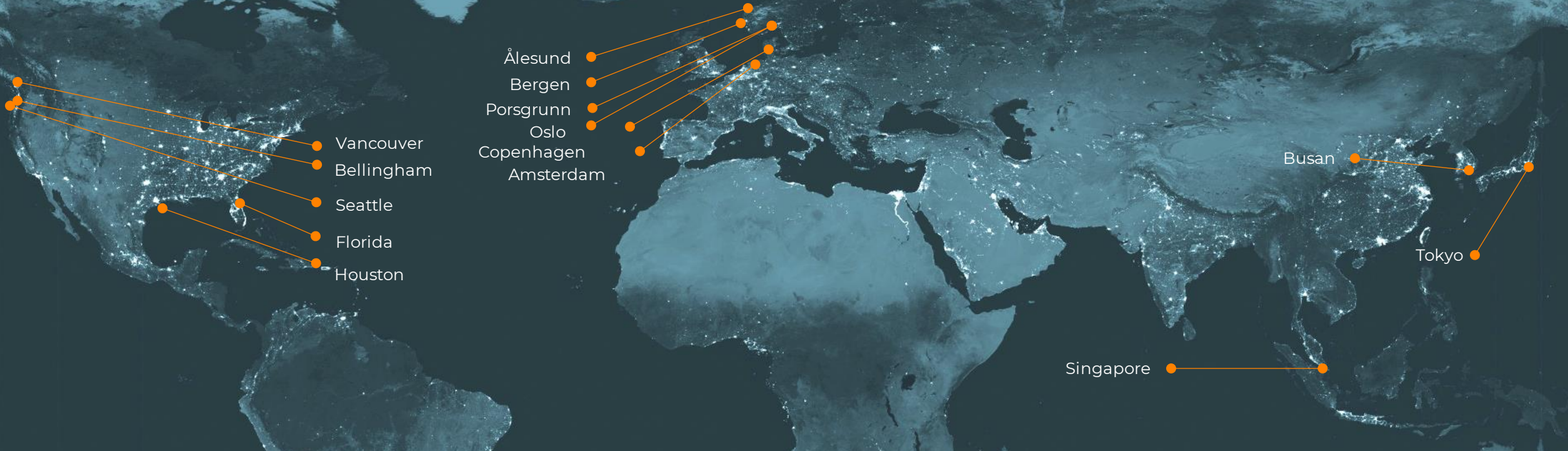


Kolbjørn Berge
SVP Global Regulatory
Affairs



Safety session
DSM 2023
Safety Meet

Locations



Bergen, Norway

- HQ
- Manufacturing
- Sales
- Project
- Service
- R&D

Oslo

- Sales

Porsgrunn, Norway

- Sales
- R&D
- Service

Ålesund, Norway

- Sales

Roskilde, Denmark

- Sales

Amsterdam, Netherland

- Sales

Singapore

- Sales

Busan

- Sales

Tokyo, Japan

- Sales
- Service

Vancouver, Canada

- Manufacturing
- R&D
- Sales
- Project
- Service

Bellingham, US

- Manufacturing

Seattle, US

- Sales

Houston, US

- Sales

800+

Projects

>5 000 000

Operating hours

650+

MWh

150

Car and
Passenger
ferries

36

Cruise
and Yachts

132

Offshore
and Subsea

152

Tugs/Workboat/
Fishing/Research

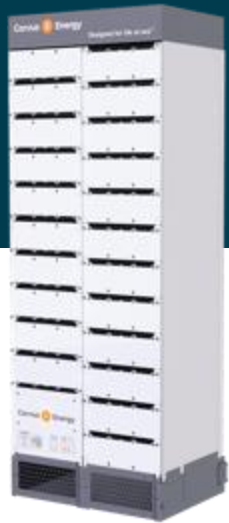
68

Merchant
vessels

186

Port
equipment
Shore stations ++

Different products for different applications



Corvus
Orca Energy



Corvus
Blue Whale



Corvus
Dolphin Power



Corvus
Dolphin Energy



Corvus
BOB Container



Corvus
Pelican Fuel Cell

Every technology transition in the ocean space has introduced new and different risks.



SOLAS

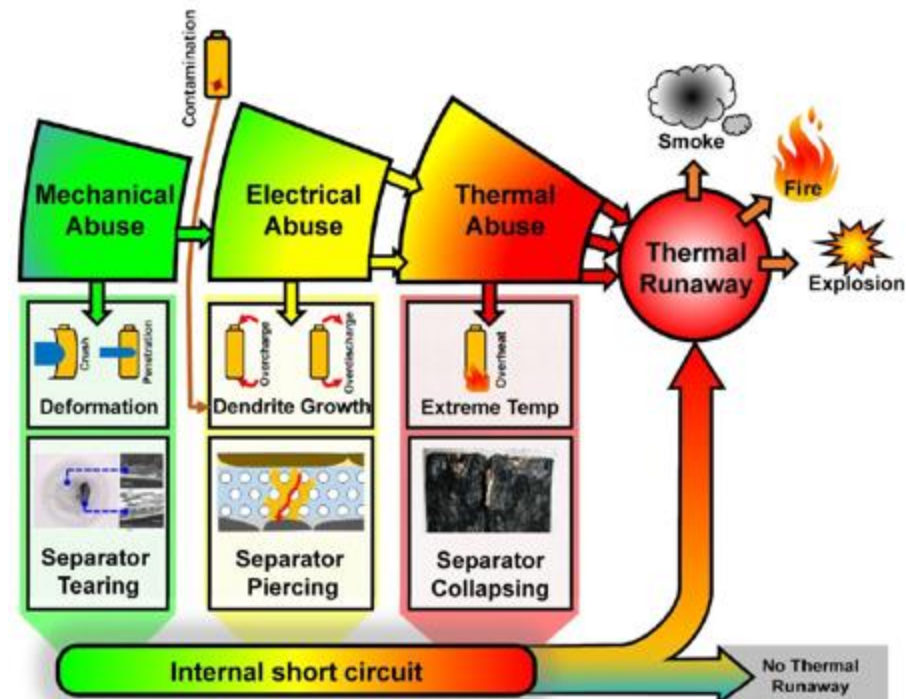
CONSOLIDATED EDITION 2020



IMO INTERNATIONAL
MARITIME
ORGANIZATION

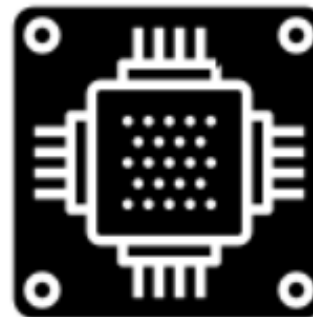
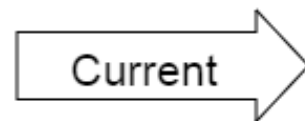
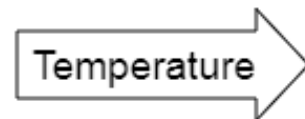
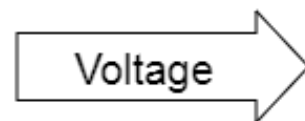
When introducing new technologies on board ships, failure scenarios should always be kept at the lowest possible level

Battery cells can, in rare, have a failures due to deviations in production or other defects that can cause a thermal runaway



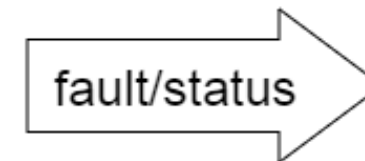
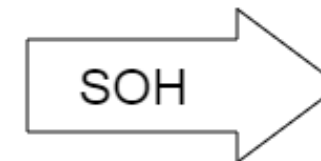
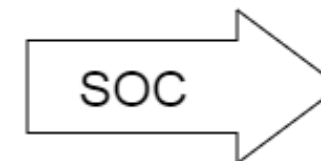
The Battery Management System protects from several risks such as overcharging, over-/under voltage and high, but it can't protect against internal short circuits

Input from Battery



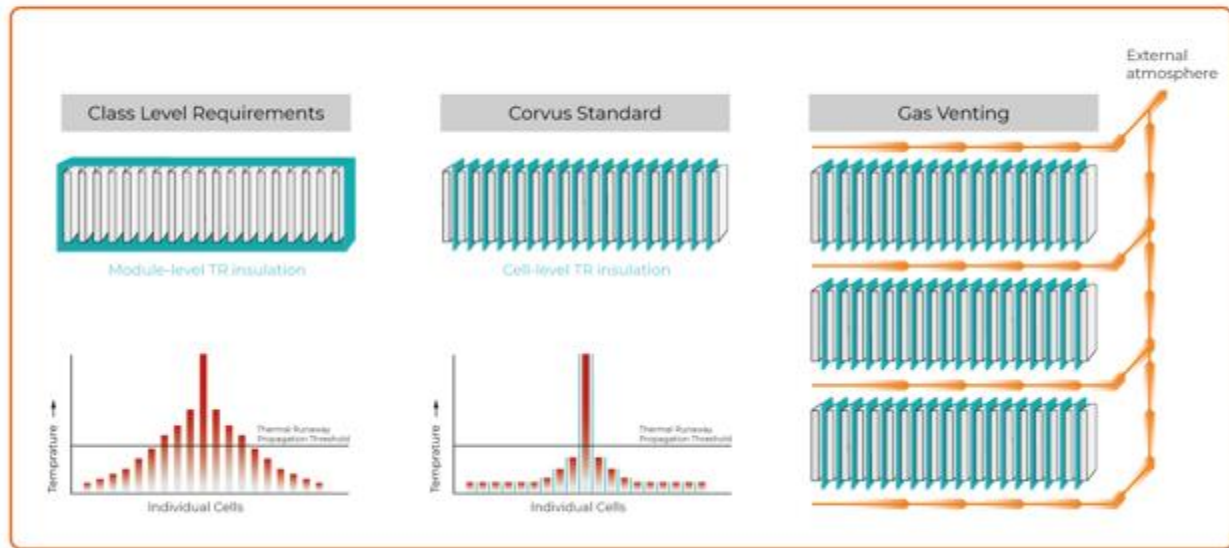
BMS

Output To Application



PASSIVE SINGLE-CELL THERMAL RUNAWAY INSULATION

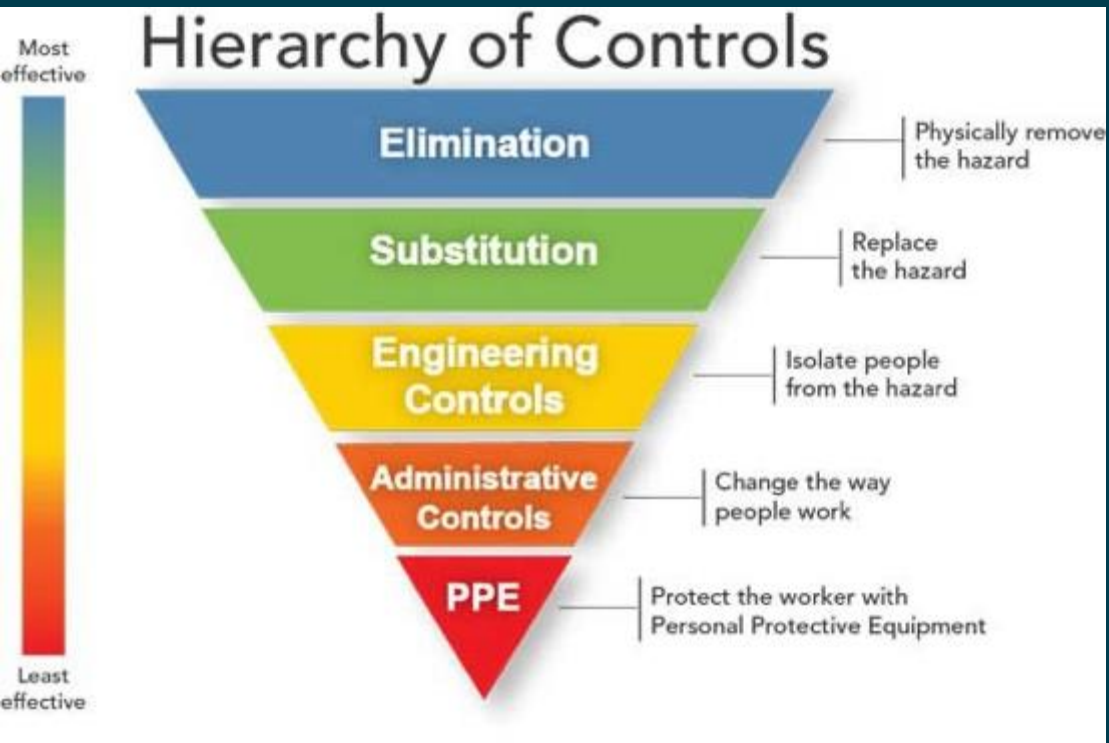
● INSULATION ● HEAT ● EXHAUST GAS



By having a system that passively handles thermal runaway on cell level, one does not rely on other systems to ensure containment of the failure

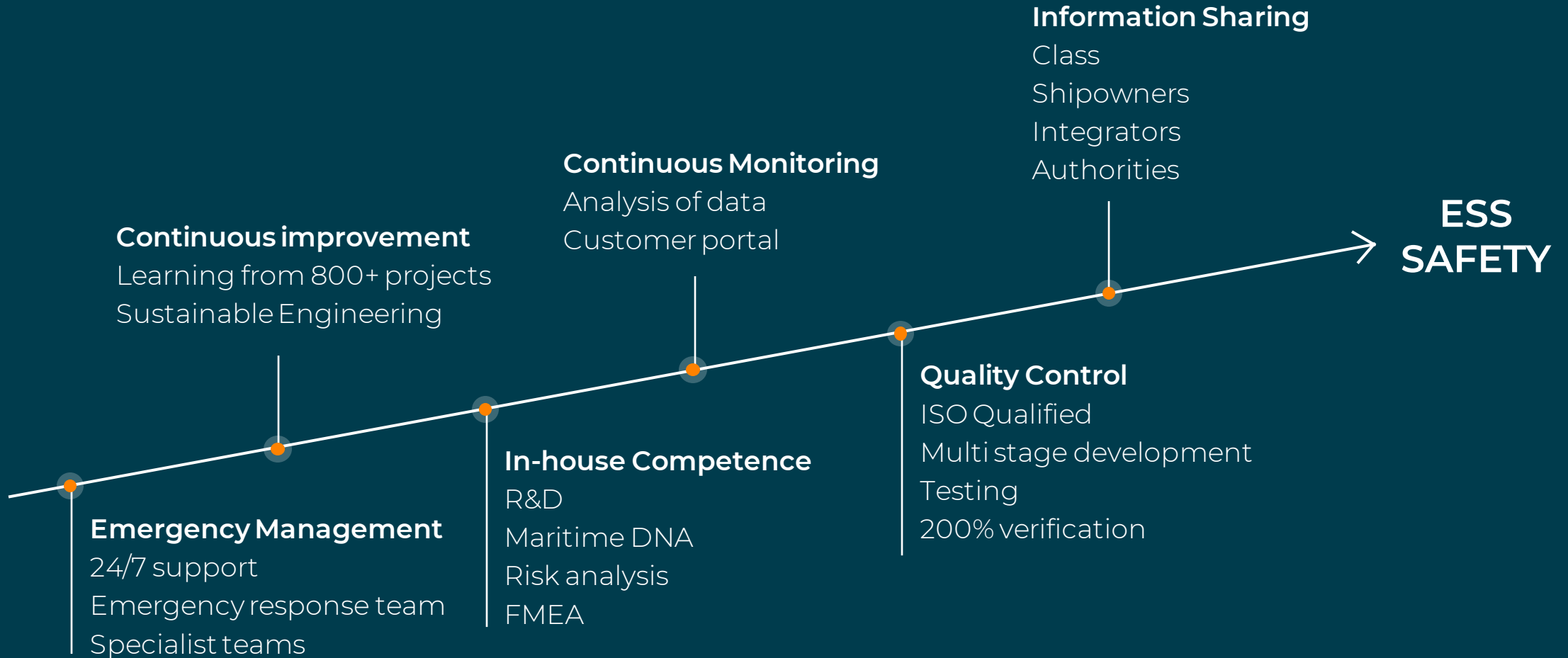
Additional systems (e.g. pumps, valves, control systems) might fail or have latent active failures. In addition, it´s an additional system to maintain. Malfunction could have severe consequences



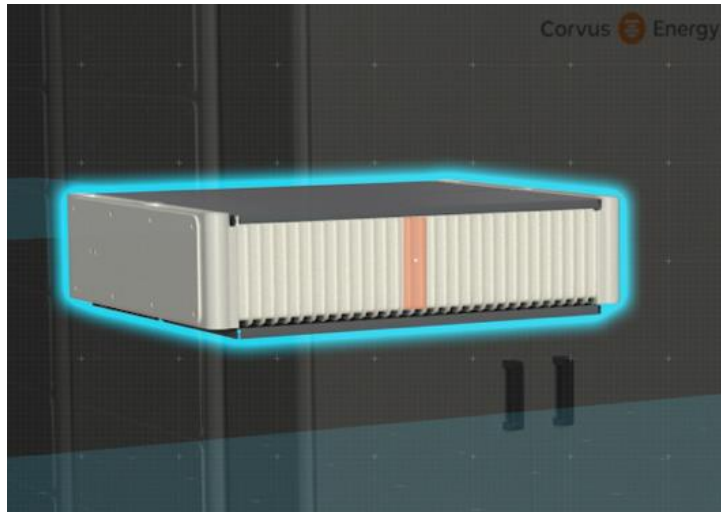


Safety should provide an equivalent level of safety by good design, and operational methods or procedures shouldn't be a substitute for good design

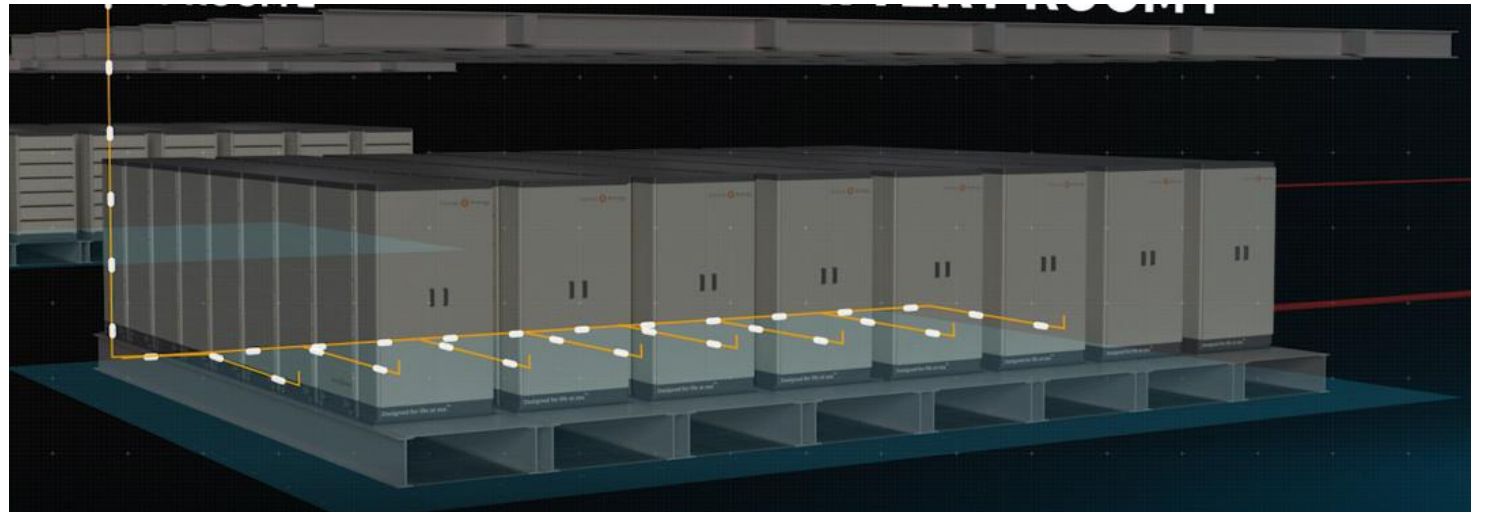
Driving Safety Further



Safety Features



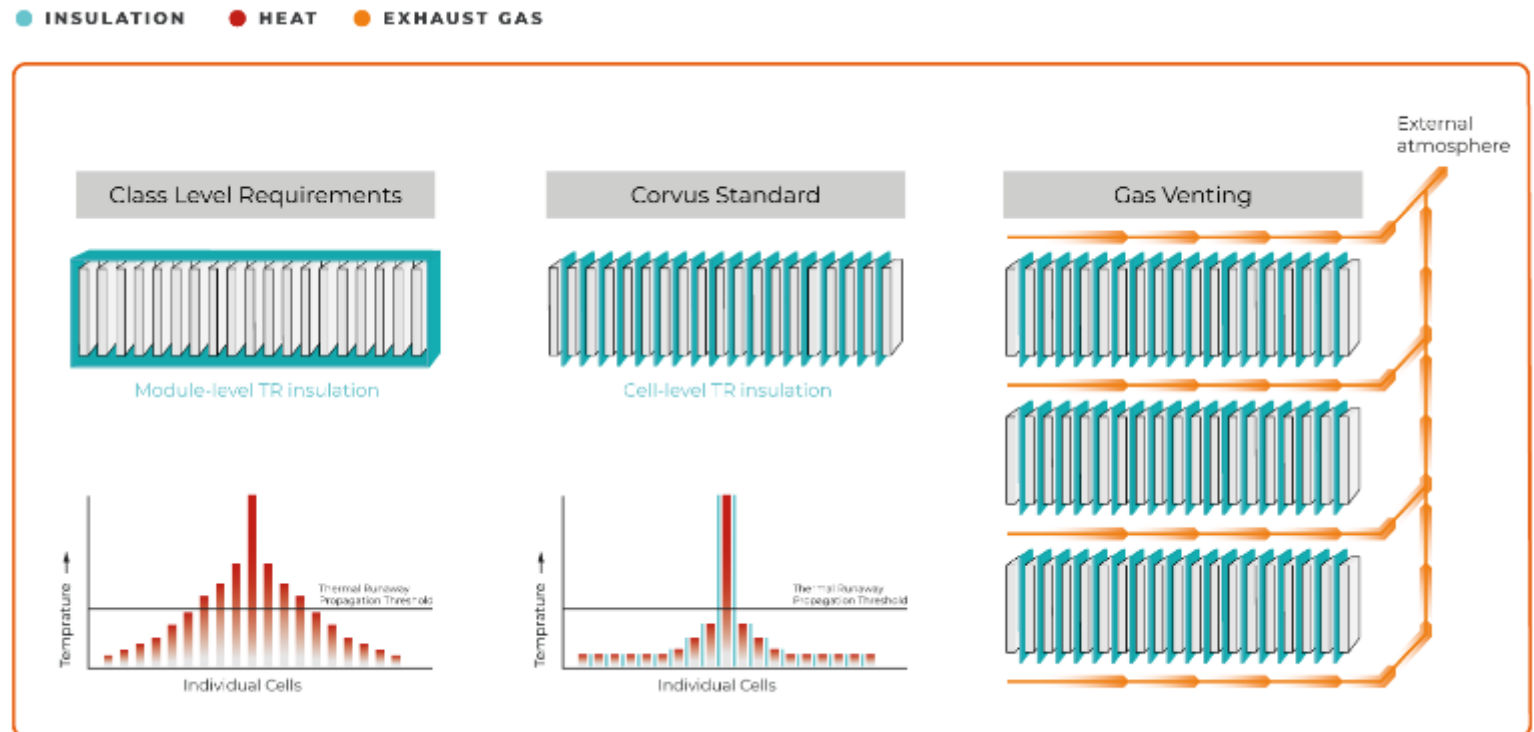
Single Cell Passive
Thermal Runaway
Insulation



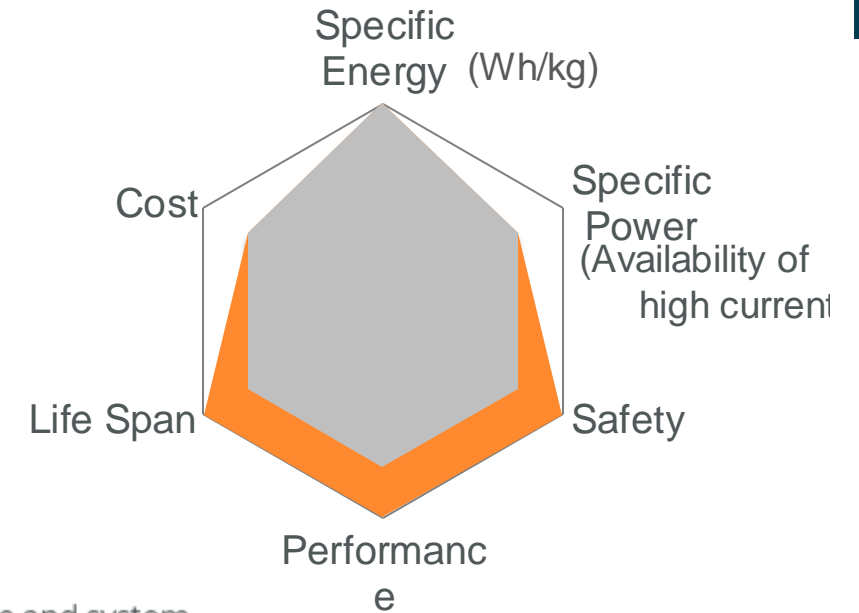
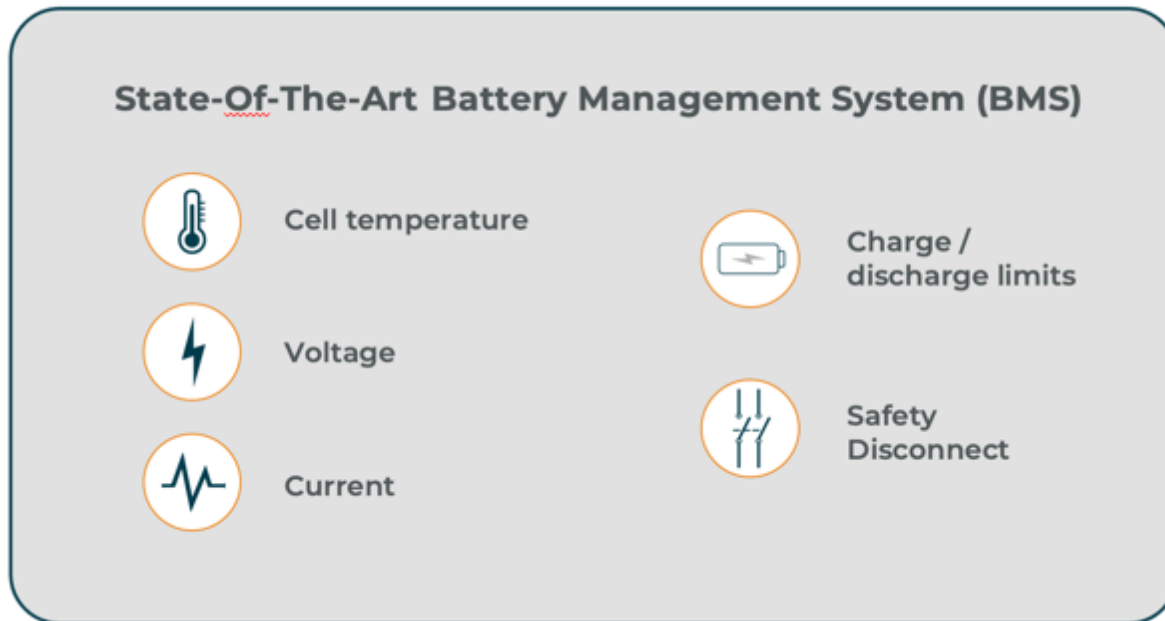
Integrated thermal runaway gas exhaust system.
TR gas is easily vented to external atmosphere.



Corvus ESS passive single cell TR insulation

- Thermal runaway consequences needs to be minimized on a vessel “semi confined space” as opposed to automotive with plenty escape possible
- Regulatory requirements are traditionally stronger for maritime ESS, but still room for improvement.
- Cost of safety in maritime is different compared to EV batteries and stationary ESS.



Different cells – Different properties



-  Lithium-NMC
-  Orca BMS, enclosure and system enhance the basic cell

From «risk based» to «risk scenario based» approach

ABUSE CONDITIONS

External to the ESS



- Overheat of battery room
- Mechanical impact/deformation
- Submersion/water intrusion
- External short circuit
- Overcharge/overdischarge
- Arrangement on board



HAZARDS

Posed by the ESS

- Thermal event
- Gas emission
- Electrolyte leakage
- Electric shock

FAULT CONDITIONS

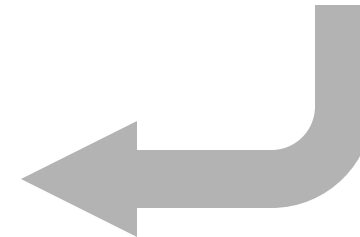
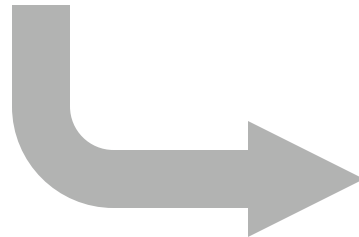
Internal in the ESS



- Cell internal short circuit
- Production fault
- Sleeping faults (e.g. SW issues)

RISK SCENARIOS

Inherent to the ESS



Safety is a joint responsibility

Battery supplier

Battery compliant to standards and regulations on all safety aspects

Integrator

Verified seamless integration of the battery system in the vessel

Shipyard/Designer

Vessel compliant to regulations and specifications

Approval bodies

Rules, regulations, product approvals, acceptance tests, inspections etc.

Ship owner/operator

Follow up on approvals and inspection results. Operation according to specifications and approvals. Training for crew





Corvus  Energy

Thank you