



# Ammonia SOFC System

Engineering and Integration

Workshop  
Sustainable Shipping Days



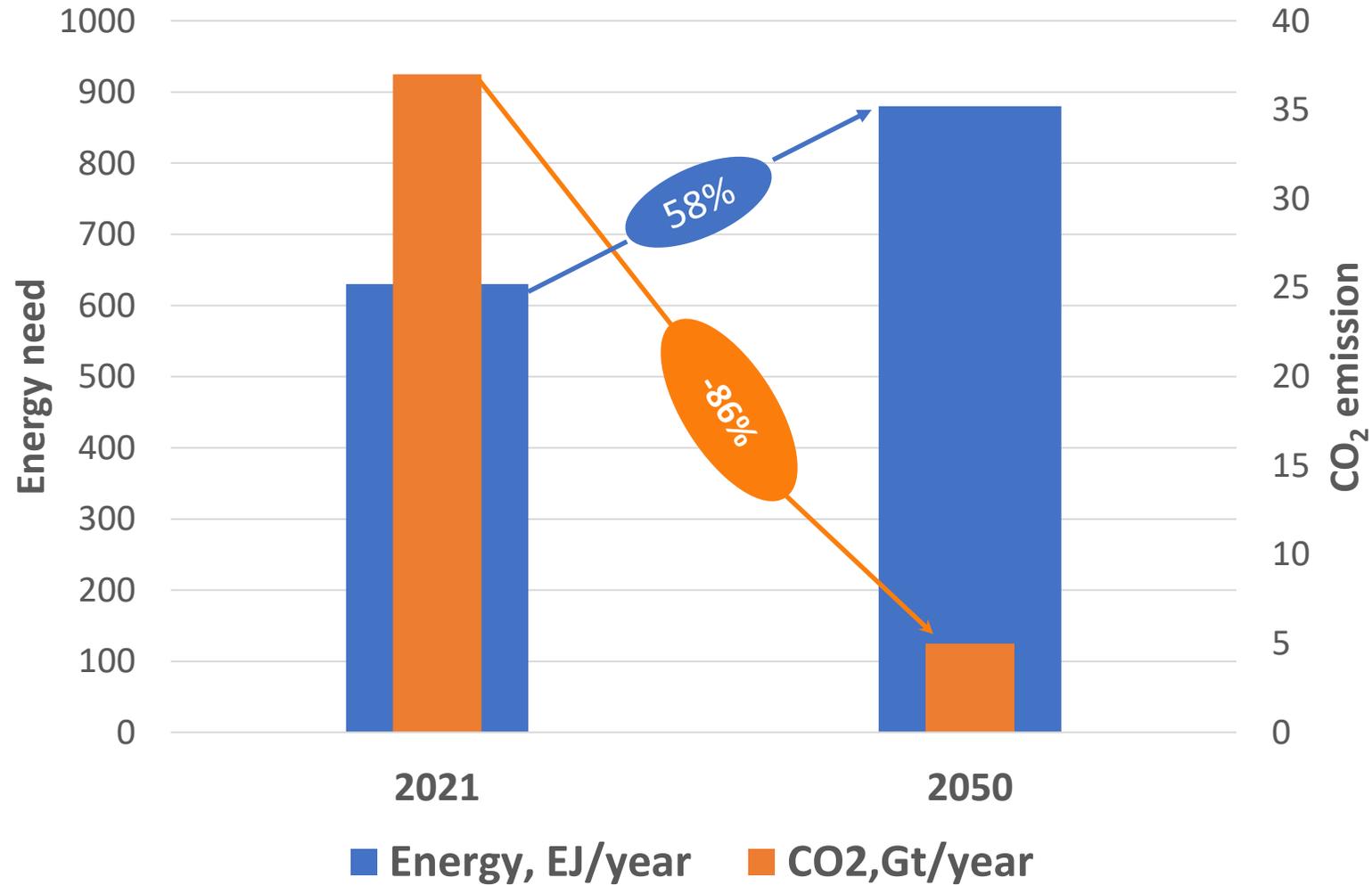
**Debasish Chakraborty**

Principal Scientist, Electrolyzer and Fuel Cell Technologies

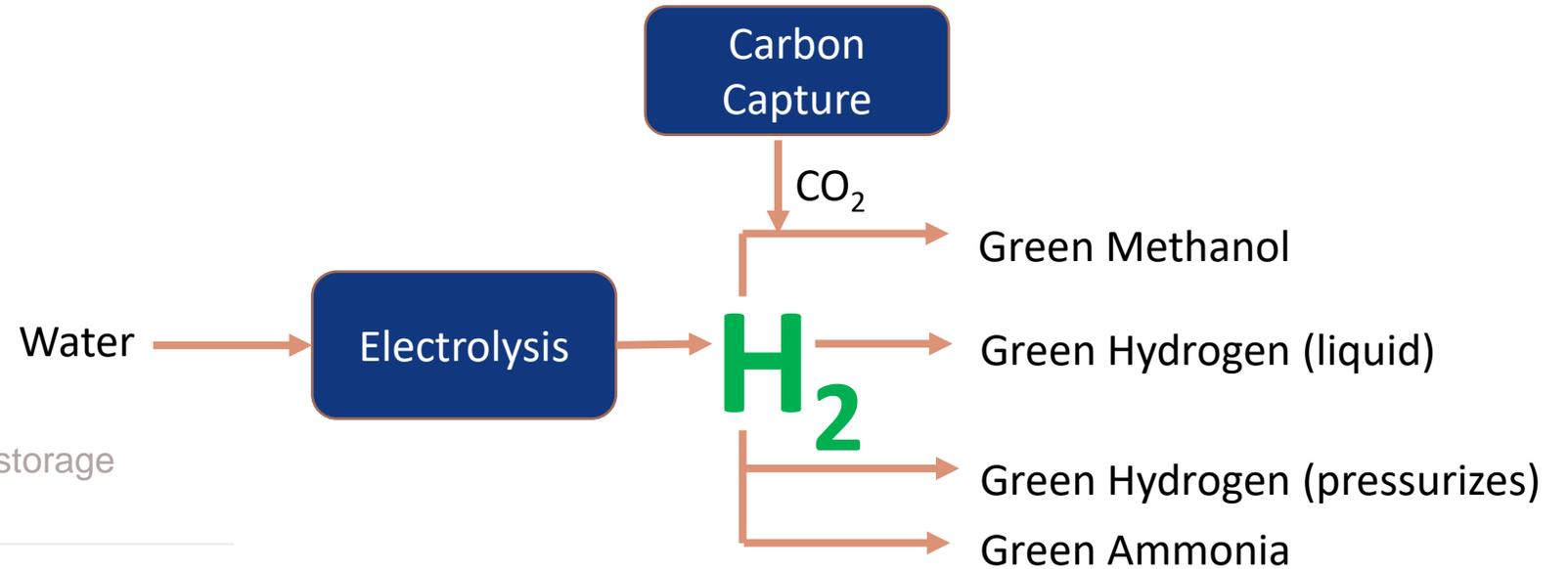
Alfa Laval Technologies A/B

[Debasish.chakraborty@alfalaval.com](mailto:Debasish.chakraborty@alfalaval.com)

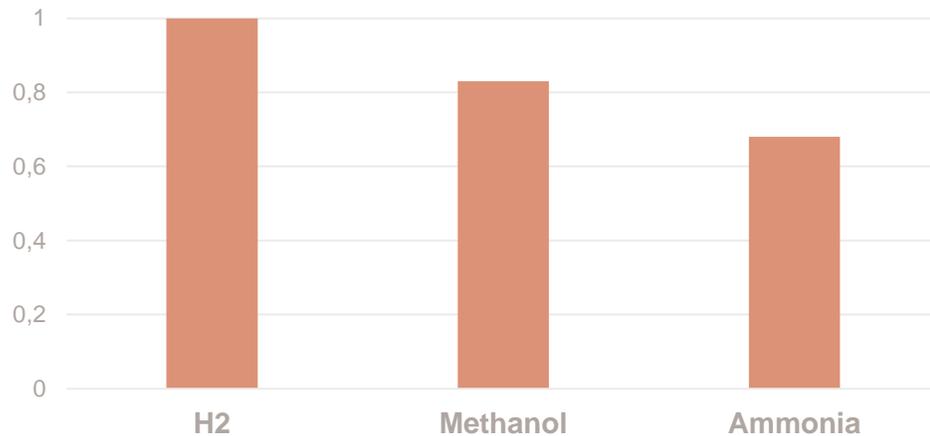
# The Challenge



# Ammonia is the cheapest e-fuel



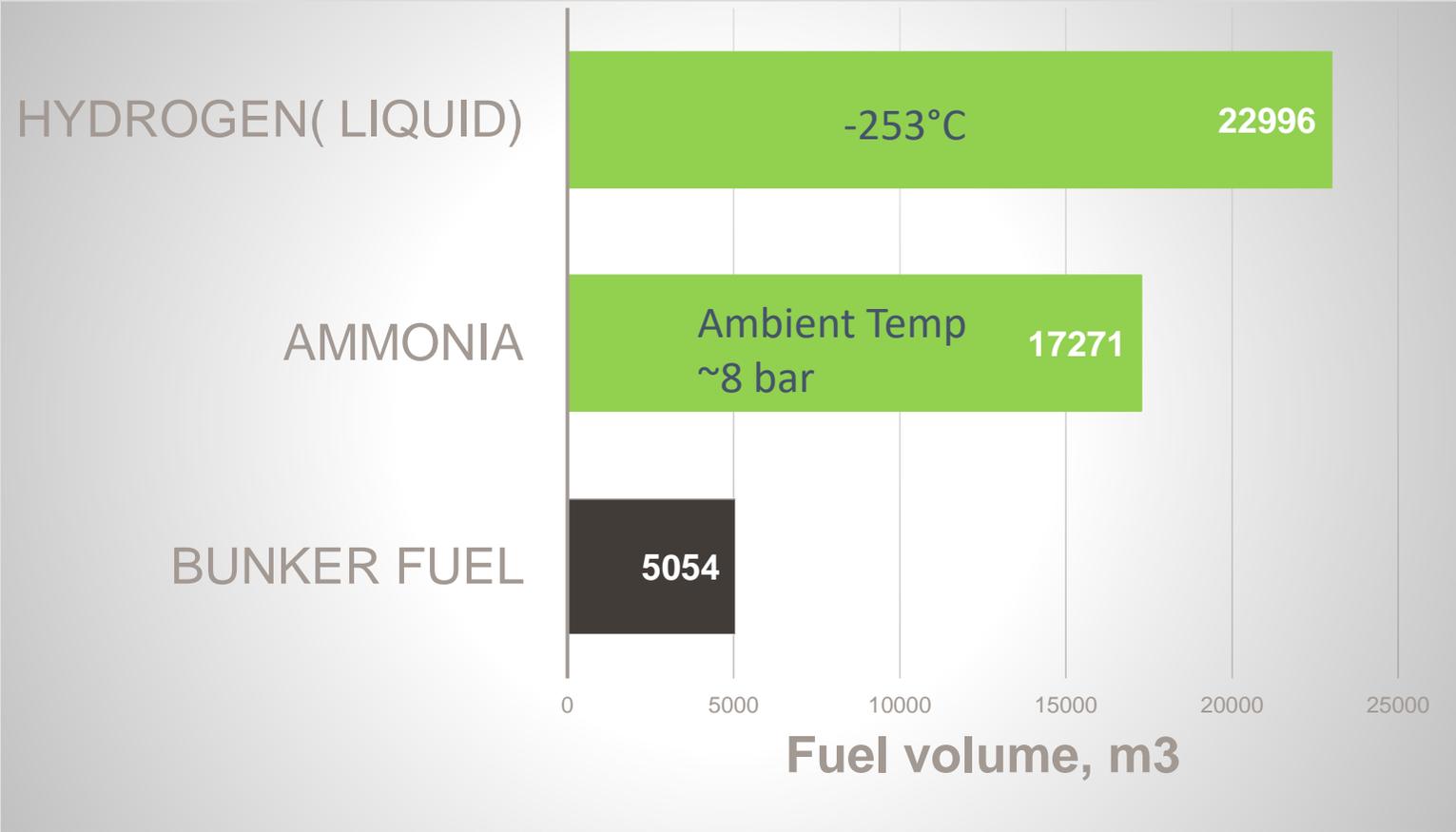
Relative Energy cost for production, storage and distribution of e-fuels



# Ammonia as potential future marine fuel



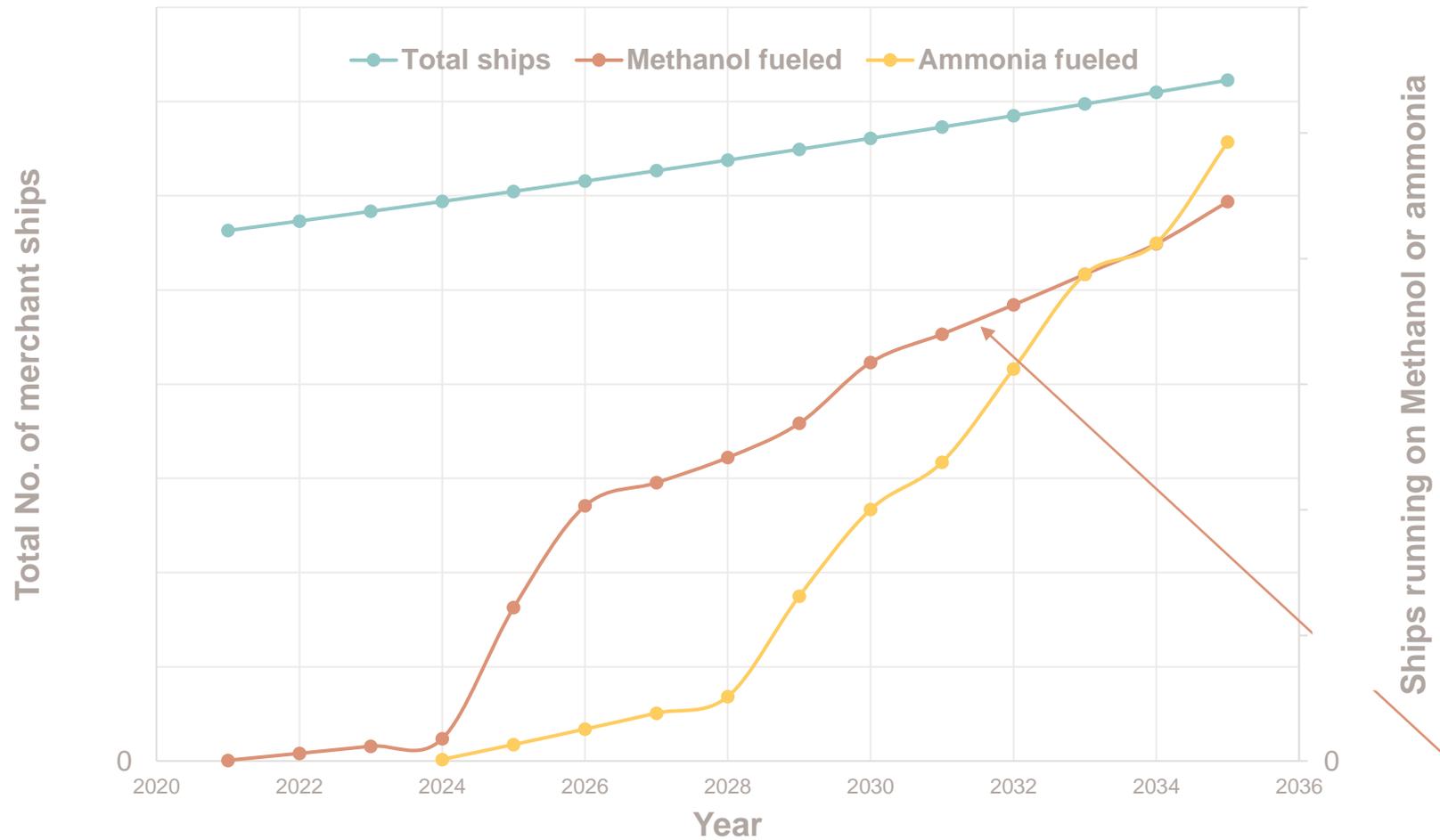
Fuel volume for today's biggest container ship



30 days trip from Hong Kong to Hamburg

# Penetration of e-fuels for shipping

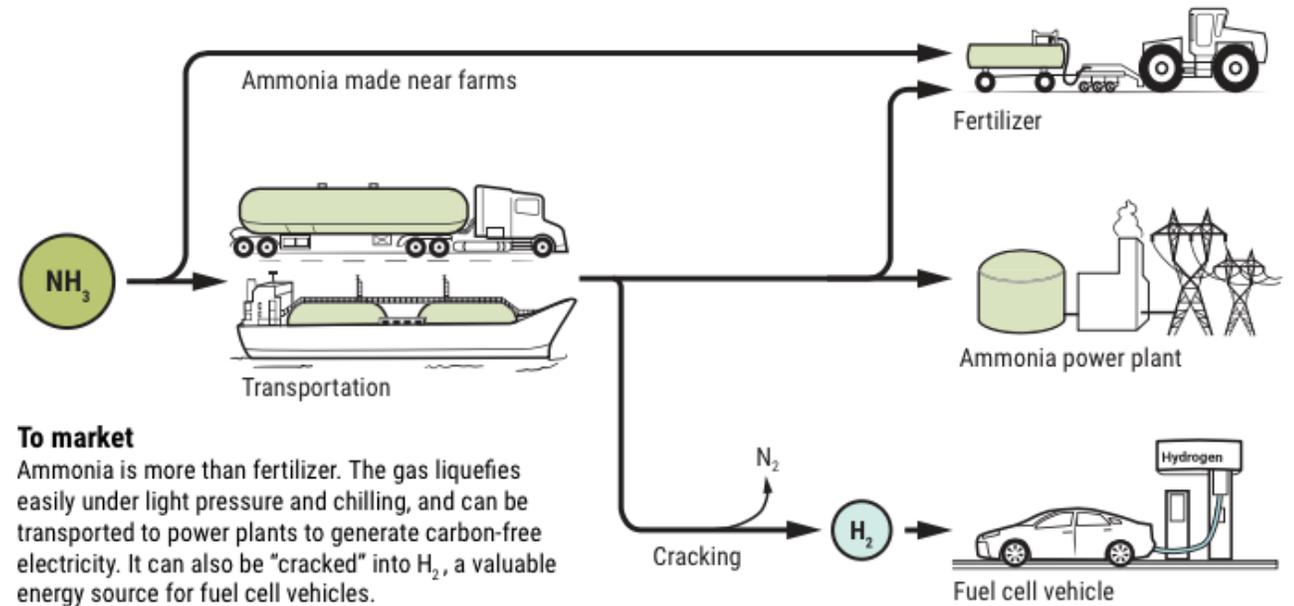
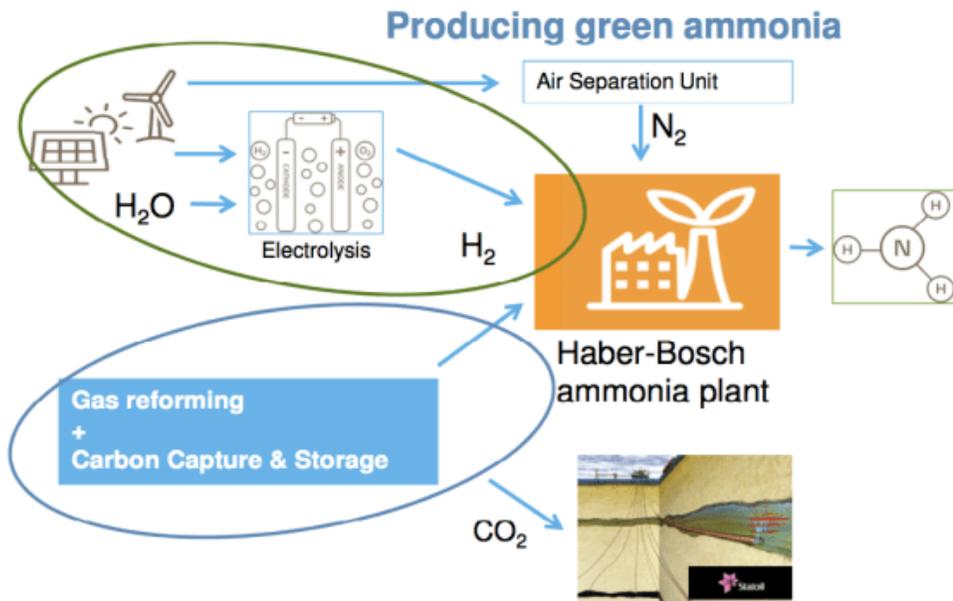
- Projection



Not enough cost-competitive C available after a few years

# Renewable Ammonia Vision

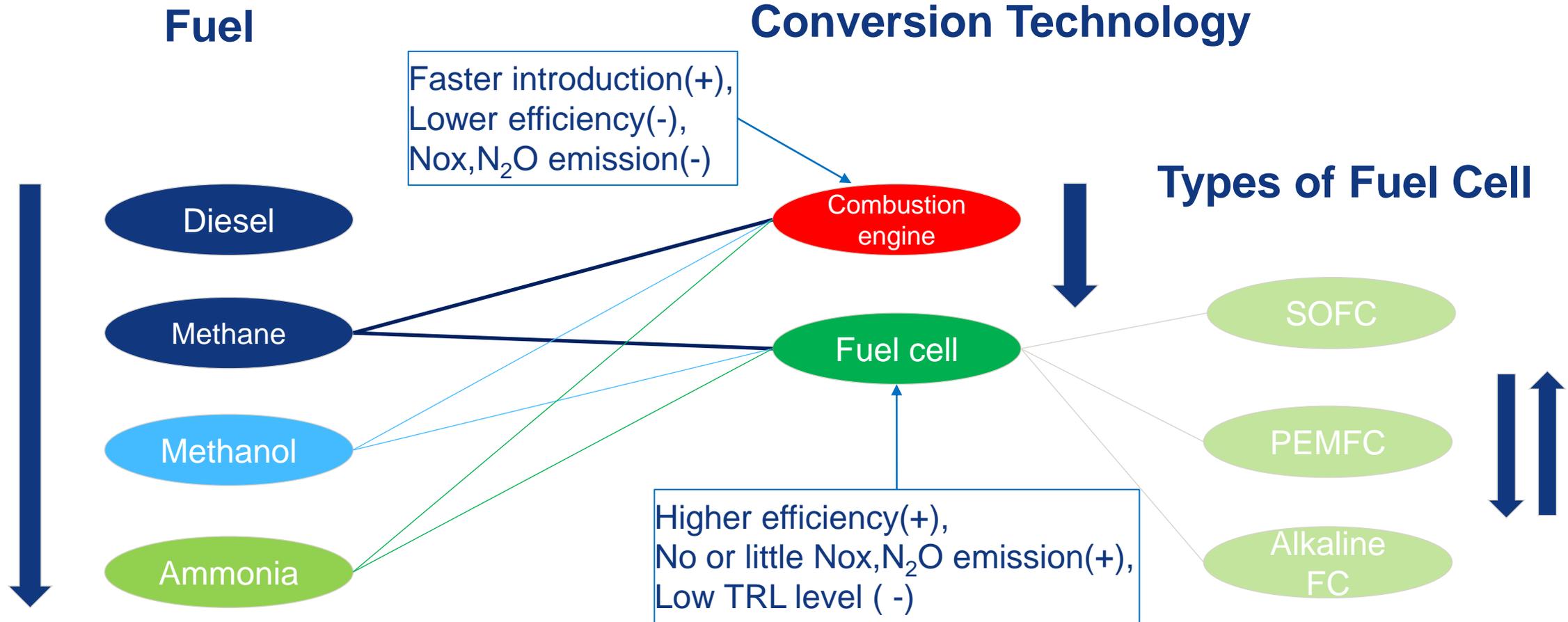
- Transporting Renewable as liquid fuel



<http://www.sciencemag.org/news/2018/07/ammonia-renewable-fuel-made-sun-air-and-water-could-power-globe-without-carbon>

# Decarbonization trend - It's complex

- Progression towards greener fuel followed by progression towards cleaner conversion



# Progress in ammonia fueled ships

## Approval in Principal

15,000 TEU Ammonia Powered Container Vessel



Project lead:



Project partners:



Mærsk Mc-Kinney Møller Center  
for Zero Carbon Shipping

Classification society:



Ship Design:



**Ammonia-fueled  
Ammonia Gas Carrier  
( AFAGC)**



**Ammonia Floating  
Storage and  
Regasification Barge  
(A-FSRB)**

[Seaspan Corporation and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping Receive Approval in Principle from ABS for Ammonia-Fueled Container Vessel | Seaspan Corporation](#)

amoni.

AMMONIA TO POWER

# AMON Consortium



FBK  
Fondazione Bruno Kessler  
(Italy)



SolydEra  
(Italy)



Alfa Laval Technologies  
AB (Sweden),  
Alfa Laval Aalborg  
AS (Denmark),  
Alfa Laval SPA (Italy)



SAPIO  
Produzione Idrogeno  
Ossigeno Srl  
(Italy)



KIWA Nederland  
BV (The Netherlands)  
e KIWA Cermet (Italy)



VTT Technical  
Research Centre  
of Finland  
(Finland)



Technical University  
of Denmark  
(Denmark)



Ecole Polytechnique  
Fédérale De Lausanne  
(Switzerland)



Electrolyser &  
Fuel Cell Forum  
(Switzerland)



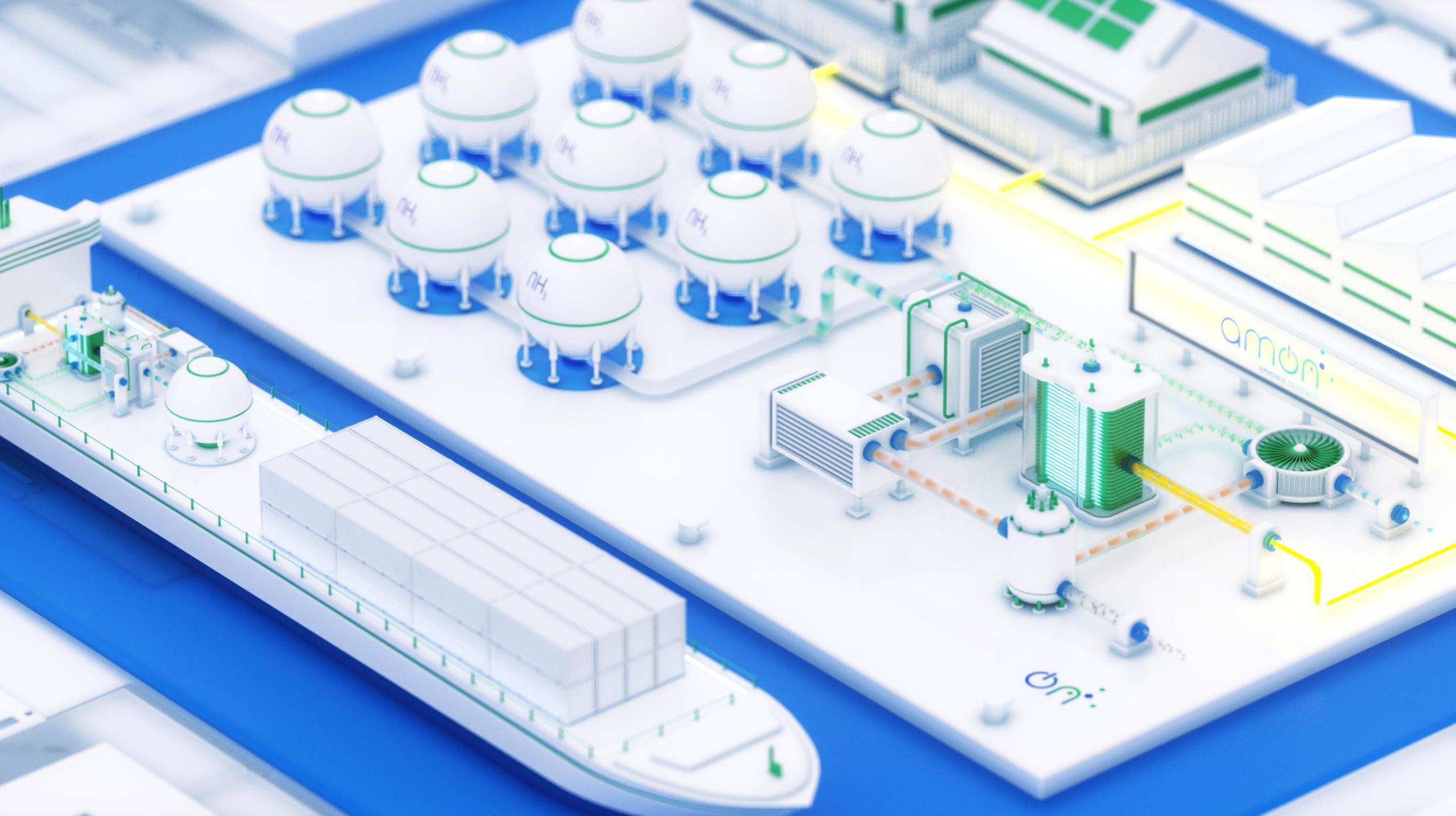
Fachhochschule Zentralschweiz  
Hochschule Luzern  
(Switzerland)



Co-funded by  
the European Union

The project is supported by  
the Clean Hydrogen Partnership  
and its members Hydrogen Europe  
and Hydrogen Europe Research,  
under Grant Agreement No 101101521





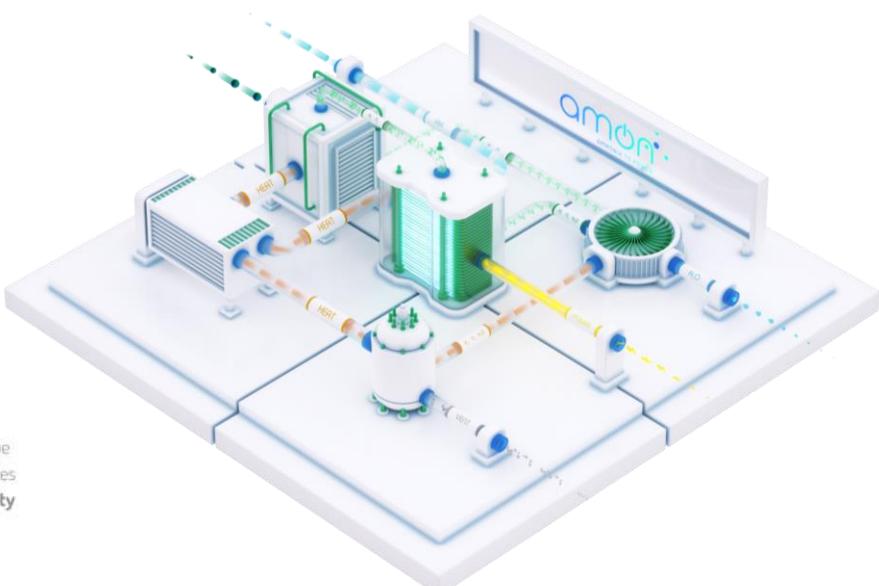
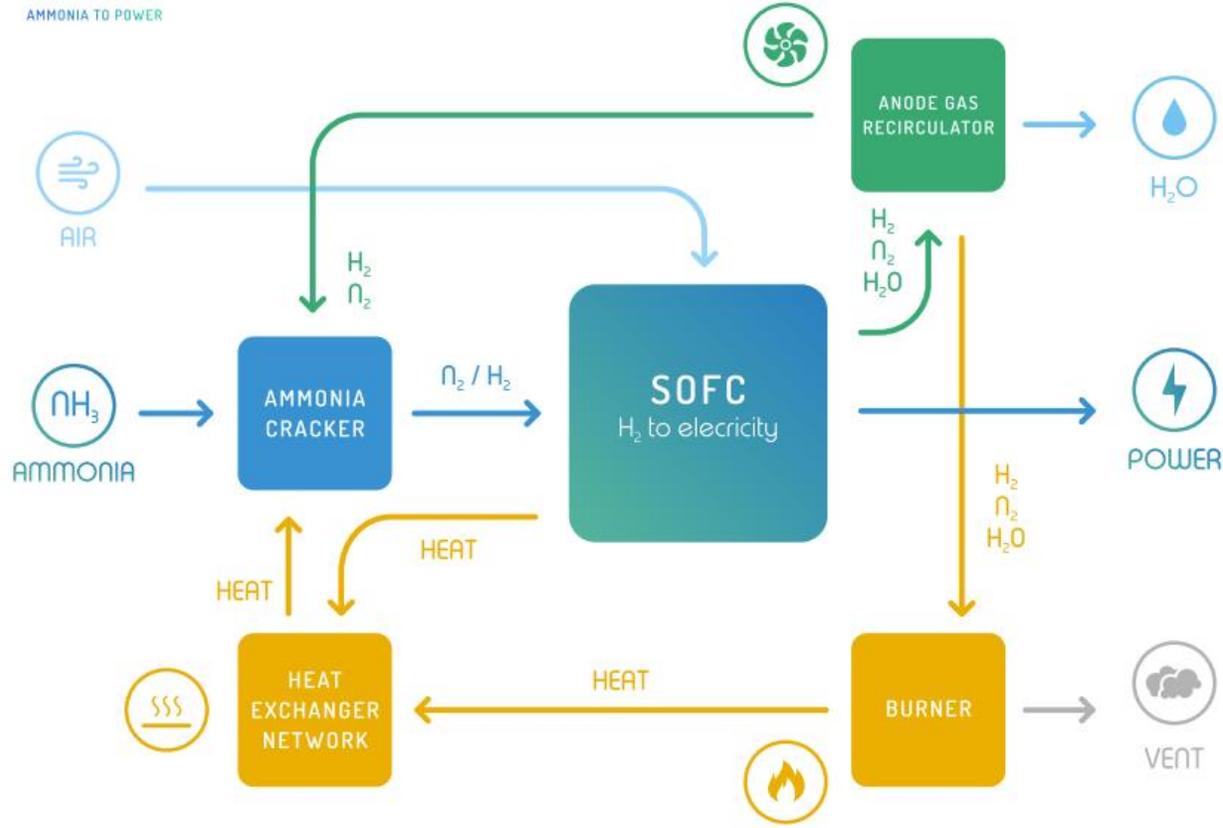
# Acknowledgement



*The AMON project has received funding from the Clean Hydrogen Partnership under Grant Agreement No 101101521. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research*



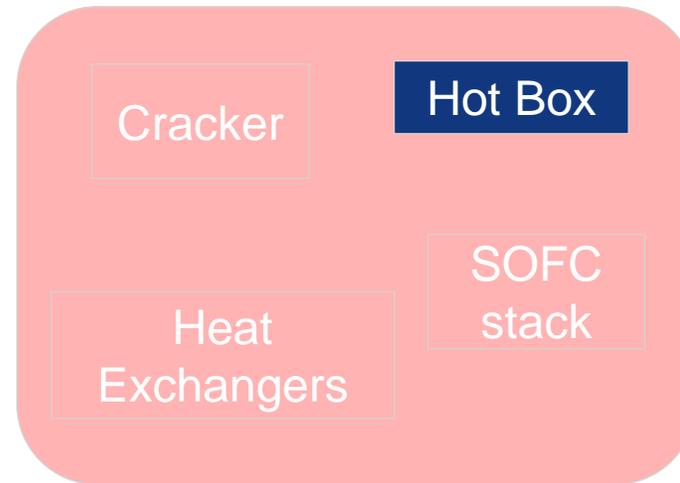
# The system will need an ammonia cracker



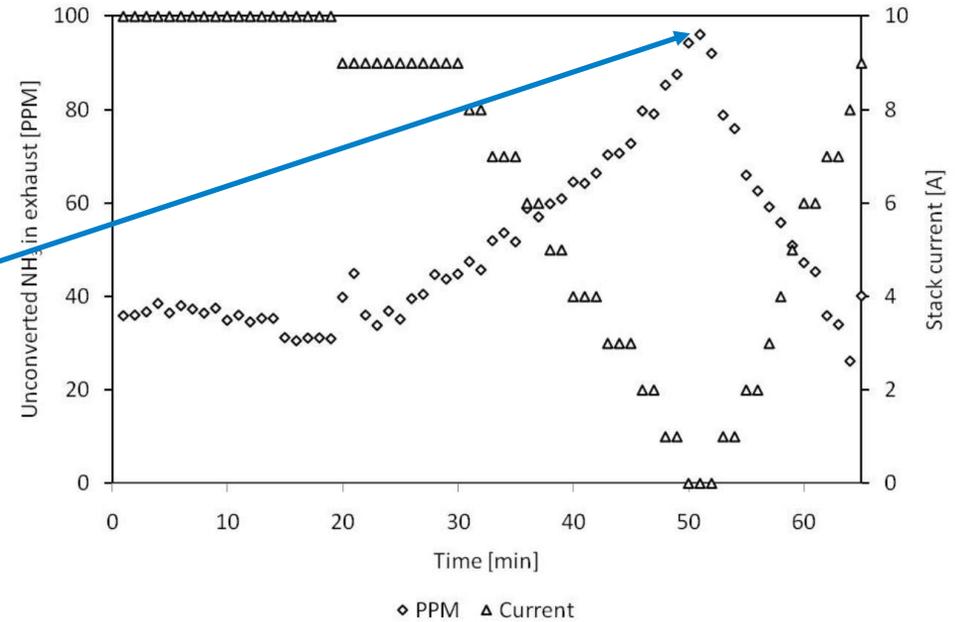
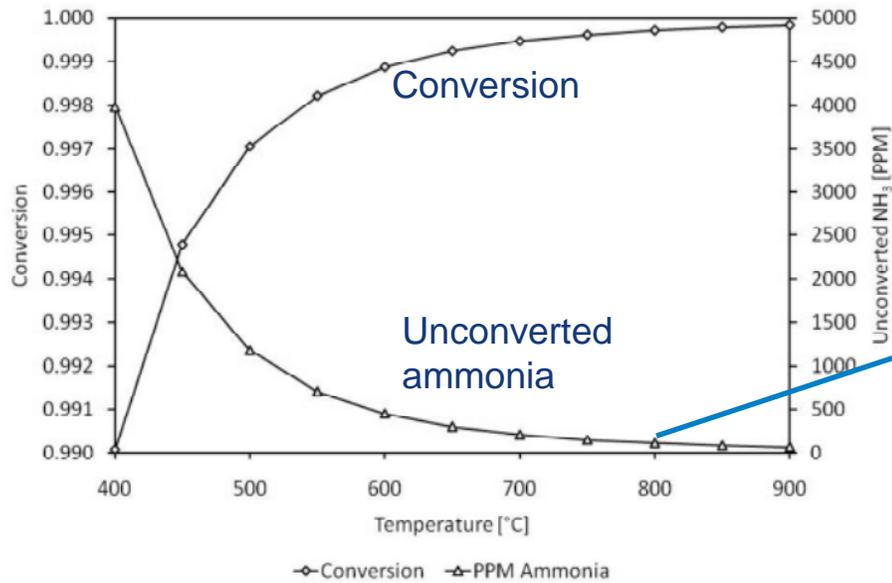
The heating value of ammonia makes 70% in electricity

Alfa Laval is responsible for developing the cracker

# AMON power generator



# Does Ammonia fed SOFC need a precracker?

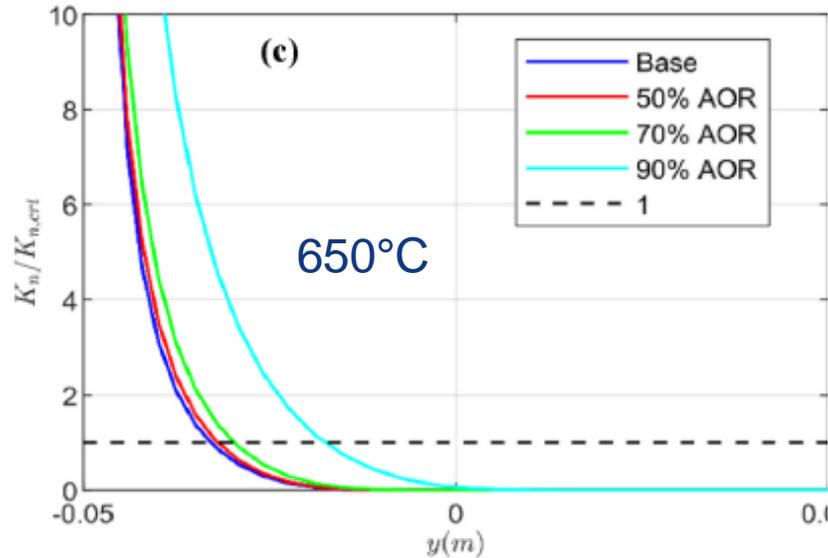


Ammonia could be cracked inside the SOFC with added advantage of lowering the cooling load as ammonia cracking is endothermic

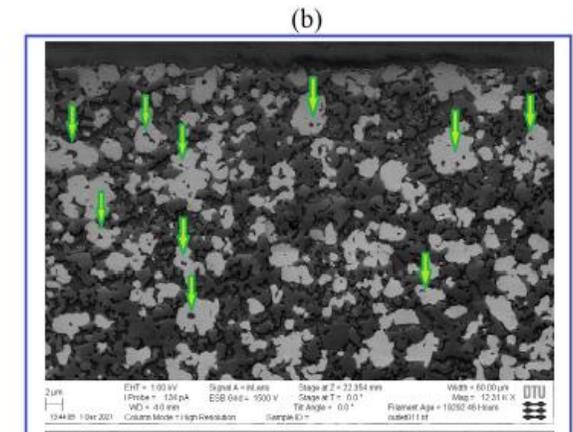
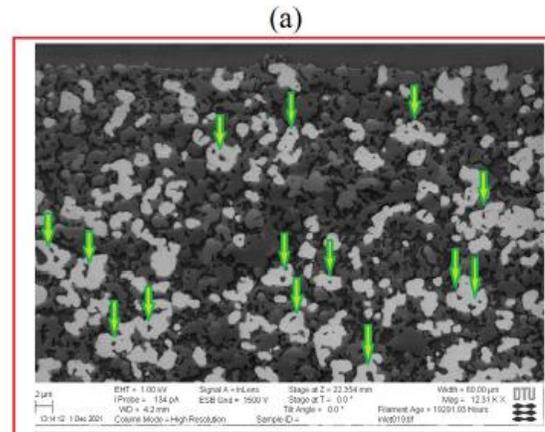
Chakraborty et al., 2010, ISBN: 978-1-61671-509-2

# Why ammonia cracker for SOFC?

– SOFC degrades via nitride formation



650°C  
→



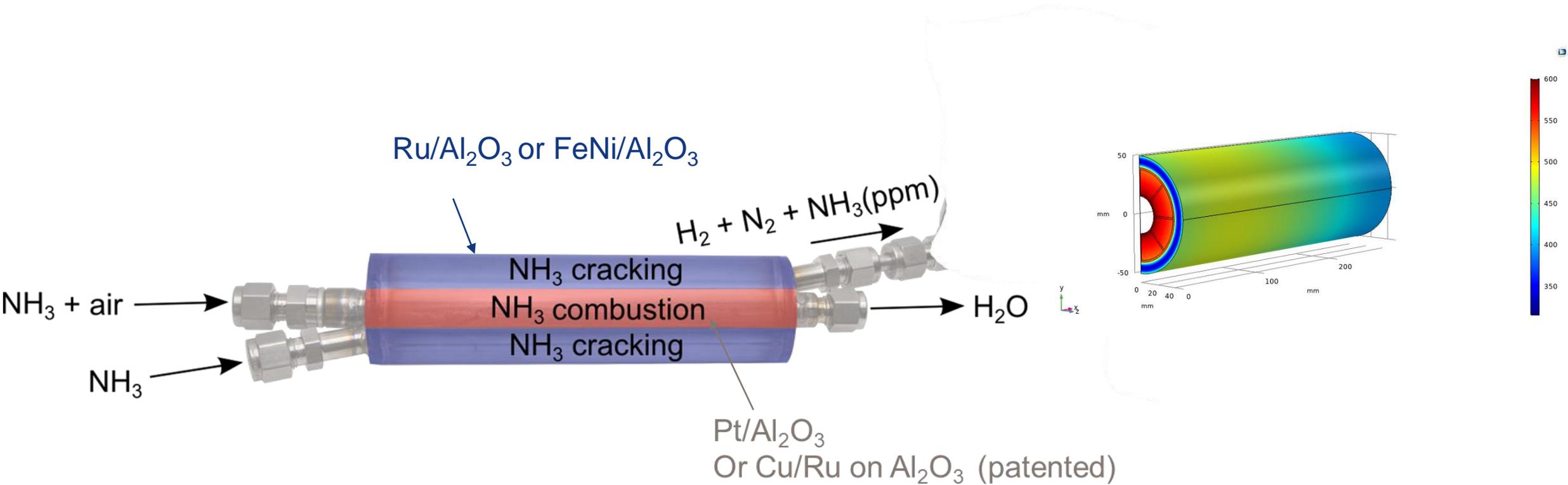
- Ni and Fe nitridation results in cell degradation
- Similar material degradation potential for piping and other BoP

Frandsen et al., <https://doi.org/10.1016/j.ijhydene.2023.12.139>

Frandsen et al., [10.1016/j.enconman.2024.118396](https://doi.org/10.1016/j.enconman.2024.118396)

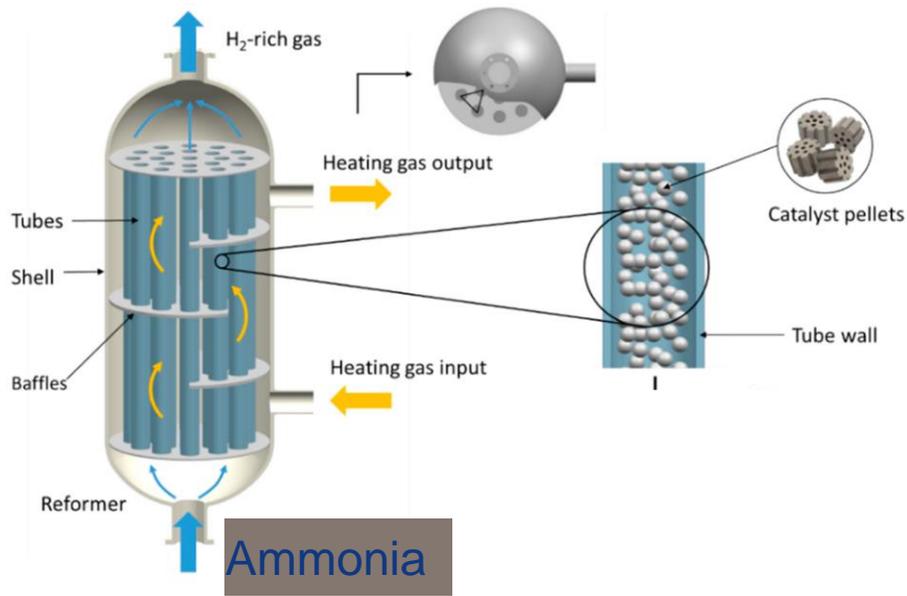
Cracker acts like the 'first line of defence'

# Ammonia cracker



# From shell and tube to plates

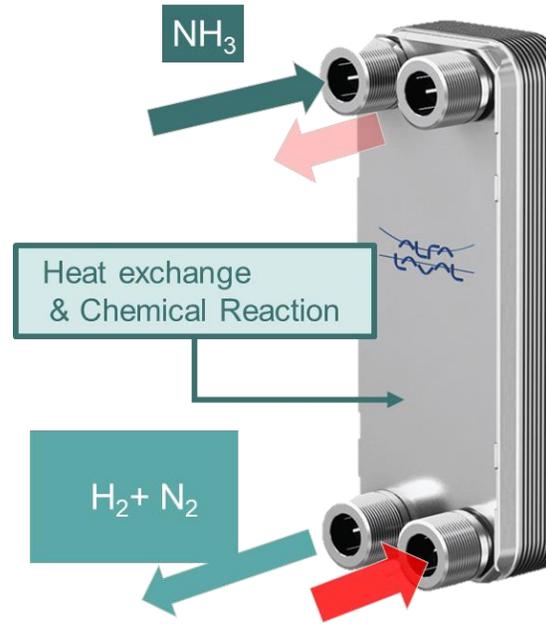
- Using our existing core competencies to expand strategic product offering



## Shell and tube design

- Poor heat transfer resulting slow reaction
- High catalyst loading increasing cost

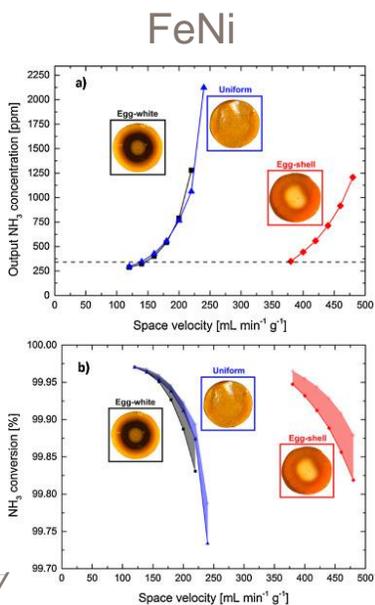
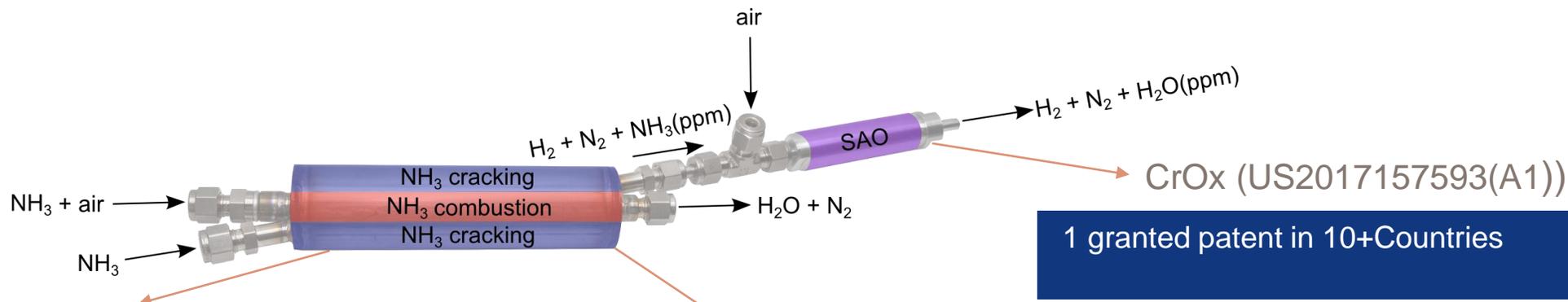
Source: MDPI



## Plate heat exchanger design

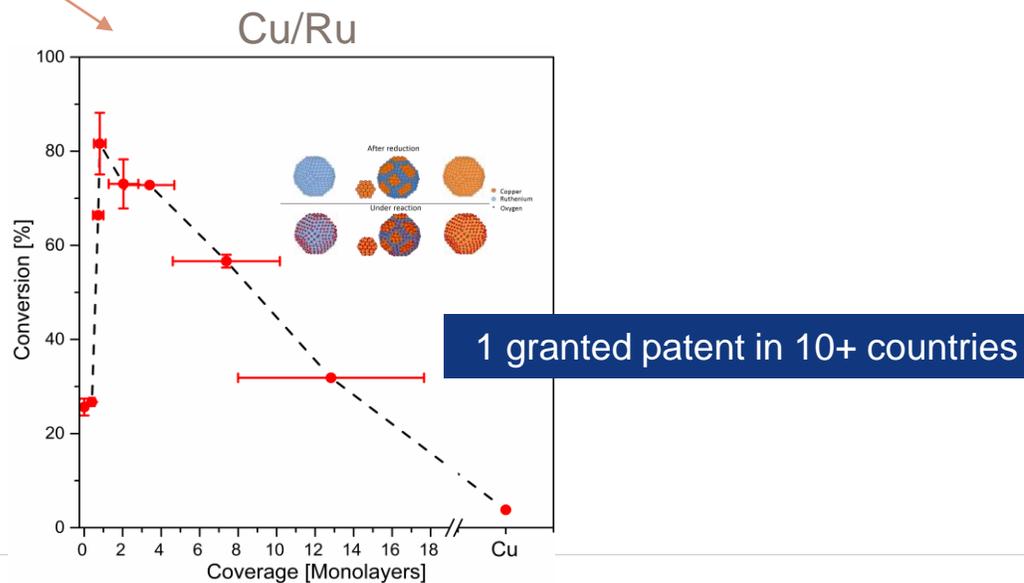
- Improved heat transfer
- An order of magnitude lower catalyst loading resulting in cost reduction

# Hydrogen from ammonia: Technology and IPR owned by Alfa Laval



Silva, Damsgaard,  
Chorkendorff, Chakraborty  
et al., Appl. Catal. 2015

Chakraborty, Damsgaard,  
Grunwaldt et al., Angew Chem  
2018



**THANK YOU**  
more info [www.amon.eu](http://www.amon.eu)



# QUESTIONS?

מחנה  
המנוחה