



## Marine Battery Systems

High performance, European-made lithium-ion battery systems for marine applications

## Why?

- We believe that zero emission technologies should be the “mainstream solution” for power transportation – not just an alternative.
- International shipping is a large and growing source of greenhouse gas emissions accounting for around 3% globally.
- Electrifying vessels contributes to a notable reduction of greenhouse gas emissions, while also offering performance improvements, providing back-up power and offering significant fuel and maintenance savings.

## How?

- We are one of the world’s leading providers of high-quality battery systems which are ideally suited to meet the demands of the marine industry.
- Our goal is to build long-lasting partnerships with major stakeholders in the industry to further the electrification of transportation.

## What?

- We engineer and produce our own lithium-ion cells in our state-of-the-art European production facility.
- Safety is engineered into our solutions at all levels from individual cells to complete battery systems.
- Our industry leading cell cycle-life allows for long lasting solutions that reduce the total cost of ownership.

Autonomous container ship



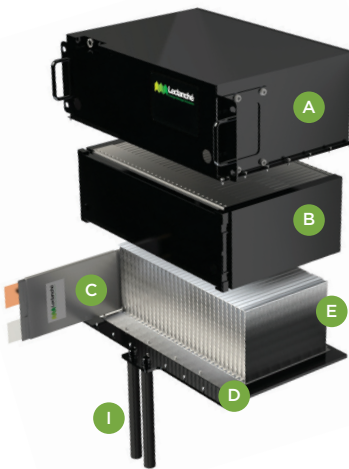
# Marine Rack Battery System

The Marine Rack System (MRS) is a modular and scalable Li-ion battery system for marine applications. Designed with the utmost safety in mind, the MRS has undergone numerous thermal propagation tests and is certified by DNV-GL as well as all other major certification authorities including RINA, Bureau Veritas

and Lloyd's Register.

With multi-layer safety measures from cell to system, including the battery management system (BMS), integrated cooling and firefighting systems, the risk of thermal propagation has been reduced to virtually zero.

- A IP65 enclosure
- B Leclanché M2 Module
- C Leclanché G/NMC 65Ah cell
- D Liquid-cooling plate
- E Cell-cooling sheets
- F MRS9 Rack
- G Control cabinet for BMS
- H Dedicated battery exhaust duct
- I Cooling pipes



IP65 enclosure with battery module and integrated cooling plate



MRS String composed of MRS9 racks and a control cabinet housing the BMS

## Benefits & Advantages



### Performance

In-house designed and manufactured G/NMC and LTO lithium-ion cells with class leading energy density and cycle-life.



### Configuration

Standardized off-the-shelf battery systems which are configurable to meet any maritime specifications.



### Certification

Type-approved battery systems means our packs are ready for operation immediately.



### Reliability

Proven battery systems that meet customer needs across all marine transport segments.



### Safety

Intrinsic safety from cell to pack level. Supplementary safety features can also be integrated if required.



### Manufacturing

High capacity state of the art automated cell and module production facilities based in Europe.



# Features and Specifications

At the core of the Marine Rack System are high energy lithium-ion G/NMC cells manufactured in Germany by Leclanché. The cells are fitted into robust modules which are packaged into IP65-rated enclosures designed for harsh

maritime environments. The IP65 enclosures are assembled into the MRS rack together with a dedicated, in-house designed, battery management system.

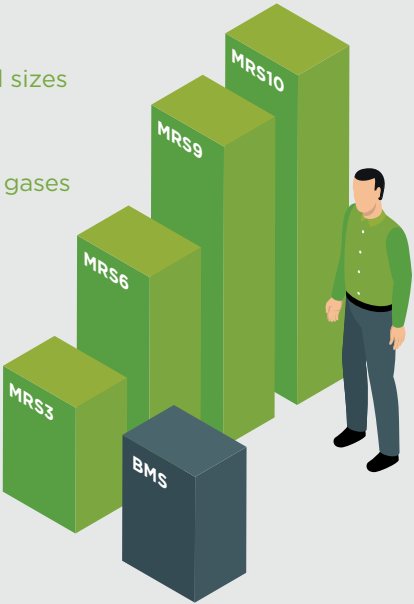
## Cells and Modules

- High energy, 65Ah G/NMC cells
- Cycle-life of 7,000 cycles (to 80% DoD)
- Multiple module configurations available
- Standard water-resistant IP65 enclosures with integrated liquid-cooling plates

Module Configuration	4s8p	8s4p	16s2p
Nominal Voltage	14.9	29.8	59.5
Nominal Capacity (Ah)	520	260	130
Energy (kWh)	7.7	7.7	7.7

## MRS Racks

- Available in four standard rack heights to suit all battery room footprints and sizes
- Easy installation and maintenance
- Certified by all major classes
- Independent ventilation ducting system to actively extract hot and flammable gases
- Real-time access to battery status, performance and diagnostic data
- Pack voltage of up to 1100 V DC
- Standard-equipped 230 VAC power supply or an optional isolated DC/DC power supply

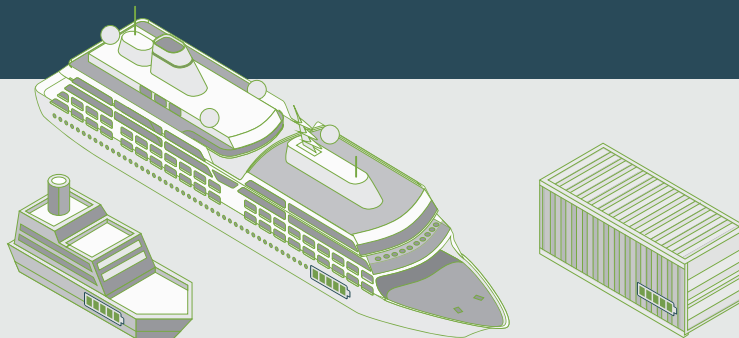


## BMS

- Remote data logging (IOT platform) using AWS cloud services (optional). This enables real time and historical data viewing using Tableau.
- Comprehensive local user interface for monitoring battery system diagnostics
- Control cabinet is similar in size to MRS3 rack
- Can be integrated into the MRS string or installed as a stand-alone unit
- Each control cabinet can manage up to 60 modules in a MRS string

	MRS.3	MRS.6	MRS.9	MRS.10
Dimensions H x W x D (mm)	931 x 618 x 440	1'578 x 618 x 440	2'440 x 618 x 440	2'440 x 618 x 440
Module quantity	3	6	9	10
Voltage range	44.6 — 178.6	89.3 — 357.1	133.9 — 535.7	148.8 — 595.2
Energy (kWh)	23.2	46.4	69.6	77.4
Weight (kg)	245	435	623	686
Wh / m <sup>2</sup>	87	173	260	289
Wh / kg	95	107	112	113

## Application Examples



Low energy  
string solution

High energy  
string solution

20 ft. container  
solution

MRS type	MRS.3	MRS.10	MRS.10
String energy - total (kWh)	116	462	1'058
Dimensions H x W x D (mm)	931 x 3'700 x 440	2'440 x 3'700 x 440	2'900 x 6'060 x 2'440
Weight (kg)	1'307	3'953	18'710
kWh / m <sup>2</sup>	70.9	283.8	60.2
Wh / kg	88.3	116.9	56.5

- Substantial savings in maintenance
- Reduced fuel costs for hybrid vessels (between 8-20%) and for fully electric vessels (over 50%)
- Payback in as little as 24 months
- Optional operation of generators under varying loads, reducing emissions
- Reduced generator wear and tear
- Vessel protected against sudden blackouts
- Lower emissions and quieter operation

## Vessel Operation Modes

Integrating a Leclanché Marine Rack System offers an array of benefits for different vessel types such as hybrid or fully electric vessels.



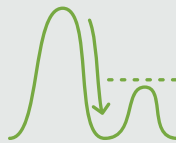
### Spinning Reserve

Switching off redundant generators allows the MRS to handle the emergency power load. It also enhances operational safety by preventing power outages.



### Enhanced Dynamic Performance

The MRS smoothenes the sudden changes in load demand on the generators.



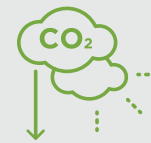
### Peak Shaving

Removing load peaks helps generators to operate at a steady and optimal power level.



### Strategic Loading

Allows switching, as appropriate, from diesel to electrical power for propulsion, manoeuvring, cargo handling, hotel load provision at port, etc.

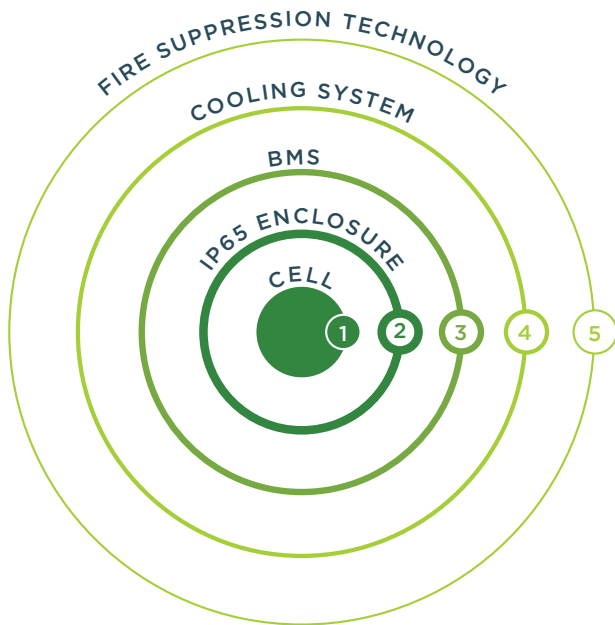


### Zero Emission Operation

The Leclanché MRS powers fully-electric vessels with no emissions, no fuel consumption and quiet operation.

# Safety

Multi-layer safety measures on a cell, module and system level, tested and certified against mechanical, thermal and electrical abuse.



## 1 CELL

- Laminated ceramic separators provide protection against internal shorts.
- Reduced electrolyte design diminishes flammable gases.

## 2 IP65 ENCLOSURE

- Enclosure provides protection against electrical failure which is the main cause of thermal incidents in marine energy storage solutions.
- All MRS parts (cabinets, modules, control box, electric components) are protected from water and pollution.
- Continuous airflow through the exhaust system and active extraction of hot and flammable gases enhances safety in the battery room.

## 3 BMS

- Battery management units are included in every module.
- Cell surface temperature detection (instead of ambient temperature) enables superior reactivity.
- Mechanical circuit breakers protect against electrical failure.
- Reliable operation in EMC hostile environments.
- Leclanché proprietary software with intuitive interface.

## 4 COOLING SYSTEM

- Modules are liquid-cooled with dedicated liquid-cooling plates.
- Separate aluminum conductive cooling-sheets in each cell eliminate hotspots and prolong battery life.
- Cooling pipe connections, external to IP65 enclosure, prevents common leaks that can cause thermal incidents.

## 5 FIRE SUPPRESSION TECHNOLOGY

- Leclanché's MRS fire suppression system offers protection against all unexpected external hazards (electrical, mechanical and thermal).
- The automatic extinguishing system uses independent heat- and smoke/gas-triggering sensors to prevent false alarms and improve reactivity.
- Both foam and water (hi-fog) systems are available:

**Foam:** The foam fire suppression system is 100% biodegradable and environmentally safe. It is a non-corrosive and non-conductive solution and considered the best-in-class firefighting system\*.

\*According to DNV-GL

**Water (hi-fog):** The hi-fog system is easily integrated with existing water-based fire suppression systems

# Technology

At Leclanché, we pride ourselves on being in control of the entire marine battery system's development process, from cell design and manufacturing to complete solutions which incorporate our own dedicated battery management systems.

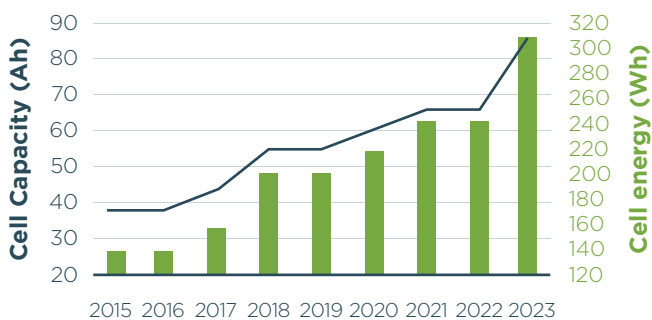
Our experienced R&D team strives continually to develop cutting-edge, high energy G/NMC

& high power LTO lithium-ion cells, which also deliver class-leading cycle life.

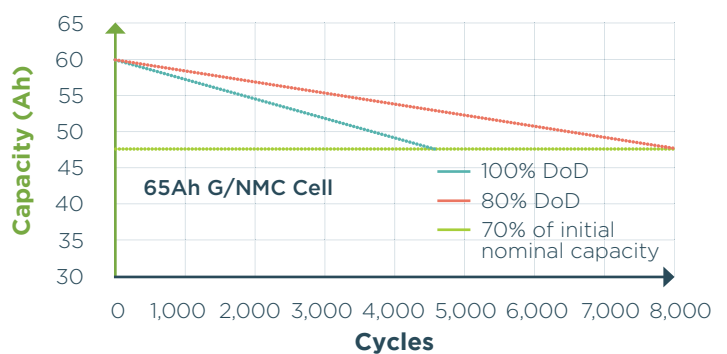
Our product roadmap is focused on continual improvements to the performance of our cells.

Based on our R&D technology roadmap we will be delivering cell energy densities of 680 Wh/litre by 2023.

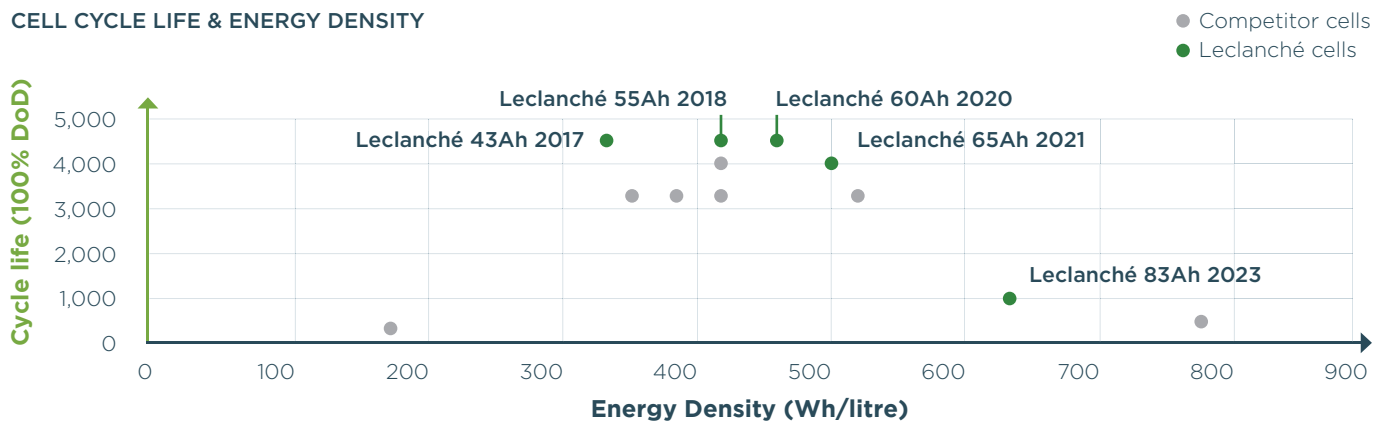
CELL CAPACITY ROADMAP



CELL CYCLE-LIFE VS. CAPACITY



CELL CYCLE LIFE & ENERGY DENSITY



## Certificates

The Leclanché Marine Rack System was first certified in 2017 by DNV and was the first marine battery system to obtain this approval. Since then, it has received numerous additional class approvals from major certification authorities.



# Leclanché Manufacturing Sites

Norway  
Oslo  
(Sales and  
engineering office)

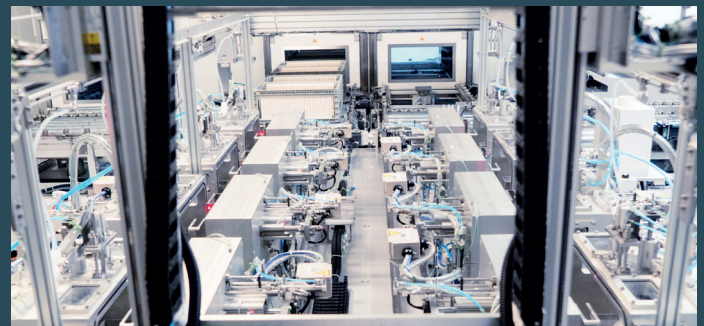
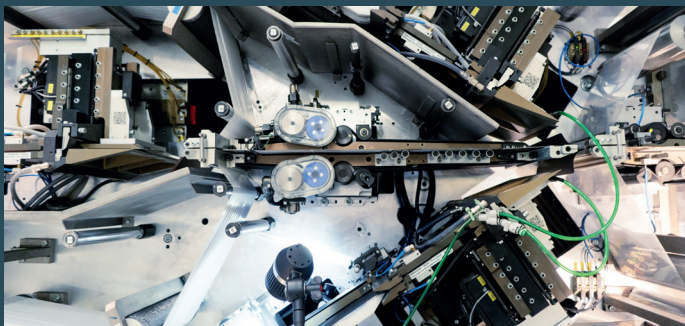
An environmentally conscious manufacturing company:

- Cell manufacturing facility fully powered by renewable energy
- The only company that utilizes a patented, fully water-based, cell manufacturing process
- Automated cell production at our state-of-the-art facility in Germany

Production and engineering facilities fully accredited by the leading international quality standards organizations including ISO 9001, 14001 and 45001

Germany  
Willstätt

Switzerland  
Yverdon-les-Bains



Willstätt manufacturing site

## Leclanché Marine Partners



### Leclanché E-Mobility SA (Headquarters)

Avenue des Découvertes 14  
1400 Yverdon-les-Bains  
Switzerland

### Leclanché GmbH

Industriestrasse 1  
77731 Willstätt  
Germany

### Leclanché North America, Inc.

2685 Enterprise Dr  
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USA

### Leclanché Norway

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