

Welcome  
to




# TODAY

1. **Introduction to SEABAT:** Why are we here, What did we learn 10 - 11



2. **Key technology:** Power Electronics, Software and Prototype 11:30 - 12:30



3. **Demo-Tour:** Manufacturing, Safety, Testing, Sizing and Integration +  13:15 - 15

4. **Networking:** Meet the experts +  15 - 16

5. **The future:** Road to Market and Panel Discussion 16 - 17

6. **Closing:** Networking +  17 - 18



# SEABAT

SOLUTIONS FOR LARGE BATTERIES FOR WATERBORNE TRANSPORT

GA NO: 963560

WHY ARE WE HERE?

SEABAT FINAL EVENT

MORNING SESSION I

# RATIO

**COP21** → decarbonisation

**IMO** → 50% lower annual GHG emissions from maritime transport by 2050 compared to 2008



Towards full electric (short sea) shipping based on battery storage systems



Current technology

(1) Limited options

High energy battery

(2) Scattered production

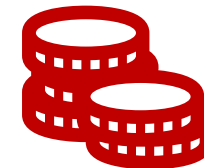
Bespoke designs, production not optimised for waterborne transport

Most battery research focus:

- Automotive applications
- Better performance
- Competitive price



**Inflexible & non-optimized design for maritime applications**



# FIND A SOLUTION



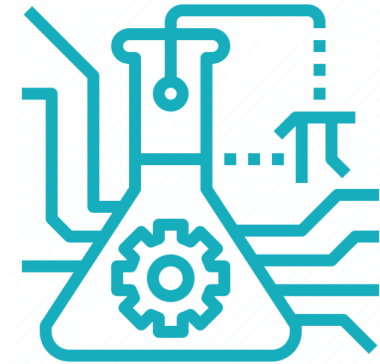
## Lifetime cost

- CAPEX
- OPEX
- Re-use
- Integration
- Footprint
- ...



## Future proof

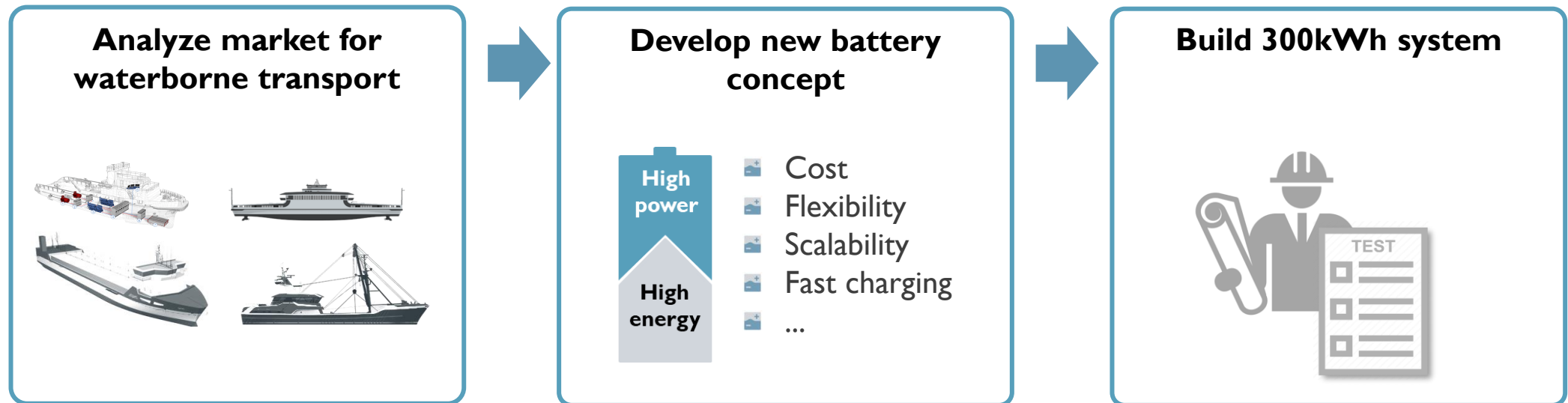
- Robust
- Upgradeable
- Sustainability in mind



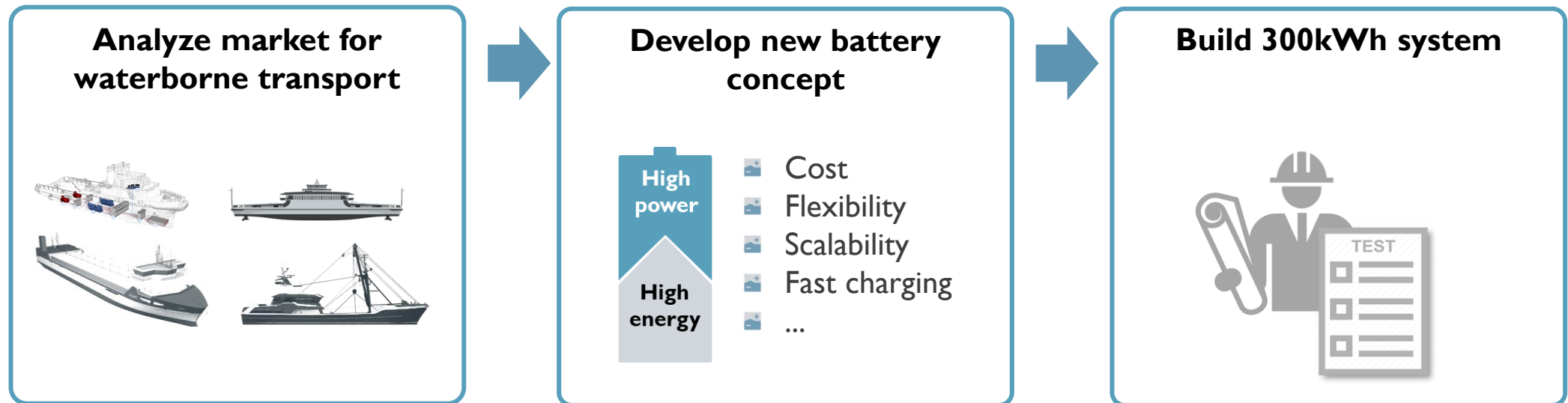
## Proven technology

- Increased TRL
- Validated models
- Prototype

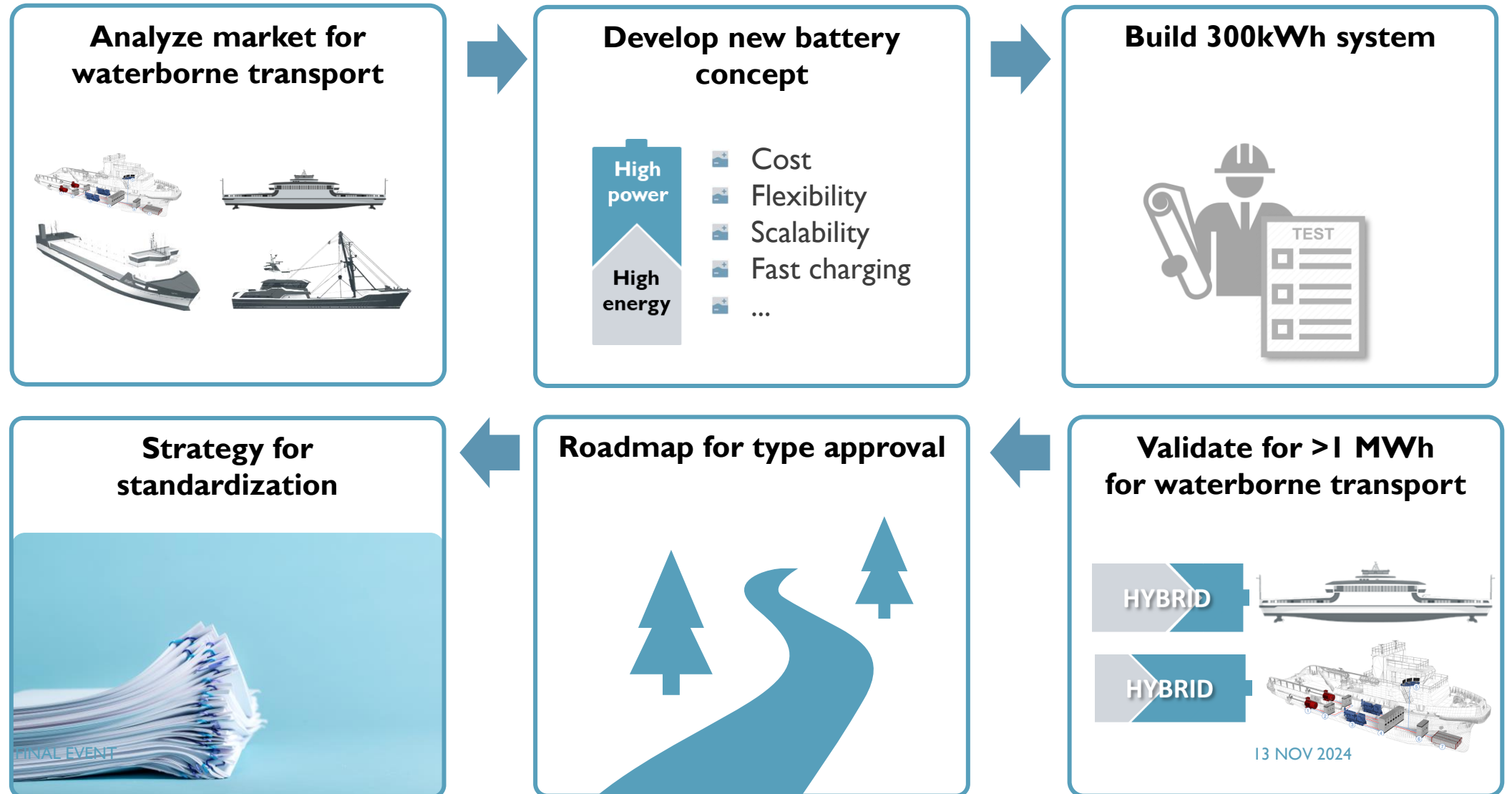
# APPROACH



# APPROACH



# APPROACH





# CONSORTIUM

- 15 partners
- 8 countries



Design and development of power electronics, energy storage systems & control thereof:



Design and development of reliable, cost-effective components & safety assessment:



Design and production of battery packs:



Testing power systems:



End users:



Research and technology transfer:



Technology qualification:



Project management, dissemination & exploitation:



Stakeholder group



# SEABAT

SOLUTIONS FOR LARGE BATTERIES FOR WATERBORNE TRANSPORT

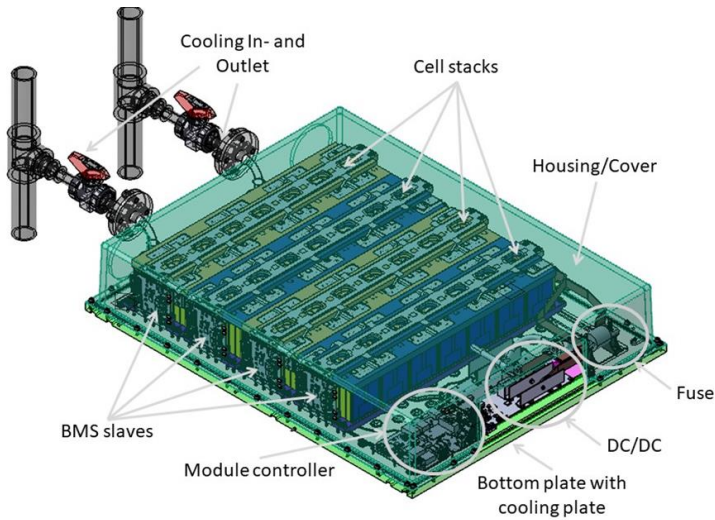
GA NO: 963560

WHAT DID WE LEARN?

SEABAT FINAL EVENT

MORNING SESSION I

# A COST-OPTIMAL MARITIME BATTERY



Modular



Hybrid battery



Optimized

... READY FOR BOARDING



Ease of integration



Safety in mind



Marine tailored



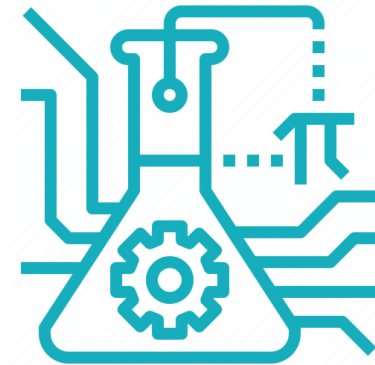
# WITH IMPACT



Lifetime cost



Future proof



Proven technology



# MODULARITY

*“the quality of consisting of separate parts that, when combined, form a complete whole”*

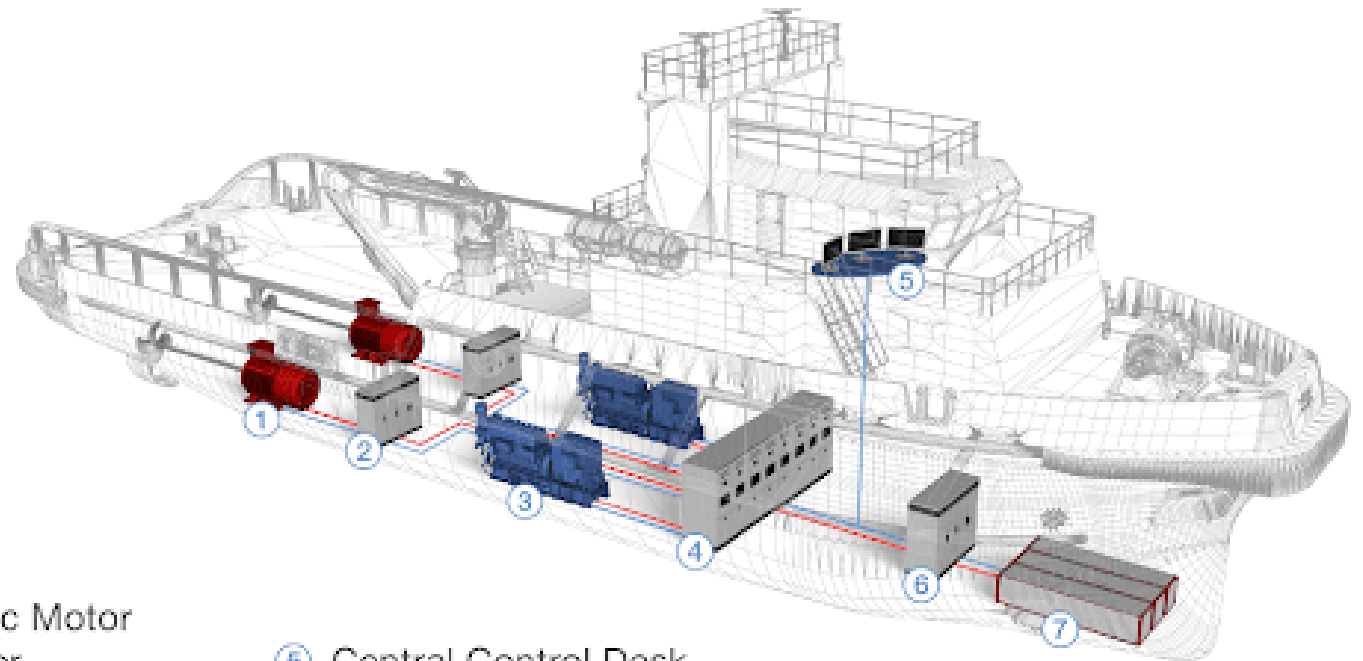
< Cambridge Dictionary >



Modular

A reference case:

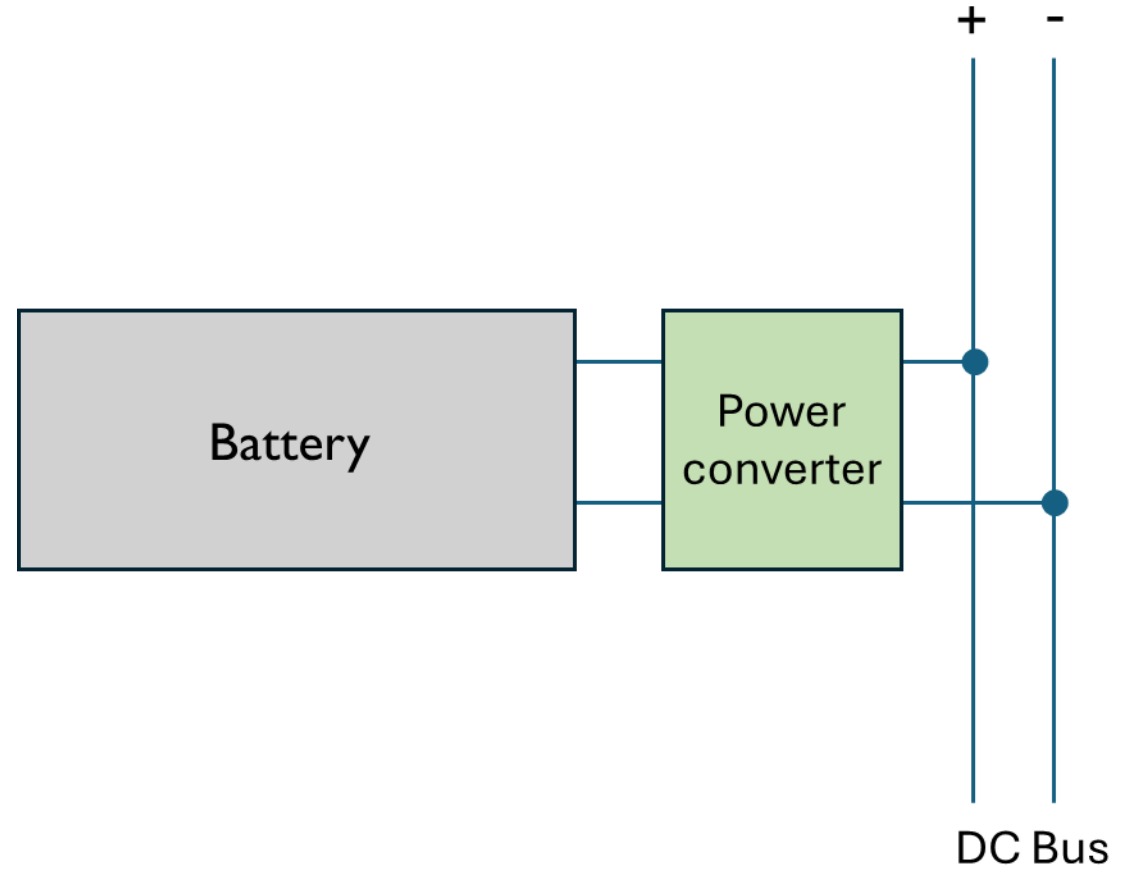
- DAMEN electric tug
- 32m length
- 1400kWh
- 3MW
- 6000 cycles



- ① Electric Motor
- ② Inverter
- ③ Engine-generator
- ④ Switchgear
- ⑤ Central Control Desk
- ⑥ Battery Converter
- ⑦ Battery Storage

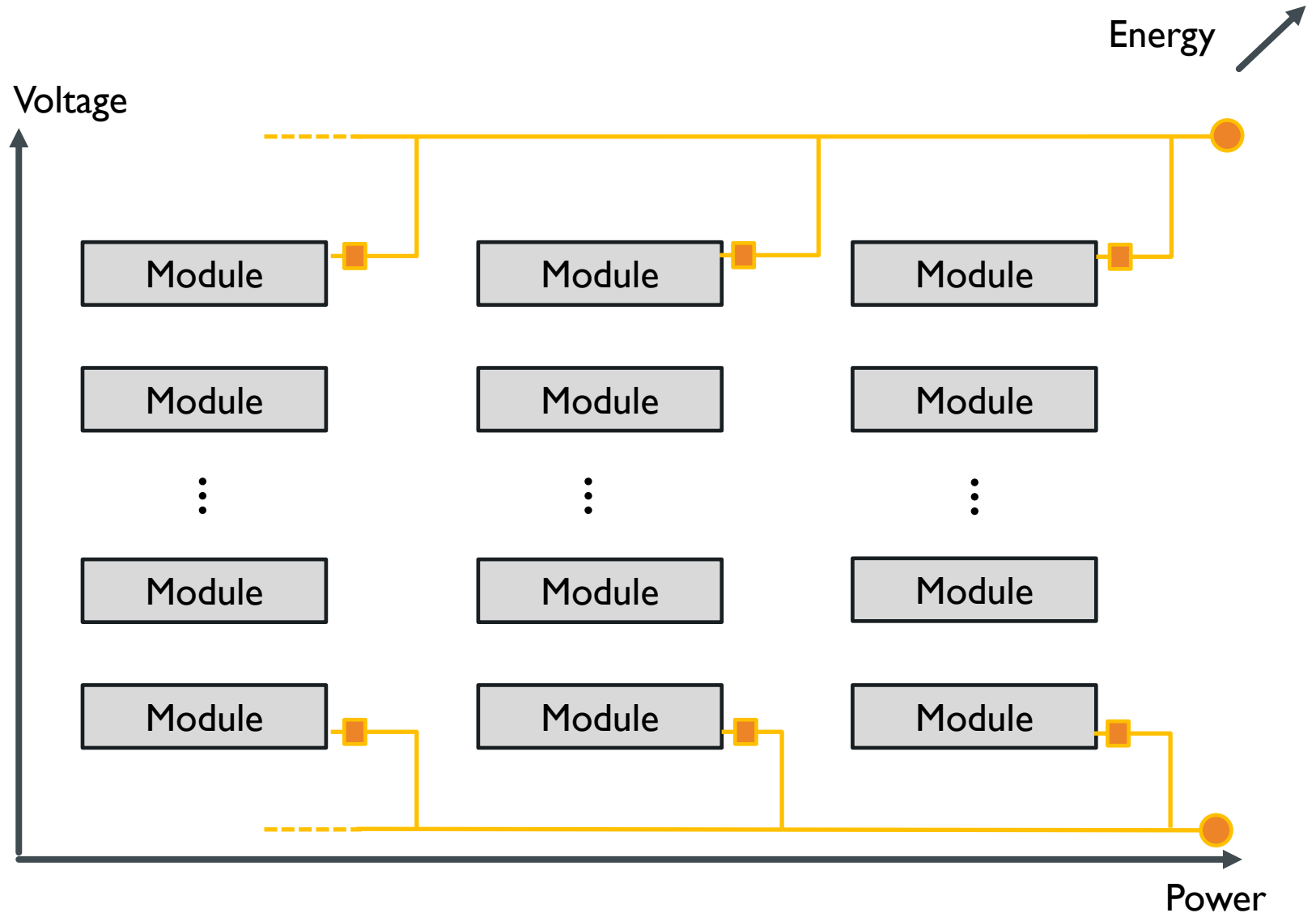


From this





➤ To this

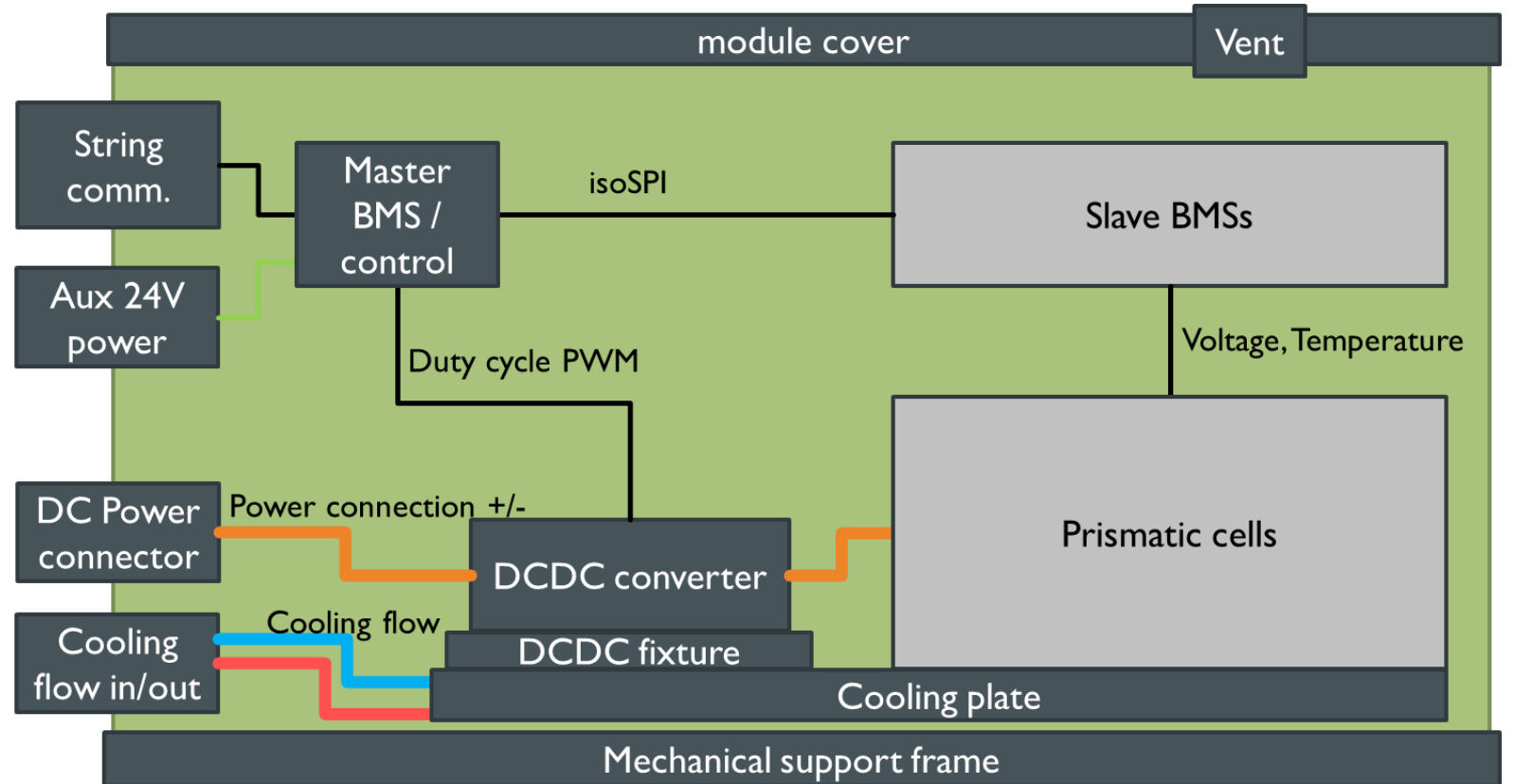






& Integration:  
Everything becomes modular

- Electric
- Control
- Thermal
- Mechanical
- ...



# IMPACT



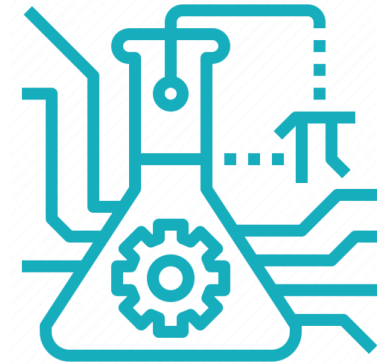
## Lifetime cost

- TCO - 48%
- Weight + 24%
- Volume + 24%



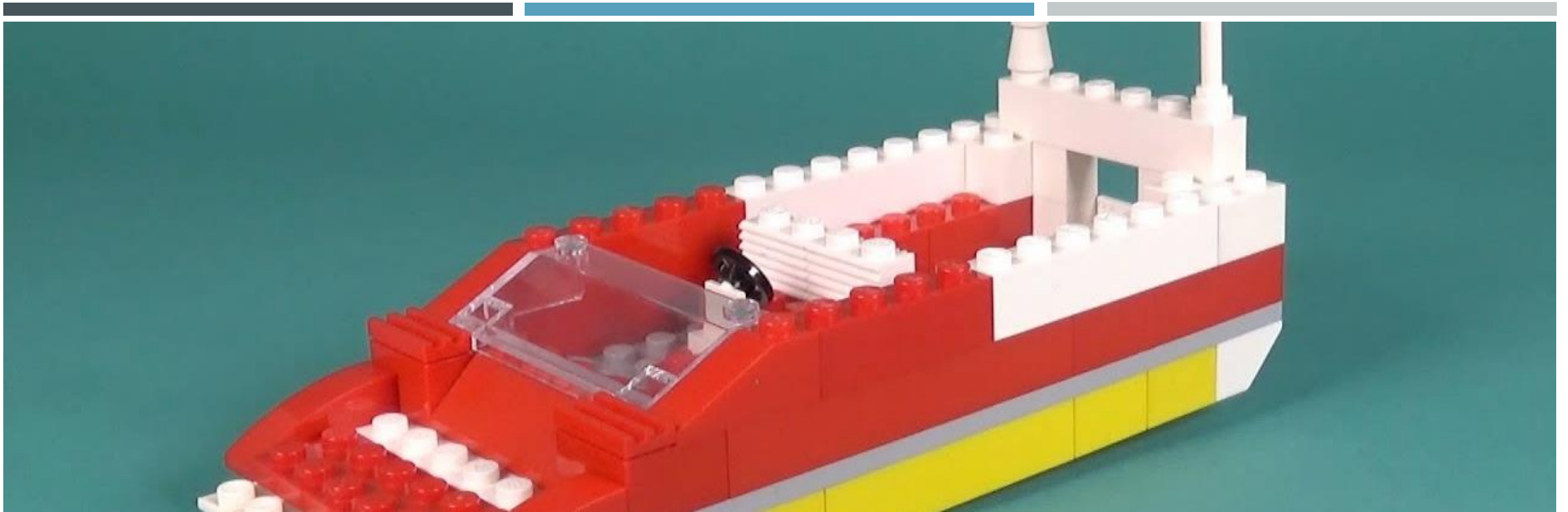
## Future proof

- Replaceable
- Upgradeable
- Reusable



## Proven technology

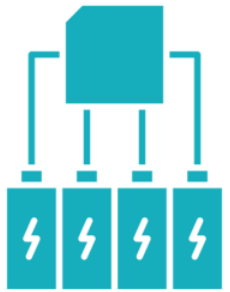
- Simulated
- Built
- Tested



## HYBRIDIZATION

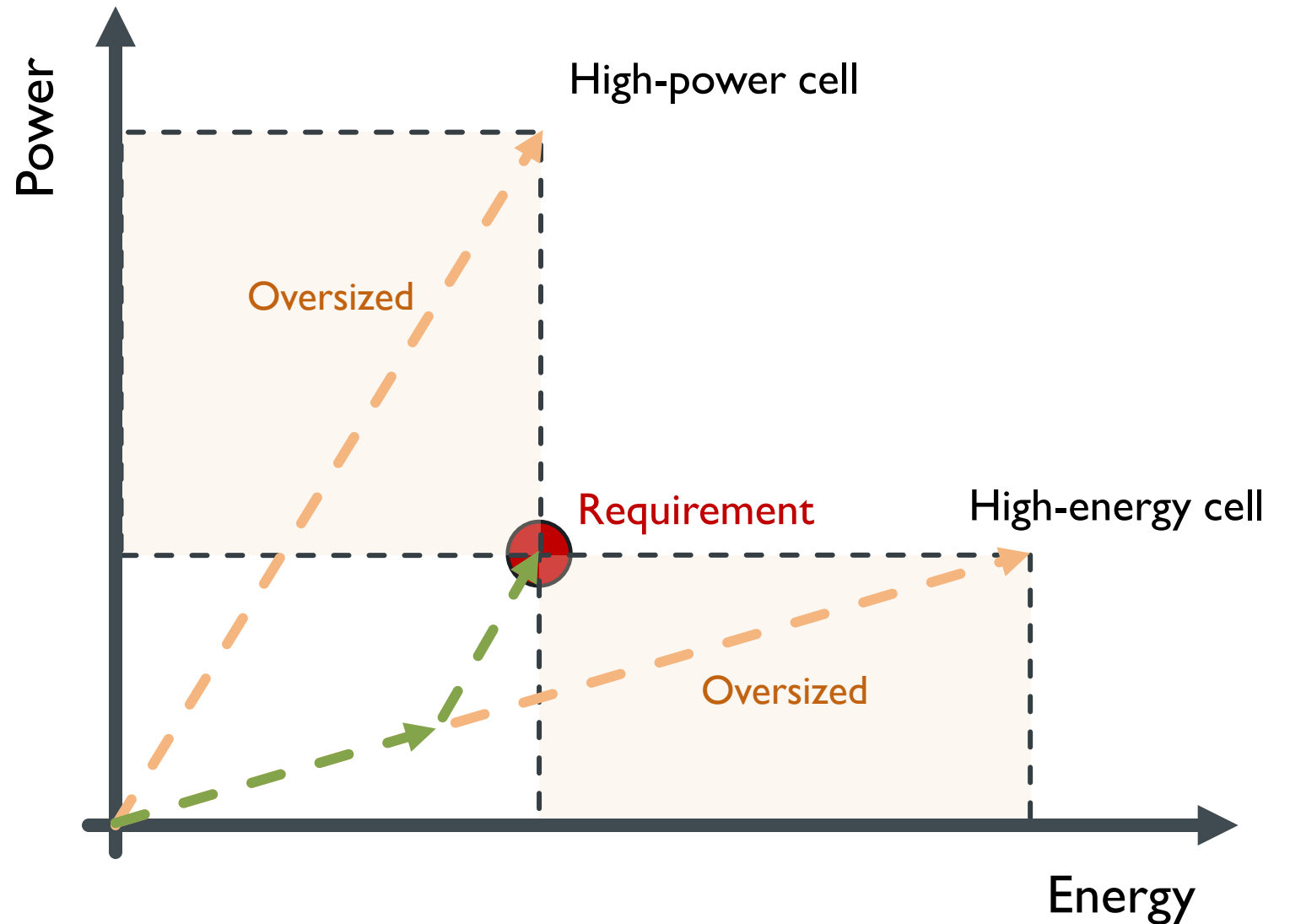
*“the process of producing a plant or animal from two different types of plant or animal”*

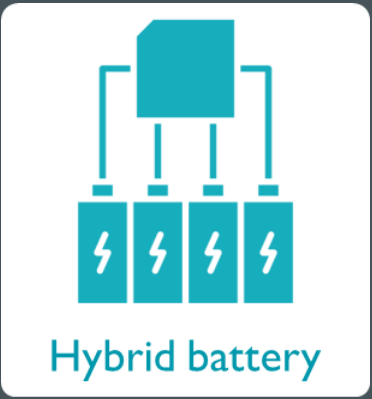
< Cambridge Dictionary >



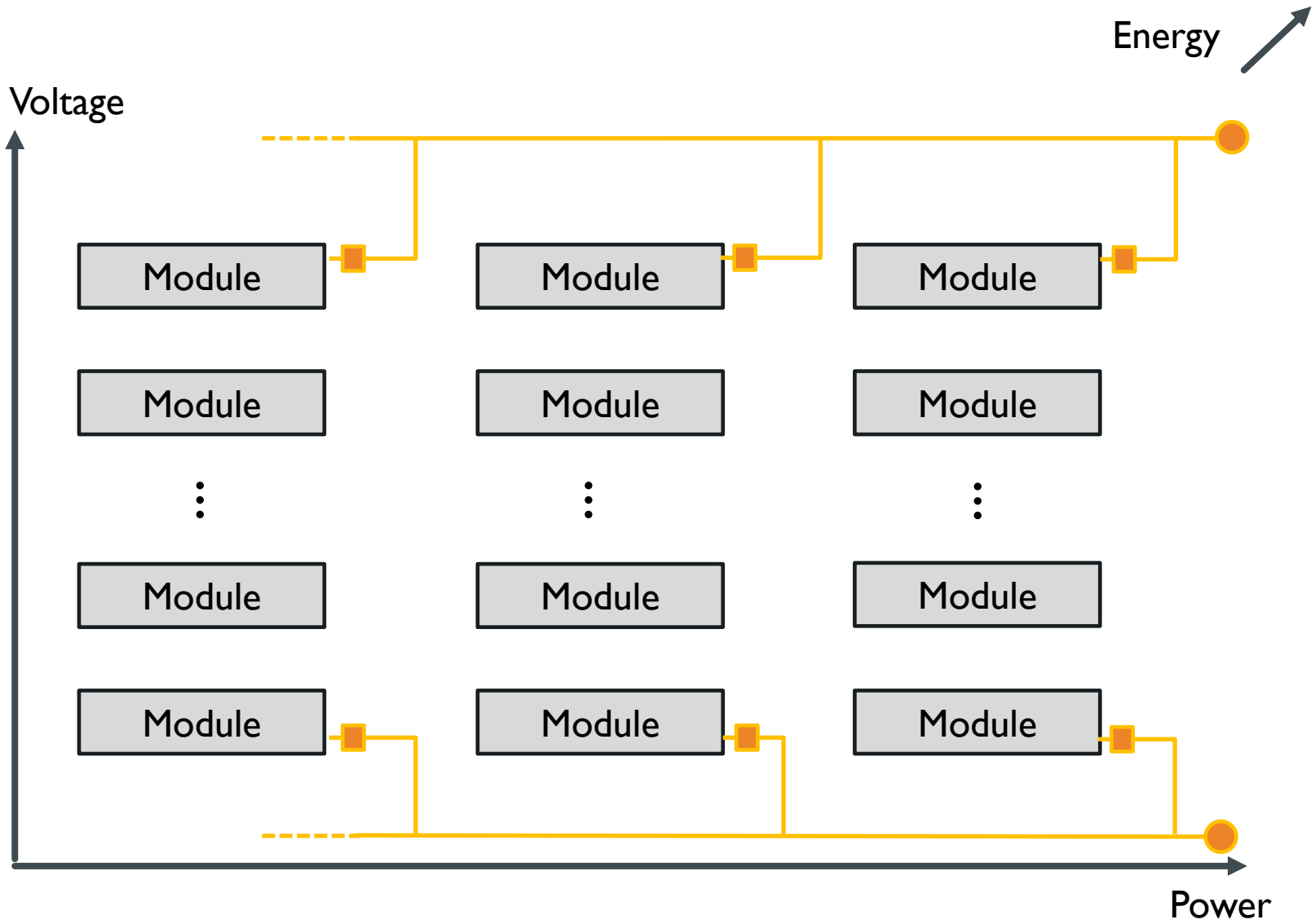
Hybrid battery

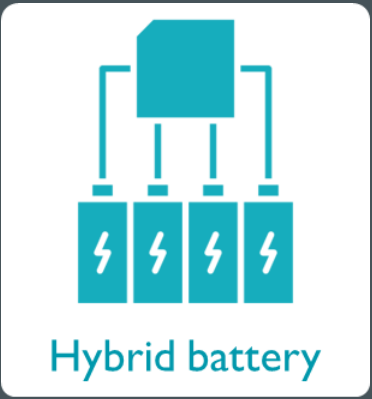
- Allows for optimal sizing



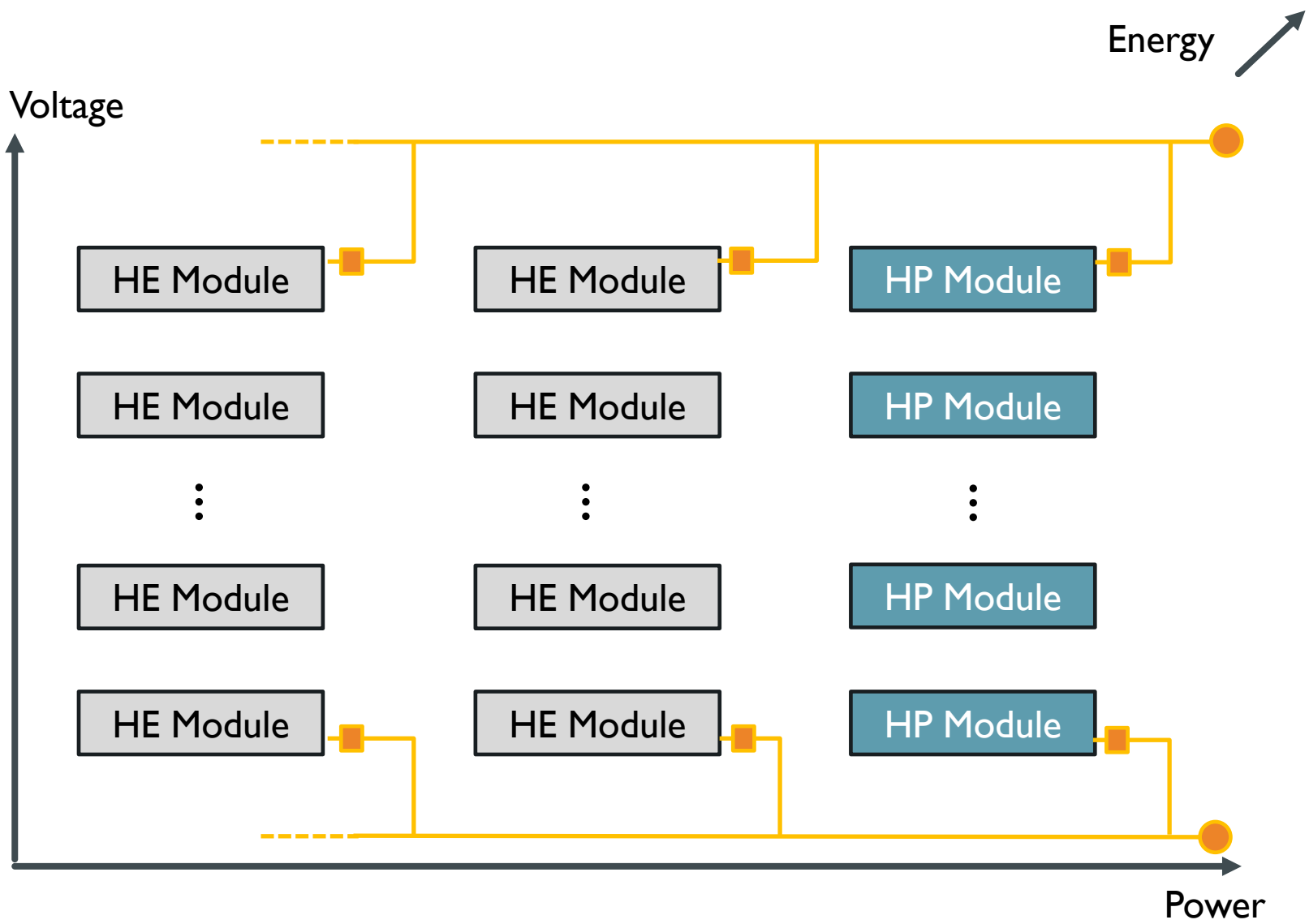


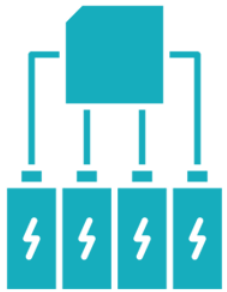
Is modular





- Is modular
- Thanks to integrated power electronics





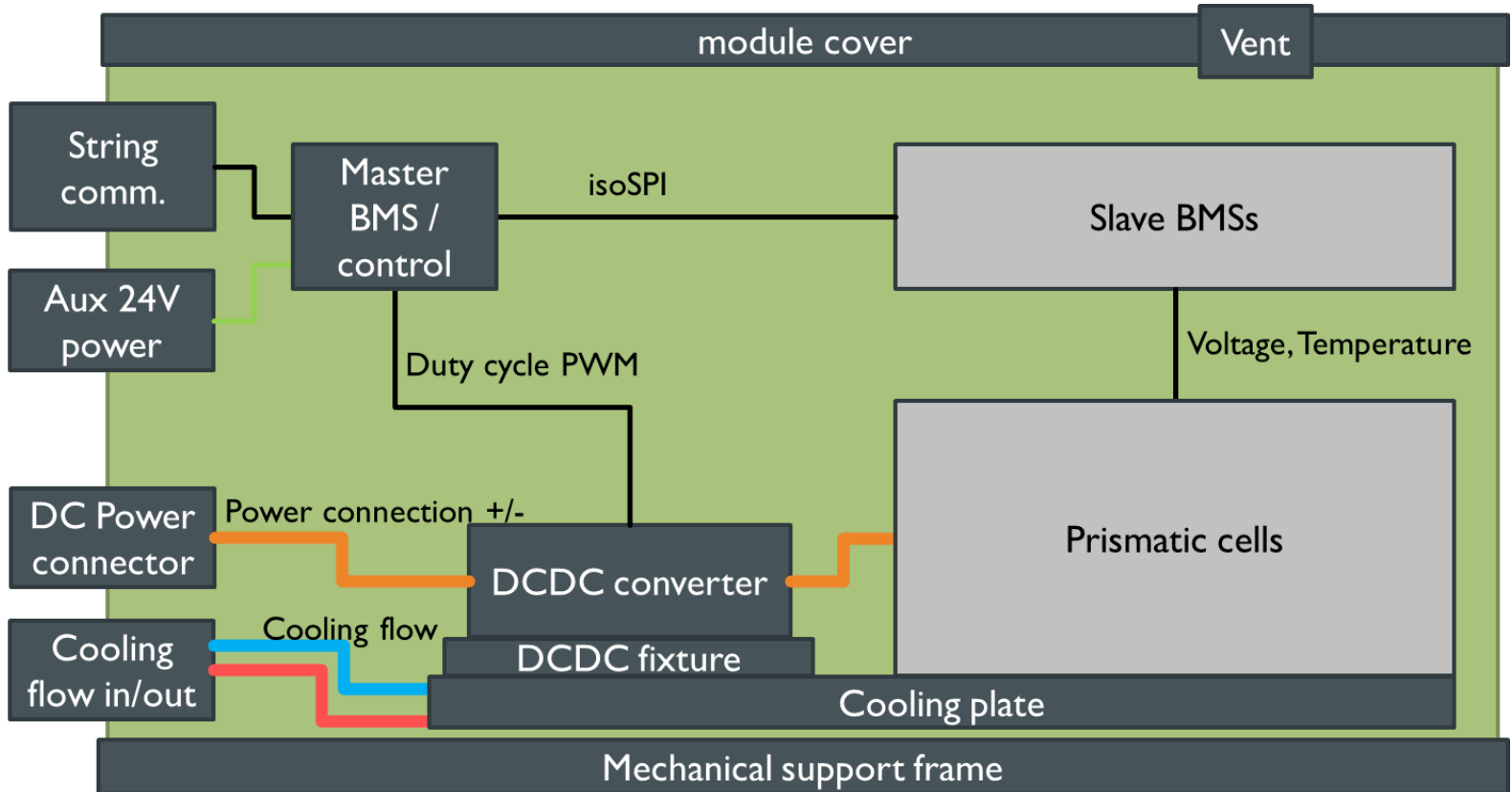
Hybrid battery

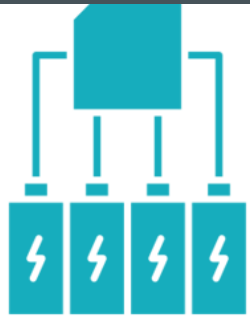
Impact on module

- Spacing & fixing of cells
- Slave BMS
- (DC/DC)

Identical

Chemistry specific

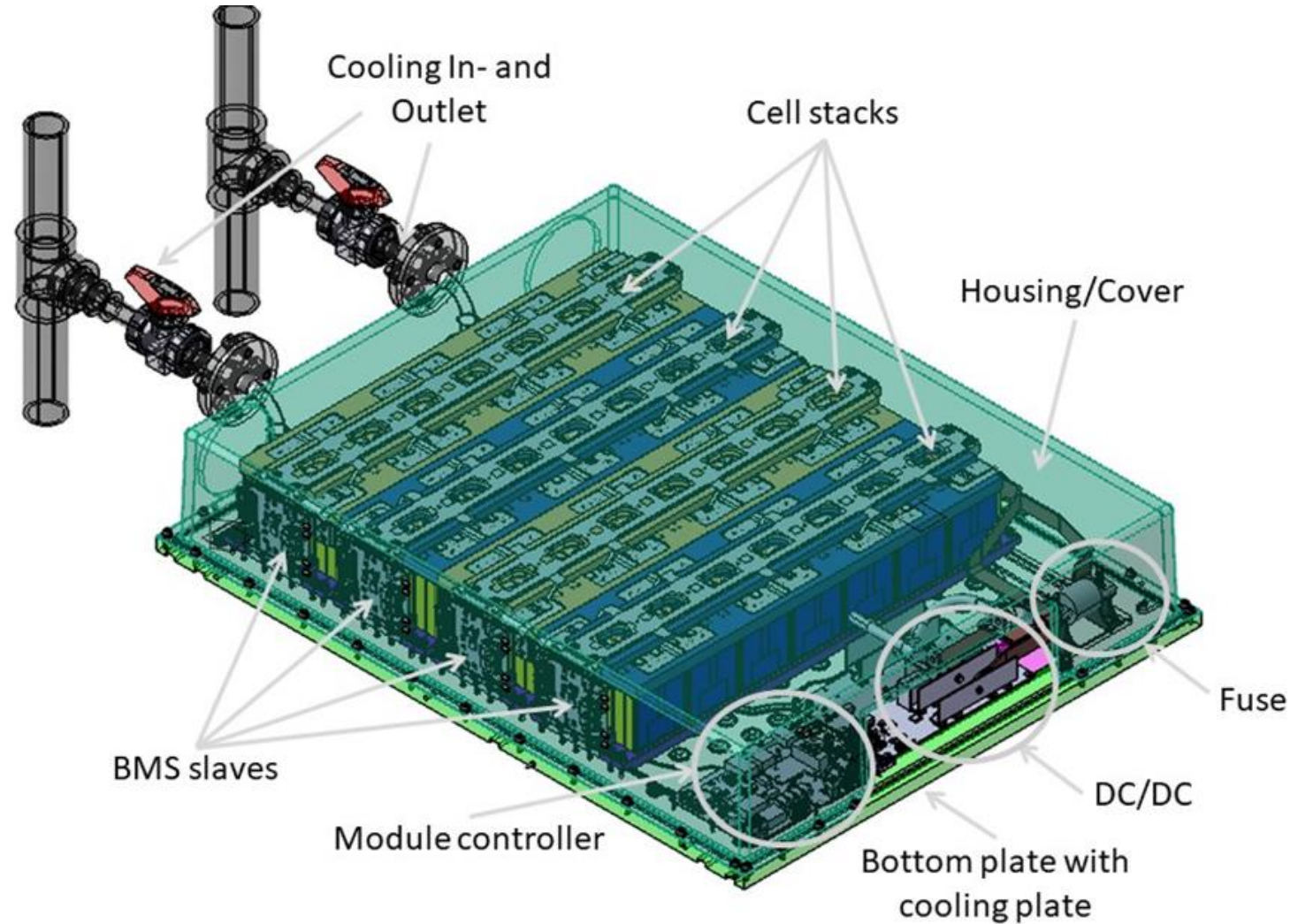




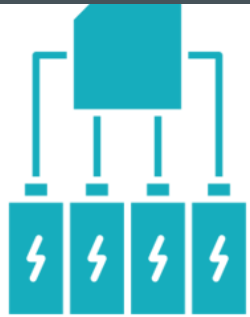
Hybrid battery

The SEABAT module:

- Modular
- Hybrid
- High Power & High Energy
- Common interfaces







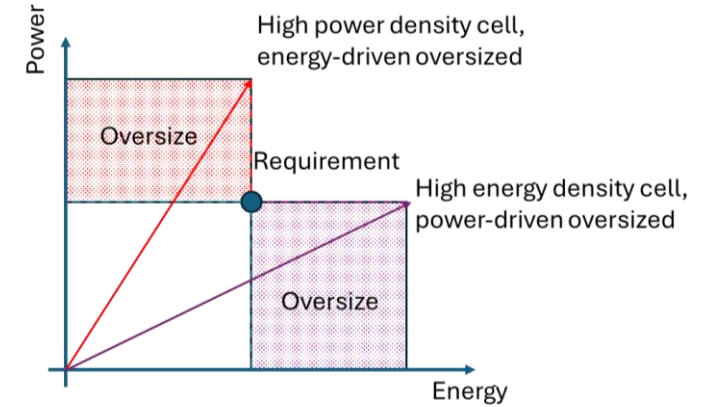
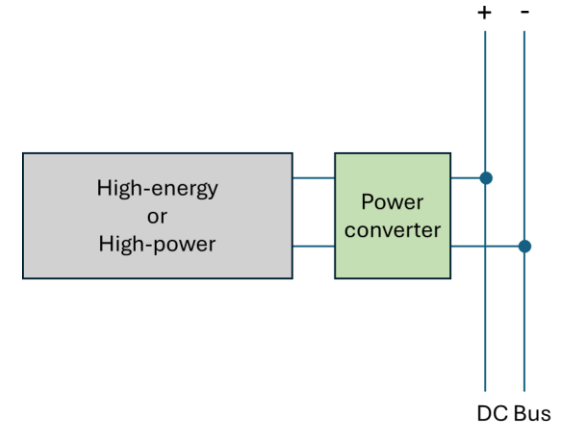
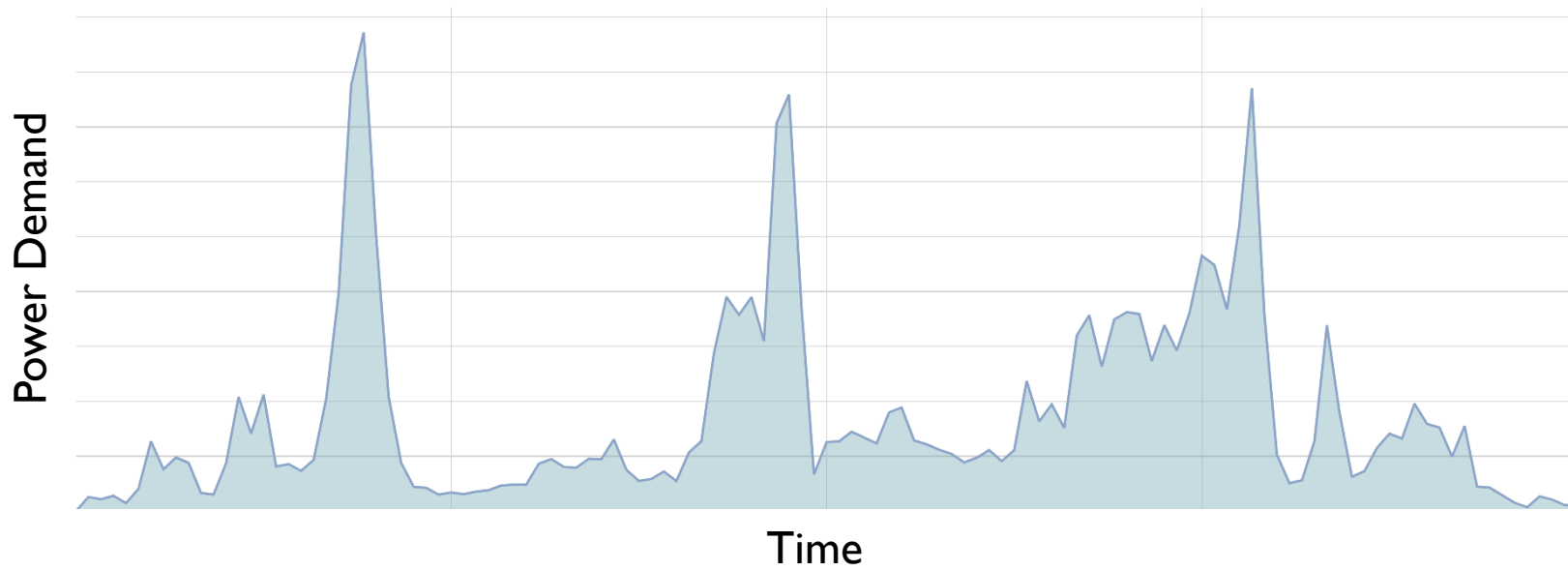
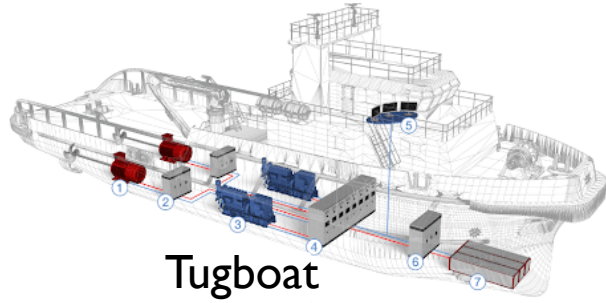
Hybrid battery

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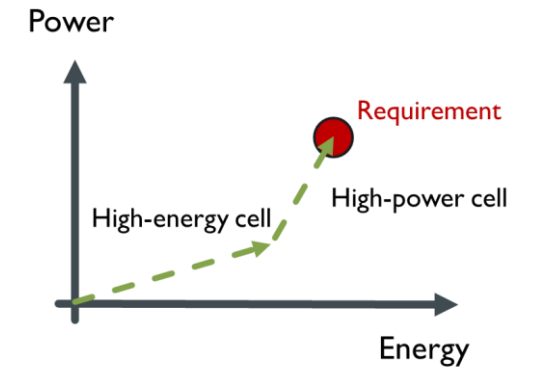
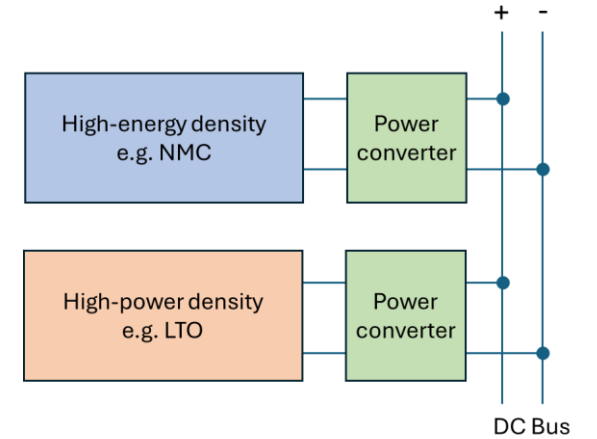
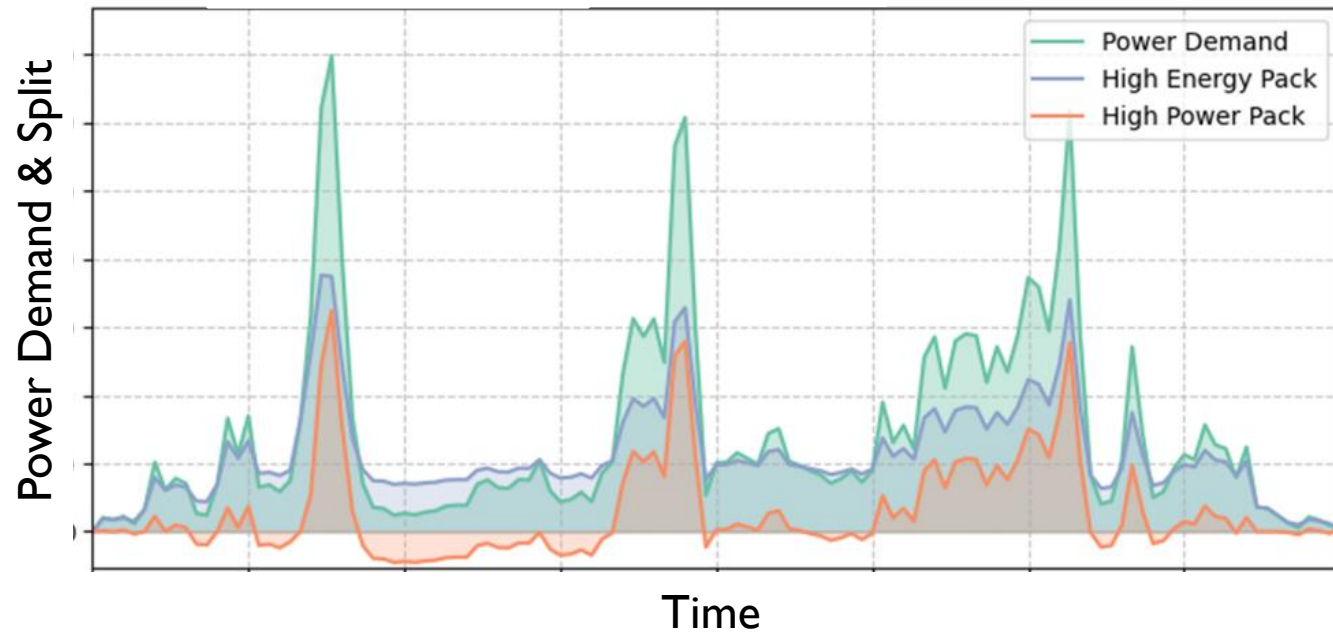
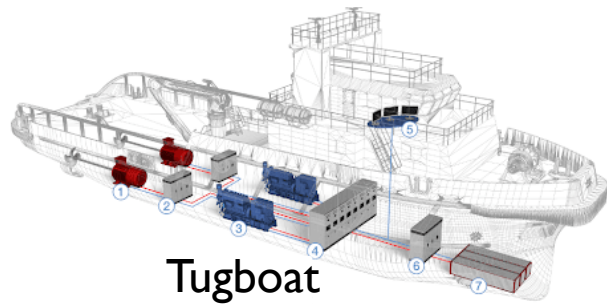


# REFERENCE CASE



Heavier, bigger, more expensive, and less sustainable

# REFERENCE CASE



# IMPACT (ON TOP OF MODULAR)



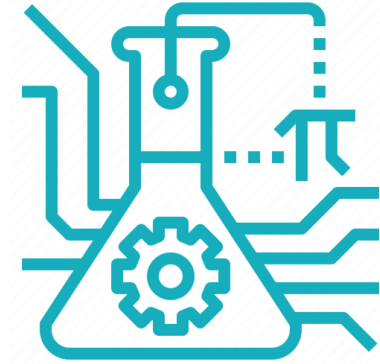
## Lifetime cost

- TCO - 19%
- Weight - 28%
- Volume - 12%



## Future proof

- Upgradeable
- Less excess material



## Proven technology

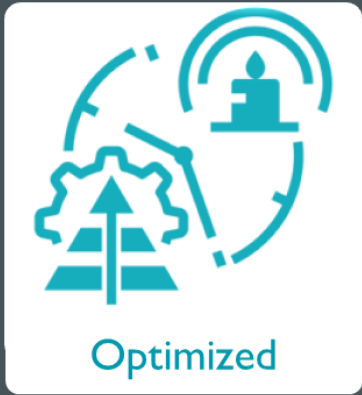
- Simulated
- Built
- Tested



## OPTIMIZED

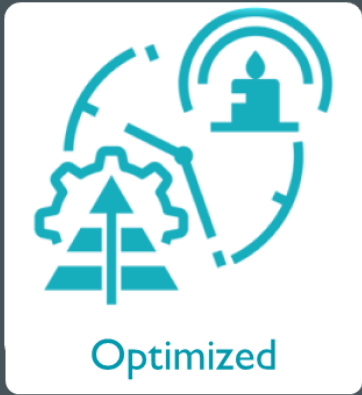
*“to have made something as good as possible”*

< Cambridge Dictionary >

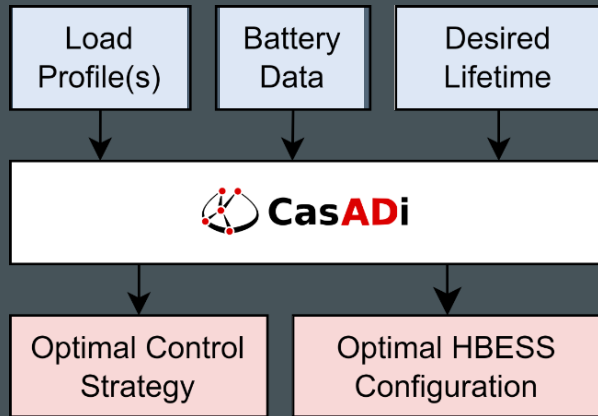


## ■ KPI evaluation

- **System cost**
- Energy density
- Power density
- Lifetime
- Thermal management complexity
- Inherent safety
- Ease of mechanical integration
- Ease of electrical integration
- Battery management complexity
- ...



### KPI evaluation



## Battery Sizing Tool

Introduction Application Battery Cells Results

Cost  $\text{€ } 79,878.40$  Mass  $2,859.50 \text{ kg}$  Volume  $1.30 \text{ m}^3$

$\downarrow -26.83\%$   $\downarrow -23.80\%$   $\downarrow -19.15\%$

Power

Parameter	HE cells	HP cells
Series cells	98	182
Parallel strings	6	13
Nominal Voltage	357.70 V	418.60 V
Energy Content	332.66 kWh	125.16 kWh
Current Rating	930.00 A	1196.00 A

Previous Clear result



This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 963560. All information on this website reflects only the author's view, and the Agency is not responsible for any use that may be made of the information it contains.

battery.flandersmake.be

# OVERALL IMPACT



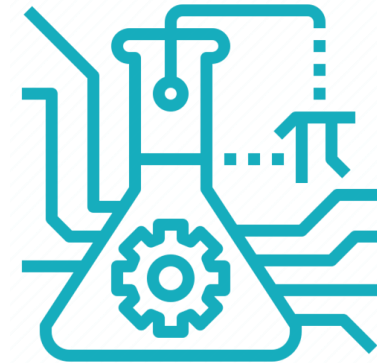
## Lifetime cost

- TCO -15 à 60%
- Weight - 0 à 15%
- Volume + 0 à 10%



## Future proof

- Scalable
- Optimizable
- Emissions - 0 à 15%

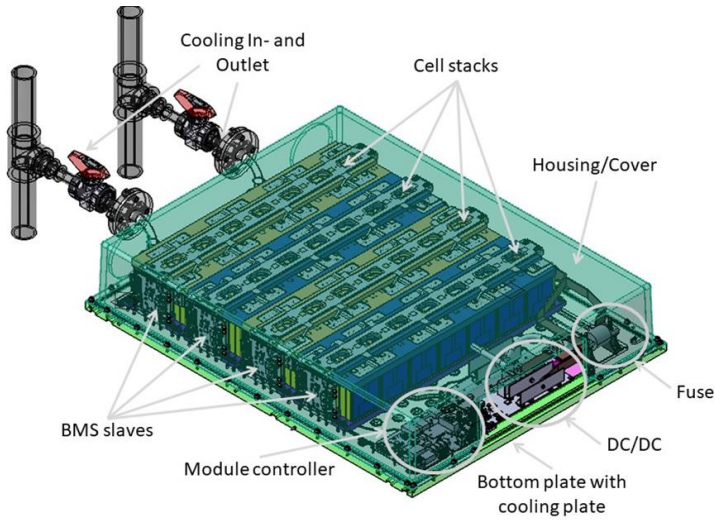


## Proven technology

- Simulated
- Built
- Tested



# A COST-OPTIMAL MARITIME BATTERY



Modular



Hybrid battery



Optimized

... READY FOR BOARDING



Ease of integration



Safety in mind



Marine tailored





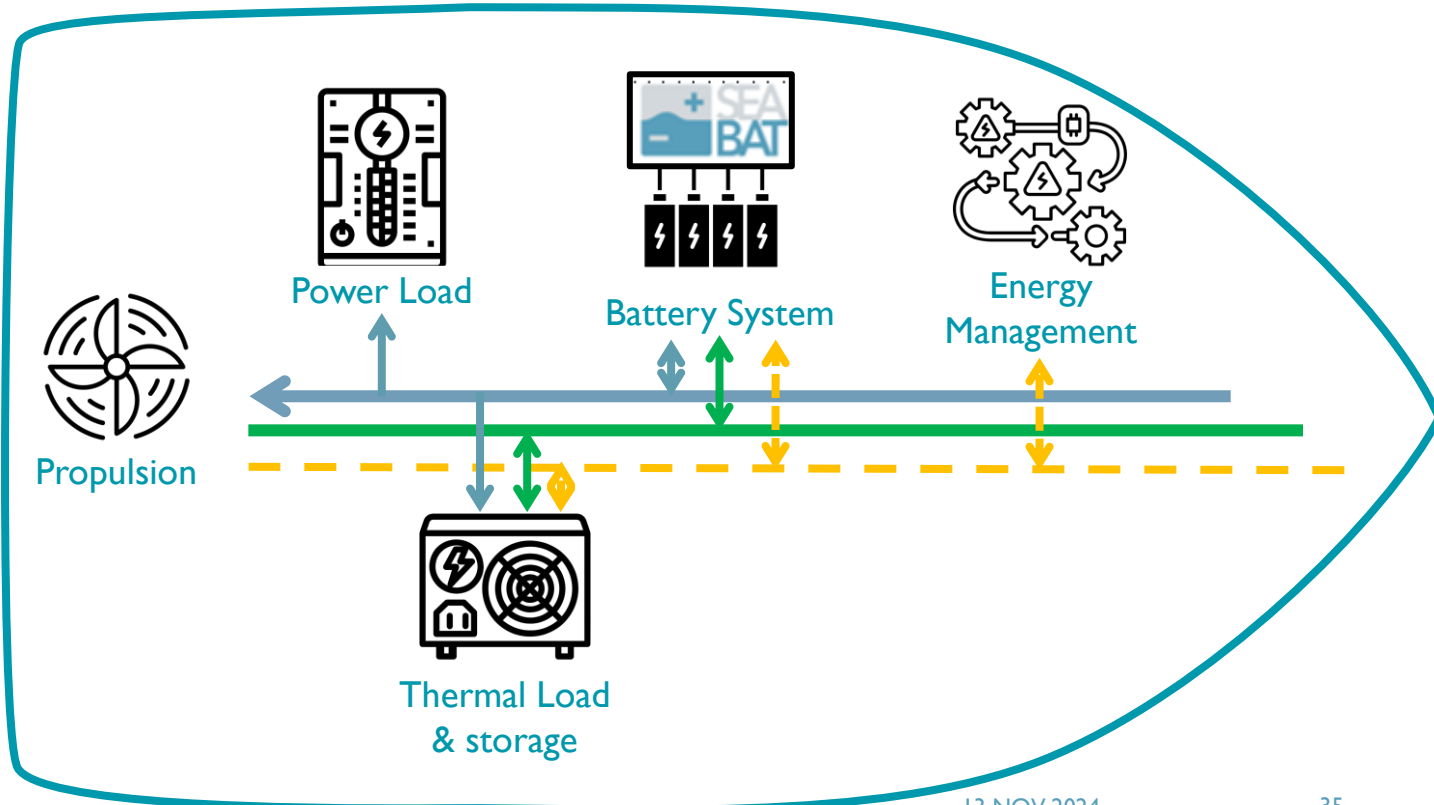
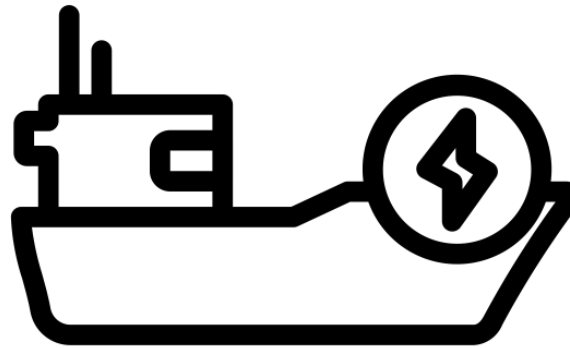
Ease of integration

- Large batteries in vessels?





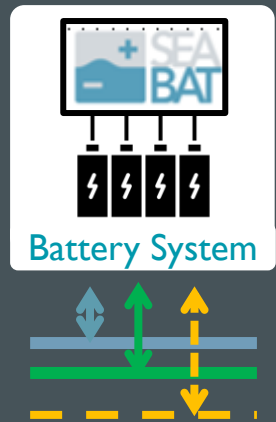
Ease of integration



- Electric Power
- Thermal Power
- - - Control & Comm.



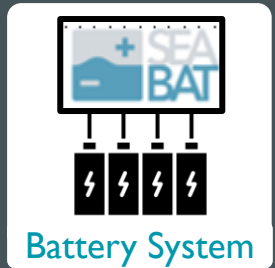
At the shipyard



- Engineering, each case is specific
- Difficult and complex logistics at the shipyard
- Commissioning with specialist personnel



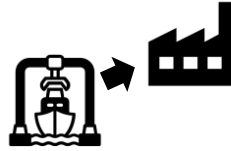
Ease of integration



Battery System



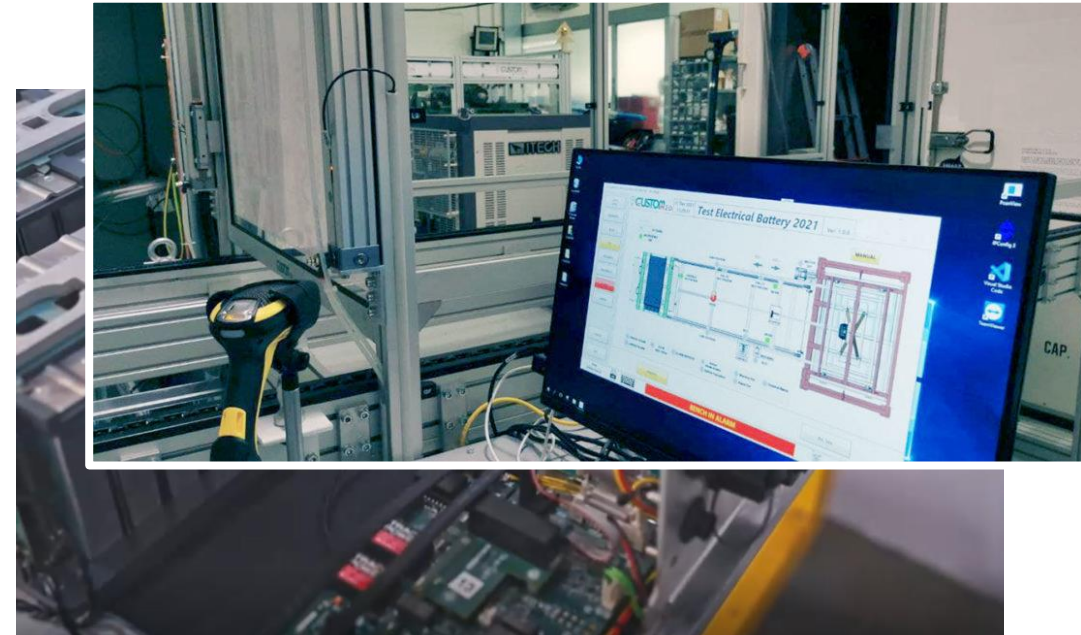
System build-up, with the 'plug & play'



Transfer work from **shipyard to factory**



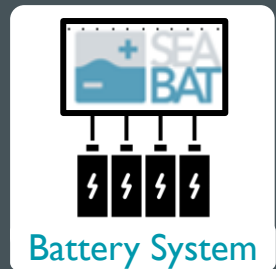
**Faster commissioning** due to End-Of-Line testing



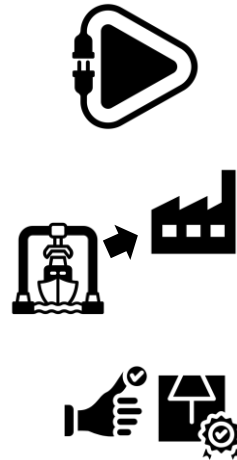
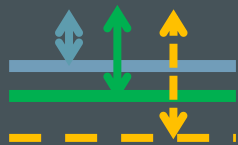


Ease of integration

Integration Costs -15%



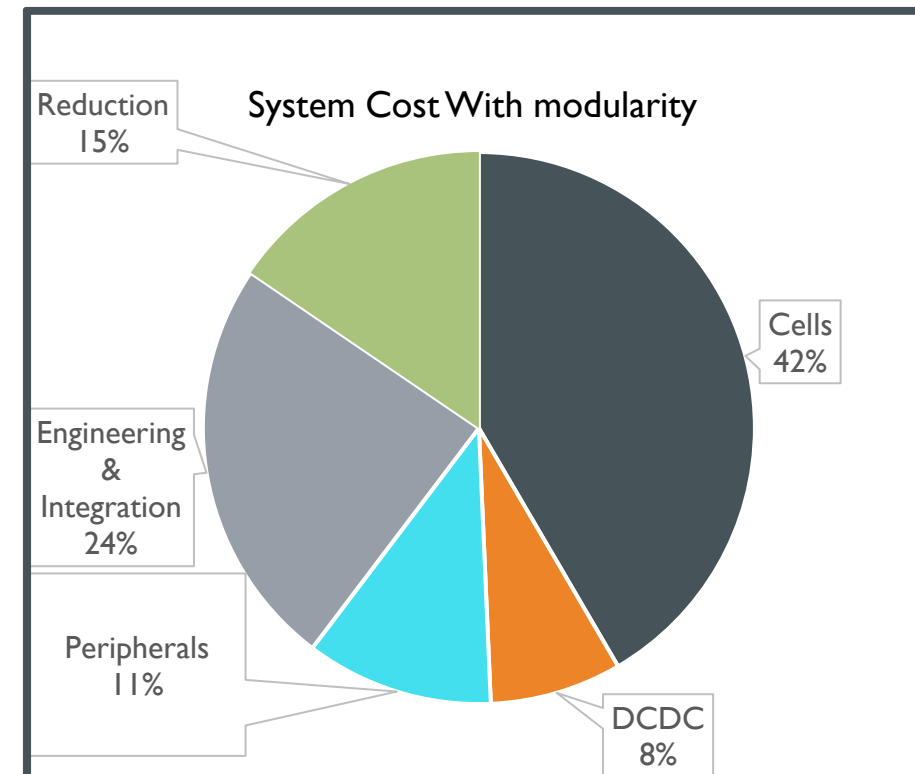
Battery System



System build-up, with the 'plug & play'

Transfer work from **shipyard to factory**

**Faster commissioning** due to End-Of-Line testing





July 2023 at North Sea

Fire on K-Line Ro-Ro Vessel – Fremantle Highway

>3500 vehicles on board, about 500 HV Electric

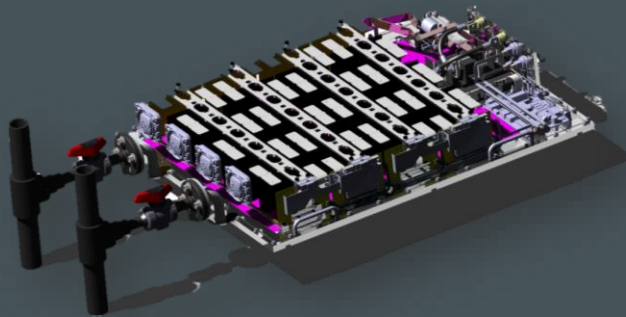






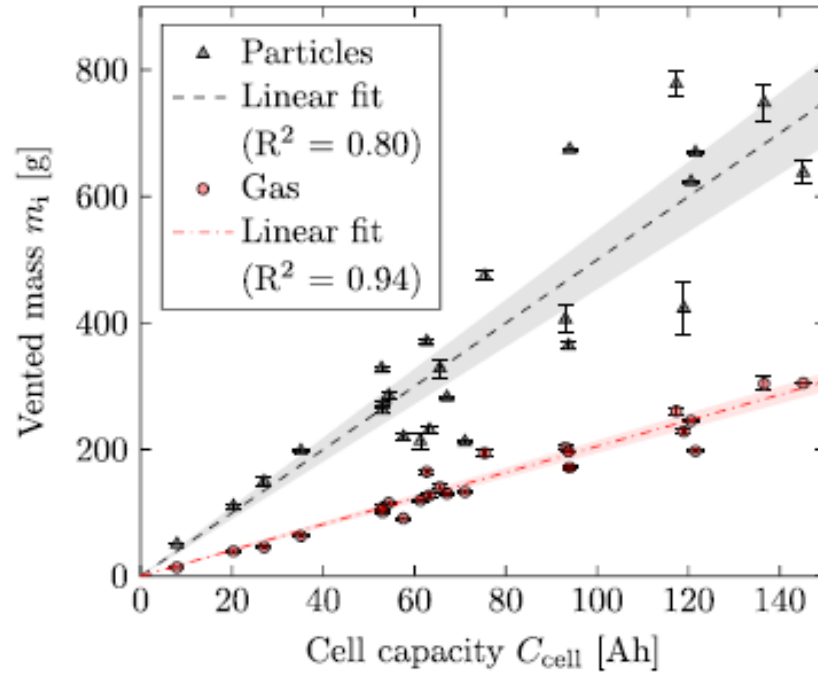
Safety in mind

What is the risk?



## The effect of a thermal runaway

- Heat generation
- Ejected particles and gas



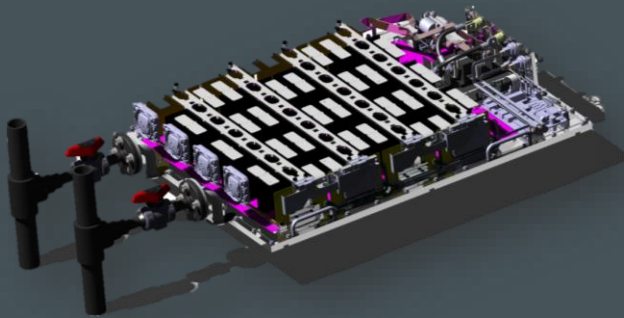
Capacity SEABAT HE cell: 155 Ah

Ref: Hoelle et al: „Analysis on Thermal Runaway Behavior of Prismatic Lithium-Ion Batteries with Autoclave Calorimetry”, Journal of The Electrochemical Society, 2021, 168, 120515: TR behavior of prismatic cells. Capacity range 8-145 Ah. Test of 25 different types (2 tests of each type, NMC and NCA). Triggering of TR by nail penetration.

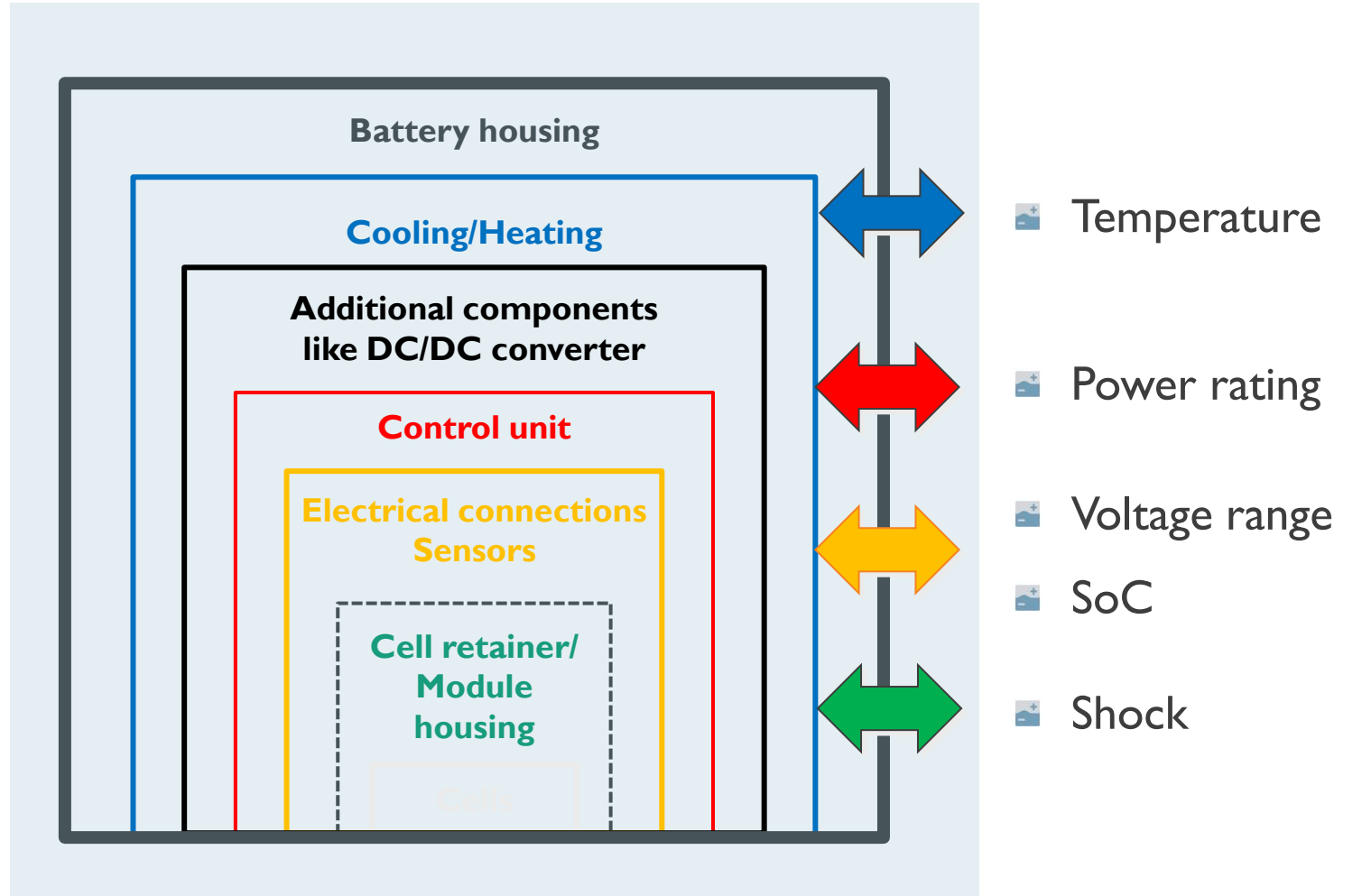


Safety in mind

Protection

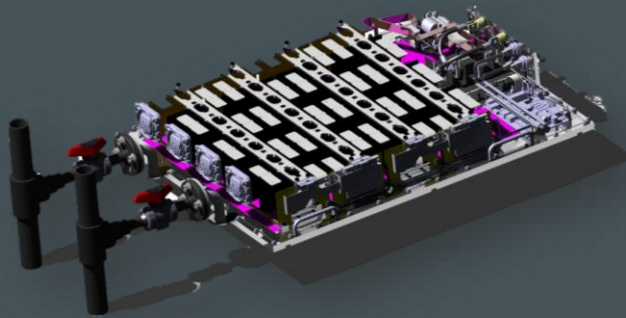


## Prevention of a thermal runaway



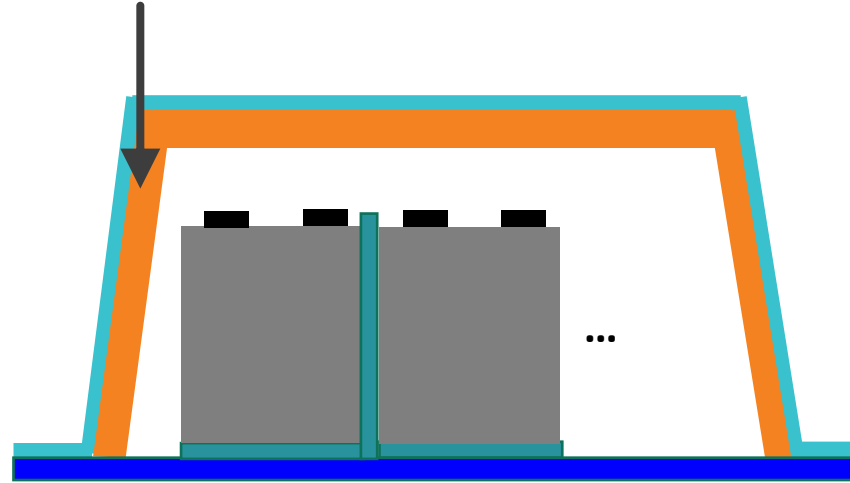


## Mitigations



## Protection and mitigations in mind – housing

### Ablation-material

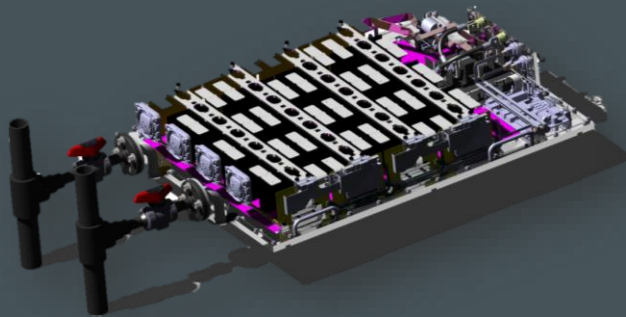


- Thermal insulation
- Flame-retarding
- Hot gas protection
- Stiffness in housing



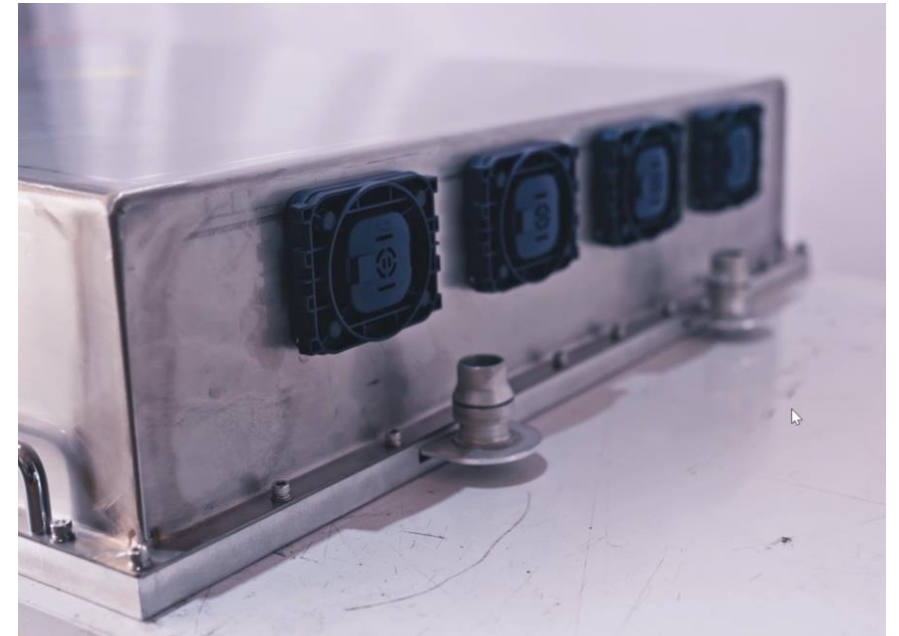


## Mitigations



## Protection and mitigations in mind - Venting

- Huge amounts of hot gas is ejected from a thermal runaway cell within about 0.5 s
- SEABAT high energy cell: 16 mol → ~2000 litres @1500 K, 1 bar
- Venting devices allow the gases to escape quickly, preventing the housing from bursting
- 4 venting devices in SEABAT module cover
- Ship battery room needs suitable pipe system for discharging the gases



→ Impact: No thermal propagation or housing crack at TE



- Compliance to standards & regulations

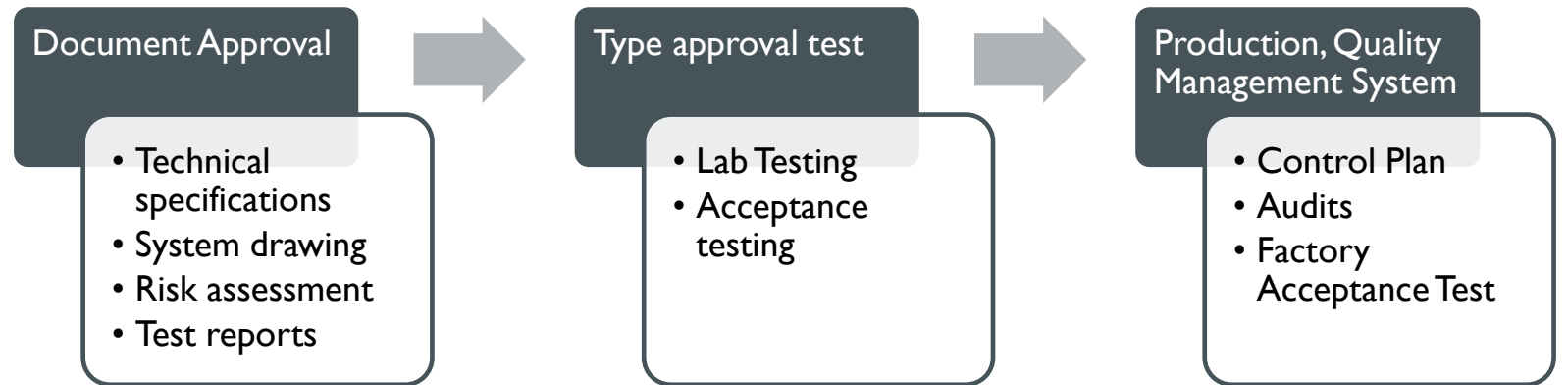


- Type approval required for battery systems
- Many difference on flag states



Marine tailored

## ■ Certification trajectory





## ■ Certification trajectory

### ■ Conformities (a.o.)

- Battery Safety conformity (IEC 62619, ...)
- IP rating
- EMI compliance
- Inclination conditions, vibration

### ■ Compliance assessment categories

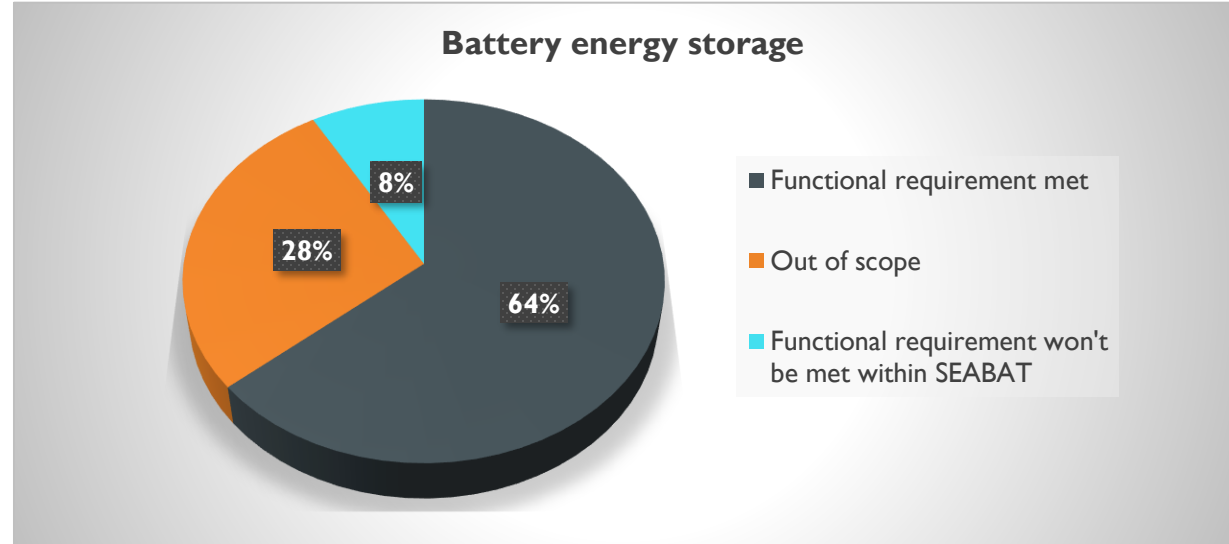
- Battery energy storage → Focus on compliance with functional requirements
- Testing & validation → Functional requirements testing
- On-board arrangements → concept is prepared for it, future work

→ Module type approval re-uses >40% of the compliance requirements



## Compliance level

## Compliance of functional requirements related to Battery Electric System

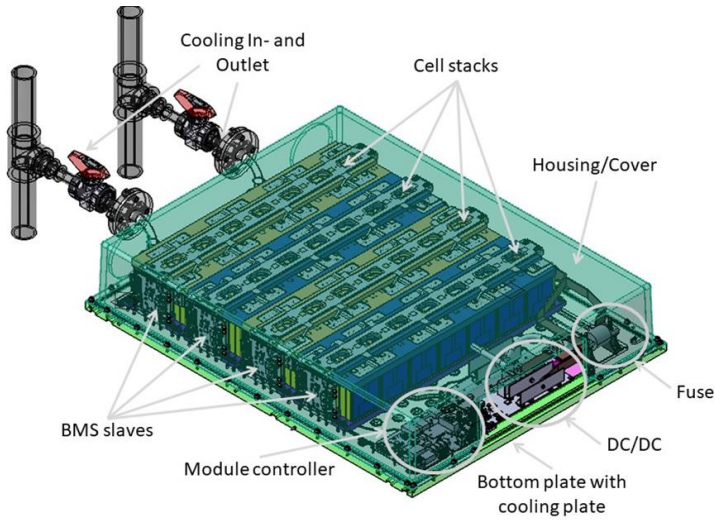


- Communication CRCs
- Cyber security
- EMS integration & diagnostics

→ Prepared for a next level to full compliance



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# QUESTIONS




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3. **Demo-Tour:** Manufacturing, Safety, Testing, Sizing and Integration +  13:15 - 15

4. **Networking:** Meet the experts +  15 - 16

5. **The future:** Road to Market and Panel Discussion 16 - 17

6. **Closing:** Networking +  17 - 18