

Thermal performance, in context.

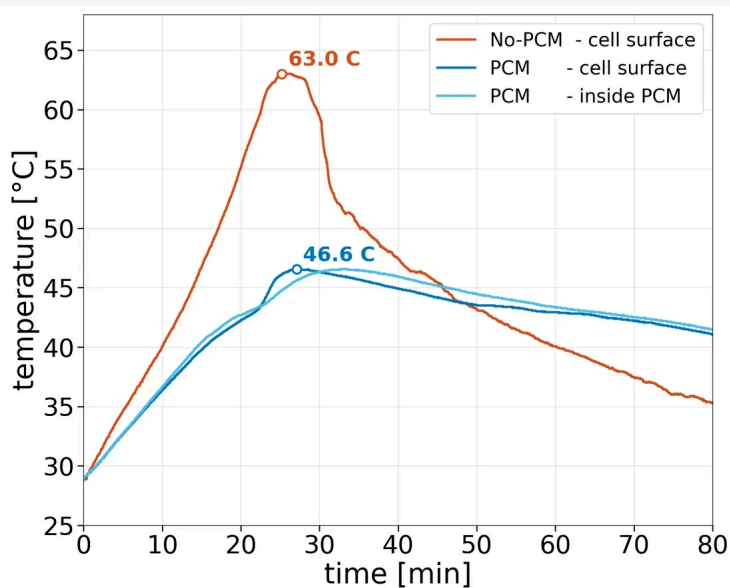
Measured results, specifications and the research behind PCM-CAGE.

Research & development Edition 2 / October 2026

01 / BENCH RESULTS

A 16.4 °C lower measured peak.

Two 19P modules, one with PCM and one without, discharged continuously at 240 A.



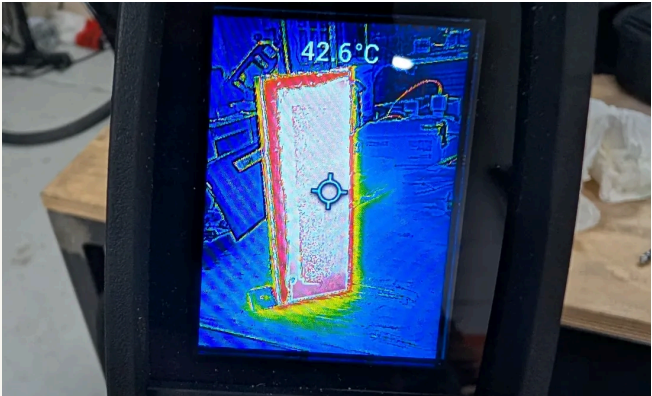
Cell-surface and in-PCM temperatures during the 240 A discharge.



Discharge on a programmable electronic load.

Discharge
240 A, about 2.5C

Recovery
About 3 hours



Thermal-camera check of a module.

Ambient
28.0–28.5 °C

The 16.4 °C difference applies to this test setup; other loads and ambients need their own measurements.

02 / SPECIFICATIONS

The pack.

Nominal values of the demonstrator pack.

Nominal energy	9.918 kWh Nominal.
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Nominal voltage	104.4 V 29 modules in series.
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Nominal capacity	95 Ah 19 cells in parallel per module.
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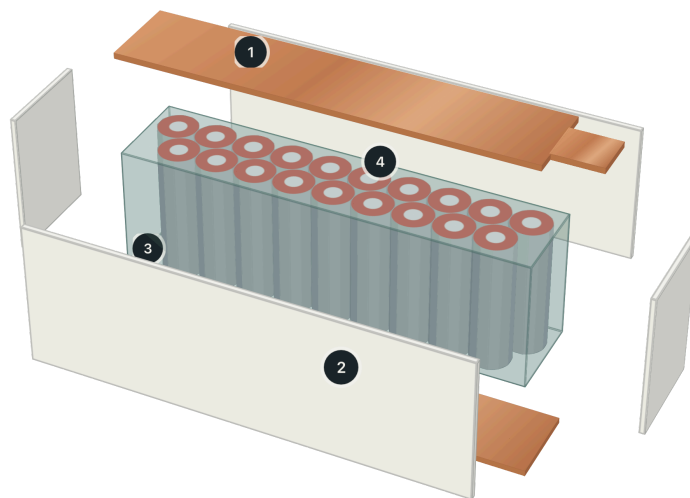
Pack mass	52 kg
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Specific energy	190 Wh/kg
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Volumetric energy density		385 Wh/L	
PCM transition		48 °C Material transition, not a cell-temperature ceiling.	
Discharge rating		3C / 8C peak Peak duration to be qualified per application.	
Power rating		30 kW / 80 kW peak	
Operating voltage window		72.5–121.8 V From cell limits of 2.5–4.2 V.	
Configuration		29S × 19P Cylindrical 21700 Li-ion cells.	
CELL		BATTERY MANAGEMENT	
Cell	Tenpower INR21700-50XG	Battery management	ANT smart BMS
Chemistry and format	Li-ion, 21700 cylindrical	Series support	21S–30S programmable, configured 29S
Nominal capacity	5,000 mAh (minimum 4,950 mAh)	Cell balancing	Passive, 180 mA
Nominal voltage	3.6 V	Protection	Short-circuit, over-current, temperature, over- and under-voltage
Charge / cut-off voltage	4.2 V / 2.5 V	Temperature sensing	4 sensors, –40 to 125 °C
Maximum continuous discharge	40 A (90 A with 75 °C cut-off)	Metering and communication	Coulomb counter; CAN, RS485, TTL, Bluetooth
Internal impedance	≤ 4 mΩ at 1 kHz, 30% SOC		
Cell mass	75 g maximum		
Download the product brochure 			

A thermal buffer inside a serviceable module

PCM-CAGE combines cylindrical cells, copper collectors and phase change material in a sealed, replaceable module. As the material melts it absorbs peak heat right next to the cells, with no dedicated fans or pumps in the module. The installation still needs a path through which that heat can leave.



The material: PCM48

The modules use PCM48, a bio-based, non-paraffinic phase change material with a transition around 48 °C, poured in as a liquid so it settles around every cell. Recent work comparing 42, 47 and 57 °C materials found 47 °C the most balanced, supporting this choice. Lot-specific calorimetry, conductivity and insulation tests are the next step.



Modules filled with molten PCM48 in the oven.

Sources [\[6\]](#) [\[10\]](#)

05 / OPERATION

The duty cycle includes cooling down

The buffer is finite: once the material has melted, the benefit changes, so 48 °C is not a ceiling on cell temperature. After the bench discharge, full thermal recovery took about three hours. Mission, recharge and recovery are therefore designed as one sequence.

Sources [\[4\]](#)

06 / FIELD DEMONSTRATION

From the bench to the water

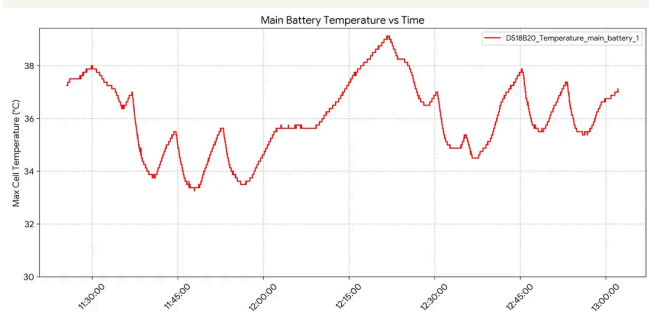
The complete 9.918 kWh pack was installed in a zero-emission racing catamaran for field trials in 2026, logging cell temperature, state of charge and power on the water. An Italian patent application for the architecture was filed in July 2026.



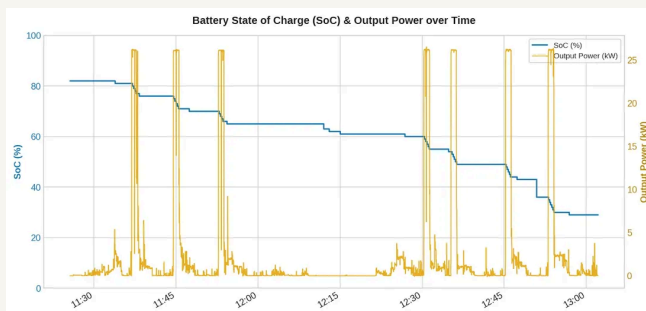
The pack installed on the catamaran.



Racing at Monaco, 2026.



One on-water session: maximum cell temperature.



Same session: state of charge and output power.

07 / DURABILITY

Lower thermal stress can support battery life

Published experiments link PCM cooling to slower degradation: one study reports 14% longer cycle life at high discharge rates, another about 81% capacity retained with PCM versus 76% without after 600 cycles. Their cells and protocols differ from ours, and cooler is not always better for every chemistry. A lifespan figure for PCM-CAGE will come from matched aging tests.

Sources [\[2\]](#) [\[3\]](#) [\[7\]](#)

08 / CHARGING

Charging is an electrical and thermal qualification

A thermal buffer can help sustain charge current where temperature would otherwise force derating, but it does not change the cell's approved limits. Charge rate is qualified together with the charger, BMS and the next mission, so no fast-charge time is claimed yet.

09 / SYSTEM DESIGN

Energy density belongs to the complete system

The pack is rated at 190 Wh/kg and 385 Wh/L. PCM adds mass and volume, so fair comparisons include every component, from cells and containment to protection and cooling hardware.

10 / RESEARCH DIRECTION

Research points to better heat paths

The next gains come from better heat paths rather than more material: conductive structures, improved cell contact and transition temperatures matched to the charge protocol. Each must keep the composite electrically insulating.

11 / DEVELOPMENT TARGETS

Where the design is going

Provisional engineering objectives for the next iteration, to be achieved together on one product configuration.

Metric	Today	Target	Stretch
Specific energy	190 Wh/kg	≥ 200 Wh/kg	≥ 210 Wh/kg
Whole-pack redesign, same energy.			
Volumetric energy density	385 Wh/L	≥ 400 Wh/L	≥ 425 Wh/L
Packaging redesign, same boundary.			

Metric	Today	Target	Stretch
Hottest instrumented cell At about 2.5C, with ≤ 5 °C spread.	46.6 °C peak surface, one module test	≤ 50 °C	—
Dedicated cooling power During passive operation.	No fans or pumps in the module	0 W	—
Charging, 10–80% SOC Within cell limits, with aging checks.	Not yet qualified	≤ 50 min at up to 1C	≤ 30 min at up to 2C
Submodule replacement After isolation and cooldown.	Replaceable by design	≤ 15 min	—
Cycle life to 80% SOH Matched aging tests. Not a claim.	Not yet measured	Research hypothesis: +20%	—
Targets, not results.			

From prototype to industrial specification

Qualification starts from the customer's operating envelope: ambient, load, state of charge and recovery time. Repeated tests on representative assemblies then fix temperature limits, charging behaviour and readiness for the next mission.

LEAD KPI

Useful mission energy, delivered repeatedly.

The useful electrical energy delivered at the requested power and within the qualified temperature window, including the next mission after the permitted turnaround.

- Peak cell temperature and spread over the full duty cycle
- Time to thermal readiness for the next mission
- Power and energy delivered before thermal derating

PRIMARY SOURCES / 2023–2026

References.

Published results guide development; they are not PCM-CAGE forecasts.

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