

Which battery for your ship?

A simplified guide to help you decide

-Page 1-

Types of Li-ion batteries

NMC

Nickel
Manganese
Cobalt

LFP

Lithium
Iron
Phosphate

LTO

Lithium
Titanate

Currently, Lithium-ion batteries are best suited for powering ships. However, there are many different types of li-ion batteries, each of them optimized for a different type of application. In maritime battery systems we mainly use NMC, LFP and LTO.

Battery cells

The smallest building block of a battery system is the battery cell. Cells come in different shapes and sizes, resulting in a varying performance per type of cell.



Cylindrical



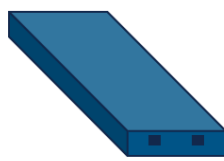
Prismatic



Pouch



Modules



Trays



Racks



Blocks

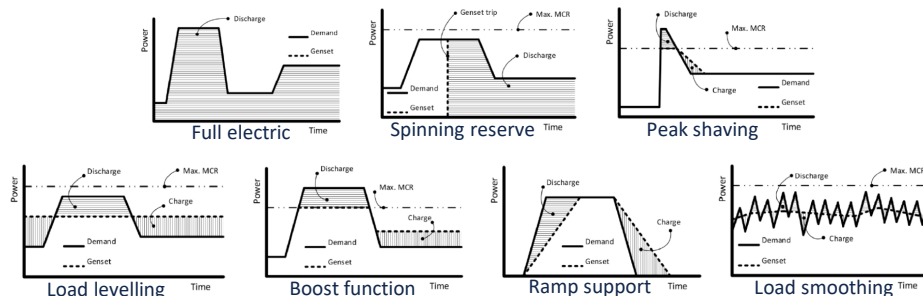
Battery system design

Also battery systems come in different shapes and sizes, varying in flexibility in design and ease of integration. Some systems can be more easily fitted on smaller ships, others are more optimized for larger ships.

The exact type of battery cell being used has its impact on certain aspects of the battery system, but is mainly important for the battery manufacturer's design choices. When selecting a battery system for a ship, what matters most is how the battery will be used regarding the required energy, (dis)charge power and the number of times the batteries will be charged and discharged, also known as the number of cycles. This will have impact on the ideal battery system design for your specific vessel when it comes to weight, volume, costs, performance, and lifetime.

Battery application

Batteries can be used for all different kinds of applications on board of ships. Not all ships can be fully powered by batteries, but every ship can benefit from installing a battery, creating a hybrid or plug-in hybrid system. This can be for zero-emission sailing, increasing the energy efficiency, or enhancing the performance of the ship.



Primary requirements to select a battery

- Minimum required usable energy in kWh
- Maximum discharge power in kW
- Maximum charge power in kW
- RMS value (dis)charge power in kW
- Number of cycles per year
- Time per (dis)charge period

(RMS = Root mean squared value)

Operational profile

To make the right decision on which battery to select, you should start with defining the operational profile of the batteries. Some ships will have different operational profiles, depending on the conditions or operational activities. The more elaborate you define the operational profile, the more you can optimize the battery design. The most important information for the battery manufacturer to receive is listed here to the left. It is not recommended to define a total installed capacity to a battery manufacturer, as this is very much depending on the type of battery in combination with the operational requirements

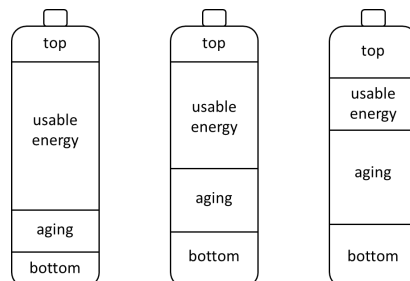
Which battery for your ship?

A simplified guide to help you decide

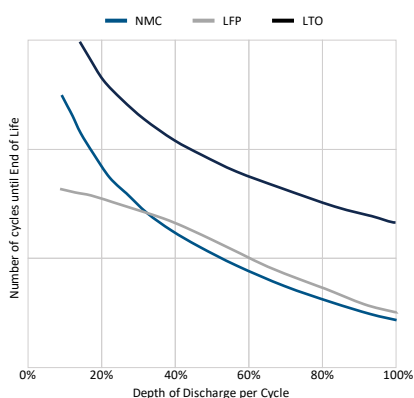
-Page 2-

Battery sizing

The total installed capacity that is required depends on the type of battery and the operational profile. Typically the top and bottom SOC are not used to increase the expected lifetime of the batteries. Depending on the usage of the batteries, the capacity will decrease over time, this is called aging. This results in only a certain part of the capacity that can be considered as usable. The total required installed capacity for your ship can be calculated by the battery manufacturer as they know their batteries best. Different batteries require different sizing strategies.



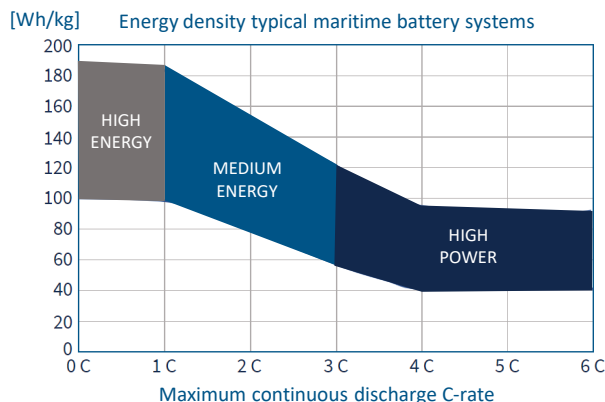
Effect of DOD on lifetime (varies per battery)



Performance

The performance of a battery system depends on multiple factors. In general, maritime battery systems can be classified as high energy, medium energy and high power batteries, based on the energy density and the maximum continuous discharge C-rates they can endure.

All batteries can be used for all types of ships, but some are more suitable than others depending on factors such as weight, volume and costs. These all need to be assessed to create a complete picture of the battery system design and to be able to compare different types of battery systems with each other.



Other requirements

There are many other things that can be considered when selecting the right battery system for your ship. Here is a list of the main aspects that should not be forgotten.

- **Voltage** – what is the required voltage range for the batteries
- **System costs** – system costs vary between 400-800 €/kWh
- **Cycle costs** – also calculate the costs per cycle depending on lifetime
- **Safety** – cell or module level thermal runaway propagation insulation
- **Firefighting** – water mist, foam or inert-gas, depending on IP-rating
- **Ventilation** – Closed or open ventilation system for emergencies
- **Gas detection** – is gas detection integrated in battery system or not
- **Cooling** – liquid or air cooled, depending on environment and use

Terms and abbreviations

SOC = State of charge
SOH = State of health
DOD = Depth of discharge
EOL = End of Life
C-rate = (dis)charge rate (kW/kWh)
kW = kilowatt (power)
kWh = kilowatt-hour (energy)

For more questions about maritime batteries, reach out to the Maritime Battery Forum via director@maritimebatteryforum.com