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Webinar

DEEP DIVE

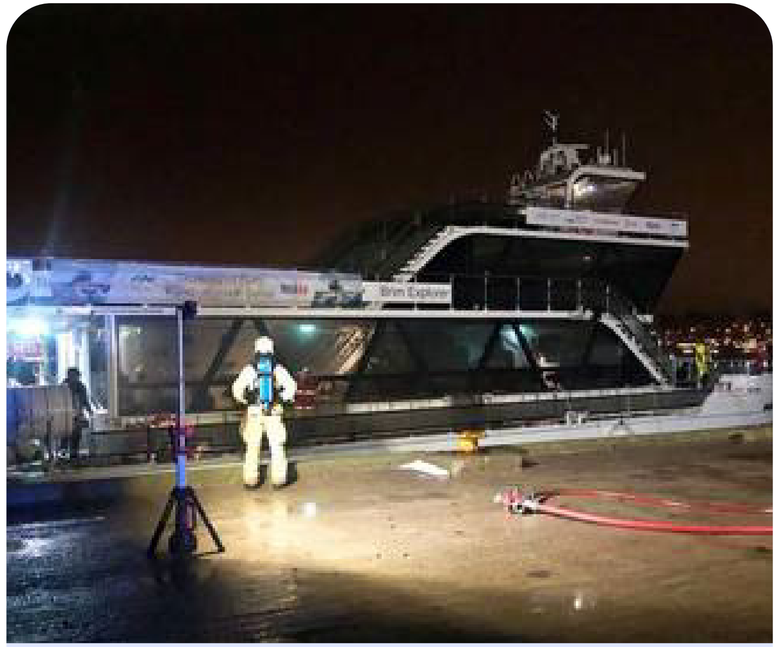
Perspectives on Battery Safety in Marine Transportation and Applications

Sandith Thandasherry

Why Battery Safety?

MF YTTERØYNINGEN

Victorian Big Battery (VBB)



MS BRIM

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Solar Electric Boat

Boat Except System

System

(Energy, Production, Storage, Usage)

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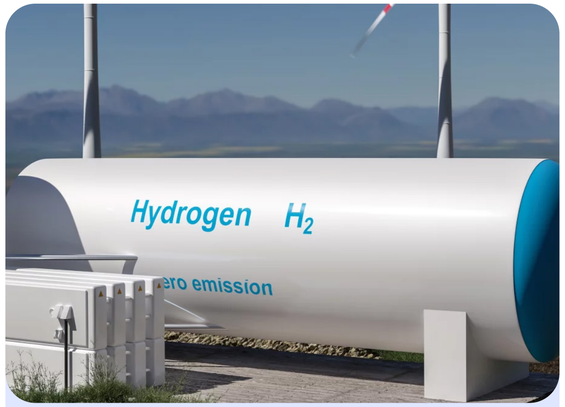
Types Of Energy

Grid + Battery

Solar

Wind



H2 fuel + Fuel cell

Diesel Fuel + Engine

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Combination

Boats (<50m)

Solar 50%

Battery 50%

Small Ships

Hydrogen fuel cell

Solar

Wind

Diesel

Battery

Large Ships

Hydrogen fuel cell 79%

Wind 20%

Solar 1%

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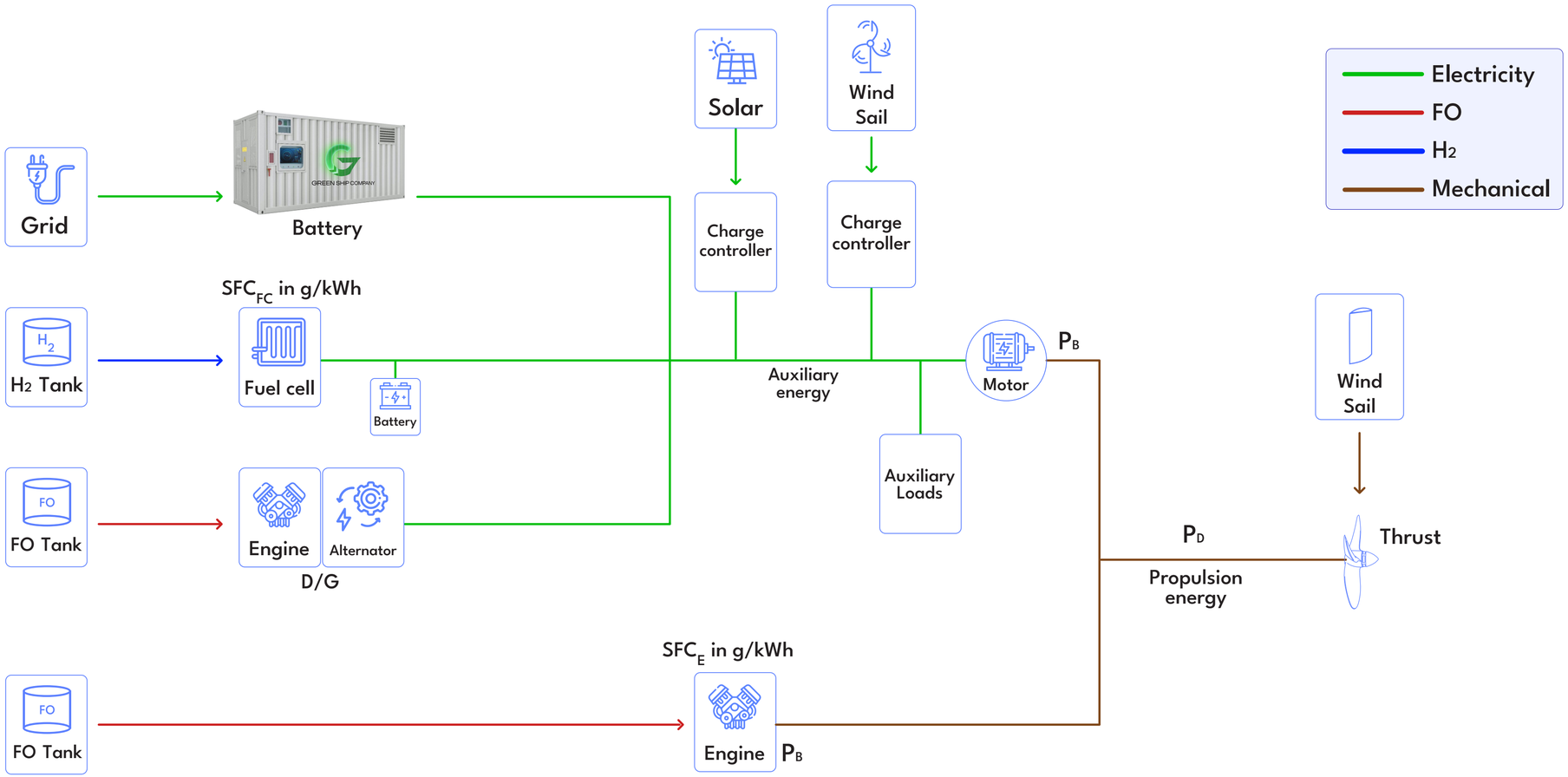
Battery



Sizing	Safety
Chemistry	Meet functional needs (speed, range,...)

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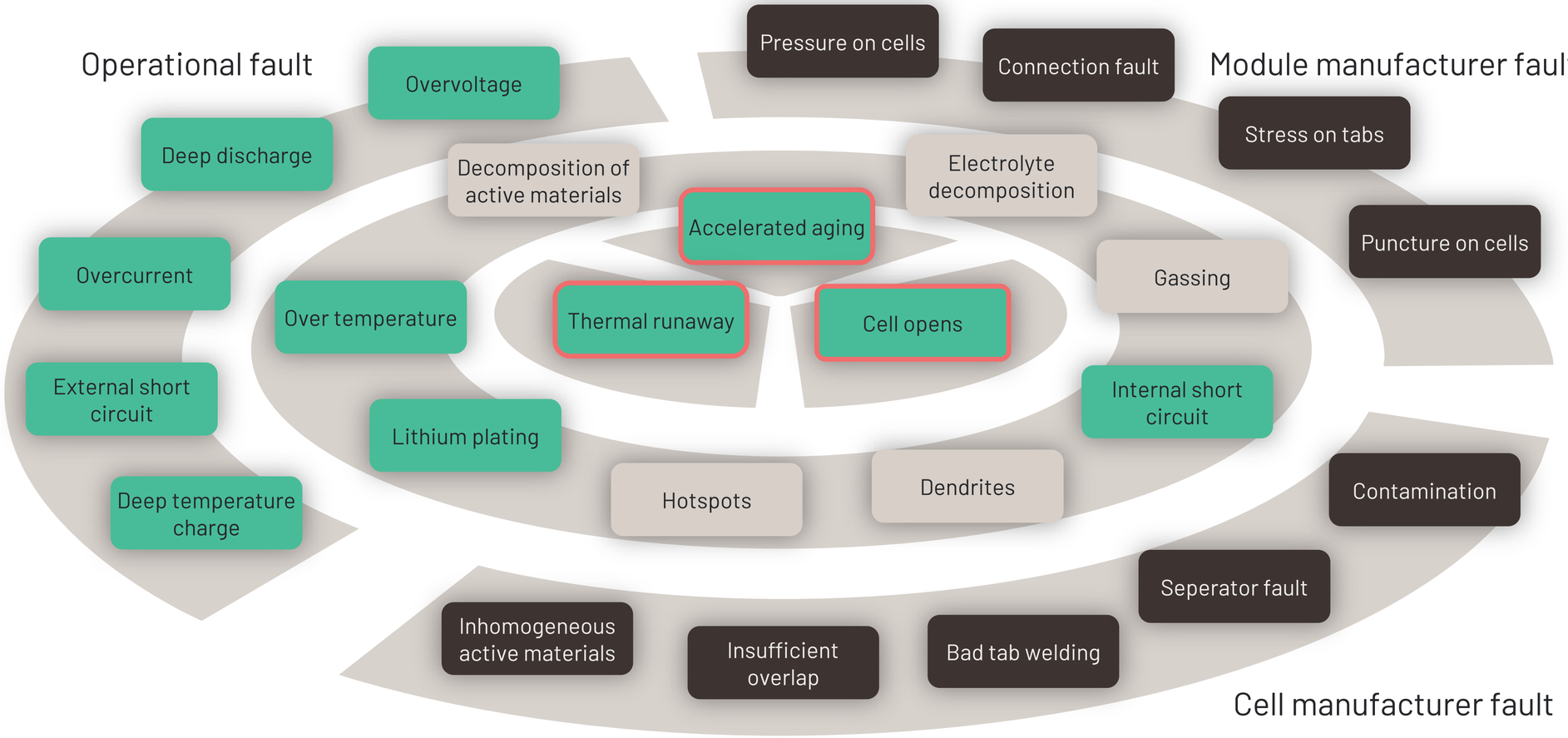
Safety



Source:Accure

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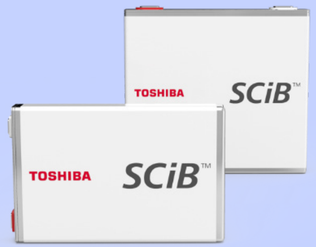
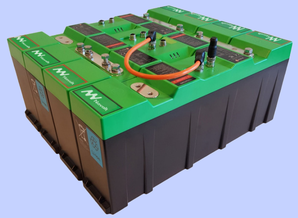
Chemistry



LTO
Lithium Titanium Oxide



LFP
Lithium Iron Phosphate

NMC

NMC
Lithium Nickel Manganese Cobalt Oxide

LCO

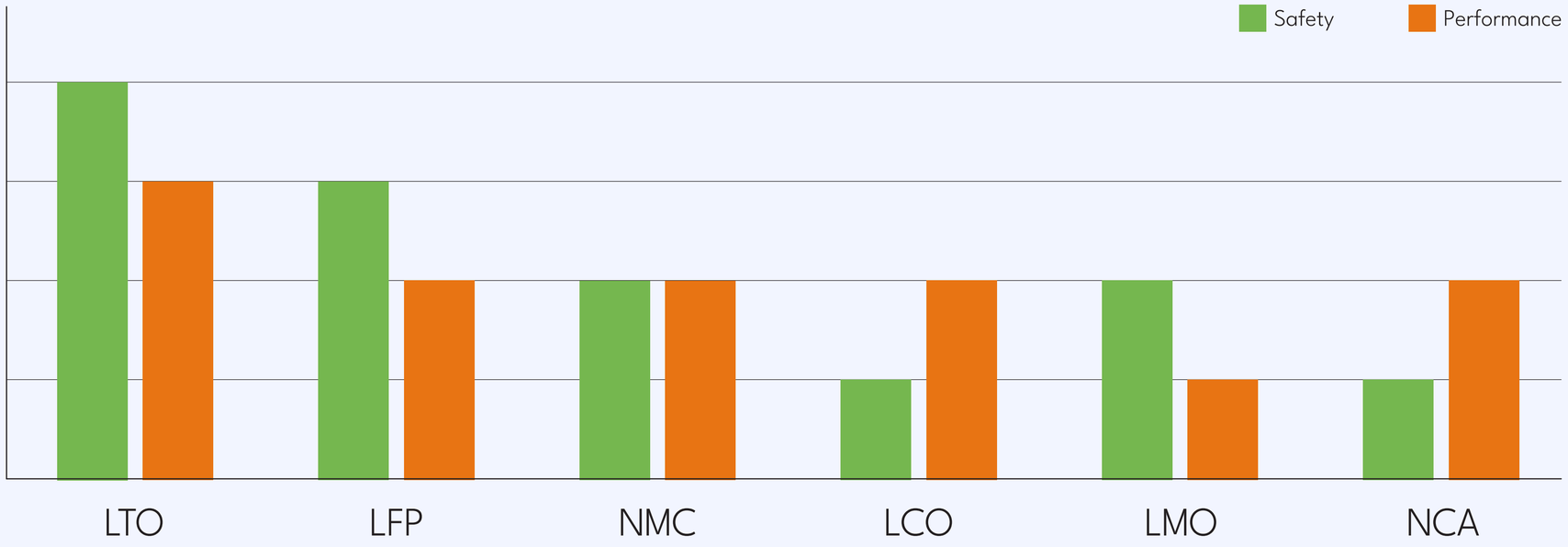
LCO
Lithium Cobalt Oxide

LMO

LMO
Lithium Manganese Oxide

NCA

NCA
Lithium Nickel Cobalt Aluminium Oxide



Charging	:	4C	0.5C
Discharging	:	2C	1C

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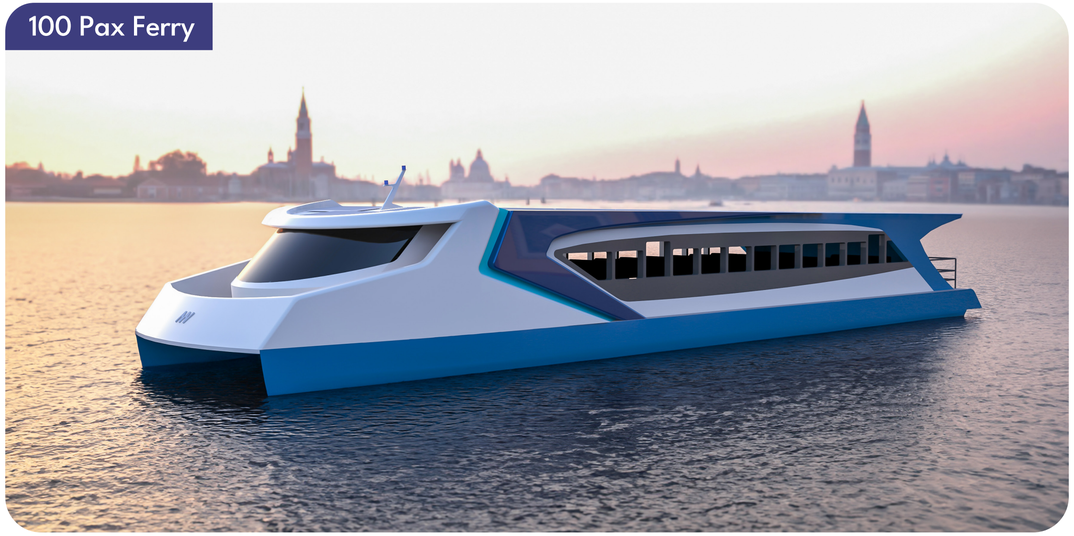
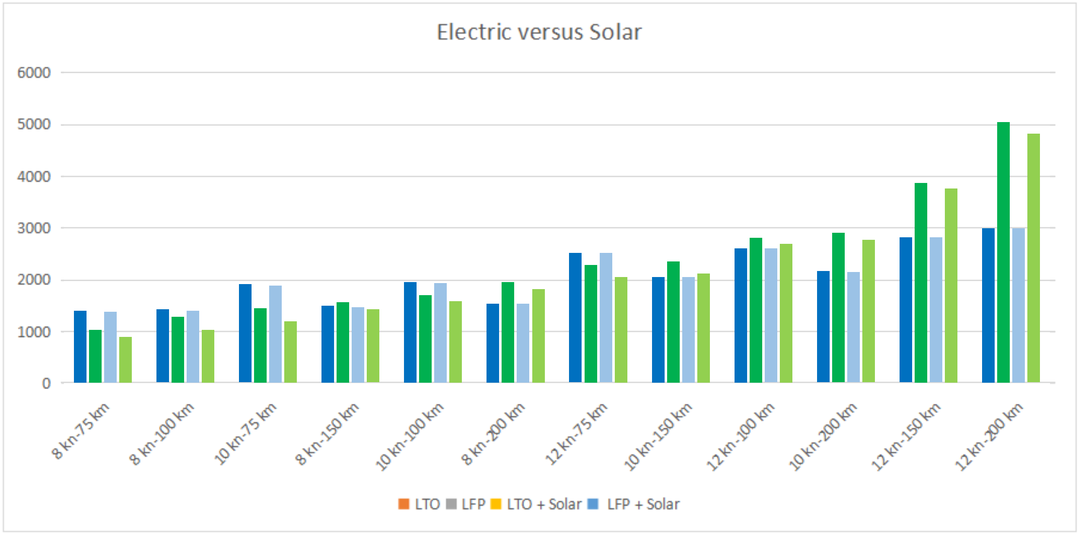
Chemistry - Economics



							5 USD/kg	3 USD/kg	2 USD/kg
Speed-Range	**Energy/day**	**Diesel**	LTO	LFP	**LTO + Solar**	**LFP + Solar**	H2+LFP+Solar (5$/kg)	H2+LFP+ Solar (3$/kg)	H2+LFP+ Solar (2$/kg)
8 kn-75 km	324	1000	1394	1042	1382	904	1512	1371	1308
8 kn-100 km	398	1141	1426	1291	1415	1046	1618	1433	1352
10 kn-75 km	458	1277	1902	1447	1892	1202	1858	1639	1541
8 kn-150 km	548	1422	1490	1573	1480	1438	1882	1610	1489
10 kn-100 km	578	1498	1953	1715	1945	1581	2054	1765	1636
8 kn-200 km	698	1699	1554	1963	1546	1830	2146	1786	1627
12 kn-75 km	772	1912	2517	2285	2512	2044	3254	2851	2673
10 kn-150 km	818	1946	2055	2361	2050	2121	2472	2042	1852
12 kn-100 km	998	2334	2613	2817	2611	2687	3627	3092	2855
10 kn-200 km	1058	2394	2157	2899	2155	2770	2889	2319	2067
12 kn-150 km	1448	3169	2805	3878	2808	3755	4393	3596	3243
12 kn-200 km	1898	4009	2996	5049	3005	4822	5160	4100	3631

Always LFP + Solar < LFP and LTO + Solar < LTO. Hence solar is always cheaper than electric



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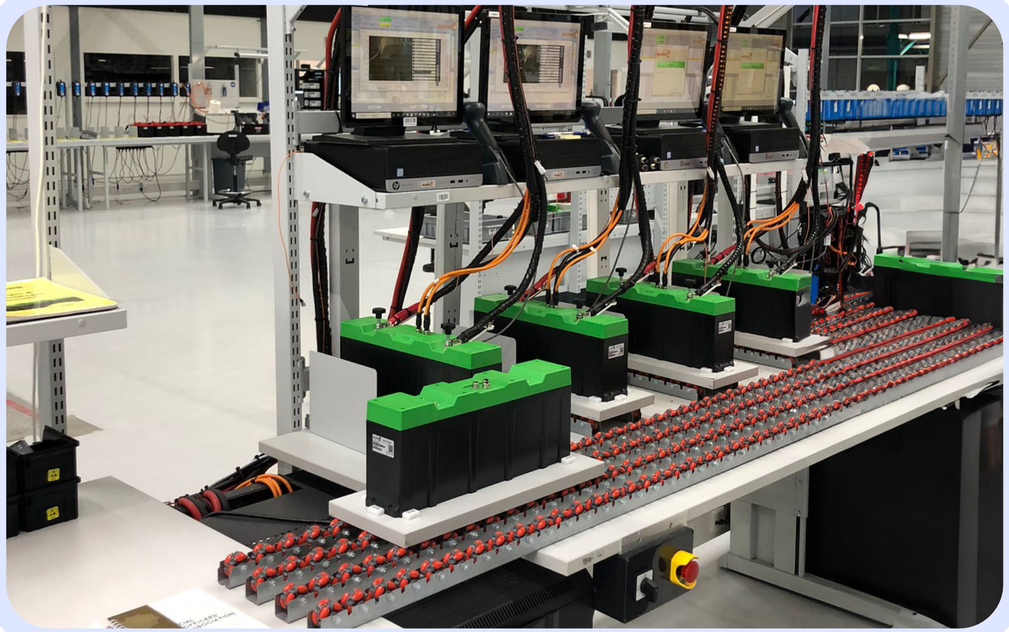
Safety - Cell

List of tests based on IEC 62619, 62620

- External short circuit - between +ive and -ive shall not cause fire or explosion
- Impact - to cell shall not cause fire or explosion
- Drop test - drop shall not cause fire or explosion
- Thermal abuse - elevated temperature shall not cause fire or explosion
- Overcharge - charging for longer periods shall not cause fire or explosion
- Forced discharge - can withstand force discharge without causing fire or explosion
- Internal ac resistance test
- Internal dc resistance
- Endurance in cycle are designed for cyclic application
- Endurance in storage at constant voltage to be conducted



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Safety - BMS

List of items monitored by BMS

- Battery charging/discharging
- Battery temperature (At cell level)
- Cell Balance
- Cell Voltage
- Available Power
- Battery system shut down
- Battery system breaker trip

List of items monitored at Control station

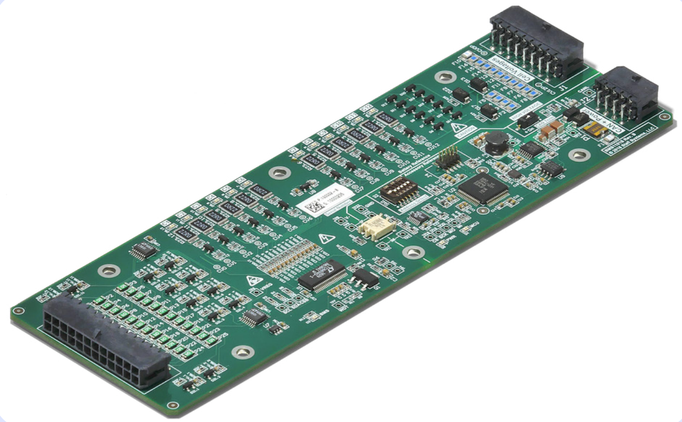
- Cell temperature and voltage
- Battery current
- Battery space temperature
- Battery charge and discharge
- Available charge
- Available energy
- Failure of ventilation

Audio and visual alarms at wheel house

- Operation of the battery protective device
- Cell temperature high
- Battery space high temperature
- Ventilation fan running status (On/Off)
- Cell voltage - Overall voltage
- Opening of cell safety venting device or high pressure in the battery
- State of charge - Minimum alarm at manned local station and at bridge
- Gas detection

List of tests based on IEC 62619, 62620

- Tests and approval along with system level tests



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Safety - System

List of tests as per IEC 62619, 62620

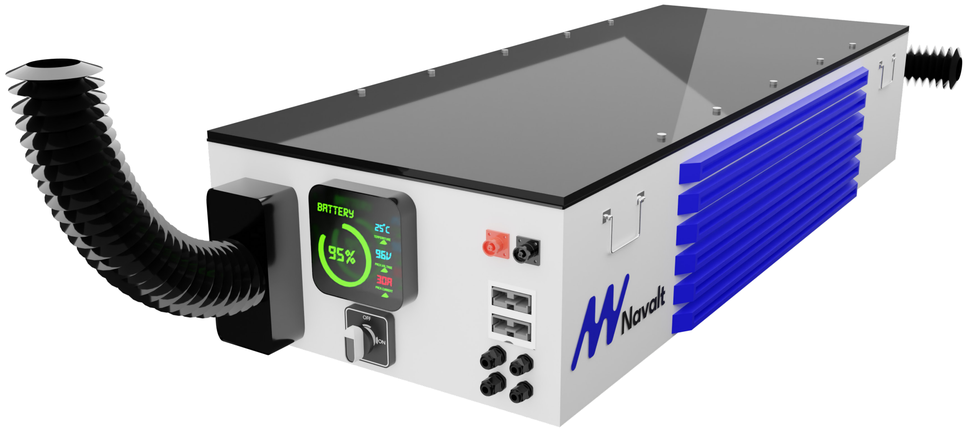
- Propagation/internal thermal event
- Overcharge with voltage
- Overcharge with current
- Overheating control
- Capacity validation
- Di-electric strength - to verify high voltage withstanding capacity
- Insulation resistance
- Pressure test of cooling system (if liquid cooled)
- Discharge performance at 25 deg C
- Discharge performance at low temperature
- High rate permissible current

Environmental tests

- Vibration
- Dry heat
- Damp heat
- Cold (if placed outside)
- Corrosion (if placed outside)
- Flame retardant
- EMC

Safety - Ventilation and Cooling

- Independent ventilation system
- Air inlet near floor level
- Normal : 2 air changes/Hour
  Emergency : 6 air changes/Hour
- Exhaust automatically activated when gas detection
- Cooling - Air cooled, water cooled



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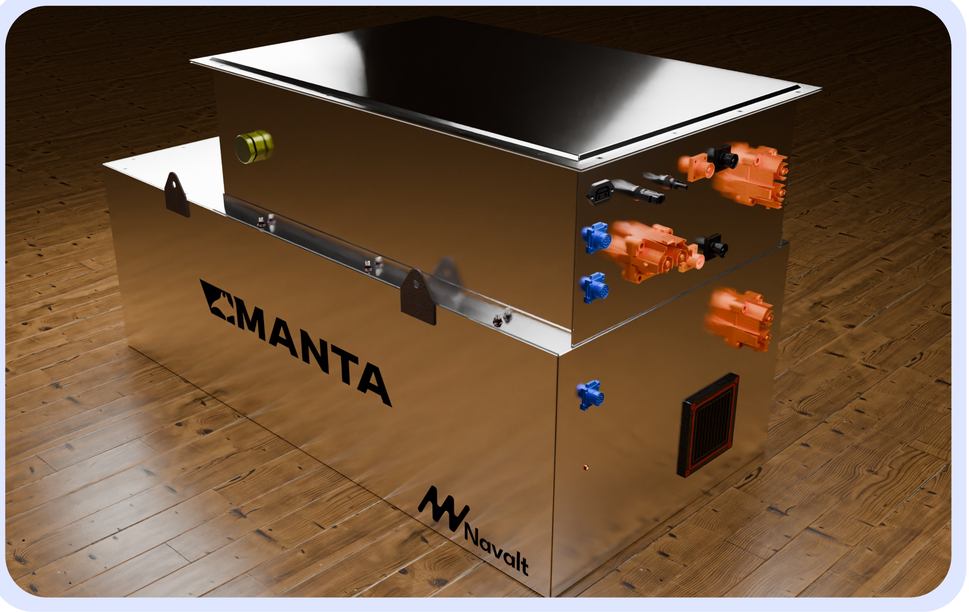
Safety - Gas detection

Battery space

- Smoke detectors as per FSS code
- Fire detection system
- Gas detection system as per chemistry.



Our practice - Position gas detection inside battery, near exhaust fan

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Safety - Other sensors

- Pressure sensor inside battery box to detect bulging
- Temperature sensor inside box and on bus bar (4 no.s)

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Safety - Fire Protection

- A60 insulation in battery compartment above water level
- Fixed water based extinguishing system
- Additional portable DCP or CO2 system

Safety - VCU (Vessel Control Unit) / Marine specific

- Level - L1 (info), L2 (slow down), L3 (shut down)
- Motors

High Temperature	→	Cut off the motor (Propulsion) load
High Current		Auxiliary will be active

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Safety - VCU (Vessel Control Unit) / Marine specific

Solar plant and MPPT

- Pack voltage is used to decide cut off by MPPT but individual cell voltage using BMS need to be monitored to cut off solar plant.

Solar only in bulk charging

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Safety - VCU (Vessel Control Unit) / Marine specific

- Shore charging must be CAN based to enable BMS communication to cut off charger if any discrepancy
- If the CAN communication is disconnected, the charger to be disconnected

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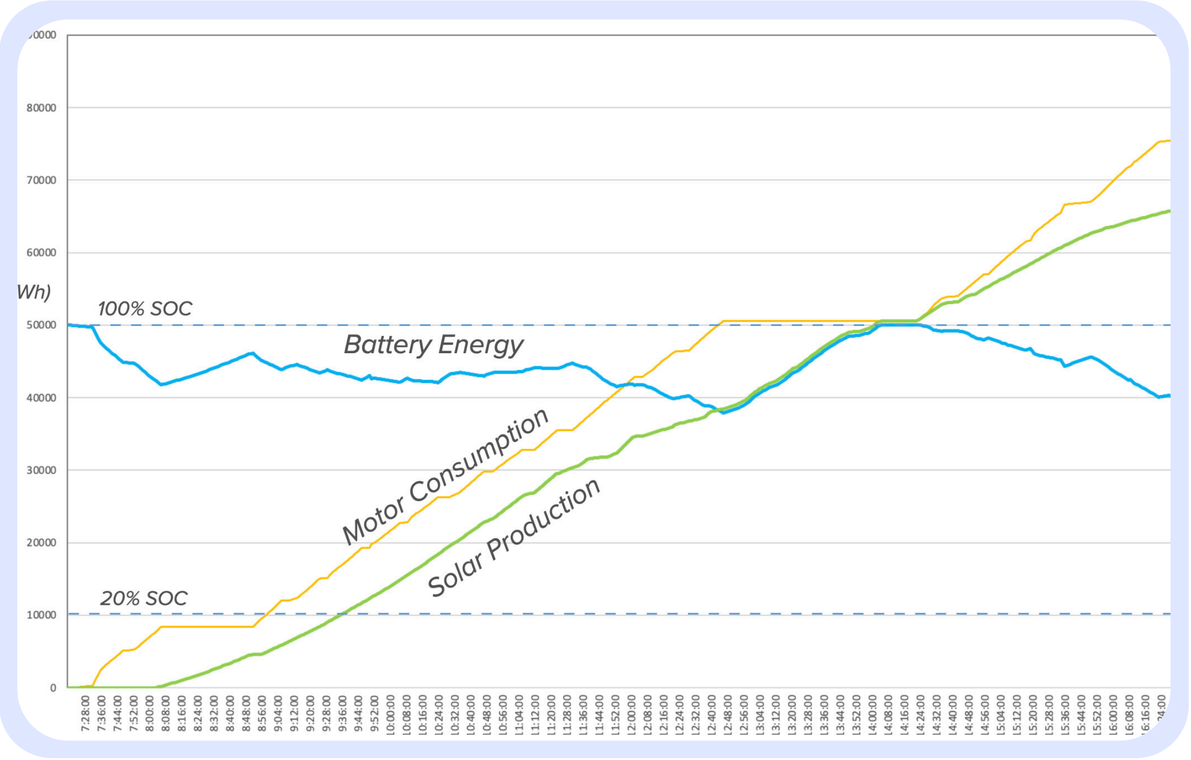
Safety - Remote Monitoring



Aditya - 7+ Years Running

India's First Solar Ferry

2.2 million passengers

250,000 Litres Of Diesel Saved

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Thank You.