e4ships
Fuel cells in marine applications

nip

Funded by:
Federal Ministry for Digital and Transport

Coordinated by:
NOW-GMBH.DE

Project management:
PtJ Projektträger Jülich Forschungszentrum Jülich

RiverCell2

A hybrid Energy System with Fuel Cells for River Cruise Vessels

Building and Testing of a shore based Demonstrator

e4ships & Zero Emission Shipping Symposium

8.9.2022 @ SMM Hamburg

Project RiverCell 2015-2021

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Fuel cells in marine applications

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National Innovation Programme Hydrogen and Fuel Cell Technology
Federal Ministry for Digital and Transport

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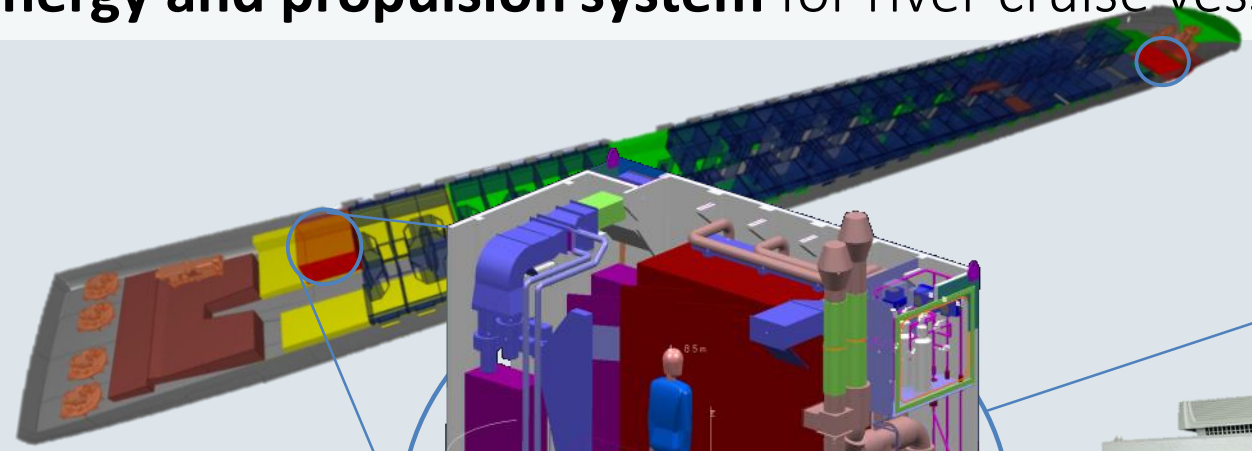
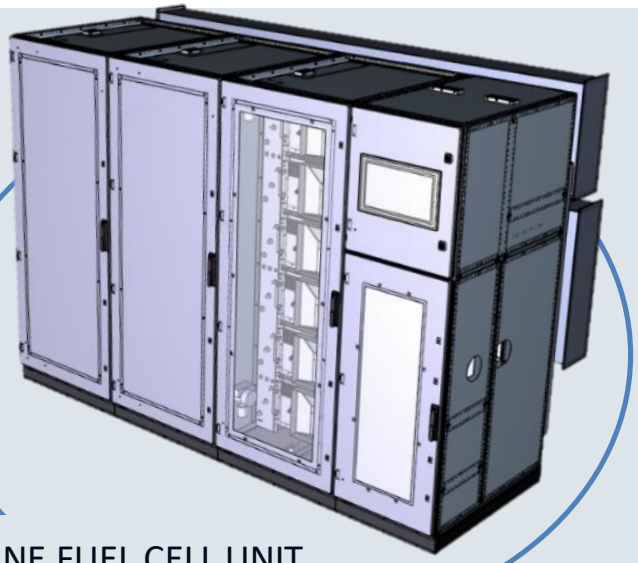
Objectives & Challenges

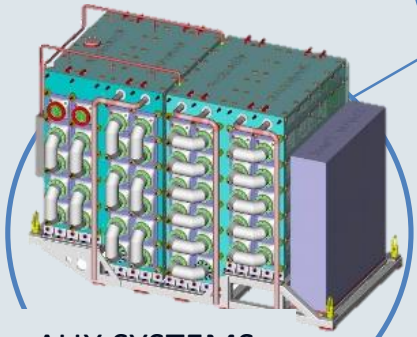
Develop, **build and test a modular hybrid electric energy and propulsion system** for river cruise vessels.



MODULAR FUEL CELL ROOM

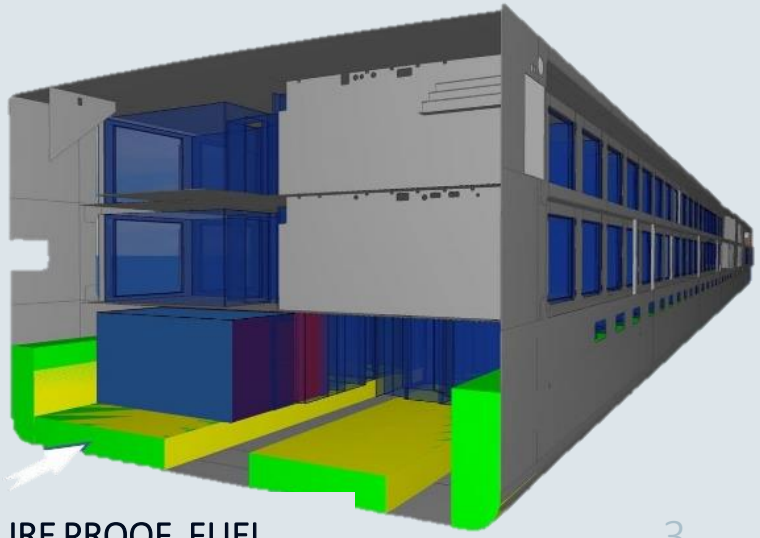


MARNE FUEL CELL UNIT



AUX SYSTEMS

ENERGY STORAGE

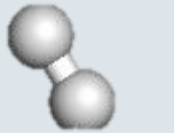


FUTURE PROOF FUEL

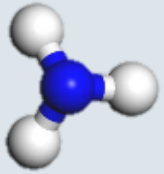
HYDROGEN for Volume Critical Ships?

Storage of gases is a challenge!

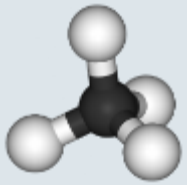
- Heavy pressure tanks, cryogenic insulation
- Challenging safety systems (overpressure control)
- Loss of payload space (cannot use double bottom structure)
- Very space consuming tank systems (LNG 3x ; LH_2 10x to Diesel!)
- Limited holding time, and energy consuming liquefaction
- LNG has high GHG potential



Hydrogen



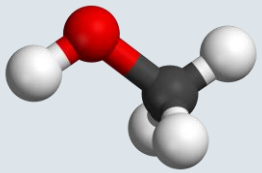
Ammonia



Methane

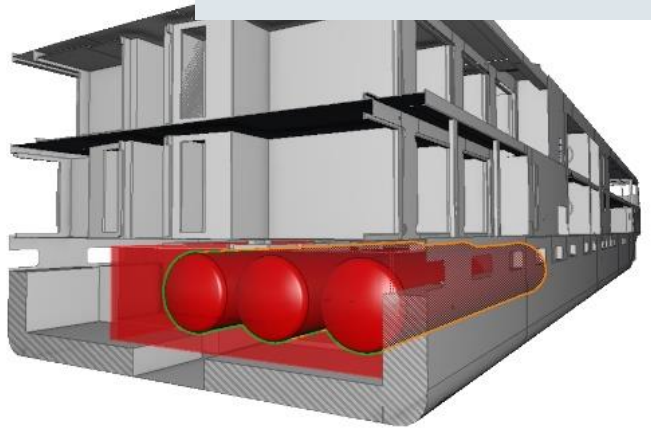
Alcohols are a solution!

- Pressureless liquid, can be stored in ship structures
- Less safety challenges
- Less loss of payload space
- Easier to handle and store (not cryogenic, low pressures)
- No GHG potential

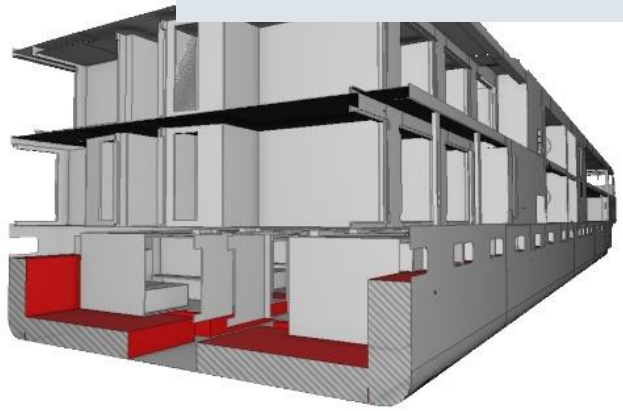


Methanol

GAS TANKS



PRESSURELESS TANKS

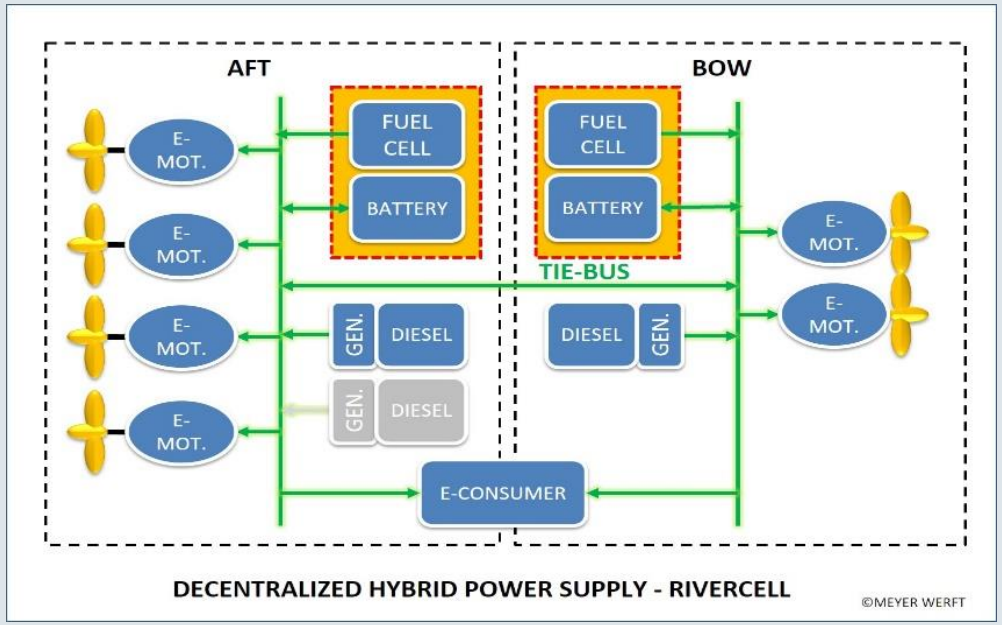


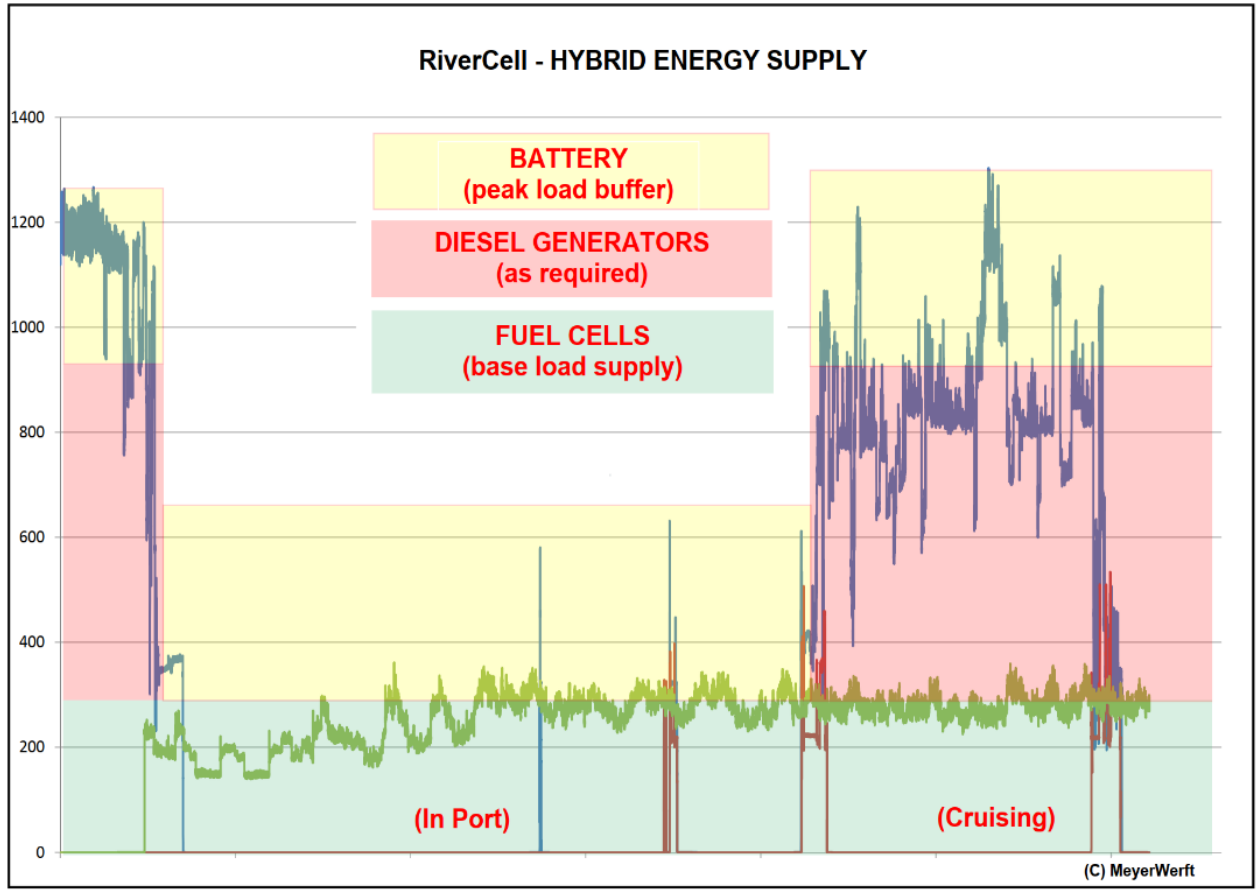
Alcohol is a more efficient means to store H2 for Fuel Cells on ships!

The RiverCell Concept

Hybrid power supply

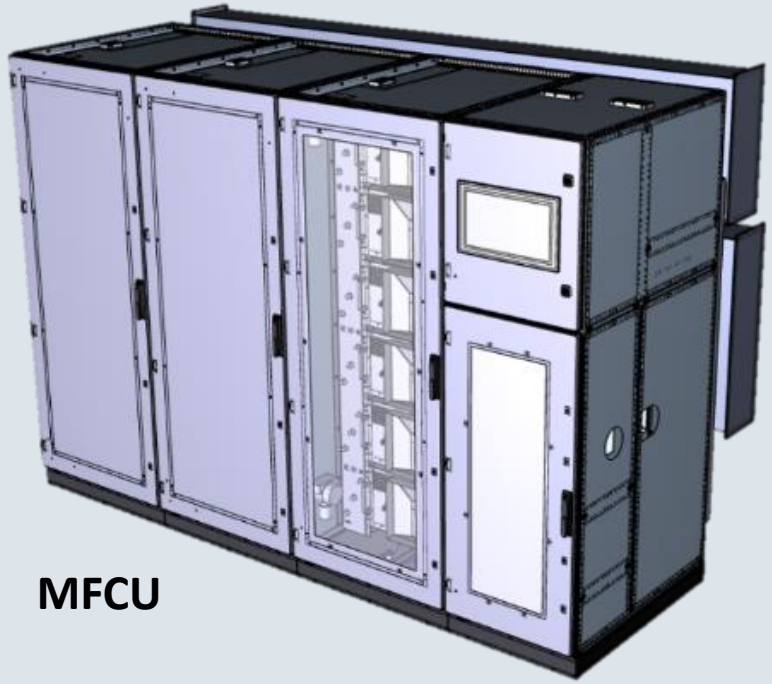
- Base load supply by fuel cells
- Peak Shaving by batteries (incl. Propulsion)
- Optimized operation of Diesel-Gensets for propoulsion.





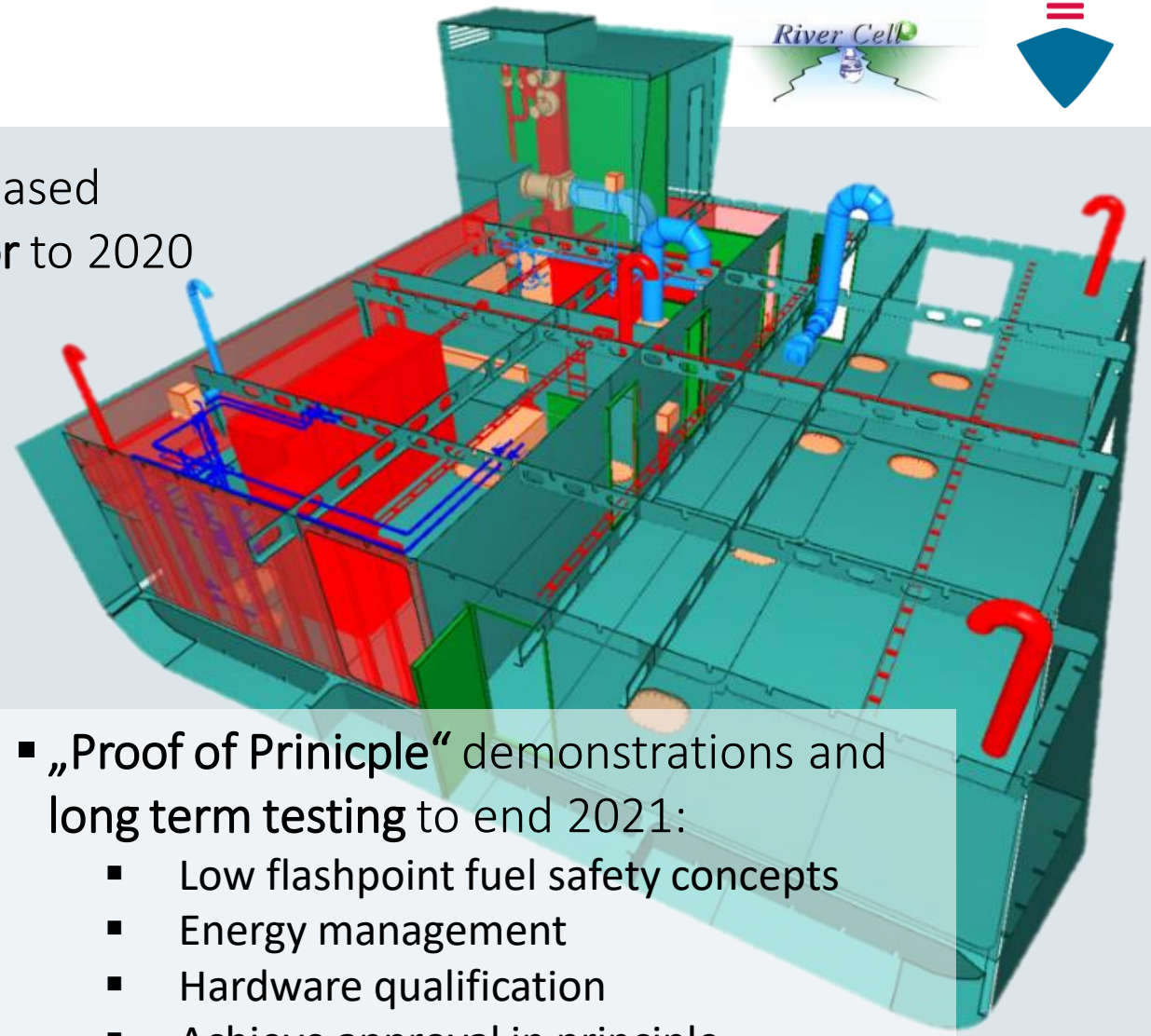
FC Hybrid Demonstrator

- Construction of a landbased **River Ship Demonstrator** to 2020



MFCU

- Develop and implement prototype of a **Marine Fuel Cell Unit (MFCU)** topology

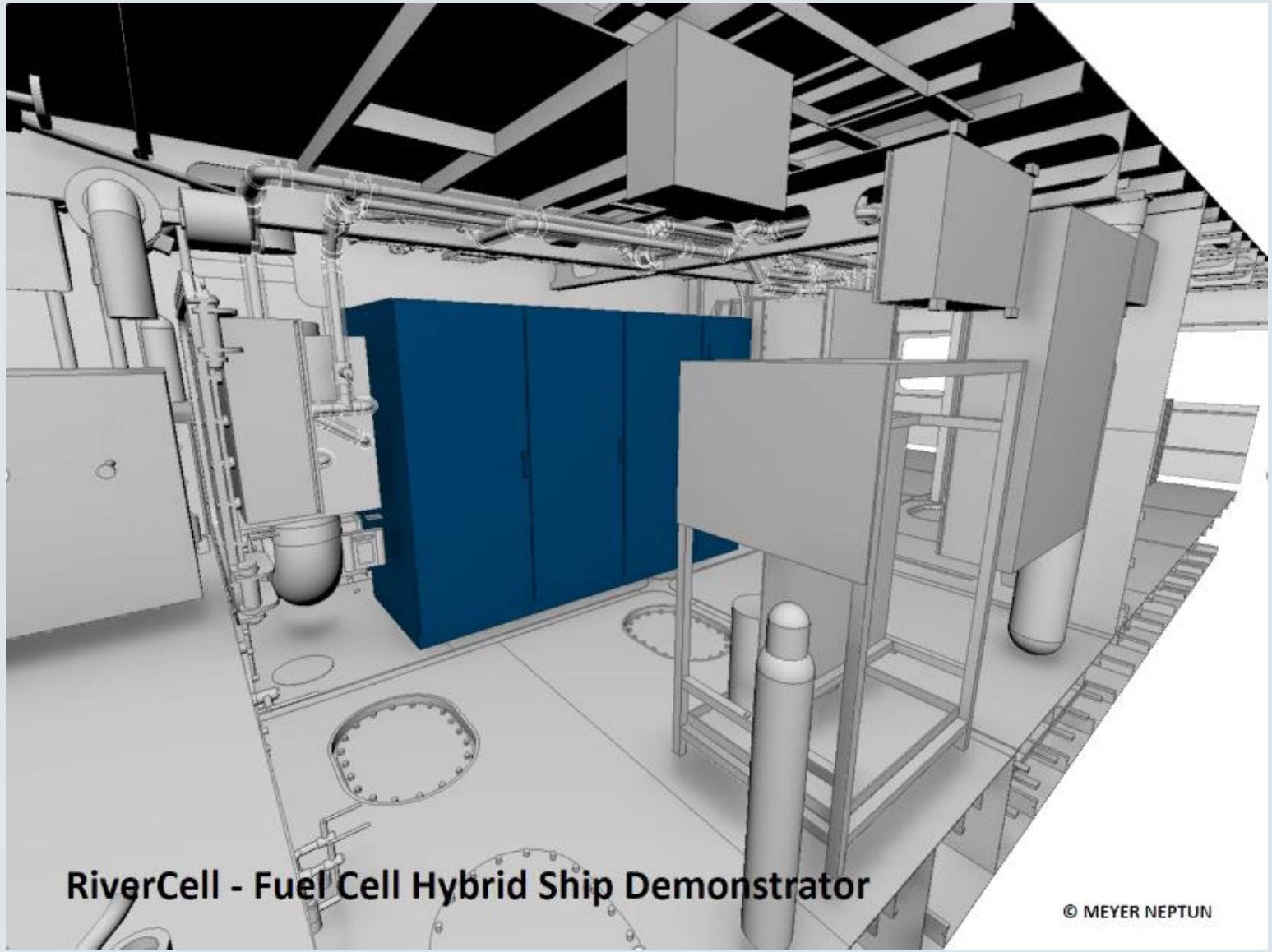


- **„Proof of Prinicple“** demonstrations and **long term testing** to end 2021:
  - Low flashpoint fuel safety concepts
  - Energy management
  - Hardware qualification
  - Achieve approval in principle

➡ **Input to rule development**

Marine Fuel Cell Unit (MFCU)

Ship Integration



Demonstrator 2021

PLANT SITE

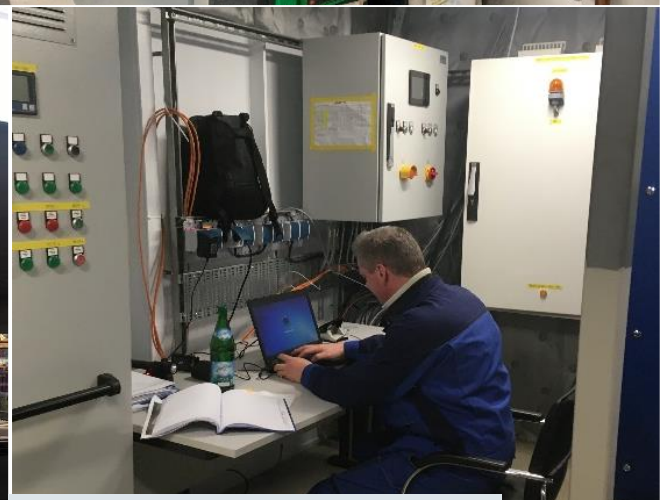
UPPER DECK

DEMONSTRATOR

Demonstrator 2021

SWITCHBOARD ROOM

LOAD BANK



CONTROL STATION

Demonstrator 2021

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MARINE FUEL CELL UNIT

FUEL CELL ROOM

FUEL CELL ROOM

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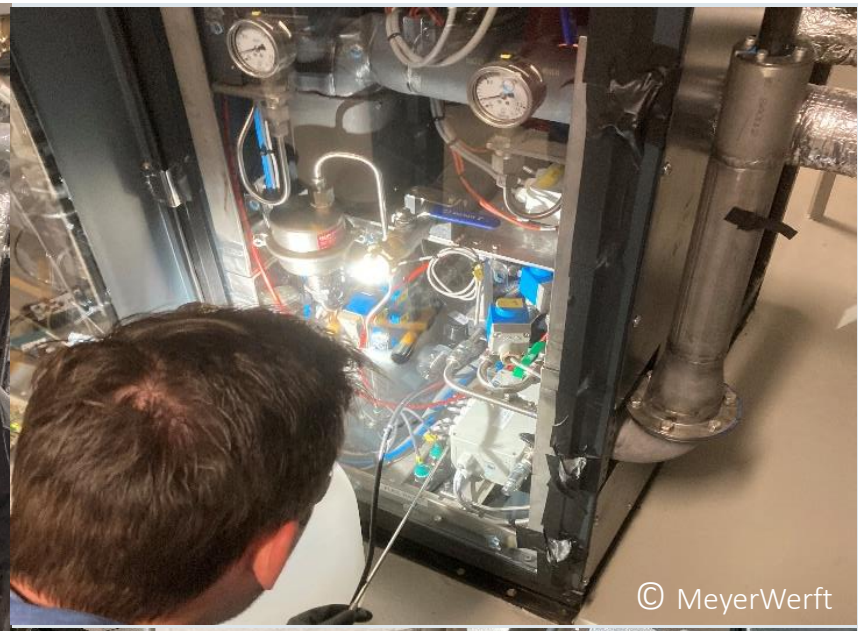
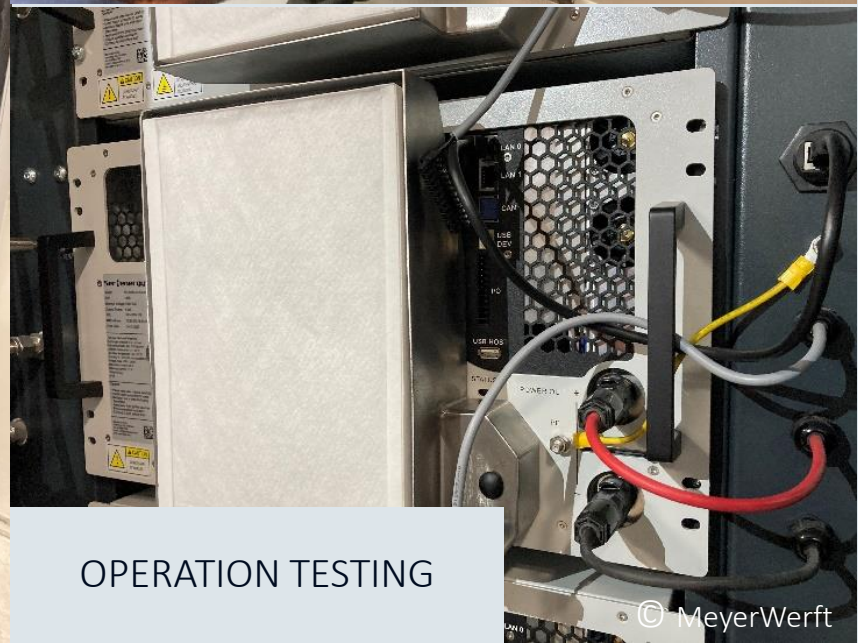
Testing

SAFETY TESTING

FUNCTION TESTING





OPERATION TESTING

Some Results – Methanol Safety

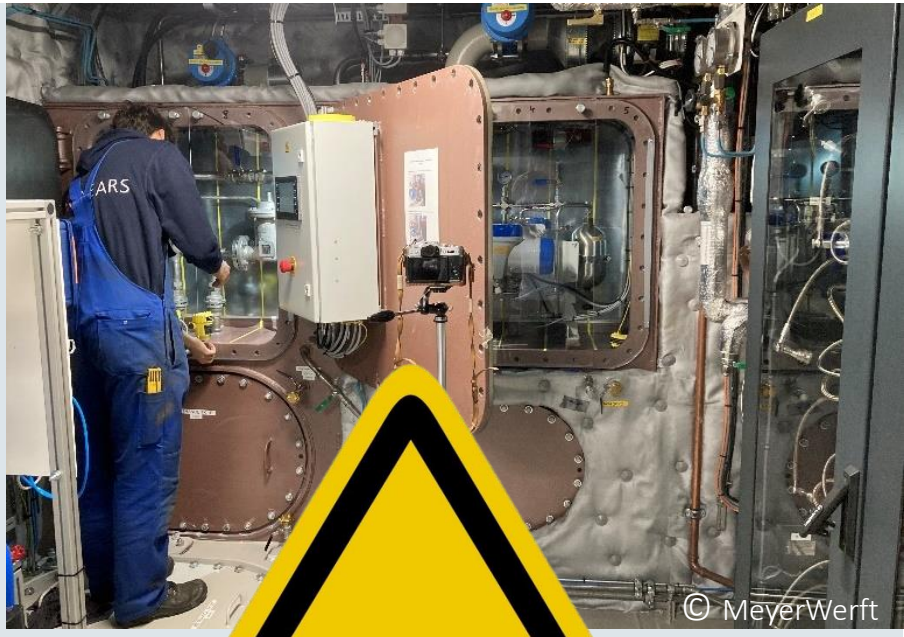
Methanol leak study:

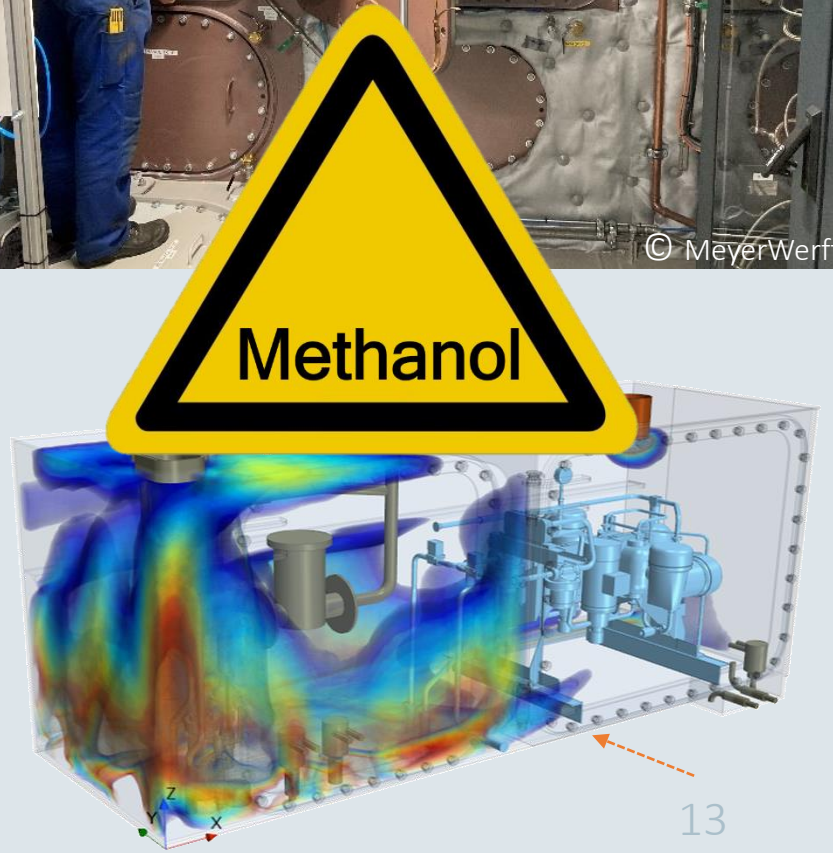
- **Gas release rate** (ex-zone formation) from methanol leaks is **significantly less critical than from gas leaks.**

- Methanol evaporates relatively slowly.

  ⇒ The **size of the pool** formed & the **air velocity** are the main decisive factors for the **gas release rate**. (Not the size of the leak itself.)

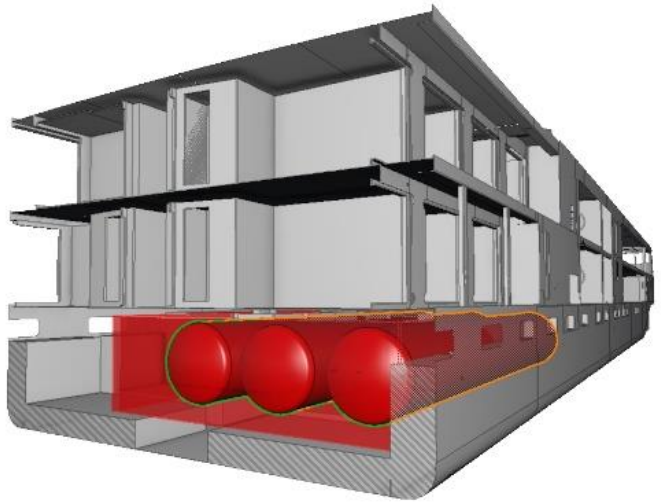
- **Manageble hazard from small spills** for ship or personnel (with PPE).

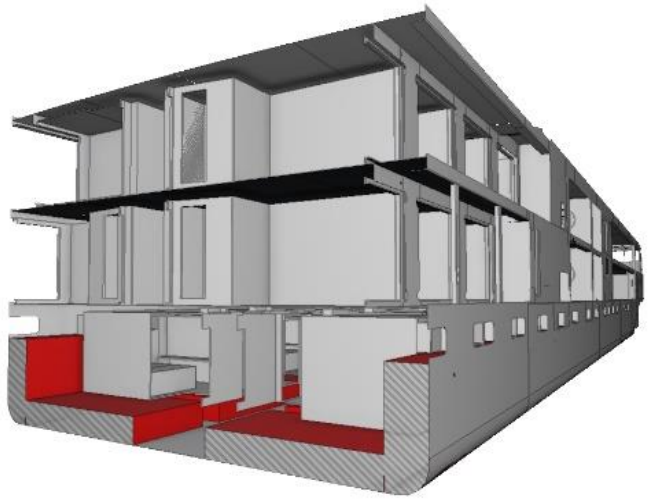




Some Results – LF Fuel Tanks

- **Compact double walled tank structures** can be built and operated.
- Considerable **less construction effort** than for gas tanks.
- Considerable **space gain achieved** to gas tanks systems.
- **Refit** of double walled tank structures is possible.
- Tank vents **without Ex-Zones at the outlet** are possible.
- **Non inerted tanks** are safe (with the appropriate measures)



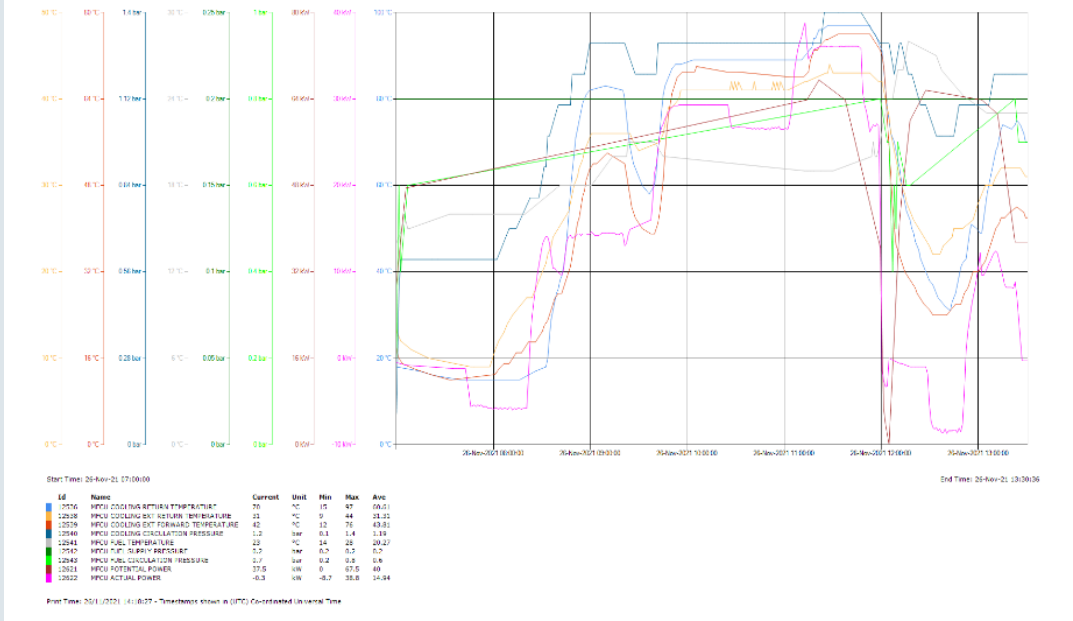


Some Results – MFCU Design

- **Safety concept** successfully validated: Very high safety level.
- Efficient ventilation design: **No ignitable gas concentrations** could be reached.
- **No Ex-Zones** possible **in the FC room .**
- Sucking the **combustion air from the room** is safe.
- Good **modularity and scalability** of the design and in operation…

Some Results – Plant Operation

- Highly **redundant and stable power supply**. Blackout is not possible.
- Good **dynamic response of the power supply** to changing propulsion loads.
- **Emission-free ship operation** (without diesel generator) is also possible during cruising (for a limited period of time).
- **Control of the MFCU** output power and power range possible



Summary

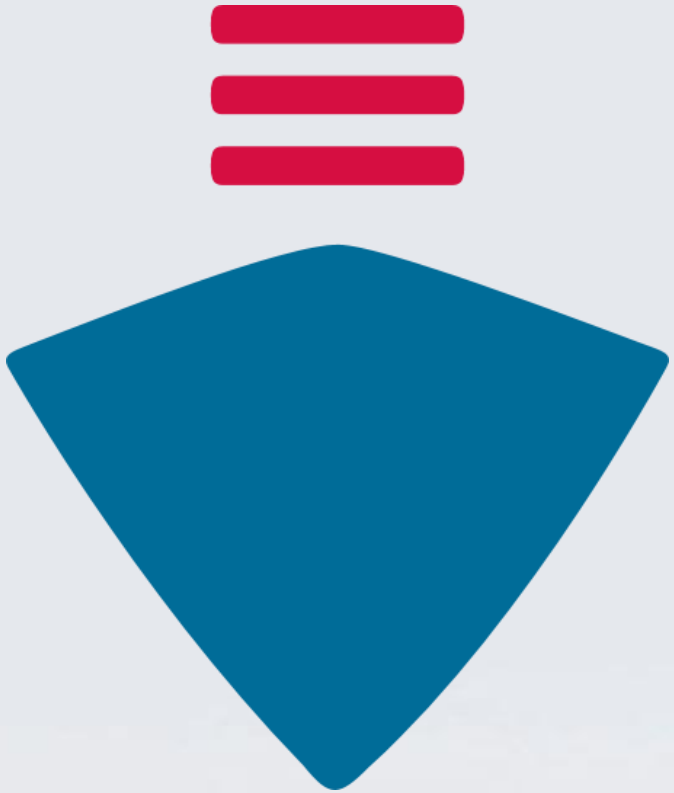
In Rivercell2 we have:

- Successfully demonstrated how a **Marine Fuel Cell Unit** should/can look like for a safe and efficient ship integration and operation.
- Demonstrated how **LF fuel tanks** can be safely integrated and operated in space limited ships.
- Demonstrated the **high potential for methanol** as safe, efficient and practical LF fuel for ships.
- Demonstrated that a **hybrid energy system** with fuel cells and batteries is improving efficiency, flexibility and safety of energy generation on board while drastically reducing all emissions.
- Contributed to the **development of maritime rules** for fuel cell installations and storage of low flashpoint fuels.
- Identified **fields of further action** and need for development.

Outlook

Fields of further action and development:

- **FC technology:** Power density, cost, lifetime, fuel flexibility.
- **FC generating units** and auxiliary systems, for efficient ship integration.
- **Solutions and components for** fuel systems and storage of new **LF-fuels**.
- Advanced **control concepts and systems** for efficient operation and ship integration of hybrid energy systems.
- **Regulatory development** (continued)
- **Field testing**!



THANK YOU FOR YOUR ATTENTION!

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