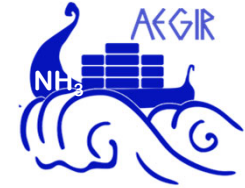




# Powering ships with ammonia through fuel cells - The Aegir project

Anke Hagen, Dr. rer. nat, Dr. techn.  
Technical University of Denmark, DTU Energy



# Overview

- The Challenge

- The Aegir Project

- The Technologies Behind Aegir

- The Final System

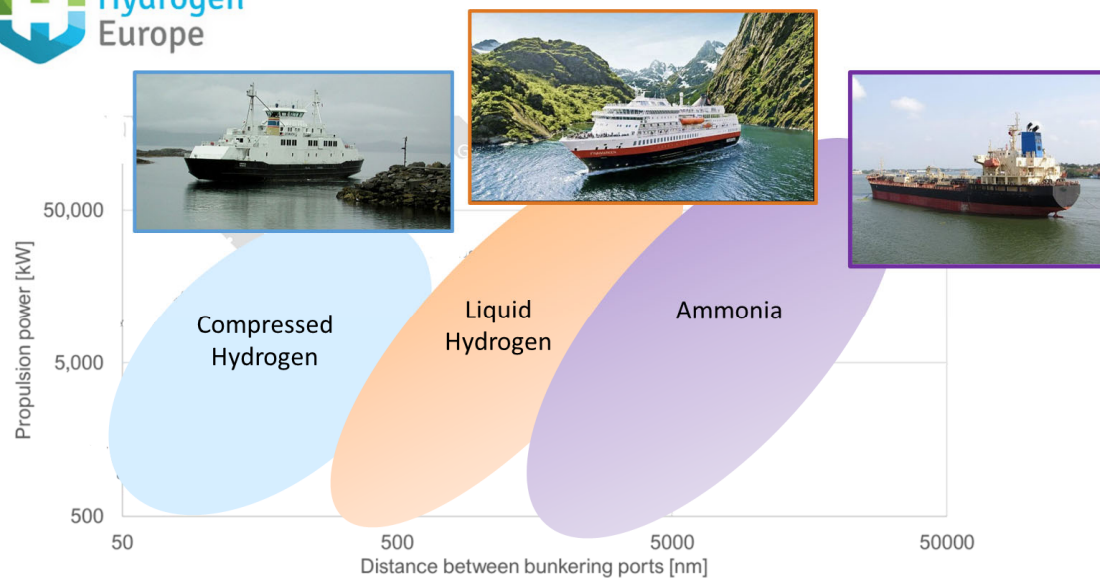


## The Challenge

- *Ships are responsible for 90% of international transport, their CO<sub>2</sub> emissions accounting for approximately 2.2% of the global total of such emissions*
- *The international maritime organization targets*
  - *50-60 % reduction in the greenhouse gas emissions from international shipping by 2050 and*
  - *complete phase out of CO<sub>2</sub> emissions by 2100*
  - *Organisation for Economic Co-operation and Development OEC*  
*Forecast: international maritime trade is expected to triple by 2050*
- *The only way to reach these targets is by wide-scale implementation of low- and zero-emission solutions within the maritime transport sector.*

# The Challenge

## ➤ Carbon free fuel: Hydrogen in maritime transport



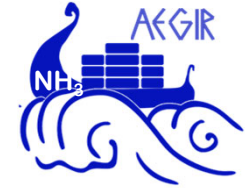
Source: Hydrogen Europe.

- Zero GHG emission at point of power production
- Attractive power density & storage properties
- Production of a zero-carbon footprint ammonia possible (renewable electricity, water, and air - electrolysis)
- Established logistics, infra structure
- Ammonia combustion with no SO<sub>x</sub>, CO<sub>2</sub>, or particulate emissions (but NO<sub>x</sub> emissions)
- Ammonia use in fuel cells



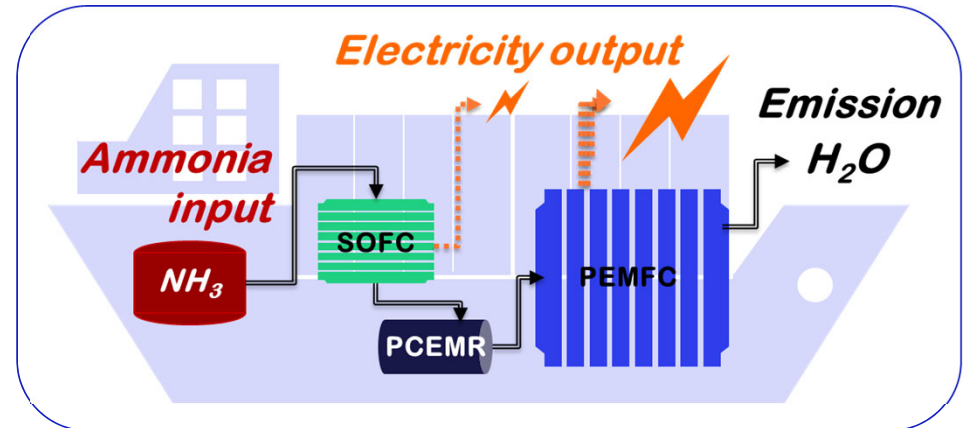
# The Aegir Project

- **Ammonia electric marine power for GHG emission reduction**
- *The overall target of the Aegir project is to develop, test and evaluate an environmentally friendly technological solution to power large marine vessels by using **green ammonia** as primary fuel.*



# The Aegir Project

- **Green ammonia** as primary fuel to power large marine vessels.
- The Aegir concept integrates three innovative technologies:
  - Solid oxide fuel cell (**SOFC**),
  - Proton conducting electrochemical membrane reactor (**PCEMR**), and
  - Polymer exchange membrane fuel cell (**PEM**)

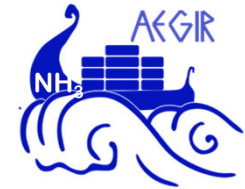








- ❖ Efficiency
- ❖ System volume and weight.

- ❖ NO<sub>x</sub> emissions
- ❖ CO<sub>2</sub> emissions

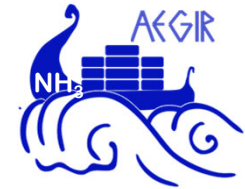
**Zero**

# The Aegir Project



Project partners		
Technical University of Denmark	DK	
Ballard Power Systems Europe	DK	
SINTEF	N	
CoorsTek Membrane Sciences	N	
VARD	N	
VTT	FIN	

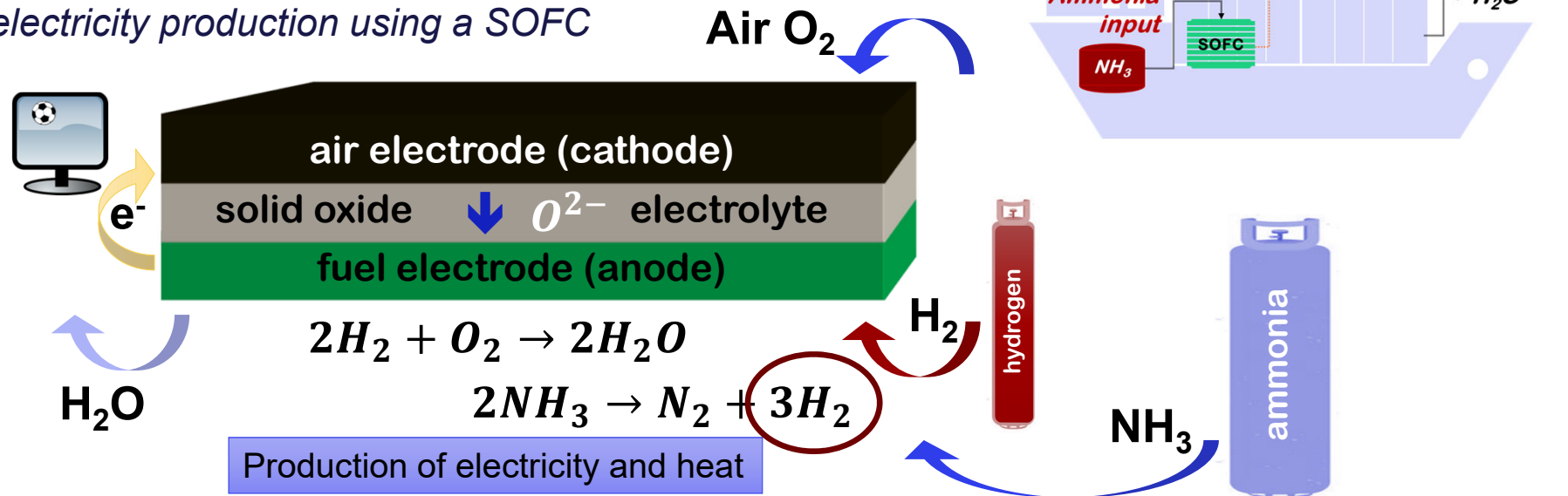




# The Technologies Behind Aegir

## ➤ Solid oxide fuel cell (SOFC)

Ammonia cracking to  $H_2$  and  $N_2$  and part load electricity production using a SOFC



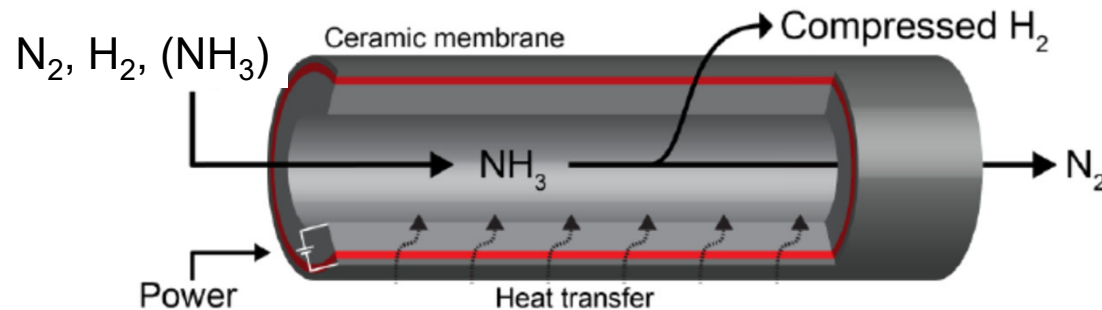
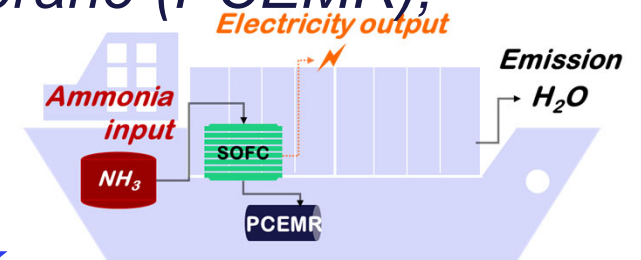




# The Technologies Behind Aegir

➤ *Proton conducting electrochemical membrane (PCEMR),*

*Extraction and purification of H<sub>2</sub> is using a PCEMR*



*Compressed H<sub>2</sub> with purity specifications suitable for PEMFC*

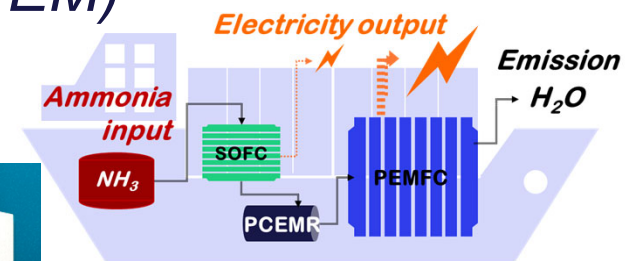
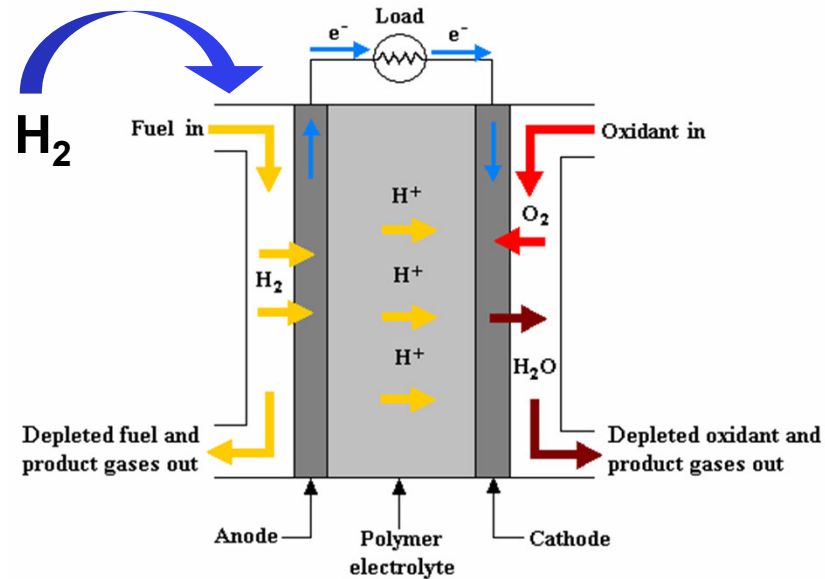
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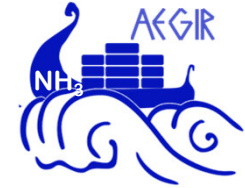
# The Technologies Behind Aegir

## ➤ Polymer exchange membrane fuel cell (PEM)

Production of electricity using a PEM

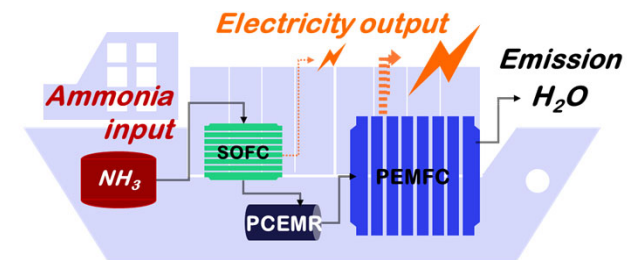
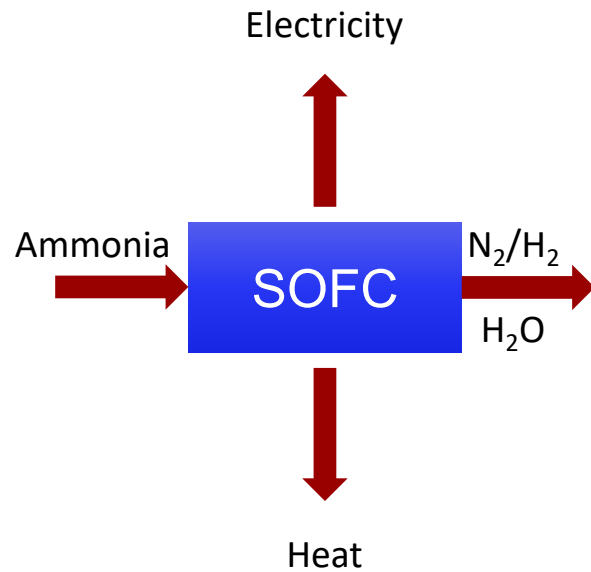


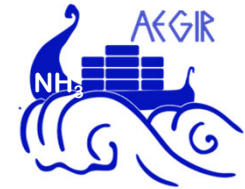
Øyvind Lindgård, Søren Winther Nielsen



# The Technologies Behind Aegir

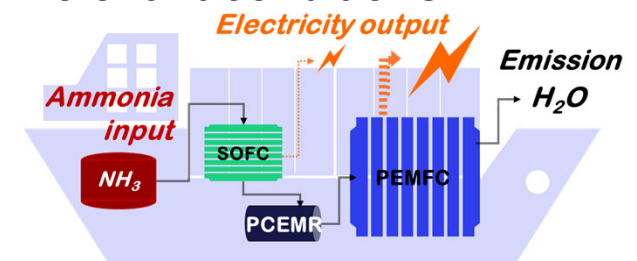
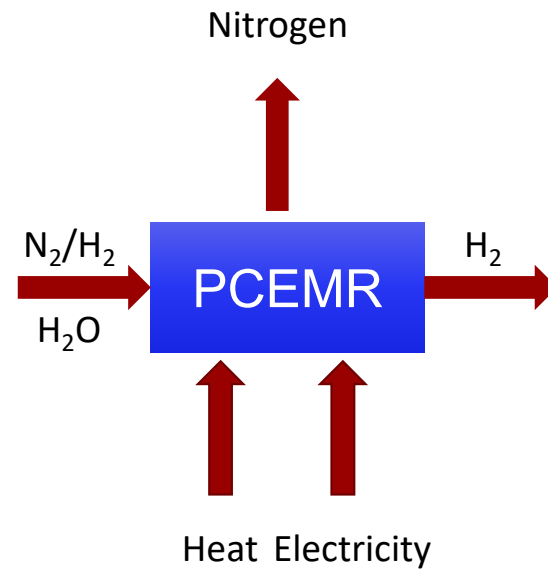
➤ *Development & demonstration of the technologies for relevant conditions*





# The Technologies Behind Aegir

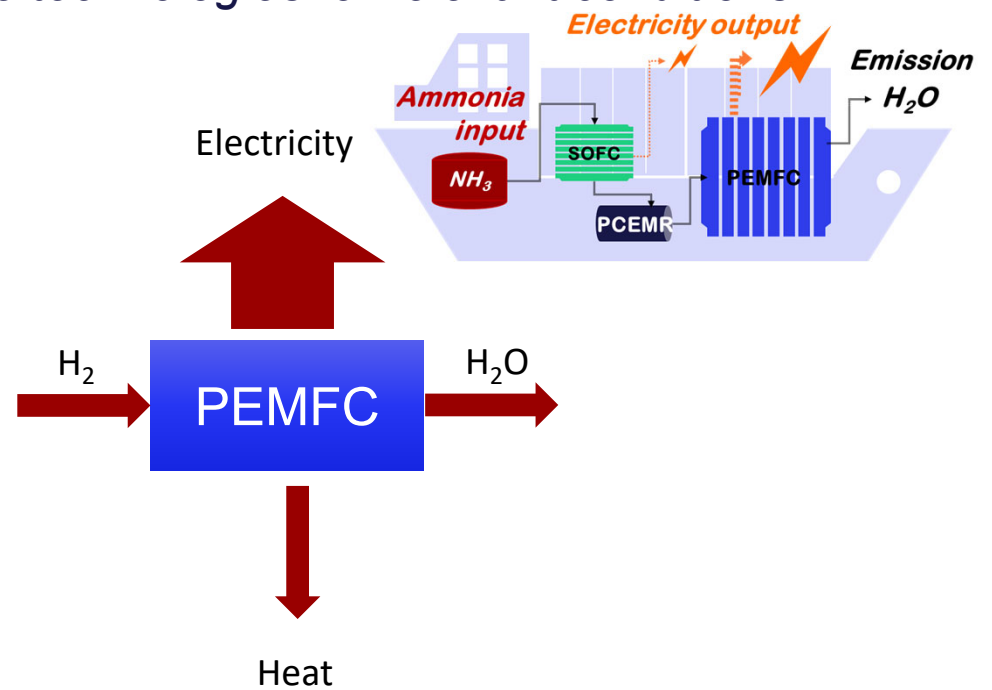
➤ *Development & demonstration of the technologies for relevant conditions*

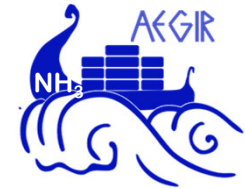




# The Technologies Behind Aegir

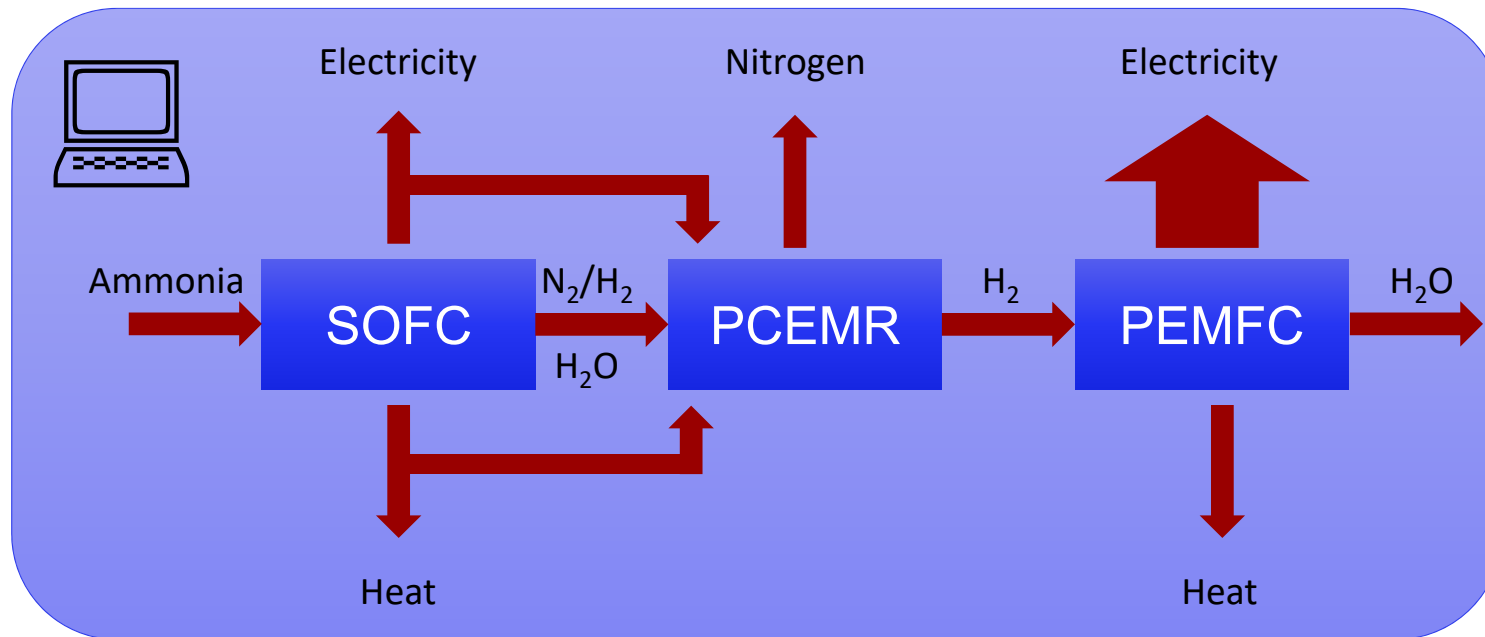
➤ *Development & demonstration of the technologies for relevant conditions*





# The Final System

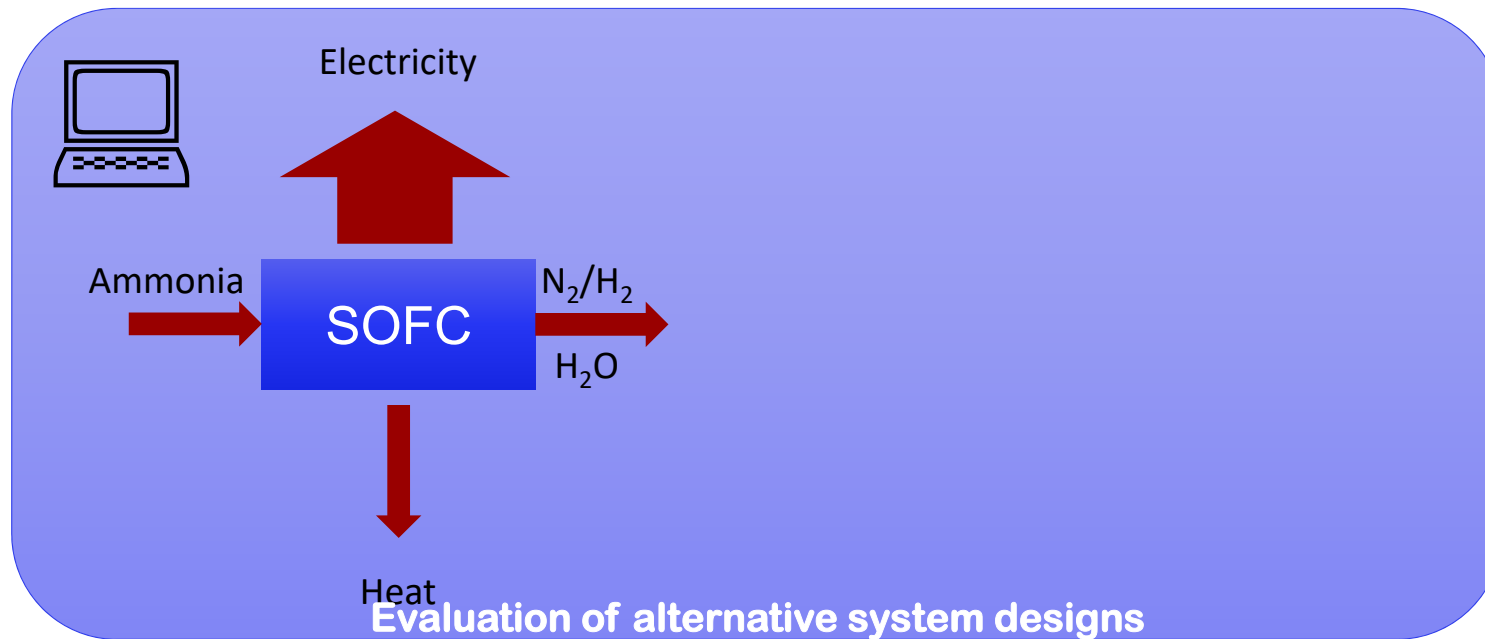
➤ *Design of the integrated concept harvesting synergies (e.g., heat, electricity, gas)*





# The Final System

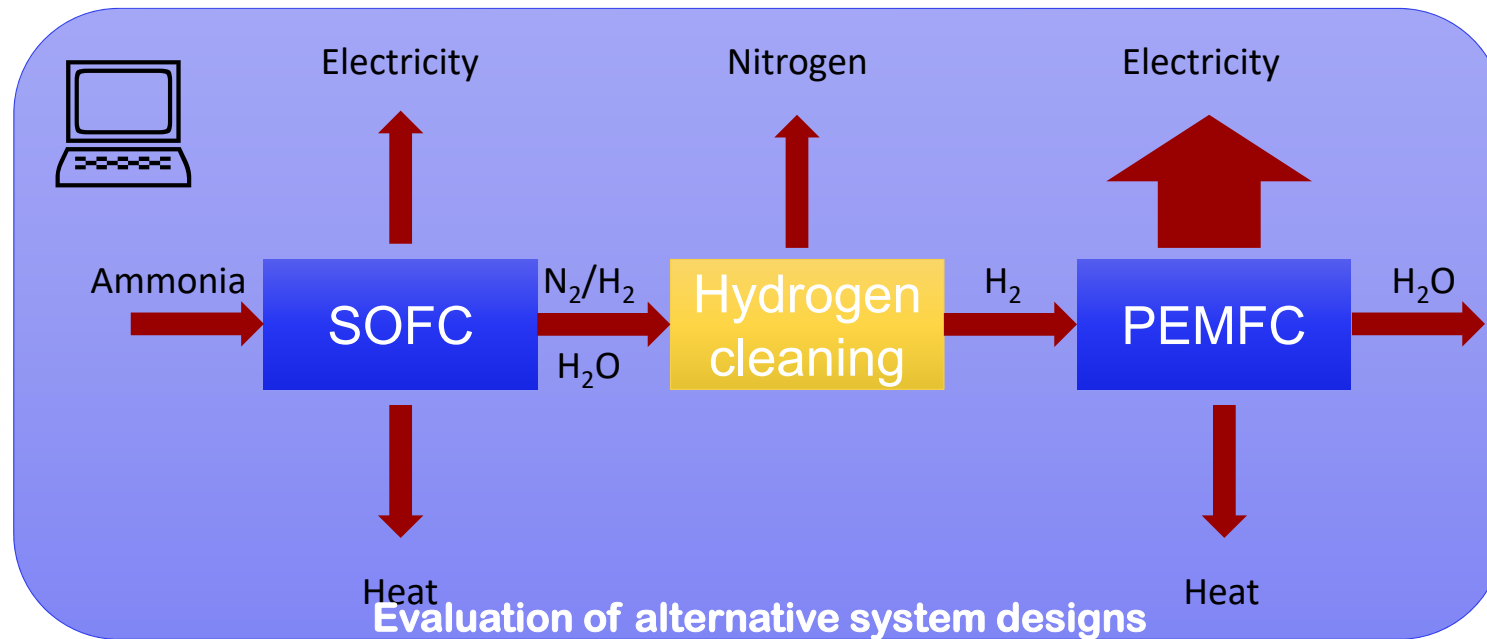
➤ *Design of the integrated concept harvesting synergies (e.g., heat, electricity, gas)*





# The Final System

➤ *Design of the integrated concept harvesting synergies (e.g., heat, electricity, gas)*

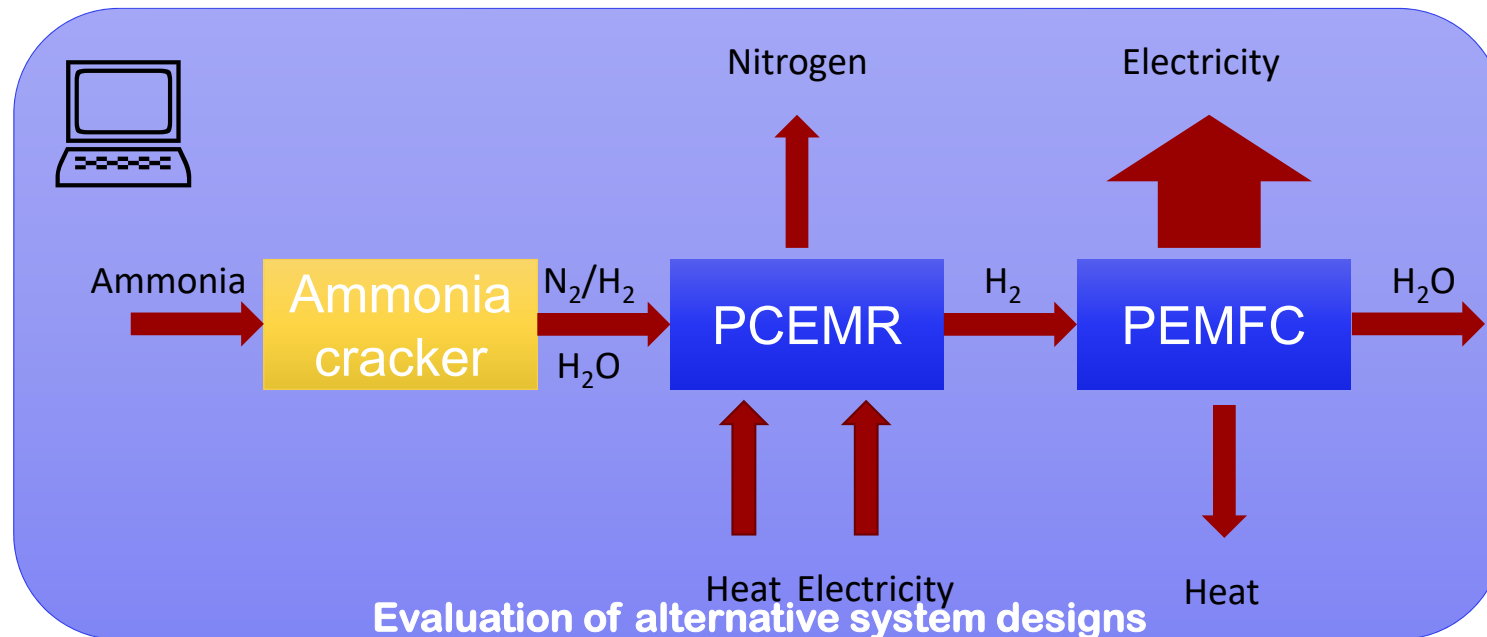






# The Final System

➤ *Design of the integrated concept harvesting synergies (e.g., heat, electricity, gas)*





<https://www.aegir-project.net/>

## Hall 13, Stand B29

This project has received funding from the Nordic Maritime Transport and Energy Research Programme through National Financiers: the Energy Technology Development and Demonstration Program (EUDP) in Denmark, the Norwegian Research Council (RCN) in Norway, and Business Finland in Finland.