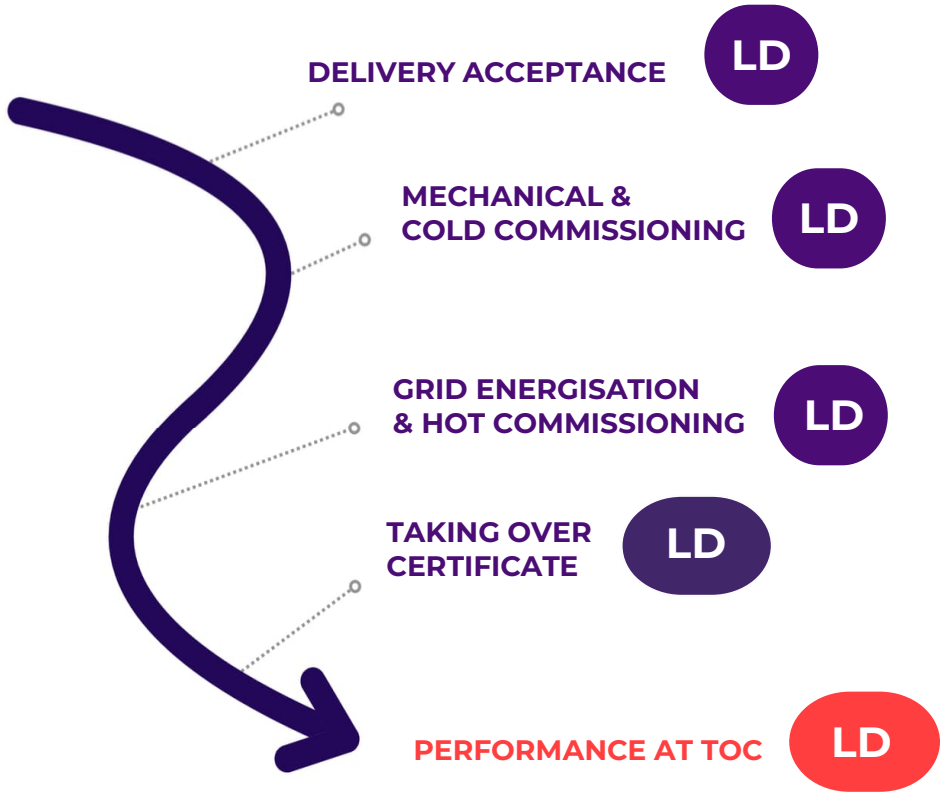
Incoterms	FOB	DAP	DDP
Owner's Risk	😭	😟	😉

COST NEUTRAL APPROACH

50% **50%**

Eliminating and Reducing Commercial Risks

- Detailed and concise technical specifications
- Detailed division of responsibilities
- Incoterms
- Payment Terms
- Liquidated Damages (Delay and Performance)



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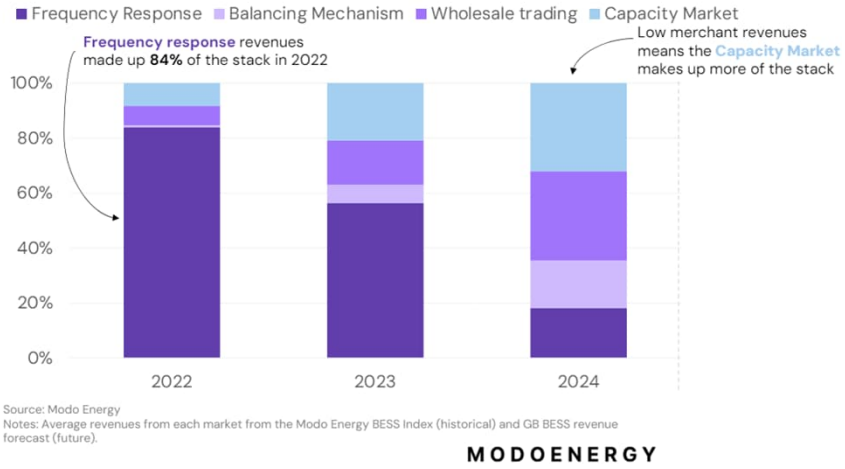
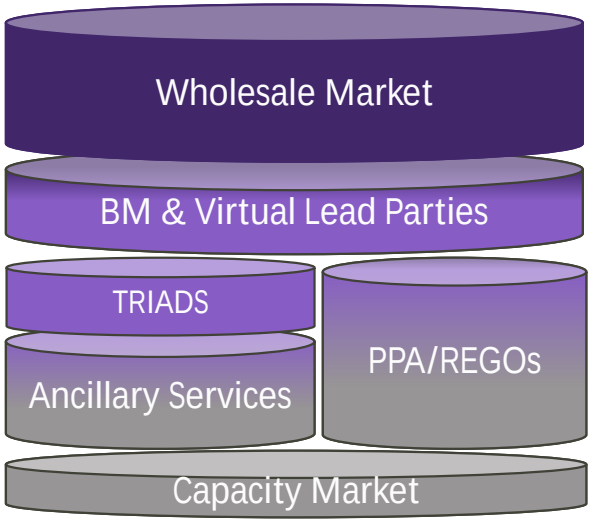
MARKETS & FUTURE OF BESS

Services Available

- Stacked-Up revenue model





→ Balancing Reserve, Obligatory Services, Slow Reserve, among others

→ Revenues expected to drop through reduced peak charges

→ DC, DR and DM – Volume reduced considerably

→ CM clearing price T-4 £60/kW/yr (2025) with a de-rating factor of 20.94% /2h

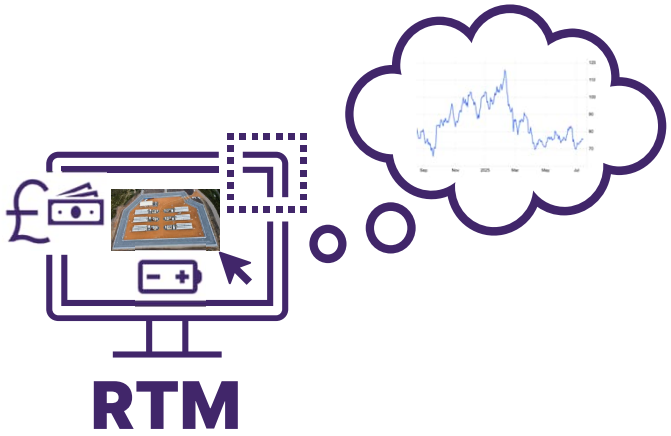
→ Day ahead, intraday, and real time
- Electricity trading strategies
- Trading platform

→ >= 1MW & BM Units

→ Increased volume of electricity sold. Increased development of co-located solar PV + BESS

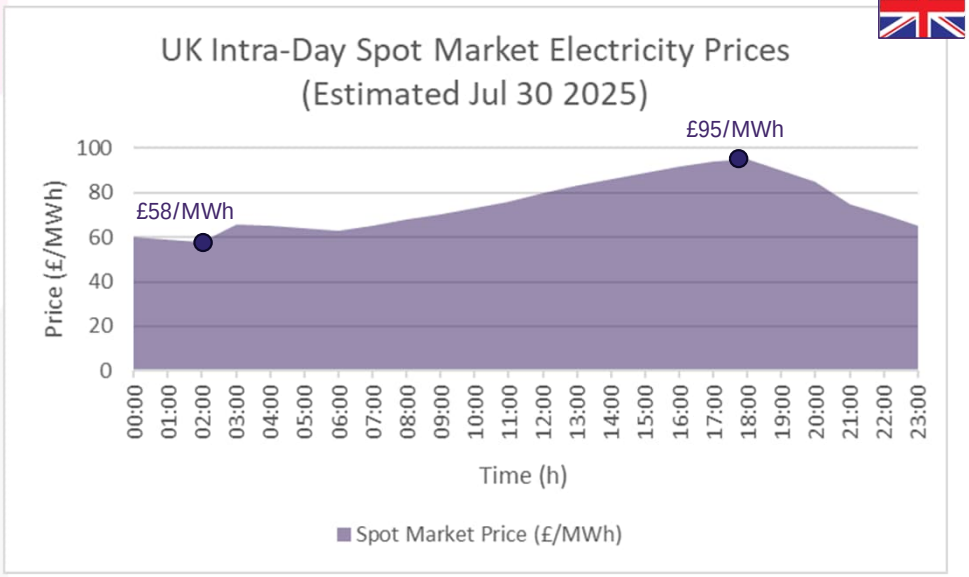
Services Available

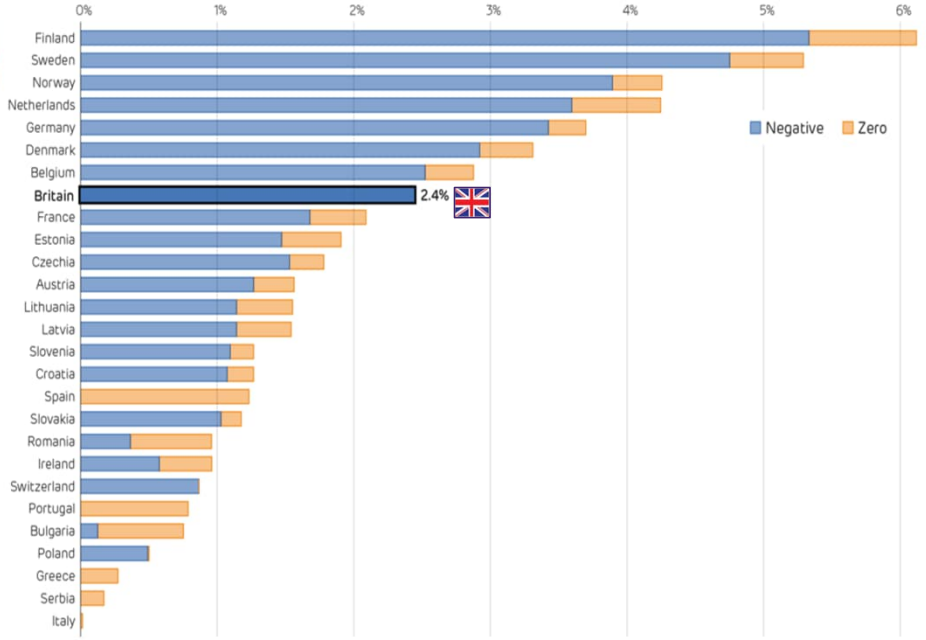
- Stacked-Up revenue model
- Operators / Route-to-Market (RTM) Providers & trading models



Low Risk	High Risk
Floor Price	Merchant
Tolling	

Wholesale Electricity Market





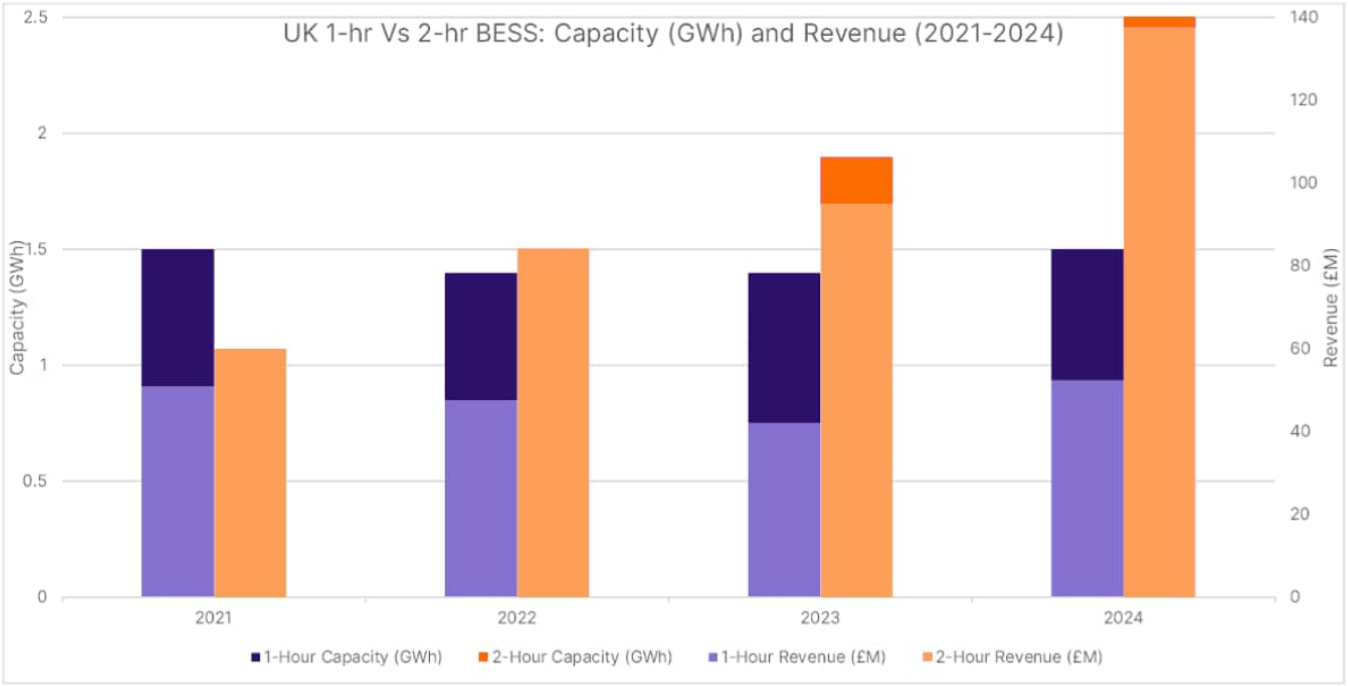
https://reports.electricinsights.co.uk/q4-2023/the-rise-of-negative-power-prices/

The Future of BESS

- Technology & Duration

Sodium, solid batteries, redox flow (Vanadium batteries), zinc batteries

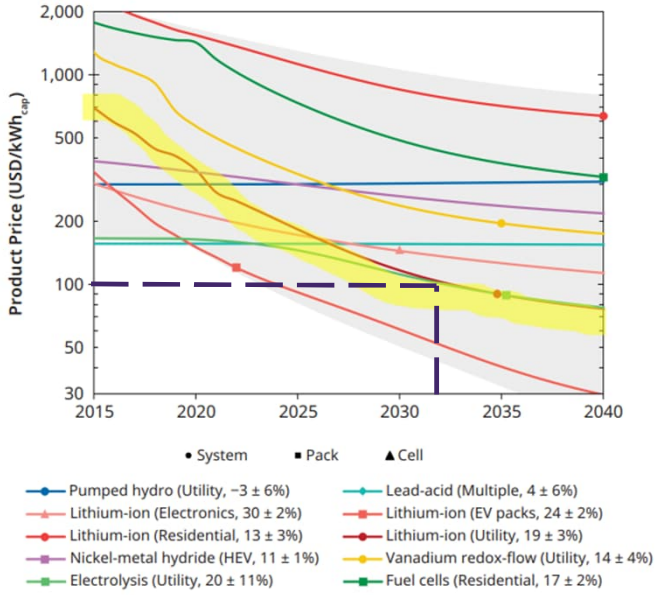
Li-ion KING



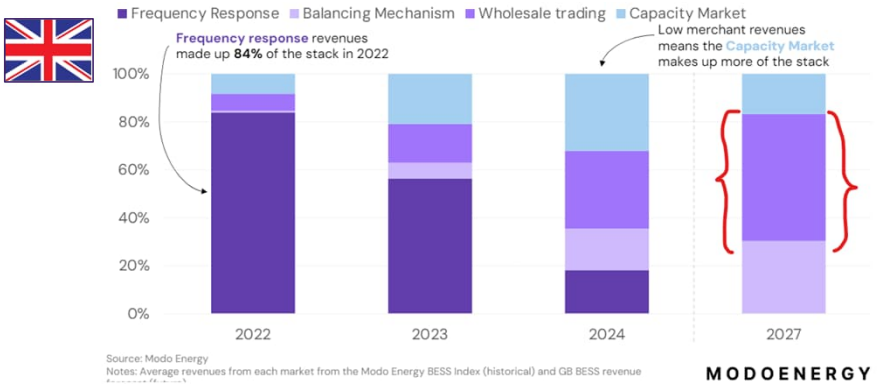
Sources:
- Modo Energy reports on capacity growth, revenue trends, and 1-hour vs. 2-hour system performance.
- Energy-Storage.News on market trends and project durations.
- RenewableUK and Statista on pipeline and operational capacity.
- Cornwall Insight and Pacific Green on revenue streams and market outlook.

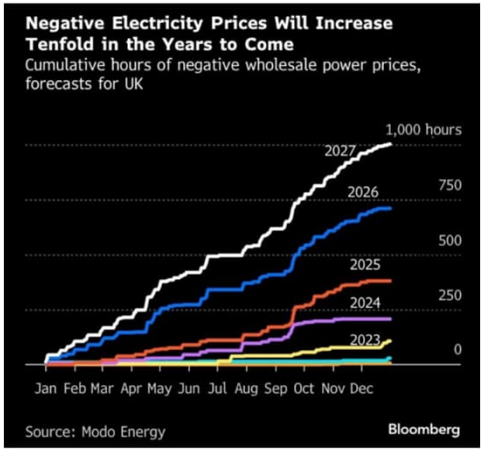
The Future of BESS

- Technology & Duration
- What the Future Might Look



Schmidt, O. Staffell, I. Monetizing Energy Storage. Oxford University Press. 2023





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Smart Renewables

WRAPPING UP, Q&As

40

Wrapping Up!

- We need BESS to meet the **Net CO_2 targets** and **Energy Security**
- **Fire and explosion risks** are becoming **more manageable**
- The **battle between AC and DC solutions continues** strong
- **All stages of testing** are crucial to a successful project
- **Li-ion** will be **king** at least until **2030**, but **other chemistries** will **make their way**
- **Wholesale electricity** market will be the **primary revenue** source, whilst **frequency services** will be **minimal**

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A presentation by Andres Blanco

THANK YOU!

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Q&A's

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