

Integration of Fuel Cells & Batteries to Power the Future

Part 1



**Corvus
Energy**



KONGSBERG

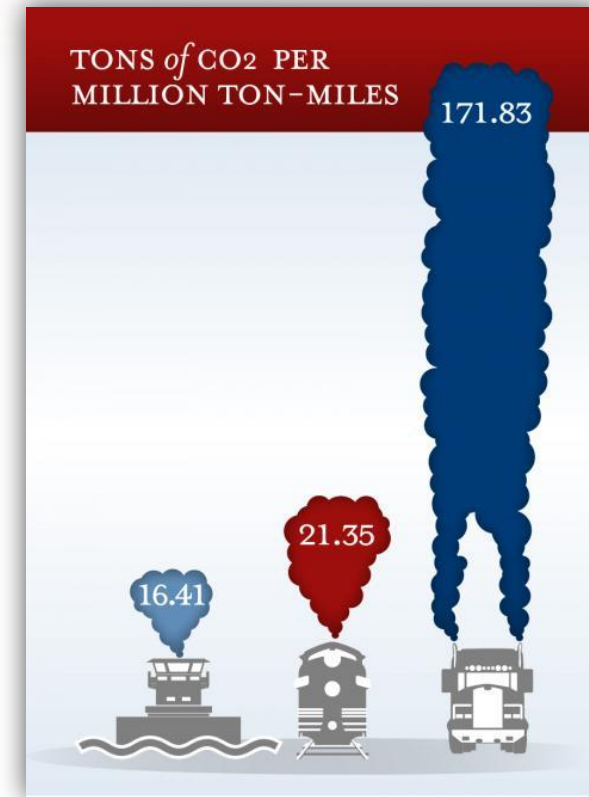


**The American
Waterways Operators**



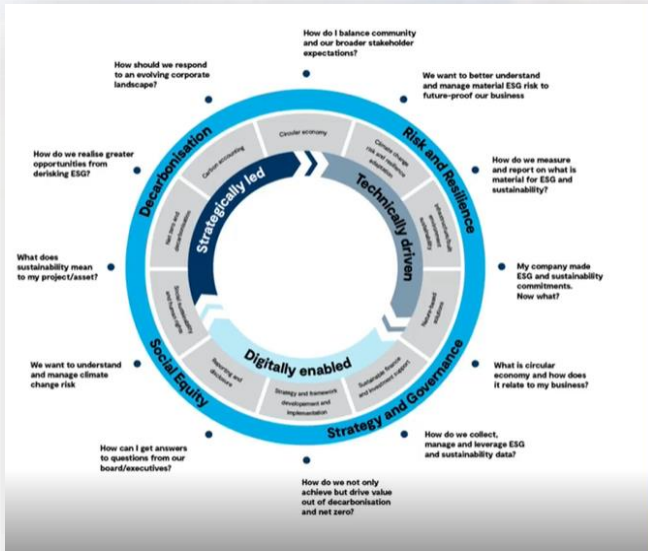
The **Most Sustainable** Mode of Transportation

- AWO is the tugboat, towboat, and barge industry's advocate, resource, and united voice for safe, sustainable, and efficient transportation on America's waterways, oceans, and coasts
- The largest segment of the U.S.-flag domestic fleet
 - 5,000 towing vessels
 - 33,000 barges
 - 665 million tons of cargo annually
 - 90% less CO₂ than trucking



Environmental Social and Governance

Webinar #1



Four principles guide the development of a sustainability roadmap:

- **Decarbonization:** Reducing or eliminating carbon emissions from operations and assets.
- **Risk and resilience:** Enhancing systems' adaptability to climate changes and mitigating environmental risks.
- **Social equity:** Ensuring that benefits and burdens of policies are fairly distributed for balanced economic, environmental, and social outcomes.
- **Strategy and governance:** Providing a framework to manage risks and opportunities, guiding organizations toward sustainable growth.

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ENVIRONMENTAL

- Climate change
- Water use
- Biodiversity and habitat
- Energy consumption
- Greenhouse gas emissions
- Air quality
- Materials
- Waste and recycling
- Disaster resilience
- Sustainable procurement

SOCIAL

- Community development
- Health and safety
- Human rights
- Inclusion and diversity
- Labor standards
- Working conditions
- Stakeholder relations
- Employee rights and protections
- Employee benefits and programs
- Product safety and quality

GOVERNANCE

- Board/management diversity, tenure and independence
- Governance policies
- Risk management
- Code of Conduct
- Anti-bribery/anti-corruption
- Cybersecurity
- Data protection and privacy
- Legal and regulatory fines

ESG

A framework to *identify, evaluate, measure and manage an organization's impact* to society, economy, and environment through their management of Environmental, Social, and Governance topics.

- ESG and sustainability considerations are integral to managing risk, strengthening financial & non-financial performance, improving stakeholder support and enhancing value creation levers over the long term; a holistic approach is key.

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Ginny Philips

Mary Morgan

BR

LD

WT

Will Tuc...

MT

+24

Moderated Panel Discussion

Sustainability in practice

Gregory Carli
GHD



Global Advisory Leader
Sustainability, Resilience & ESG

Mike Miller
McAllister Towing



DPA and HSQE
Manager

William Tucker
American Commercial Barge Line



Senior Environmental
Manager



The American Waterways Operators
The Tugboat, Towboat & Barge Industry Association

Environmental Social and Governance

AWO Winter Sustainability Webinar #1

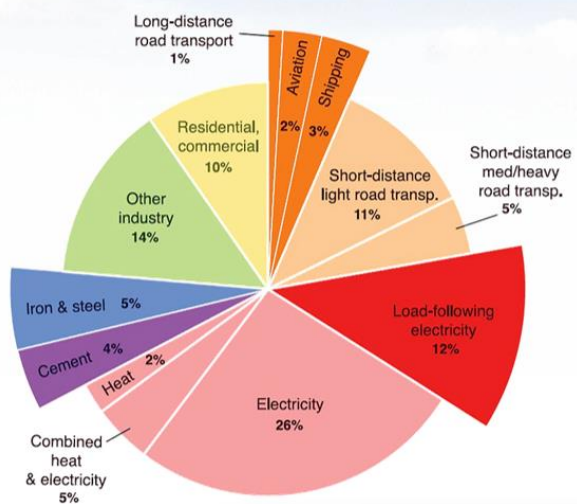
Link to **ESG** Webinar:



Efficiency Unlocked: Fuel Tracking & Data-Driven Optimization

Webinar #2

Global GHG Emissions Comparison



Smart Fleet Management

Integrate your data silos to optimize the performance of your vessels and your organization

- Vessel Positions
- Daily Reports
- Weather Data
- Geofencing
- Fuel Sensors
- Engine Data

DATA SOURCES (Internal + External) | ANALYTICS ENGINE | AI-DRIVEN ANALYTICS

Moderated Panel Discussion

Sustainability in practice

<p>Dave Hill Mobile Ops</p>  <p>CEO Founding Partner</p>	<p>Falon Hernandez Spinergie</p>  <p>Business Development Manager, Americas</p>	<p>John Donovan Fueltrax</p>  <p>VP, Energy and Defense Solutions</p>	<p>Kyle Durden Bergan</p>  <p>President CEO</p>
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Efficiency Unlocked: Fuel Tracking & Data-Driven Optimization

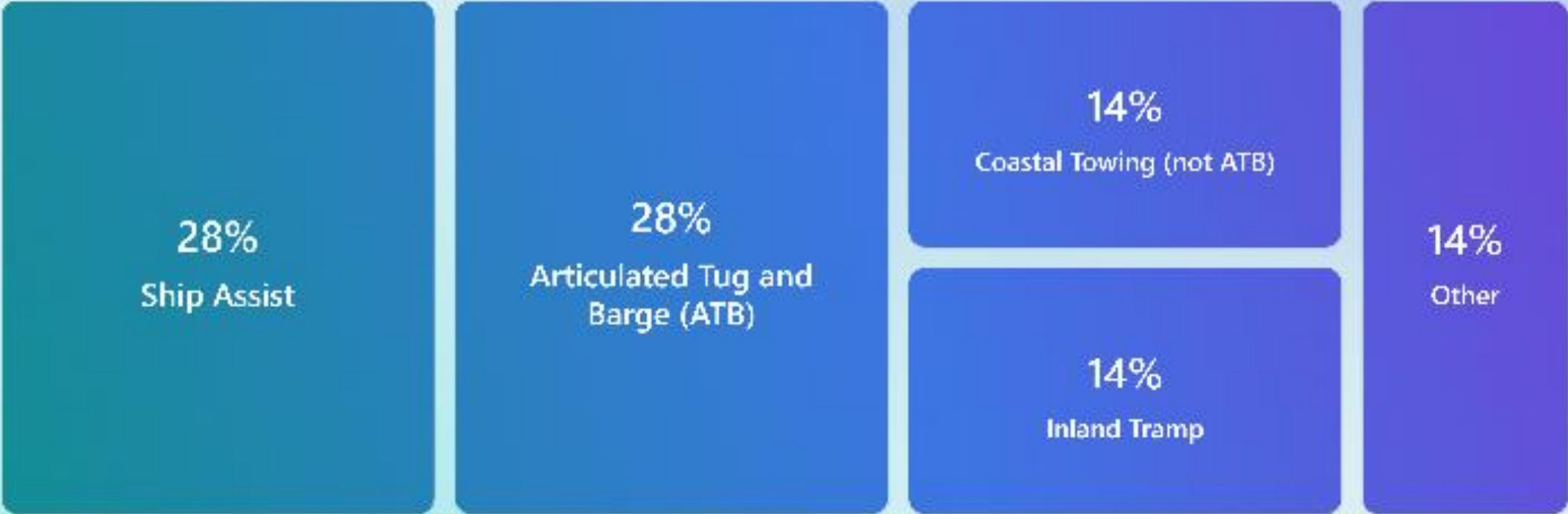
Webinar #2

Link to **Fuel & Data** Webinar:



7 responses submitted

What type of tug operation does your fleet primarily focus on?



Treemap

Bar



1 of 1



9 responses submitted

Is your organization considering hybridization or electrification of your vessels?



Treemap

Bar



1 of 1



Powering the Future

Today's Discussion
The Integration of
Fuel Cells & Batteries
to Power the Future

Part 1



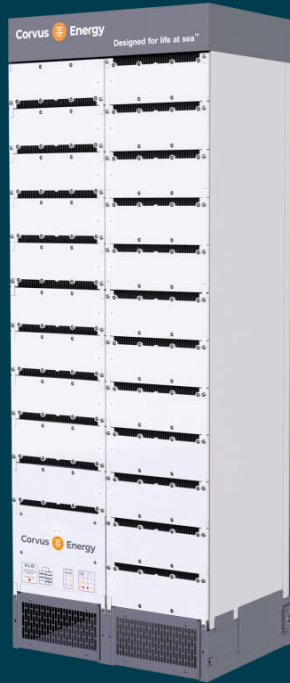


Sveinung Odegard
SVP Business Development
Fuel Cell Technology
Corvus Energy



<https://corvusenergy.com/>





Extending zero-emission operations with energy storage & fuel cell systems combined.

Presented by:

Sveinung Odegard
SVP Business Development
Fuel Cell Technology
Corvus Energy

The Green Energy Shift and Regulatory Push

Influencing Factors

Driving regulations

- IMO - Reduce CO² emissions across international shipping by >40% by 2030
- California Air Resources Board (CARB)
- Environmental Protection Agency (EPA)

Zero-emissions rules in ports

United States EPA
Clean Ports Program
[EPA Clean Ports Program Fact Sheet](#)

Oil majors' action

Targets carbon neutral operations by 2030-2050



Public demand for greener business practices

Engaged passengers, communities and political bodies support emissions reduction

Battery economics

Increasing ratio of energy and power density / price per unit

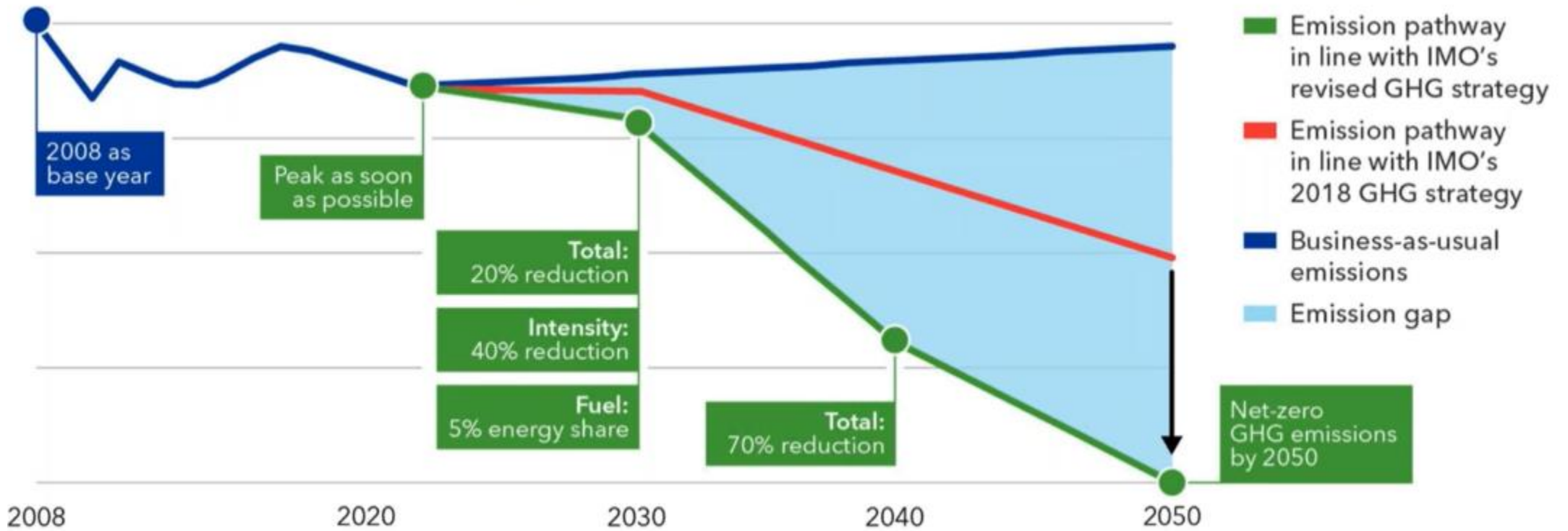
Adoption rate

Contractual developments increase shipowner incentives to prioritize fuel savings

IMO & EU target **net-zero** by 2050

Shipping must reduce GHG emissions

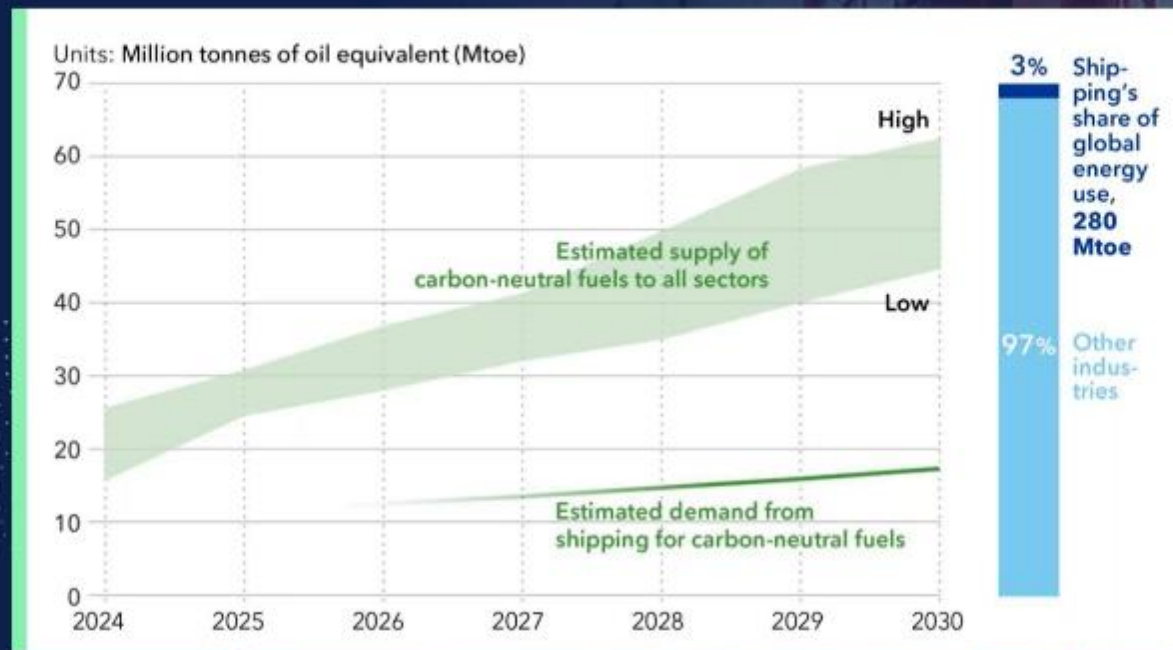
Units: GHG emissions



Total: Well-to-wake GHG emissions; Intensity: CO₂ emitted per transport work; Fuel: Uptake of zero or near-zero GHG technologies, fuels and/or energy sources

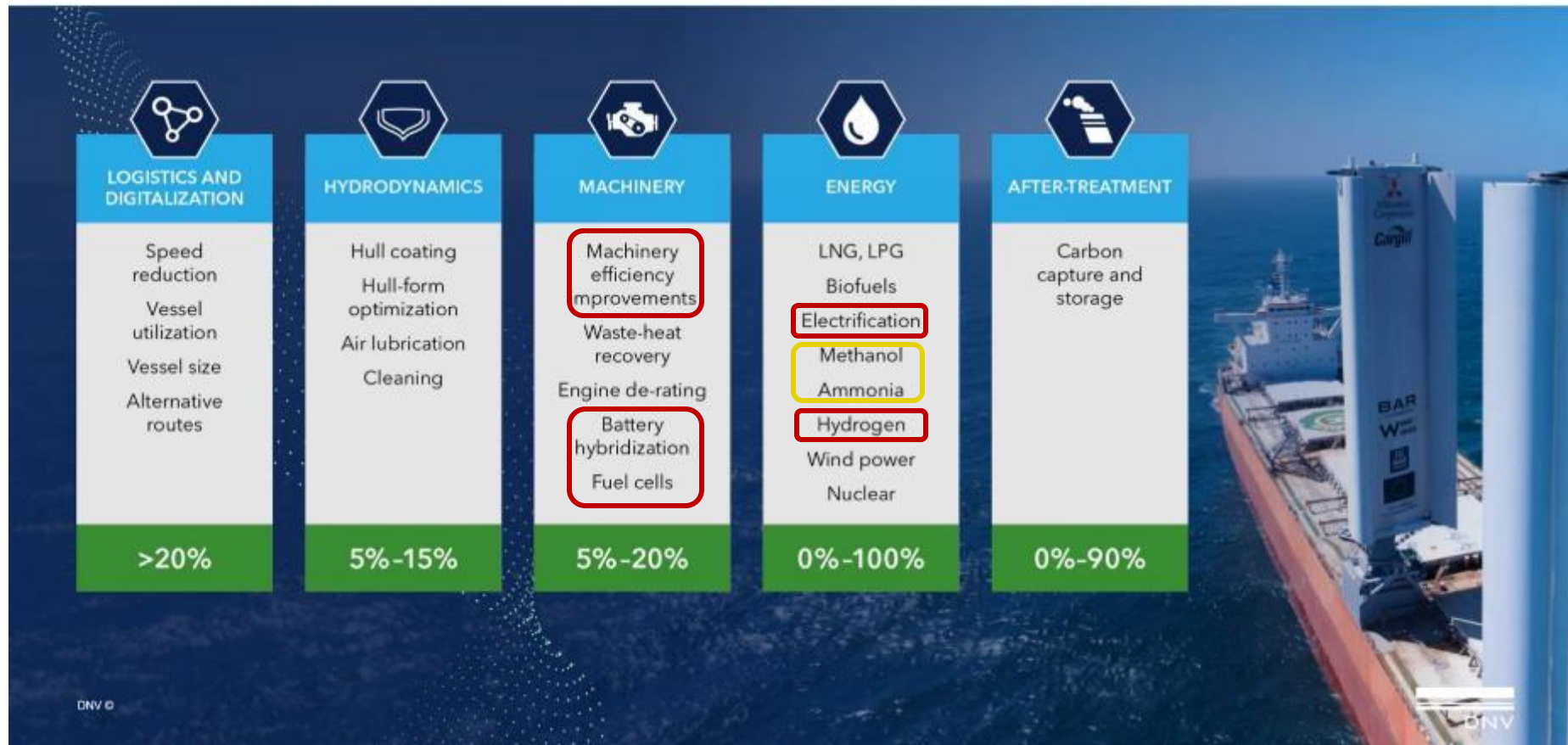
Estimated global availability of carbon-neutral fuels

Shipping requires an estimated 30-40% of global carbon-neutral fuels in 2030

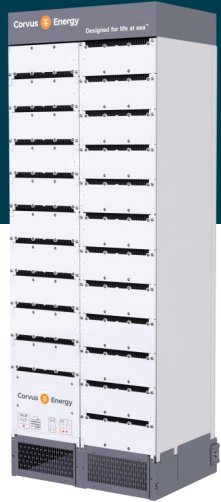


How to achieve the goals set by IMO?

All decarbonization solutions must be explored



Different products for different applications



Corvus
Orca



Corvus
Blue Whale



Corvus Dolphin
Energy NxtGen



Corvus BOB
«Battery on Board»



Corvus
Pelican Fuel Cell

Marine Electrification

The main principles of hybrid/electric propulsion.

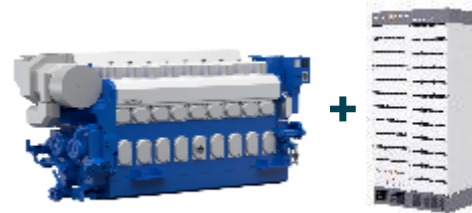


Emission free operations

Batteries only



Ex: Tesla



Reduced emission operations

Combustion engines + batteries



Ex: Ford Escape hybrid



Emission free operations

Fuel Cell + batteries



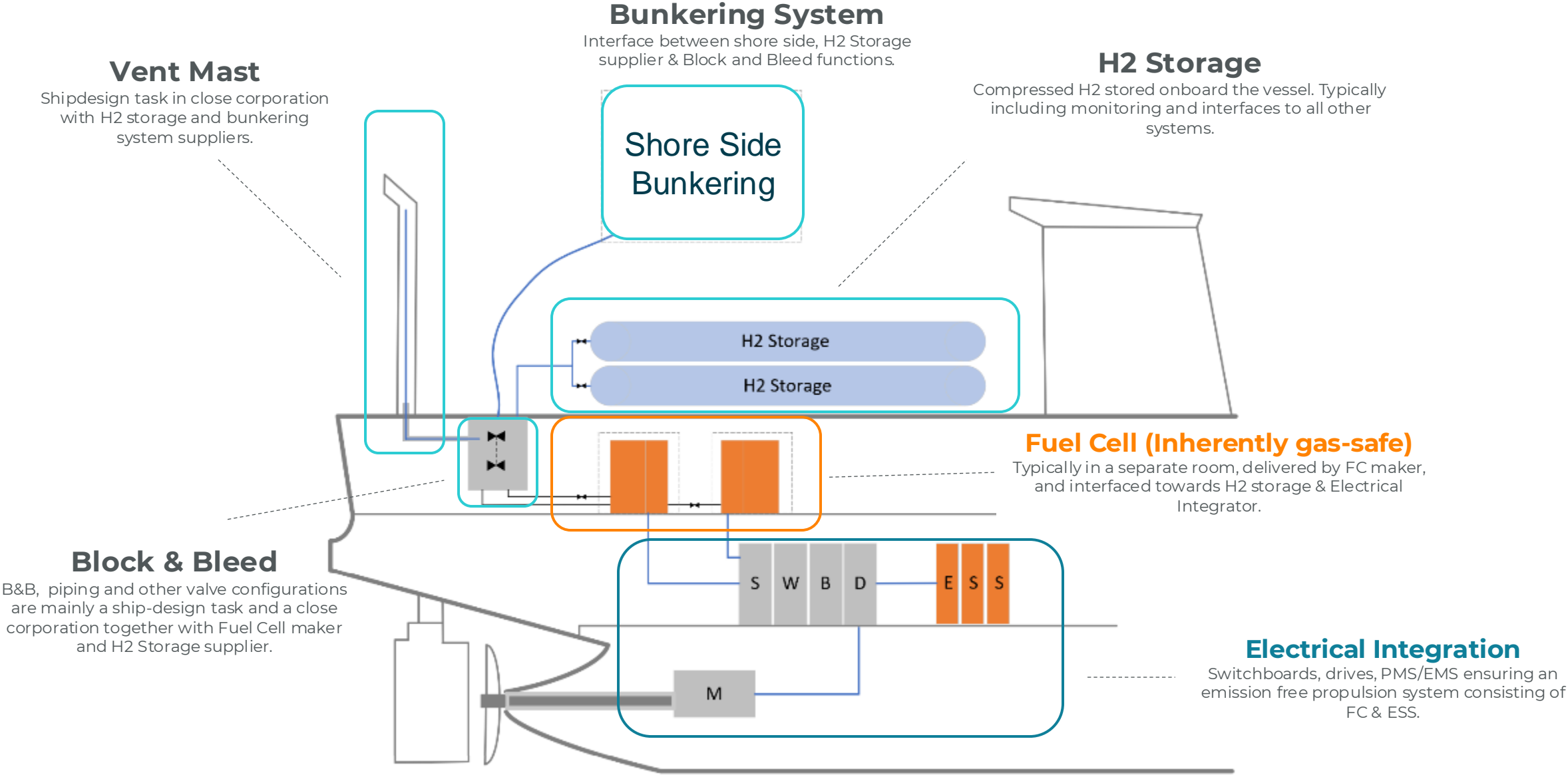
Ex: Toyota Mirai



Different Fuel Carriers for PEM Fuel Cells.



Principle breakdown CH2 systems



Corvus Pelican Fuel Cell System

Advanced Technology



- Gas tight and pressure safe enclosure
- Operating pressure below ambient
- Inerted secondary barrier
- Independent safety system
- Mature and proven technology

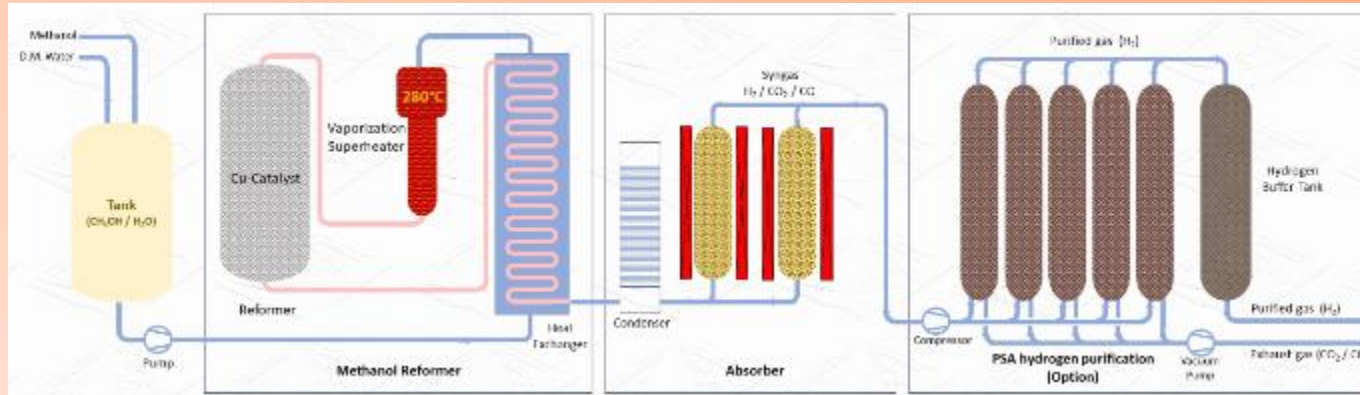
Inherently gas safe with type approval

- Design is based on IMO's IGF codes and regulations being developed.
- Contains the risks within the FC system
- Minimize special requirement for the vessel or FC room.

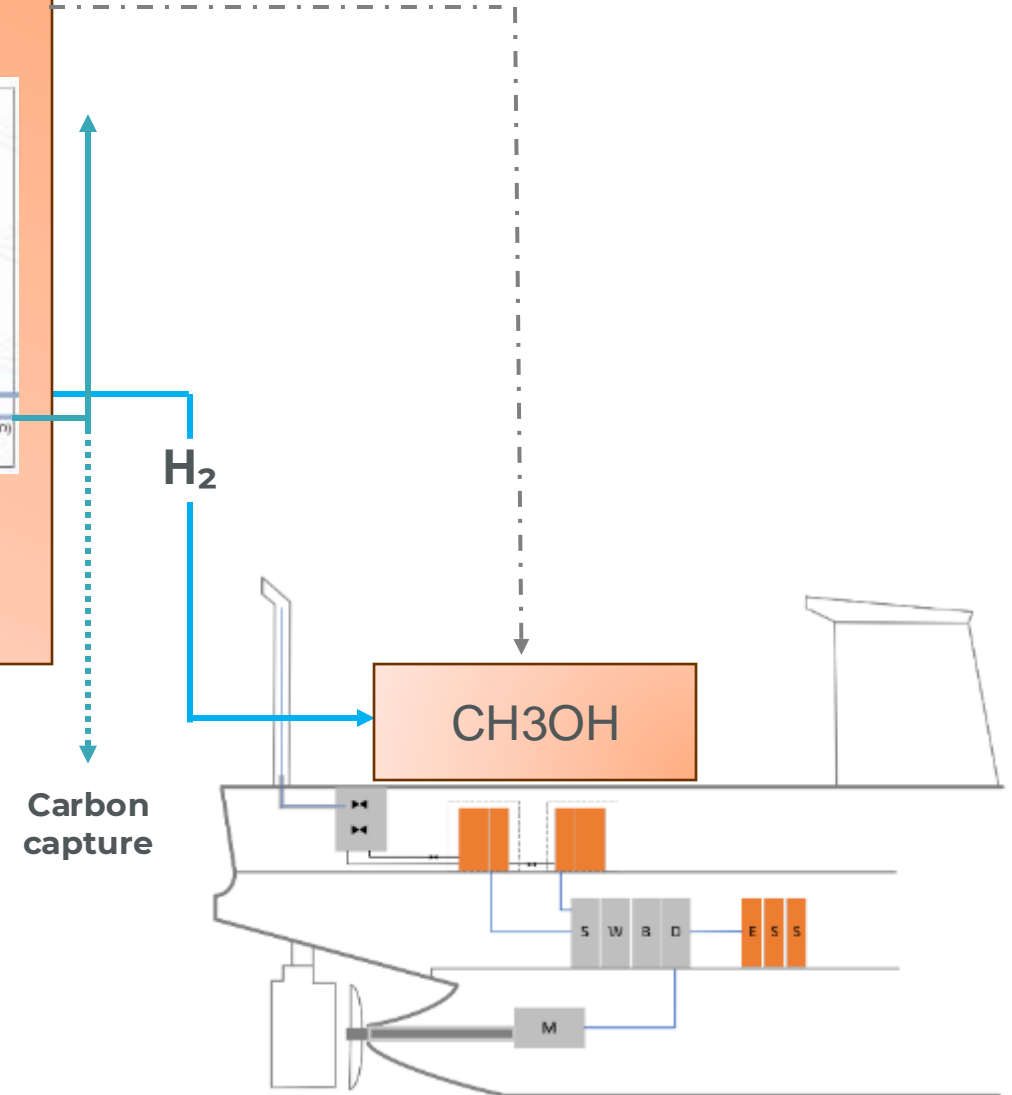


Methanol Reformer Technology

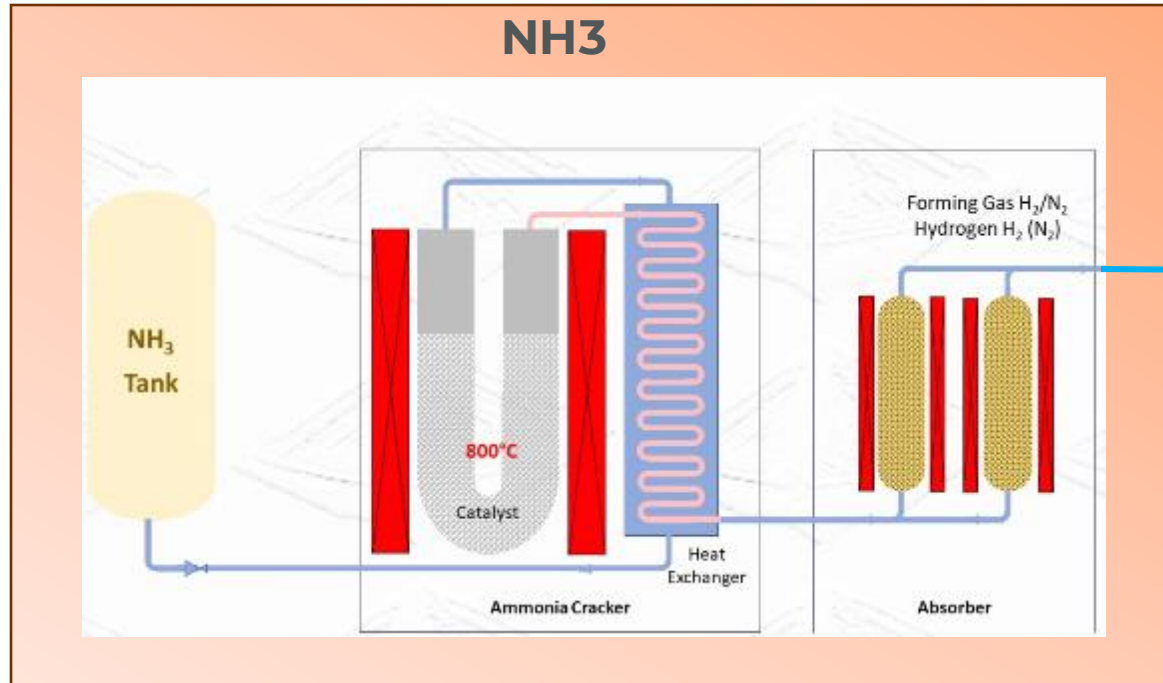
CH₃OH



Methanol reformer technology separates the hydrogen by use of heat and catalytic material. A carbon capture systems can also be included to make the entire system emission free.

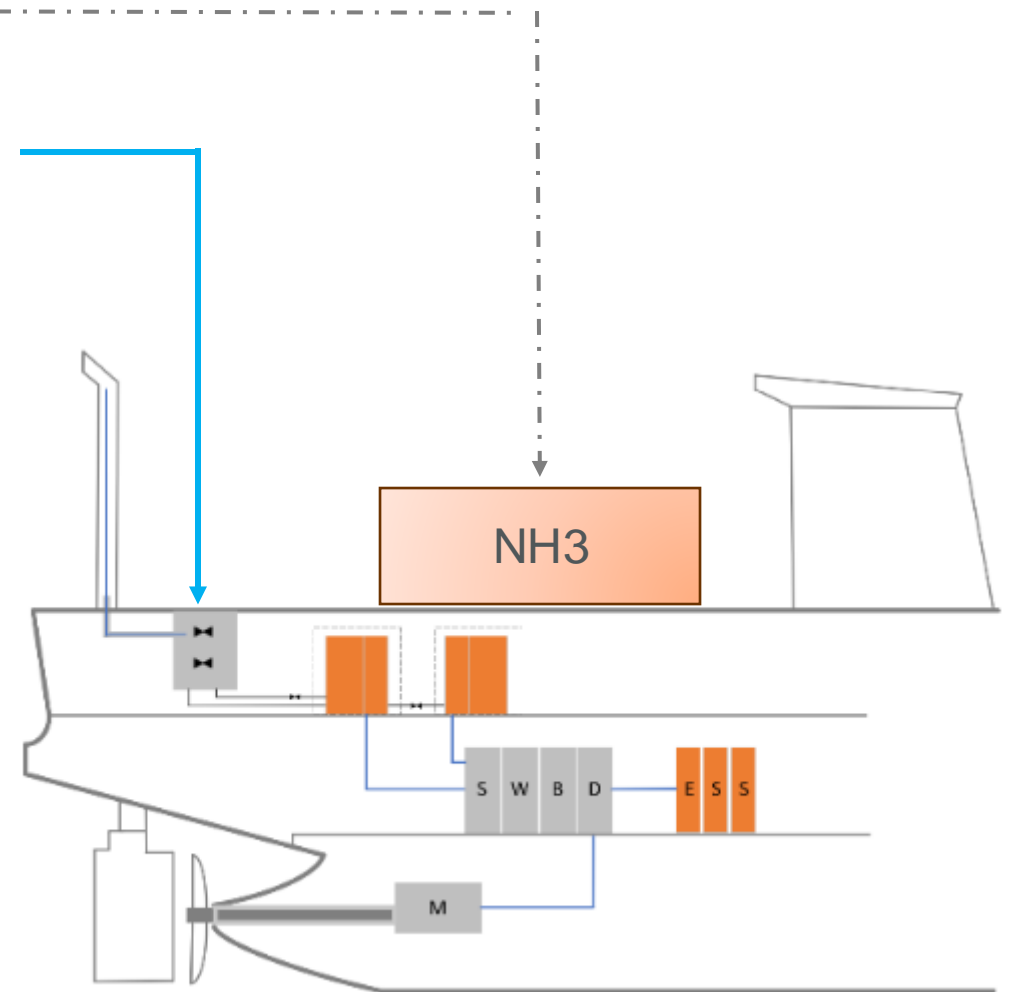


Ammonia Cracker Technology (Amogy)

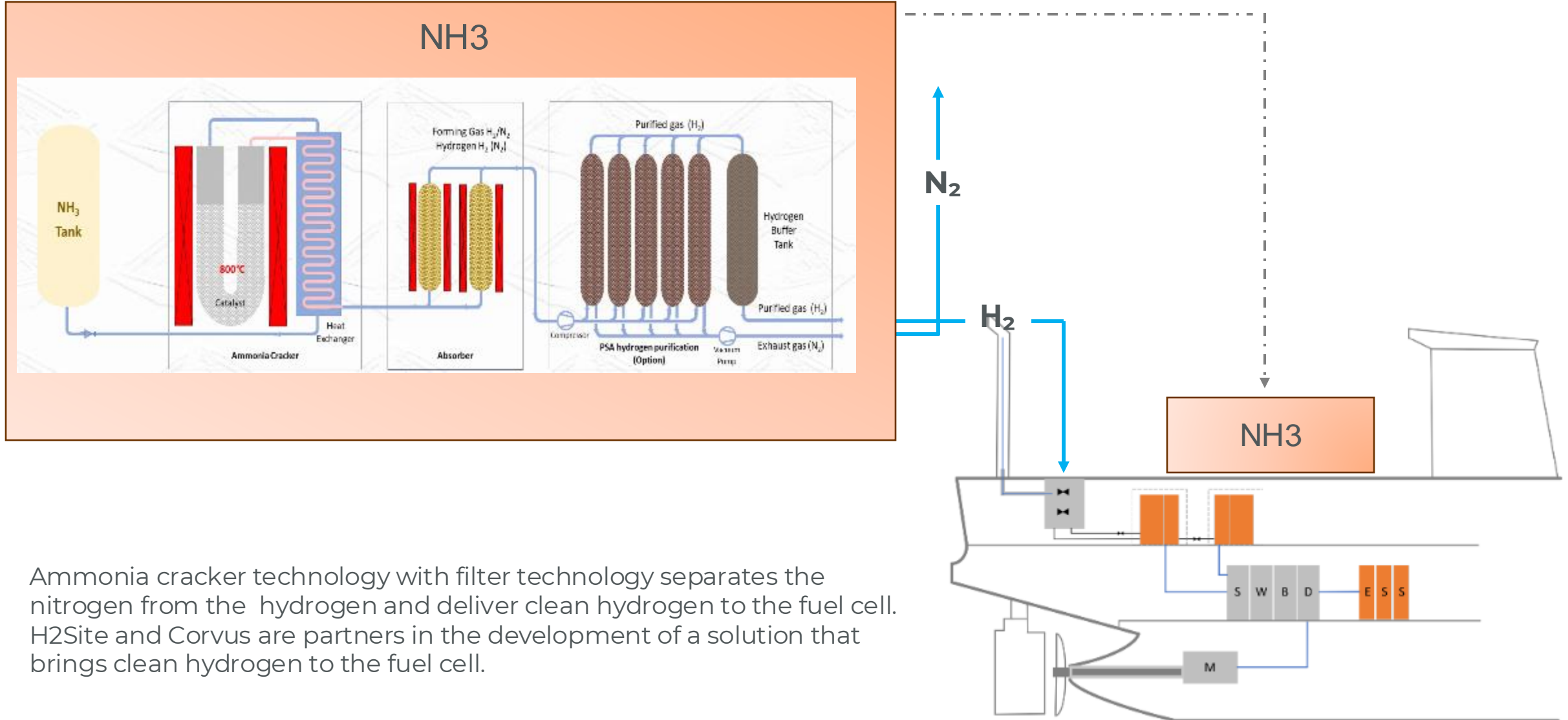


H₂N₂

Ammonia cracker technology without filter will separate the nitrogen and hydrogen, but depends on a fuel cell technology that accept nitrogen to flow through as a byproduct.



Ammonia Cracker Technology with Hydrogen Purification system (H2SITE)



Ammonia cracker technology with filter technology separates the nitrogen from the hydrogen and deliver clean hydrogen to the fuel cell. H2Site and Corvus are partners in the development of a solution that brings clean hydrogen to the fuel cell.



Inherently Gas Safe Principles



Corvus Pelican Safety Features

What is an Inherently Gas Safe Fuel Cell?

- For inherently gas safe concepts, machinery spaces are considered gas-safe under all conditions.
- This is achieved by multiple safety barriers embedded into the design.
- Safety barriers are independent to ensure maintained safety different types of scenarios.



Multiple layers of safety

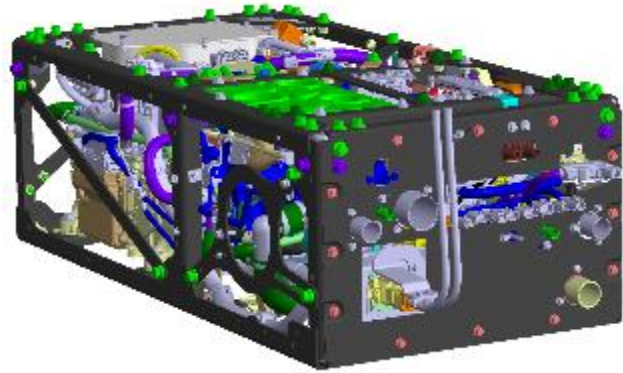
Benefits with Inherently Gas Safe Fuel Cell

- Allowing it to be installed inside the vessel in technical rooms.
- Less requirements for the safety and ventilation support systems.
- Increased flexibility in ship design to accommodate spaces for fuel cells.
- Enabling a more efficient integration onboard the ship.
- Increased overall safety and operational reliability.

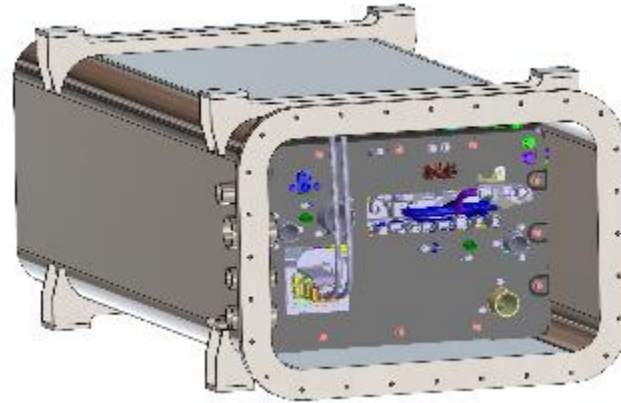


Inerting principle for Inherently gas Safe Fuel Cell

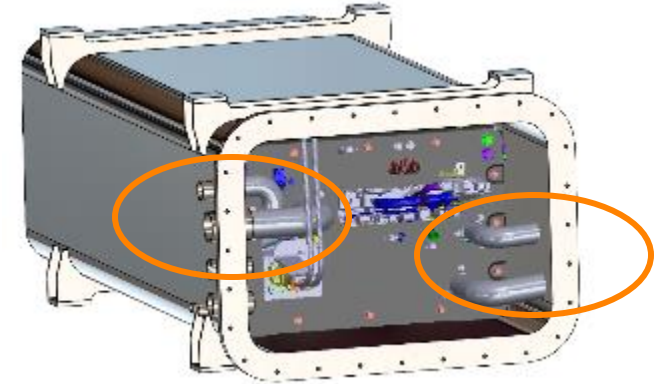
1: Complete Fuel Cell Module from supplier



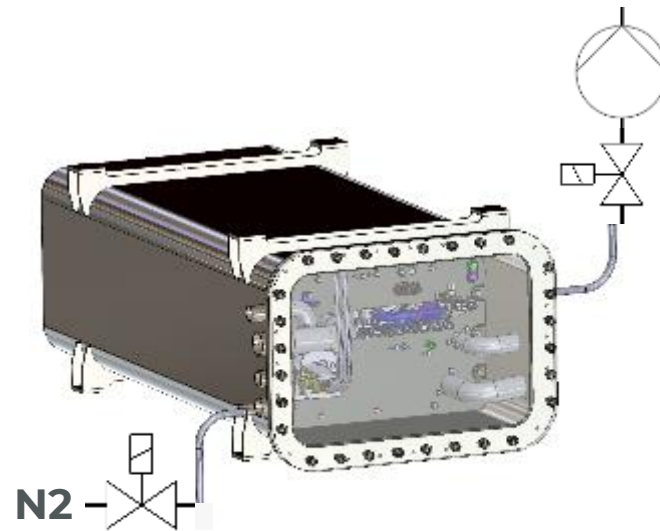
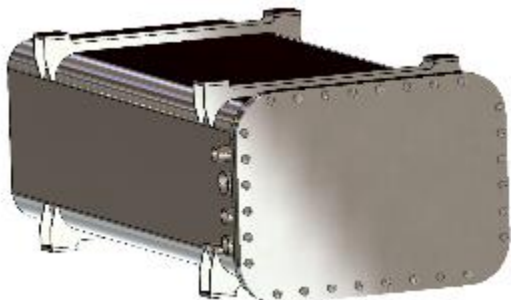
2: Module inserted into Corvus Fuel Cell Enclosure



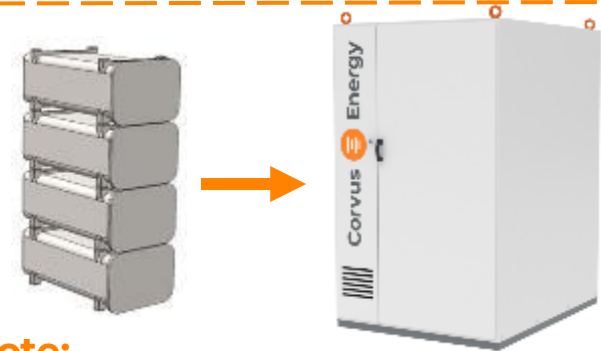
3: Connections between module and enclosure is completed. – Including double wall piping for H2 supply.



4: Enclosure provides a leak-proof barrier between Fuel Cell and the ambient environment.



5: The volume inside the Fuel Cell Enclosure is replaced by Nitrogen and reduced to below atmospheric pressure.



Note:

The enclosures will be stacked vertically making up a column of 4 enclosures. Interfaces towards the column are welded manifolds. The column and auxiliaries will be integrated into the Corvus Fuel Cell Cabinet which is the Corvus product boundary towards ship integrator.



Integration of Fuel Cells onboard

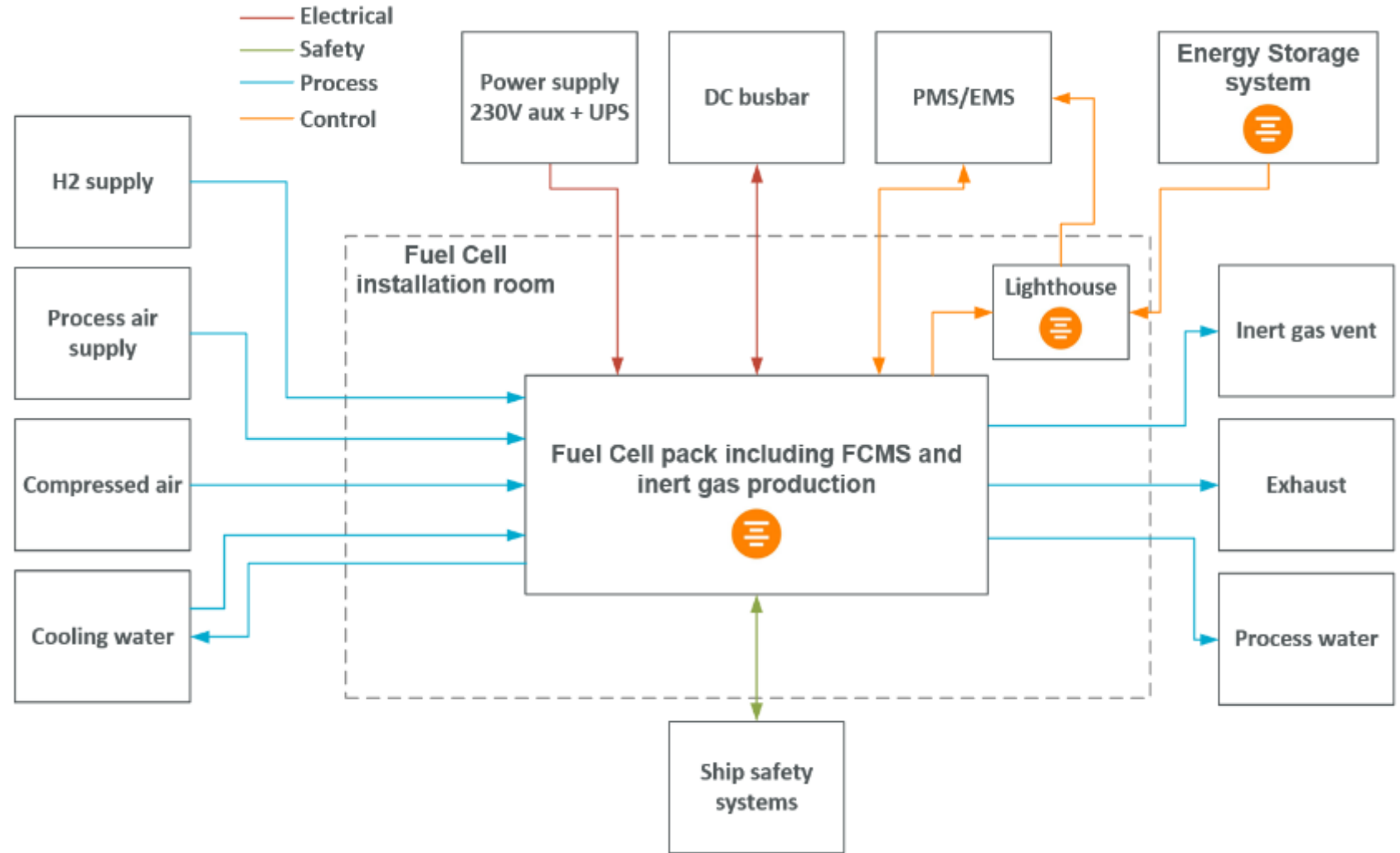


Diagram

Fuel Cell Interface

Clearly defined interface points enabling integration with all participating suppliers.

A comprehensive solution having all the necessary components to minimize other auxiliaries to make a system complete onboard a vessel.

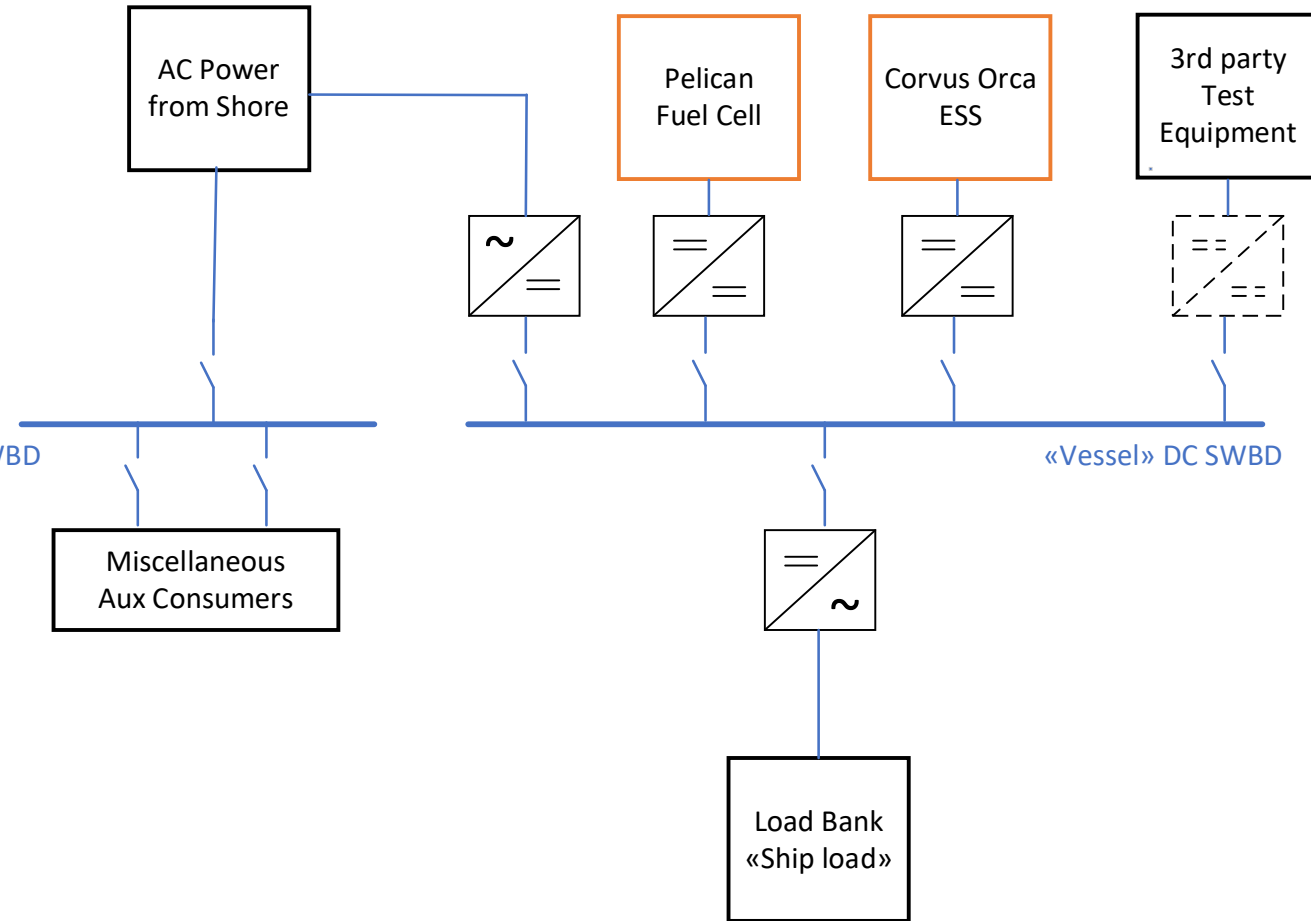


Corvus FC/ESS test site in Bergen

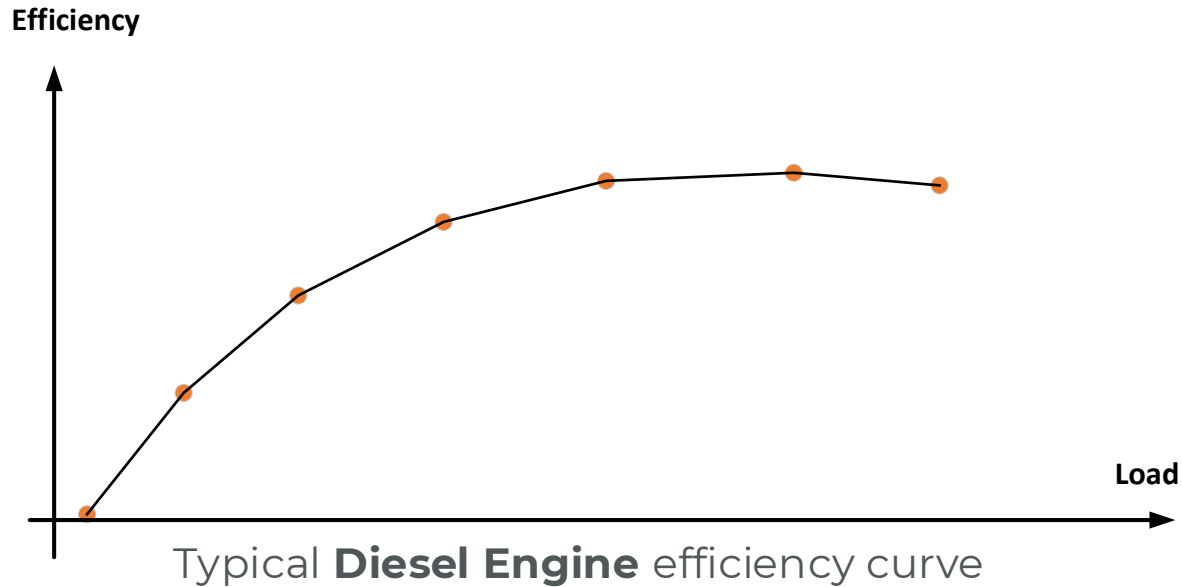
A complete setup to simulate a virtual ship load scenario



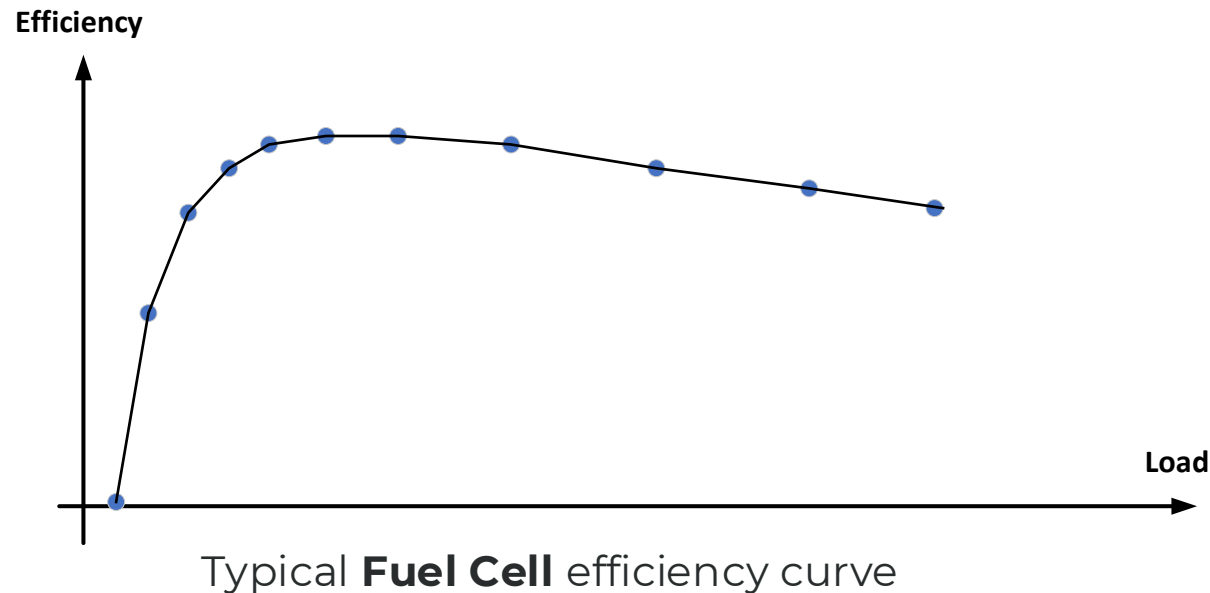
«Vessel» AC SWBD



Optimization of a FC & ESS system



Fuel cells have different efficiency and lifecycle characteristics compared to a traditional combustion engine.

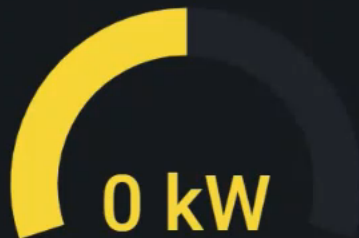


Optimization parameters are significantly different compared to a traditional Diesel/ESS hybrid configuration.

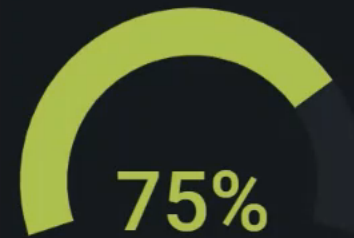
Fuel Cell Power



Battery Power



Battery State of Charge



Measurements



Energy Storage System Applications

ESS Use Cases



Spinning Reserve

- Backup energy source
- Reduce number of engines
- Fuel efficiency
- Reduce engine hours



Peak Shaving

- Reduce power peaks
- Engine load optimization
- Fuel efficiency
- Reduce engine hours



Zero-emission

- All-electric operations
- No running engines
- No emissions
- No noise



Dynamic Performance

- Instant power
- Mitigate slow engine response



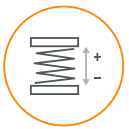
Enhanced Ride Through

- UPS like functionality
- Like spinning reserve in local subsystem



Strategic Loading

- Optimize energy
- Reduce fuel consumption



Energy Regeneration

- Optimize use of energy from lifting operations
- Fuelsaving



Compliment to Fuel Cell

- ESS optimize fuel cell function
- Used together, they extend zero-emissions operations

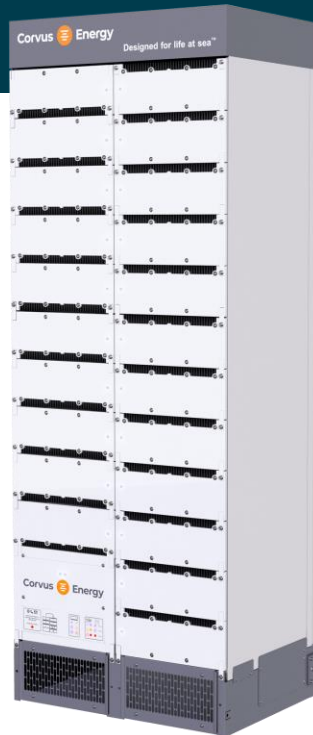


Shoreside Charging

- Plug-and-play battery room
- Reduce costs by drawing grid power during off-peak times

ESS + FC PARTNERS IN POWER

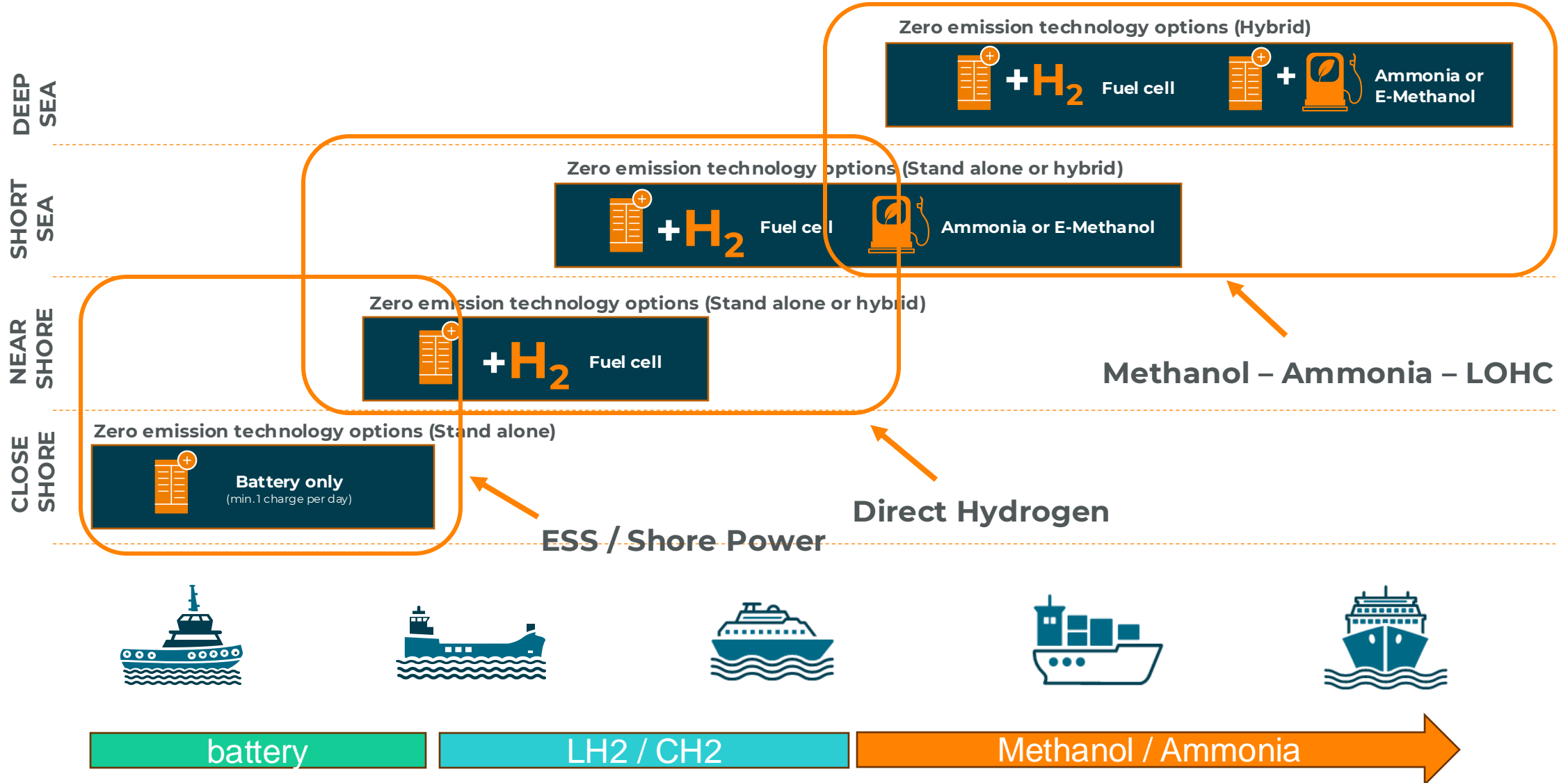
Energy Storage Systems (ESS)



Fuel Cell System (FCS)



Different means to extend emission free operations





Extending the range of zero emission operations

The Corvus Pelican Fuel Cell System (FCS) is built to be the perfect range extender for near shore and short sea vessels that are not able to reach zero-emission operations on batteries alone.



Safety is a joint responsibility

Battery and fuel cell supplier

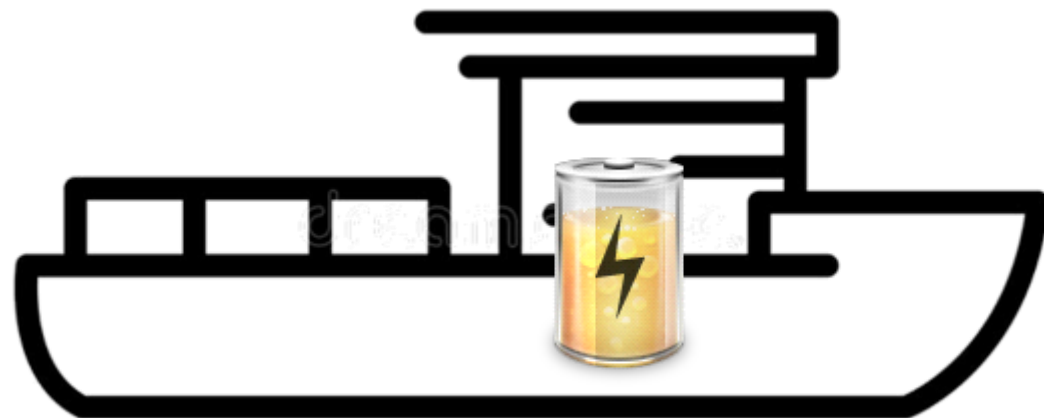
Battery compliant to standards and regulations on all safety aspects

Integrator

Verified seamless integration of the fuel cell and battery system in the vessel

Shipyard

Vessel compliant to regulations and specifications



Class society

Class rules, type approvals, acceptance tests, inspections



Flag authority

Local rules and guidelines, approvals, acceptance tests, inspections



Ship owner/operator

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



Sveinung Odegard
SVP Business Development
Fuel Cell Technology
Corvus Energy



<https://corvusenergy.com/>



11 responses submitted

What do you see as the biggest barriers to hybridization and electrification of U.S. domestic vessels?



Treemap

Bar



1 of 1



Moderated Panel

Sustainability in practice

Discussion

Sveinung Oddegard
Corvus Energy



SVP Business Development
Fuel Cell Technology

Ricardo Cogliatti
Kongsberg



Sales Director
Houston, TX USA

Erik Larsen
Corvus Energy



VP Sales
Americas



Audience Q & A



**The American
Waterways Operators**

The Tugboat, Towboat & Barge Industry Association

HAVE A FOLLOW-UP QUESTION?

Sveinung Odegard – Corvus Energy -

Sodegard@corvusenergy.com

Erik Larsen – Corvus Energy -

Elarsen@corvusenergy.com

Ricardo Cogliatti - Kongsberg -

Ricardo.cogliatti@km.kongsberg.com

Eirik Olsen – Kongsberg

The American
Waterways Operators
BUILDING TOMORROW'S LEAKY

Eirik.olsen@km.kongsberg.com

REGISTER FOR OUR NEXT WEBINAR:

Integration of Fuel Cells and Batteries to
Power the Future - Part 2: Feb 5, 12:00 pm EST

Thank you!

