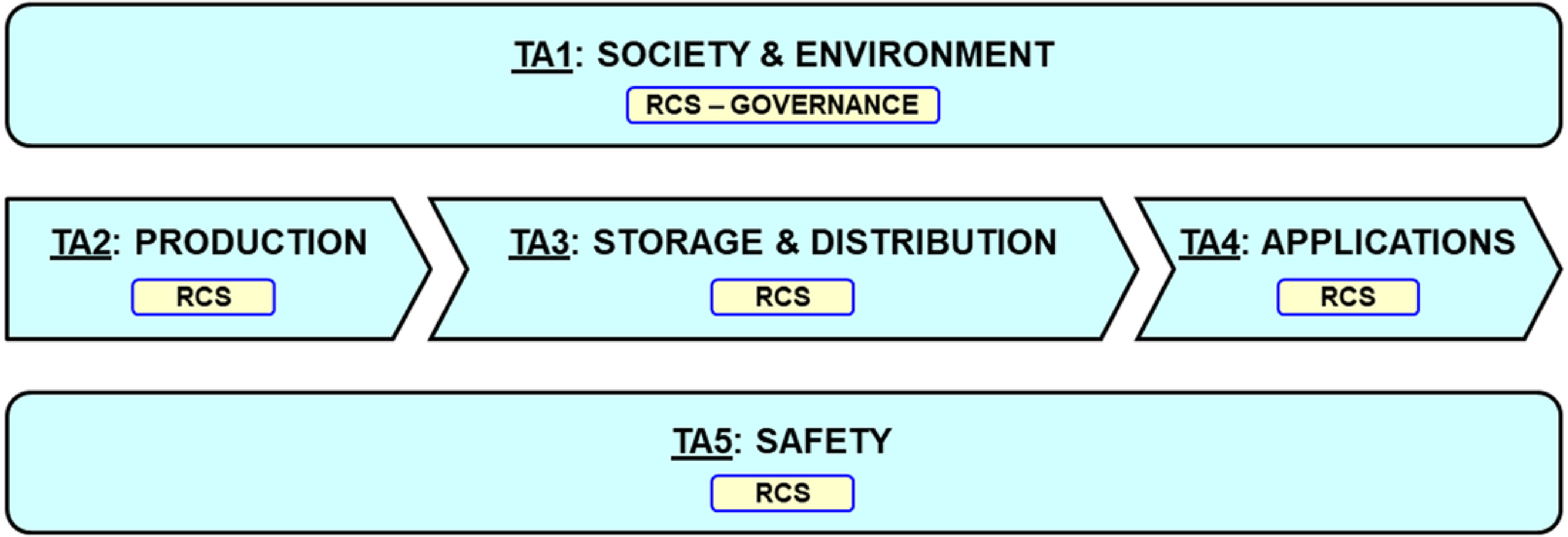
PHD POSTERS

Norwegian research school
on hydrogen and hydrogen-based fuels



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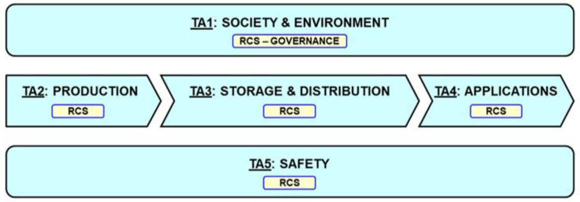

Topical Area 1: Society and Environment

Name (affiliation)	Title of PhD project
Teymur Gogiyev (NTNU)	Environmental sustainability analysis of hydrogen production and use in Norway
Vedant Ballal (NTNU)	Sustainability assessment of advanced biofuels and synthetic fuels for transport applications

Topical Area 2: Production

Name (affiliation)	Title of PhD project
Amalie Bisgaard Møller (UiO)	Modeling and control of PEM water electrolyzer systems
Anders E. Kvåle (UiB & Element One Energy)	Near field electrospinning for electrodes in electrochemical cells
Aritro Banerjee (UiT)	Green hydrogen/bio-hydrogen production with microbial electrolysis cells (MECs)
Ashika Dilshani Wackwella Gamage (UiS)	Hydrogen purification by pressure swing adsorption (PSA)
Kristoffer Skjelanger (HVL)	Modelling and simulation of a rotating electrolyser
Lucas Cammann (NTNU)	Plantwide control for flexible operation of alkaline water electrolysis systems
Luyang Wang (UiO)	Minority bulk and surface proton conduction in ceramic positrodes for proton ceramic electrochemical cells
Marius Fredriksen (NTNU)	Modeling, optimization, and control of PEM electrolysis systems
Mikias Hailu Kebede (NTNU)	Adaption of the electric energy system for large-scale hydrogen production in Norway
Minh Chi To (UiS)	Nanomaterial-enhanced metal-organic-framework composites for photocatalytic water splitting
Patrick Ewerhardt (UiO)	Characterization and simulations of model electrodes in proton ceramic electrochemical cells
Willow Dew (NTNU)	Pd-based membranes for hydrogen and ammonia

Topical Area 3: Storage and distribution

Name (affiliation)	Title of PhD project
Abhishek Banerjee (UiS)	Structure and dynamics for hydrogen storage in hydrogen-rich alloys
Ingrid Marie Stuen (UiB)	Supply chain losses and quality degradation for large-volume hydrogen transport chains
Johan Raftevold Espelund (NTNU)	Computational fluid dynamics simulations of cryogenic storage tanks
Josef Kosler (UiO)	Magnetocaloric metal-oxides for efficient hydrogen liquefaction
Raymond Mushabe (UiB)	Experimental reservoir physics for underground hydrogen storage (UHS) in porous media
Sadegh Ahmadpour (UiS)	Underground hydrogen storage in porous media
Vilde Gahr Sturtzel Lunde (IFE)	Magnetocaloric Hydrogen Liquefaction

Topical Area 4: Applications

Name (affiliation)	Title of PhD project
David Zilles (NTNU)	Experimental study of low-carbon fuel injection and combustion in marine engines
Duc Duy Nguyen (NTNU)	Combustion of ammonia and hydrogen fuel mixtures in marine engine
Giulia Collina (NTNU)	Loss prevention and maintenance modelling for hydrogen-based industry
Giulia Fede (NTNU)	Digital twin for integrated production and maintenance planning in hydrogen-based process industries
Hederson Nascimento (NTNU)	Novel Vacuum Insulation Concepts for Large-Scale Liquid Hydrogen Storage

Topical Area 5: Safety

Name (affiliation)	Title of PhD project
Abhishek Subedi (NTNU)	Improved modeling of socio-technical systems for hydrogen value chain
Anne Marie Lande (USN)	Mitigation of hydrogen explosions
Davide Rescigno (NTNU)	Modelling of physical phenomena in liquid hydrogen releases for safety analysis and risk assessment
Donghun Lee (NTNU)	Empirical Systems Approach for Safe Zero-Emission Transportation Systems
Leonardo Giannini (NTNU)	Risk-based inspection and maintenance for safe handling and use of hydrogen
Petar Bosnic (USN)	Experimental and numerical study of hydrogen gas explosions with a focus on deflagration-to-detonation transition

Topical Area 1: Society and Environment

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Teymur Gogiyev (NTNU)	Environmental sustainability analysis of hydrogen production and use in Norway
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Environmental Sustainability Analysis of H_2 Production and Use in Norway

Introduction

Reducing the carbon footprint of the energy, transportation, and industrial sectors is a major challenge in the fight against climate change that requires inventive solutions. This research aims to improve hydrogen-based value chains in Norway through advanced Life Cycle Assessment (LCA), promoting sustainability-driven innovation. It aims to quantify the climate change mitigation potential and identify environmental co-benefits and trade-offs of large-scale deployment of H_2-based technologies in Norway, particularly in hard-to-abate sectors

Primary objective

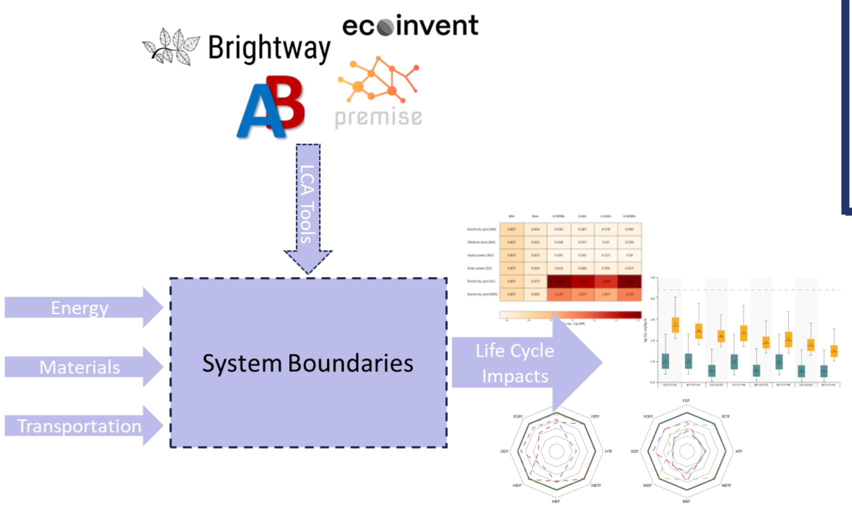
- Promote H_2 technologies to fulfill a green shift in Norway

Secondary objectives

- Identify environmental co-benefits and trade-offs
- Assessment of H_2 impact on the environment

Methods

The research focuses on two key areas. Method development involves refining integrated assessment tools that combine LCA with future scenario data for tailored prospective assessments in Norway. Applications include using these refined methods to assess specific value chains representing different combinations of hydrogen production and use.



Teymur Gogiyev

Affiliation(s): *NTNU*

Related projects: *FME HYDROGENi*

Educational Background:

- BSc Environmental Engineering (ADNSU)
- MSc Engineering (NTNU)
- MSc Industrial Ecology (NTNU)

Supervisor: Francesco Cherubini

Co-supervisors: Nicola Paltrinieri; Marcos Djun Barbosa Watanabe

Estimated progress of the PhD project:

Just started ... | < 50 % | > 50 % | Almost done ☺

Publications (WIP)

- Environmental implications of alternative production, distribution, storage, and leakage rates of hydrogen from offshore wind
- Environmental assessment of H_2 use as a reducing agent in the metallurgical industry
- Perspective LCA assessment of hydrogen use in NPK fertiliser production

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Norwegian Centre for Environment-friendly Energy Research

HYDROGENi

NTNU Kunnskap for en bedre verden

Industrial Ecology Programme

Sustainability assessment of advanced biofuels and synthetic fuels for transport applications

Introduction

EU climate goals
2030: 55% reduction *(EU Fit-for-55 package)*
2050: Net-zero *(EU Green deal)*

Transport sector accounts for **30% of GHG emissions** in the EU

Hard-to-abate transport applications Aviation, Shipping, Road-freight transport need **renewable drop-in substitutes** for mitigation

Advanced biofuels and synthetic fuels can offer up to **94% GHG reduction** compared to fossil

Primary objective

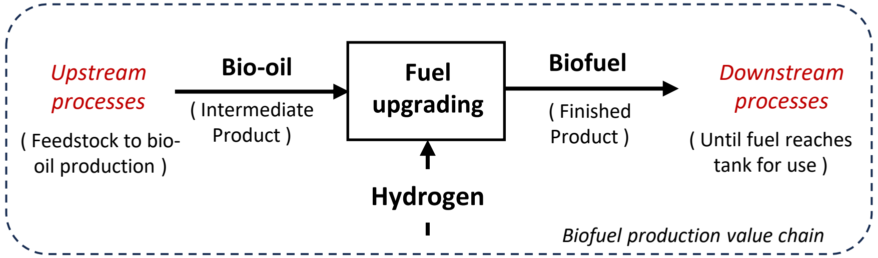
Assess climate mitigation potentials of emerging technological pathways for advanced biofuels and synthetic fuels in transport sector

Secondary objectives

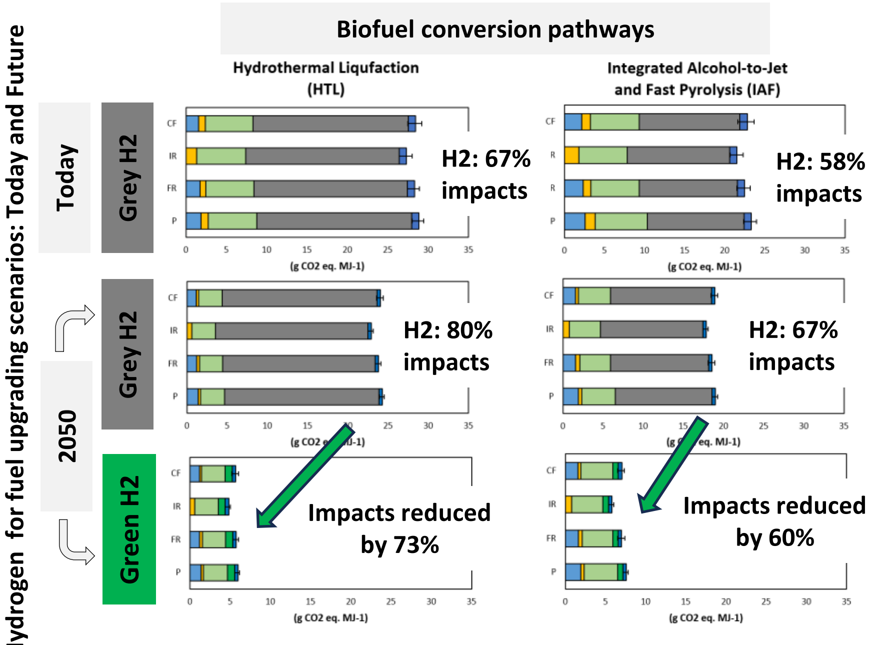
- Identify **key feedstocks**; **Carbon** and **Hydrogen** sources (scenario analysis)
- **Prospective impacts** (future projections until 2050)
- Calculating **'Cost-of-abatement'** ($/ton CO_2 removed)

Hydrogen for biofuel upgrading:

Main driver for GWP100 life cycle climate impacts



Contribution Analysis: Climate impacts of advanced biofuels



Feedstocks for biofuel production
P- Pulpwood, FR- Forestry residues, IR- Industry residues, CF- Combined feedstocks

Vedant Ballal

Norwegian University of Science and Technology (NTNU), Trondheim

Related projects: FME Bio4Fuels, ICARUS

I am assessing emerging technological pathways for producing **advanced biofuels** and **synthetic fuels** for hard-to-abate **transport sectors**, including aviation, shipping, and road-freight in Norway and Europe. My work involves conducting **techno-economic** and **life cycle assessments** to evaluate their sustainability performance.

Supervisor: Francesco Cherubini
Co-supervisor: Marcos Djun Barbosa Watanabe

Estimated progress of the PhD project:

Just started ... | < 50 % | > 50 % | Almost done ☺

Impact category:
GWP100

Lifecycle stage:
- Forestry operations
- Feedstock transport
- Technological conversion
- Grey H2 for upgrading
- Green H2 for upgrading
- Distribution

Publications

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NTNU Norwegian University of Science and Technology
BIO4FUELS
Icarus INTERNATIONAL COOPERATION FOR SUSTAINABLE AVIATION BIOFUELS

Topical Area 2: Production

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Willow Dew (NTNU)	Pd-based membranes for hydrogen and ammonia

Modeling and Control of PEM Water Electrolyzer Systems

Amalie Bisgaard Møller

Affiliation: *Department of Technology Systems, University of Oslo & Hydrogen Department, Institute for Energy Technology*

Related projects: REHSYS-project REHSYS - IFE

2019-2022: Bachelor's degree in Chemical Engineering, DTU

2022-2024: Master's degree in Renewable Energy Systems, UiO

2024-2027: PhD Research Fellow, UiO & IFE

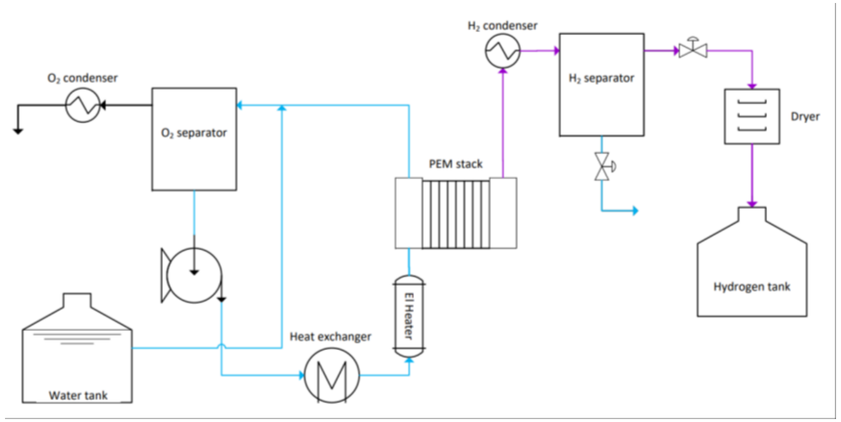
Estimated progress of the PhD project:

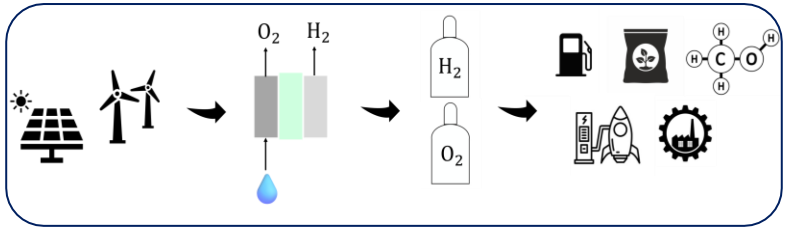
Just started ... | **< 50 %** | **> 50 %** | **Almost done ☺**

Introduction

Dynamic process modeling can be used as a tool to analyze and optimize the operation of a PEM water electrolysis plant that is coupled with a renewable energy source.

Optimal process control can improve the system efficiency and safety under varying load conditions.





Primary objective

- Optimize operation of industrial scale PEM water electrolysis systems coupled with wind and solar power

Secondary objectives

- Develop a dynamic model of an industrial scale PEM water electrolysis plant to describe the transient behavior of the process variables
- Test different controllers and operating strategies that can improve system efficiency and safety

Near field electrospinning for electrodes in electrochemical cells

Anders E. Kvåle

University of Bergen & Element One Energy AS

Introduction

This PhD project develops a novel near-field electrospinning (NFES) technique to fabricate three-dimensional (3D) structured nanofiber electrodes for enhanced electrochemical energy storage and conversion. The modified NFES method with precise control of fiber deposition enables the creation of controlled porosity and fiber pattern architectures. This approach is applicable to a range of devices, including electrolysers, fuel cells, batteries, flow batteries, and supercapacitors. The resulting 3D nanofiber networks exhibit increased surface area and improve electronic/ionic conductivity, leading to enhanced electrocatalytic activity. A primary focus is on water electrolysis, specifically addressing the challenging oxygen evolution reaction (OER), which typically requires high loadings of iridium catalysts. By optimizing the 3D electrode structure and tuning the catalyst ink composition, this work aims to significantly reduce the need for critical raw materials like iridium, while simultaneously improving overpotential, current density and durability of the electrodes in water splitting. This advancement offers a pathway towards more sustainable and efficient energy technologies.

Primary objective

- Prepare 3D structured electrodes with nano fibers for improved electrochemical performance with a novel near field electrospinning method

Secondary objectives

- Fiber optimized for catalyst contact, pores for mass transfer and electron/ proton conductivity
- Develop the method for preparing electrodes for batteries, super-capacitors, and other energy storage devices

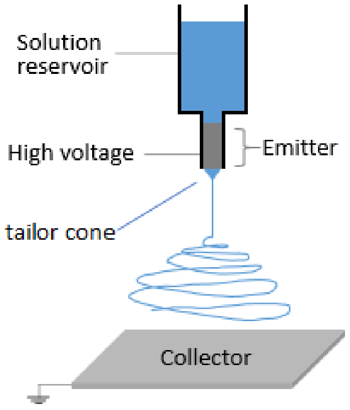


Figure 1 Traditional electrospinning method

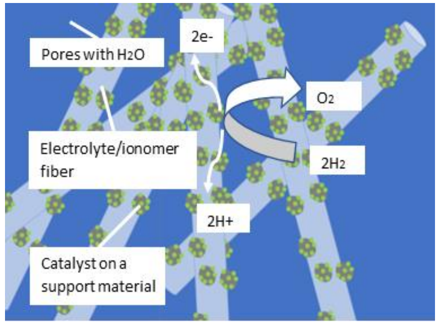


Figure 2 Electrospun fibers with electrochemical reaction

I have a M.Sc. Degree in Engineering, Energy and Process from NTNU and worked for a couple of decades in the energy domain. The project is an industrial PhD for my start-up company Element One Energy AS where I am the founder

Estimated progress of the PhD project:

Just started ... | **< 50 %** | **> 50 %** | **Almost done ☺**

Publications

- Preparing a paper "Nanofiber electrodes for water splitting fabricated with novel near-field electrospinning method"

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UNIVERSITETET I BERGEN

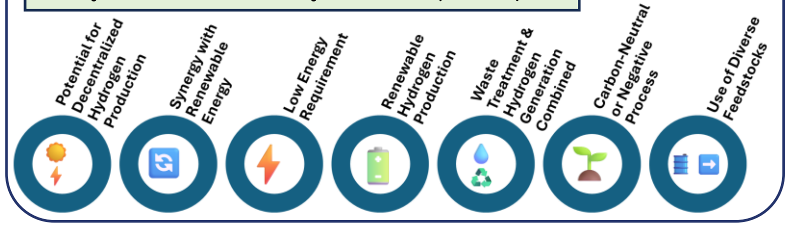
EoneE

Green Hydrogen/Bio-Hydrogen Production with Microbial Electrolysis Cells (MECs)

Why Bio-Hydrogen?

- **Highest energy content** per unit weight among other gaseous fuels (143GJ/ton).
- It is a **Clean Fuel with only water as byproduct,** is rapidly produced from Biomass.
- **Utilizes waste** and is Environmentally friendly with **no CO_2 emissions.**
- Potential use in in **hydrogen fuel cell vehicles (HFCVs).**

Why Micro Electrolysis Cell (MEC)?



Factors influencing Bio-hydrogen production in MECs

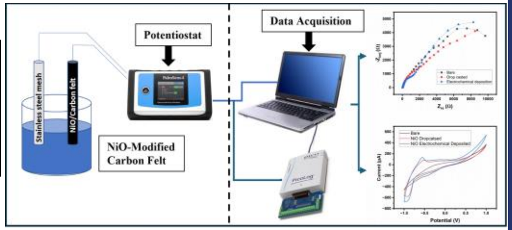
Electrode Material	Membrane Material	Design of Reactor	Feed Wastewater

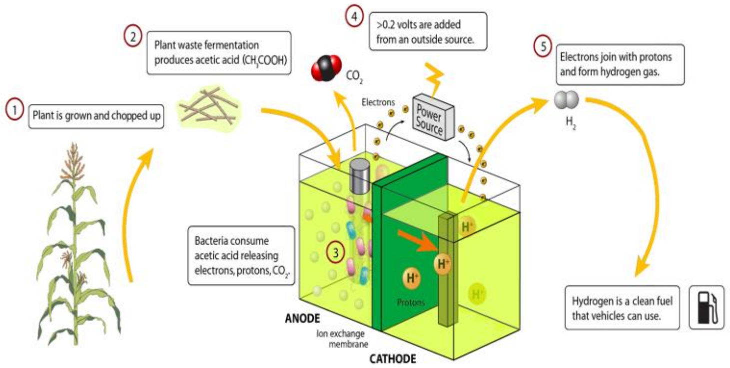
Benefits	Green Energy Transition	Low Carbon Footprint	Decentralized Treatment
Challenges	Expensive	Low Production Rate	Still in Infancy Stage

Bio-Hydrogen yield in MECs with various substrates

Substrate	Predominant microorganisms	Biohydrogen production	Reference
Palm oil mill effluent	Geobacter, Pseudomonas sp	1.16 m3 H_2/m^3d	(Chandrasekhar et al., 2022)
Lignocellulosic hydrolysate	Enterococcus spp.	10.9 mol H_2/mol of glucose	(Wang et al., 2021)
Palm oil mill effluent	Geobacter sp., Desulfovibrio sp., and Thermoanaerobacterium sp.	134 ml-H_2/gCOD	(Khongkliang et al., 2019)
Crude glycerol	Enterococcus sp., Acetobacterium sp., and Geoalkalibacter sp	0.46 LH_2/L/d	(Badia-Fabregat et al., 2019)

Development and Characterization of a High-Sensitivity NiO-Modified Carbon Felt





How do MECs work

Aritro Banerjee

Affiliation: UiT The Arctic University of Norway

Department of Building, Energy and Material Technology

Aritro Banerjee is a Chemical Engineer with expertise in environmental science, water treatment technologies, design and process optimization, and microbial fuel cells (MFCs). As a PhD researcher at UiT, The Arctic University of Norway, his work focuses on developing MFC technology for wastewater treatment and energy recovery. His background includes industrial wastewater treatment process design, community drinking water treatment systems, and industrial production, where he has worked as a shift supervisor. Additionally, he has been involved in learning about Recirculating Aquaculture Systems (RAS) projects.

Aritro has contributed as a researcher to the SPRING project, focusing on water treatment technologies, and is currently working on the ENFORCE project.

Estimated progress of the PhD project:

Just started ... | **< 50 %** | **> 50 %** | **Almost done ☺**

Publications

1. *Role And Important Properties Of A Membrane With Its Recent Advancement In A Microbial Fuel Cell*, Banerjee A, Calay Rk, Eregno Fe .Energies. 2022;15(2). Doi:10.3390/En15020444
2. *Review On Material And Design Of Anode For Microbial Fuel Cell* **Banerjee** A, Calay Rk, Mustafa M, Energies. 2022;15(6):2283. Doi:10.3390/En15062283

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Norwegian Directorate for Higher Education and Skills

Acknowledgement: The ongoing work is supported by PEERS (UTF 2020/10131) &BRIDGE (INTPART-322325) UiT The Arctic University of Norway

The Research Council of Norway

Hydrogen Purification by Pressure Swing Adsorption (PSA)

Ashika Dilshani Wackwella Gamage

Affiliation(s): University of Stavanger, PhD Candidate

Related projects: *HyValue*

Supervisor: Assoc Prof Sachin Chavan

- Masters in Chemical NanoEngineering (Erasmus Mundus)
- B.Sc. in Chemical and Process Engineering.

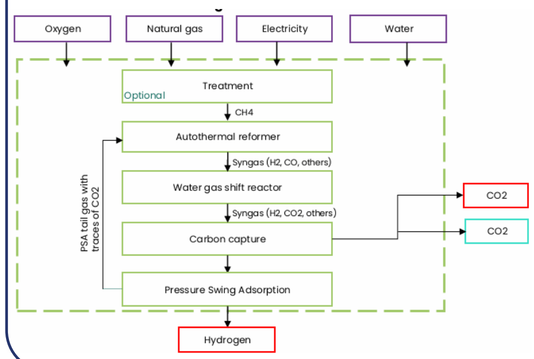
Estimated progress of the PhD project:

Just started ... | **< 50 %** | **> 50 %** | **Almost done ☺**

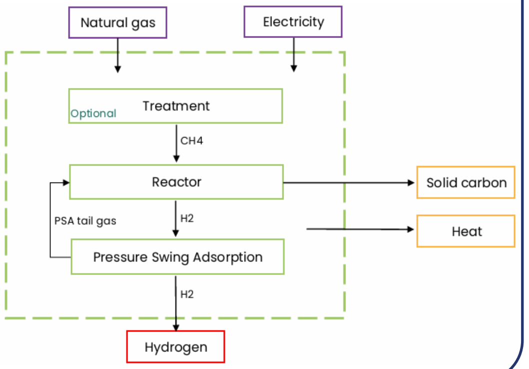
Introduction

- H_2 is a key component in the global shift toward cleaner energy sources.
- Achieving high purity H_2, remains a significant challenge.
- **Aim** is to find the best adsorbent for H_2 purification to improve hydrogen purity, and recovery, and optimize PSA process parameters.

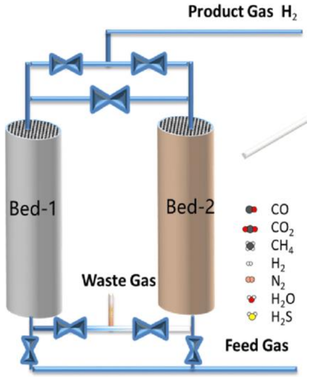
Autothermal Reforming-CCS

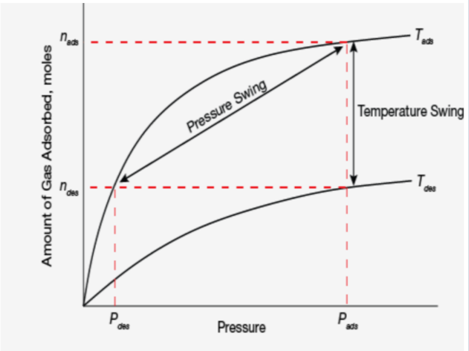


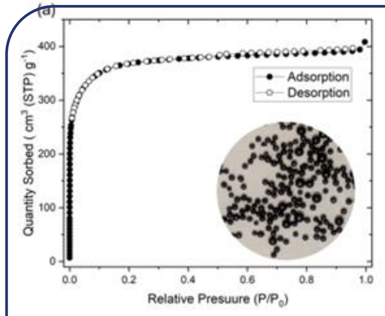
Methane splitting



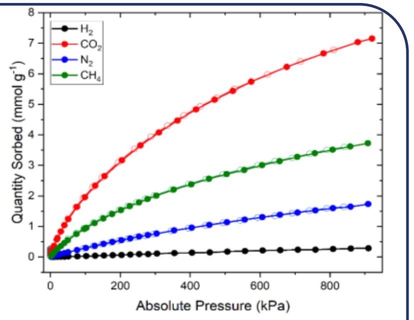
PSA Operating Principle



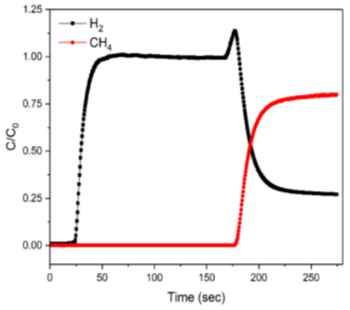




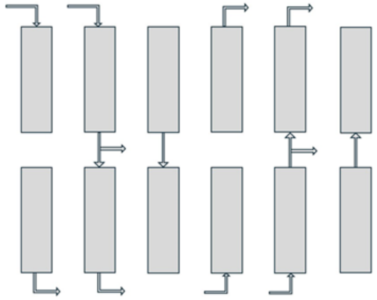
Adsorbent characterization



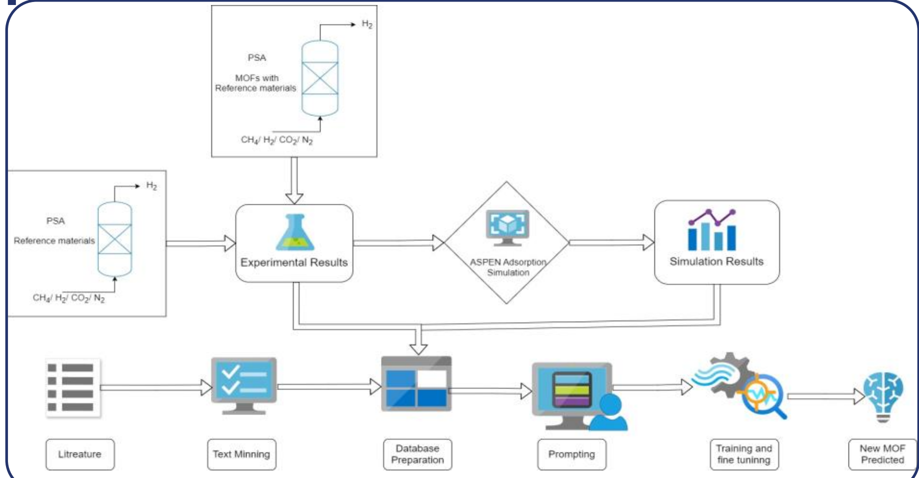
Adsorption Isotherms



Breakthrough Curves



PSA Cycles



Publications

- Du Z, et al. Catalysts. 2021;11(3):393.
- Yu S, et al. Artif Intell Chem. 2024;2(2):100076..

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Norwegian Research School on Hydrogen and Hydrogen-Based Fuels

Universitetet i Stavanger

HyValue

Modelling and simulation of a rotating electrolyser

Introduction

It has been demonstrated that imposing an external gravity field on an electrolyser can improve its efficiency.
This effect is believed to be a result of bubbles being removed faster from the catalyst surface and/or gas dissolved in the water being transported away such that the nucleation rate at the catalyst surface is reduced. Both these phenomena will lead to a reduced bubble coverage and therefore a reduced bubble overpotential.

Primary objective

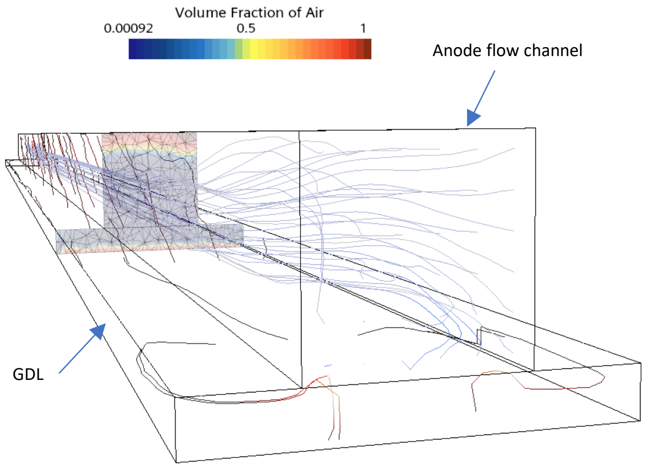
- Create a model describing the bubble evolution and lifetime at the catalyst surface.
- Use numerical methods to determine the steady-state bubble coverage at the catalyst surface.
- Determine the overpotential associated with the bubble coverage and compare with experimental results.

Secondary objectives

- Develop and improve on existing numerical methods and tools.

Cross-disciplinarity

The project belongs to the fields of computer science and hydrogen technology. It is therefore important to bring contributions to both of these fields in an efficient and appropriate fashion.



Kristoffer Skjelanger

Affiliation(s: Western Norway University of Applied Sciences (HVL).

Related projects: HyValue

*PhD Candidate,
Department of Mechanical Engineering and Maritime Studies,
Western Norway University of Applied Sciences*

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺
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Publications

N/A

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Western Norway University of Applied Sciences

HyValue

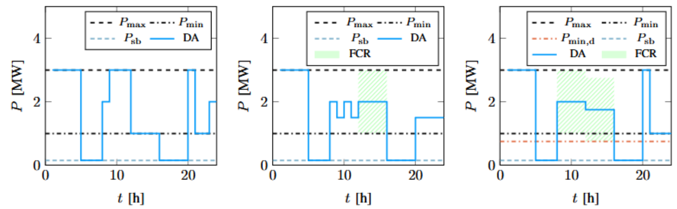
Plantwide control for flexible operation of alkaline water electrolysis systems

Introduction

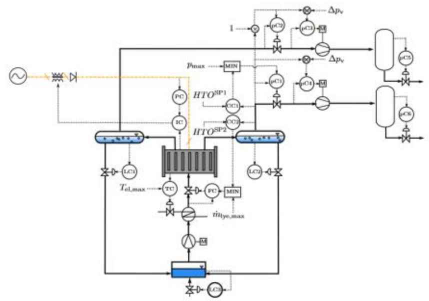
Coupling alkaline water electrolysis processes to renewable energy sources requires rethinking operating practices that today assume constant power supply. We are developing control methods to enable safe and efficient operation for renewably fueled electrolysis systems, both on and off the electricity grid. The methodologies used are from the fields of process systems engineering, optimization and control.

Selected publications

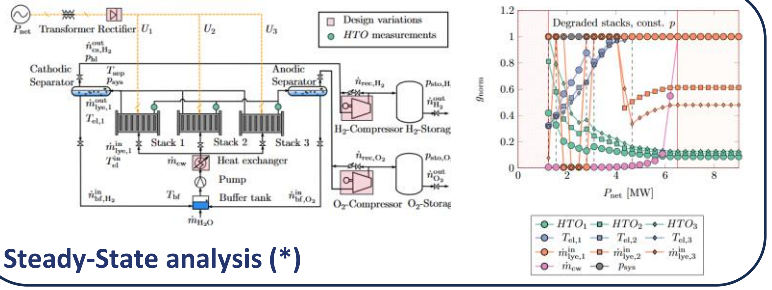
- L. Cammann et al. "Design and operational analysis of an alkaline water electrolysis plant powered by wind energy", *International Journal of Hydrogen Energy* (*)
- L. Cammann, J. Jäschke. „A simple constraint-switching control structure for flexible operation of an alkaline water electrolzyer", *IFAC-PapersOnLine* (**)
- L. Cammann, E.F. Alves, J. Jäschke. „Dynamic minimum loads for FCR market participation of alkaline water electrolyzers", *50th Annual Conference of the IEEE Industrial Electronics Society* (***)



Operating strategies (***)



Regulatory Control (**)



Steady-State analysis (*)

Lucas Cammann

Norwegian University of Science and Technology

NTNU (`22 -)
Ph.D. Candidate

TU Delft (`19 - `21)
M.Sc. Chemical Engineering

TU Berlin (`15 - `18)
B.Sc. Chemical Engineering

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺
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Primary objective

- Develop control strategies for the plantwide operation of alkaline water electrolysis systems, specifically regarding process safety (HTO)

Secondary objectives

- Elucidate bottlenecks in current operating practices
- Analyze the control requirements for on-and off-grid operation
- Develop advanced operating strategies

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NTNU
Department of Chemical Engineering

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+47 73 55 99 86
www.linkedin.com/in/lcammann/

Minority bulk and surface proton conduction in ceramic positrodes for proton ceramic electrochemical cells

Introduction

The positrode is critical for proton ceramic electrochemical cells for **hydrogen** and ammonia, as a major contribution to the over-potentials and hence losses in the whole cell. It is challenging to characterise the proton transport in predominantly electronic conductors.

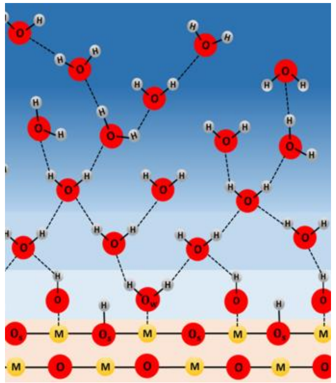
We want to establish theory and methodology for **measuring minority protonic** conductivities in *electronic conductors.* The results will be used as input to other project which perform computer simulations to seek strategies for optimization and effects on electrodes in scaled-up cells.

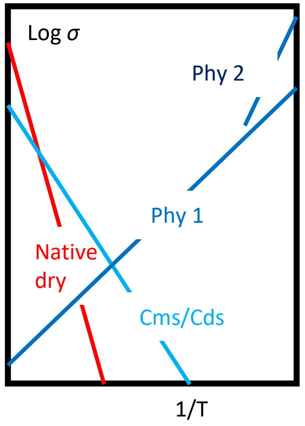
Primary objective

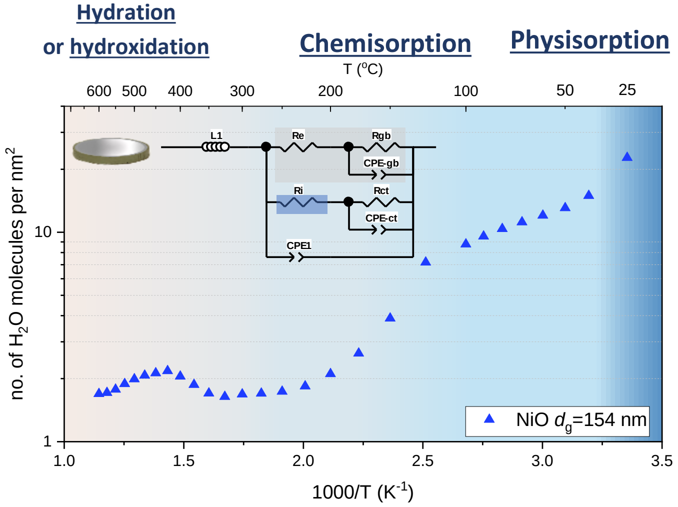
- Characterizing the proton concentration and migration in the bulk and on surfaces of positrode materials.

Secondary objectives

- P-type oxide model materials.
- Theoretical model of the protonic and electronic conduction.



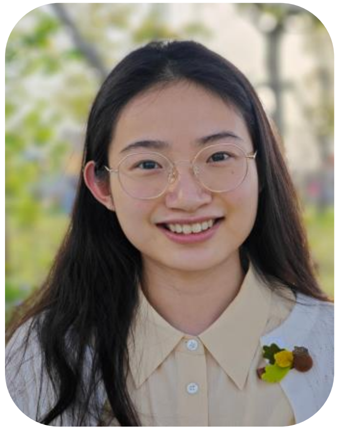




Luyang Wang

University of Oslo

Related projects: FME HYDROGENi



I am doing PhD in Materials Chemistry at the Electrochemistry group with Truls Norby as my supervisor.

Bachelor in Environmental Engineering - Huazhong University of Science and Technology, China.

Master of Research in Green Chemistry: Energy and Environment - Imperial College London, UK.

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺

Planned deliverables

- Manuscript on surface protonics and electronic conduction on NiO.

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Centre for Materials Science and Nanotechnology

Modeling, Optimization, and Control of PEM electrolysis systems

Marius Fredriksen

Norwegian University of Science and Technology (NTNU)

Related projects: FME HYDROGENi

Ph.D. candidate in the Process Systems Engineering group at the Department of Chemical Engineering, NTNU. Master's degree in chemical engineering from NTNU.

Estimated progress of the PhD project:

Just started ...	**< 50 %**	**> 50 %**	**Almost done ☺**

Introduction:

The successful transition to a hydrogen-based energy economy relies on the development of efficient and sustainable hydrogen production methods. Proton Exchange Membrane (PEM) water electrolysis is a promising technology due to its high energy efficiency and operational flexibility [1]. However, the intermittent nature of renewable energy sources, such as wind and solar, makes proper control essential to optimize stack performance and lifespan [1].

Primary Objective:

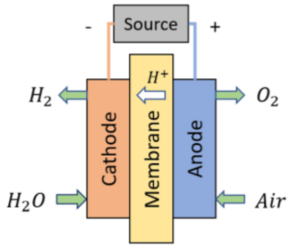
- Develop control strategies for PEM electrolysis systems

Secondary Objectives:

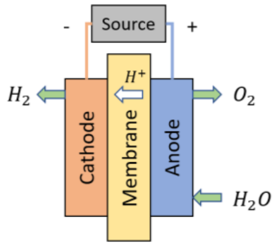
- Develop dynamic models for PEM systems
- Study optimal operating conditions

Current activities:

- Modelling the electrolyzer stack and Balance of Plant units, such as heat exchangers, separators, and pipes, for both conventional and Hystar PEM system layouts.
- Implementing Advanced Regulatory Control (ARC) techniques, such as active constraint control and constraint switching.
- Evaluating the feasibility of Model Predictive Control (MPC) as an alternative to the ARC-based strategies.



Hystar layout [2]



Conventional layout [1]

References:

[1] Majumdar, A., Haas, M., Elliot, I., & Nazari, S. (2023). Control and control-oriented modeling of PEM water electrolyzers: A review. International Journal of Hydrogen Energy.

[2] https://hystar.com/patented-technology/

Adaption of the Electric Energy System for Large-scale Hydrogen Production in Norway

Introduction

- Fossil fuels, coal etc. → Greenhouse gasses → Global warming → Decarbonization needed → Need for energy transition → Renewable and clean energy sources!
- Hydrogen is a clean energy carrier and green hydrogen production is essential to meeting decarbonization goals of Norway.
- "Hydrogen pathways 2050" or "ZeroKyst" project is studying hydrogen demand (road map) to be used for national purpose in Norway and to be exported as a product.
- When large-scale hydrogen production systems are installed (electrolyser, fuel-cells, compressors, storage, power electronic components), they will interact with the Norwegian energy system.
  - The challenge: increased power/energy demand.
  - The opportunity: it supports the grid service/flexibility.

Primary objective

- To address the energy system challenges and look for support possibilities coming from the hydrogen production installations.

Secondary objectives

- Study the need for new renewable energy generation and grids to support new hydrogen production installations.
- Assessment of the technical ability of hydrogen systems to provide flexibility/grid services to the energy system.
- Techno-economic analysis of the economic benefits of providing grid services versus normal operation.
- Evaluation of different energy storage technologies (H2, electrical) for flexibility in production and cost containment.
- To work with actual use cases to assess the local grid constraints and operation modes of the hydrogen systems.

Method/s

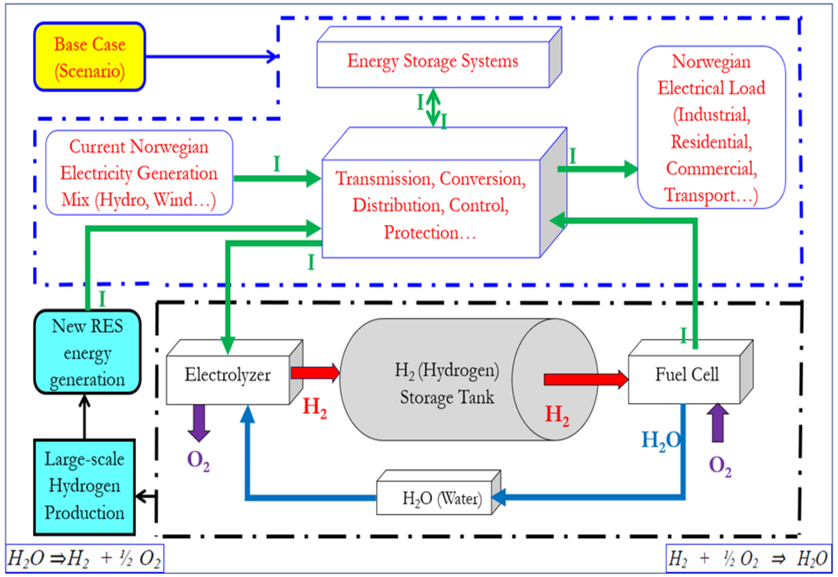


Figure 1: Large-scale Hydrogen Production in Norwegians Grid: Macro-level Conceptualization

Mikias Hailu Kebede

Affiliation(s) = NTNU, Department of Electric Energy

Supervisor: Associate Professor Steve Völler

Co-supervisors: Professor Magnus Korpås and Professor Irina Oleinikova

Related projects: *HYDROGENi*

B.Sc. in Electrical Engineering

M.Sc. in Power Engineering

Before joining NTNU I was full-time academic staff member at Aksum University and Debre Berhan University, Ethiopia.

My research interests include renewable energy, hydrogen systems, distributed generation, electric power engineering, energy efficiency, power quality, and reliability.

Estimated progress of the PhD project:

Just started …	< 50 %	> 50 %	Almost done ☺
■			

Publications (See at the links)

→ Google Scholar: https://scholar.google.com/citations?user=oivfDKYAAAAJ&hl=en

→ Research Gate: https://www.researchgate.net/profile/Mikias-Kebede-2

→ ORC iD: https://orcid.org/0000-0001-6927-0277

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NTNU

HYDROGENi

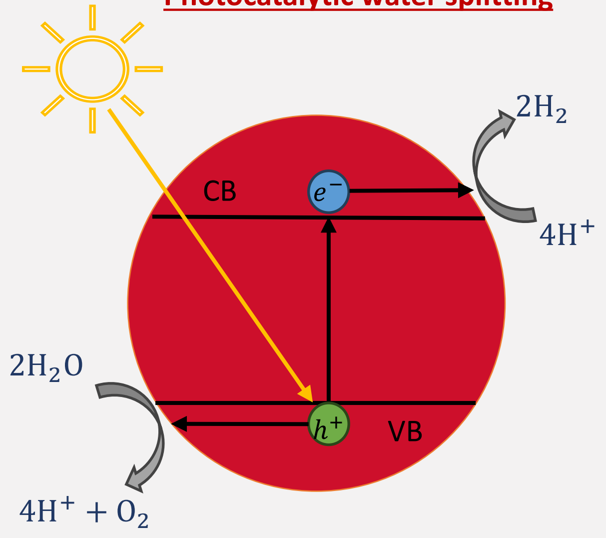
Nanomaterial-Enhanced Metal-Organic-Framework Composites for Photocatalytic Water Splitting

Introduction

Metal-Organic Frameworks (MOFs) are semiconductor-like materials composed of metal nodes and organic ligands. These materials are highly porous, which leads to large surface areas. This makes them excellent candidates as catalysts. Through certain modifications, MOFs can be tuned to absorb light and can be used as photocatalysts [1].

The effectiveness of MOFs as photocatalysts can be enhanced through different methods, where one is through the creation of composites with other materials. The introduction of nanomaterials to MOFs can give different types of enhancement, such as acting as co-catalysts or through plasmonic enhancement. The nanomaterial and MOF composite can potentially give greater efficiencies through their synergies [2,3].

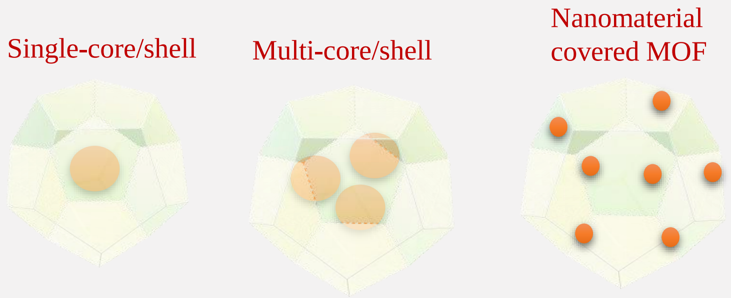
Photocatalytic water splitting



Primary objective

- Synthesise and characterise nanomaterial-enhanced MOFs
- Compare hydrogen production of MOF with nanomaterial-enhanced MOF composites.

Nanomaterial-enhanced MOF composites



Minh Chi To

University of Stavanger, Department of Mathematics and Physics

PhD-candidate in Material Physics

MSc in Physics from UiB

BSc in Physics from UiB

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺
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Reference

[1] Sergio Navalón, Amarajothi Dhakshinamoorthy, Mercedes Álvaro, Belén Ferrer, and Hermenegildo García. Metal–organic frameworks as photocatalysts for solar-driven over-all water splitting. Chemical Reviews, 123(1):445–490, 2023. PMID: 36503233

[2] Ma, W.; Yu, L.; Kang, P.; Chu, Z.; Li, Y. Modifications and Applications of Metal-Organic-Framework-Based Materials for Photocatalysis. *Molecules* **2024**, *29*, 5834. https://doi.org/10.3390/molecules29245834

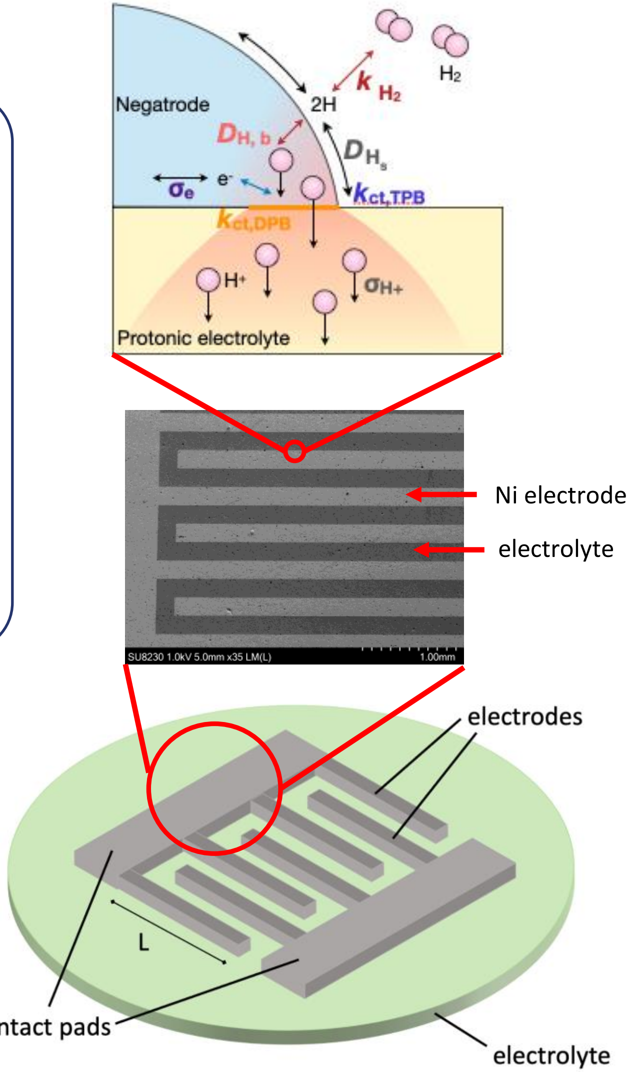
[3] Rou Li, Xianfeng Wang, and Ming Chen. Non-noble metal and nonmetallic plasmonic nanomaterials with located surface plasmon resonance effects: Photocatalytic performance and applications. Catalysts, 13(6), 2023.

Characterization and simulations of model electrodes in proton ceramic electrochemical cells

Introduction

Proton Ceramic Electrochemical Cells (PCECs) are promising candidates for energy conversion and storage of renewable energies using hydrogen. PCECs can be used as reversible cells operating either in electrolysis or fuel cell mode solely with hydrogen, oxygen and steam, but are capable of operating with other fuels too.

Current cells suffer from sluggish reaction kinetics especially at the steam electrode (positrode) as well as poor durability. While many studies concentrate on the improvement of the used materials, in depth investigations of the reaction pathways are scarce. Therefore, we focus on a fundamental understanding and want to elucidate the limitations of operating cells by the use of model electrodes with well-defined geometry.



Primary objective
- Fundamental understanding of the electrodes and their limitations

Secondary objectives
- Development of finite element models for the positrode (air electrode) and negatrode (hydrogen electrode) implemented in Comsol
- fabrication and characterization procedure for model electrodes

Patrick Ewerhardt

Affiliation:

University of Oslo, Department of Chemistry, Centre for Material Science and Nanotechnology

Related projects: FME HYDROGENi

PhD research fellow in the Group for Electrochemistry under the supervision of Jonathan Polfus at UiO

B.Sc. Nanoscience, University of Hamburg

M.Sc. Nanoscience, University of Hamburg

Estimated progress of the PhD project:

Just started ... **< 50 %** **> 50 %** **Almost done ☺**

Publications

- Doppler, M. C., Fleig, J., Bram, M., & Opitz, A. K. (2019). Comparison of electrochemical hydrogen oxidation on different metal/ceramic model anodes and mechanistic implications. Journal of Physics: Energy, 1(3).
- Zhu, H., & Kee, R. J. (2017). Modeling Protonic-Ceramic Fuel Cells with Porous Composite Electrodes in a Button-Cell Configuration. Journal of The Electrochemical Society, 164(13), F1400-F1411.

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Pd-based membranes for hydrogen and ammonia

Introduction

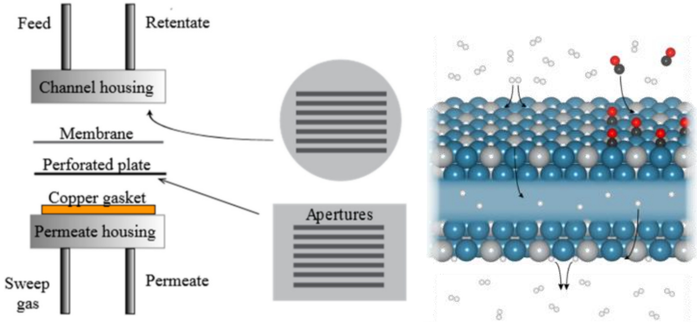
- To address distribution challenges in the development of hydrogen systems, ammonia is regarded as a high-potential carrier.
- While this solution would improve economic and safety considerations of hydrogen transport, it requires efficient separation and purification of hydrogen prior to end use.
- Palladium-silver (Pd-Ag) membranes have been shown to separate H_2 from gas mixtures with high purity

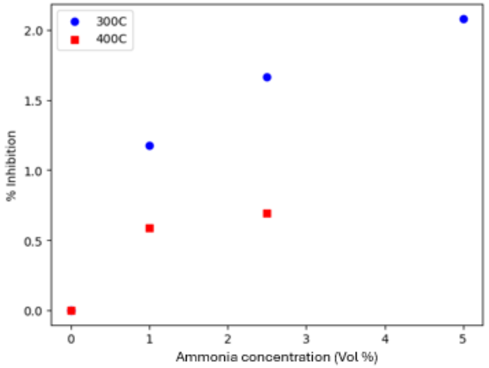
Primary objective

- Investigate performance and stability of Pd-Ag membranes for hydrogen separation when exposed to ammonia

Secondary objective

- Improve understanding of Pd-Ag membrane surface changes (adsorption, segregation) in presence of impurities





Willow Dew

Affiliation(s) = Norwegian University of Science and Technology (NTNU)

Related projects: *FME Hydrogeni*

PhD Candidate, Department of Chemical Engineering, NTNU, Norway

Education

- MSc. in Science Technology, Aalto University, Finland
- MSc. in Engineering, Taltech, Estonia
- MSc. Biology AgroSciences, URCA, France
- BSc. In Chemical Engineering, University of Alberta, Canada

Estimated progress of the PhD project:

Just started ... **< 50 %** **> 50 %** **Almost done ☺**

Publications

- Peters T, Caravella A. Pd-Based Membranes: Overview and Perspectives. Membranes (Basel). 2019 Feb 1;9(2):25. doi: 10.3390/membranes9020025. PMID: 30717272; PMCID: PMC6410063.
- Vicinanza, Nicla & Svenum, Ingeborg-Helene & Næss, Live & Peters, T.A. & Bredesen, Rune & Borg, Anne & Venvik, Hilde. (2015). Thickness dependent effects of solubility and surface phenomena on the hydrogen transport properties of sputtered Pd77%Ag23% thin film membranes. Journal of Membrane Science. 476. 602-608. 10.1016/j.memsci.2014.11.031.

Topical Area 3: Storage and distribution

Name (affiliation)	Title of PhD project
Abhishek Banerjee (UiS)	Structure and dynamics for hydrogen storage in hydrogen-rich alloys
Ingrid Marie Stuen (UiB)	Supply chain losses and quality degradation for large-volume hydrogen transport chains
Johan Raftevold Espelund (NTNU)	Computational fluid dynamics simulations of cryogenic storage tanks
Josef Kosler (UiO)	Magnetocaloric metal-oxides for efficient hydrogen liquefaction
Raymond Mushabe (UiB)	Experimental reservoir physics for underground hydrogen storage (UHS) in porous media
Sadegh Ahmadpour (UiS)	Underground hydrogen storage in porous media
Vilde Gahr Sturtzel Lunde (IFE)	Magnetocaloric Hydrogen Liquefaction

Structure and Dynamics for Hydrogen Storage in Hydrogen-Rich Alloys

Abhishek Banerjee[1], Sato Toyoto[2], Stefano Deledda[3], Olena Zavorotynska[1]

[1] Department of Mathematics and Physics, University of Stavanger, 4021, Stavanger, Norway
[2] Department of Engineering Science and Mechanics, Shibaura Institute of Technology, Tokyo, Japan
[3] Department of Physics, Institute for Energy Technology, Kjeller NO-2027, Norway

equinor

Introduction

Background:

Titanium-iron (**TiFe**) is known for its hydrogen storage capabilities at room temperature, high volumetric capacities (**0.096 kg_{H2}/L**). However, it is prone to **oxide** layer formation upon exposure to air, requiring energy-intensive activation processes.

Challenges and Solutions:

1. Elemental Doping: Incorporating different transition elements as **dopants** can potentially replace **Fe** and **Ti** in the crystal **lattice structure**, enhancing lattice **size** and creating new diffusion pathways.

2. Mechanical Processing: Post-mechanical processing offers further solutions to these challenges.

3. Research Gap: Limited studies exist showing **correlative**, **quantitative** understanding between **crystallographic** structures and H_2 **sorption** properties for TiFe metal-alloy systems doped with elements: **Nb**, **Ta**, **V** and in combinations.

Research Objectives and Methodologies

This project aims to address this gap by synthesizing TiFe samples with varied **Nb**/**Ta**/**V** stoichiometries using synthesis techniques: vacuum arc-melting (**VAM**) and mechano-chemical synthesis (for ex: **ball-milling**).

Utilizing state-of-art **characterization** techniques: Synchrotron powder X-ray diffraction (**S-PXRD**), X-ray Absorption Spectroscopy (**XAS**), Extended X-Ray Absorption Fine Structures (**EXAFS**) analysis to locate dopant **position** in TiFe crystal structure and understand its related effects on H_2 uptake/storage properties.

Acknowledgements

- Equinor ASA, Research Council of Norway, HyTack: Collaborative project between: UiS, USN, Savitribai Phule Pune University (SPPU), India, Tohoku University (TU), Japan, Shibaura Institute of Technology (SiT), Japan, IFE, NORCE, ISER, India.
- Staffs of ESRF (Grenoble, France) beamlines: BM01 (Swiss Norwegian Beamline (SNBL) in particular Dr. D. Chernysov) and BM31 (SNBL, in particular Dr. Stoian Dragos), respectively.

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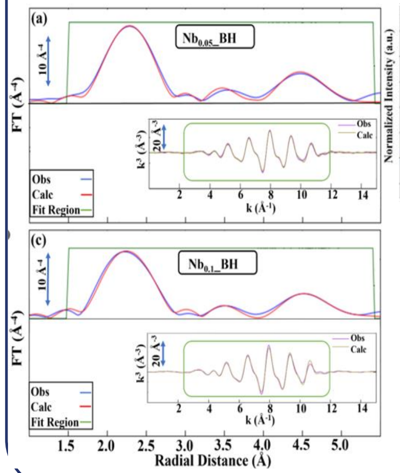
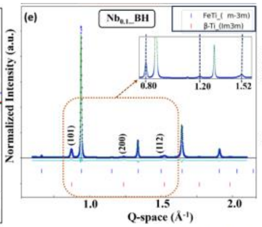
Characterization Techniques

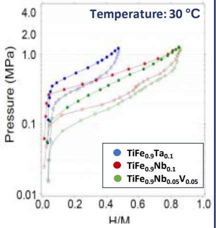
Extended X-ray Absorption Spectroscopy (EXAFS)



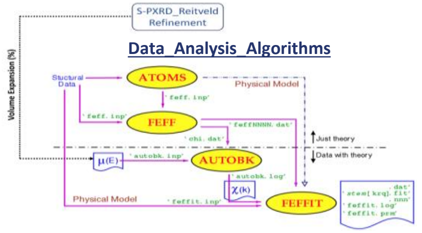
X-ray Diffraction (XRD)



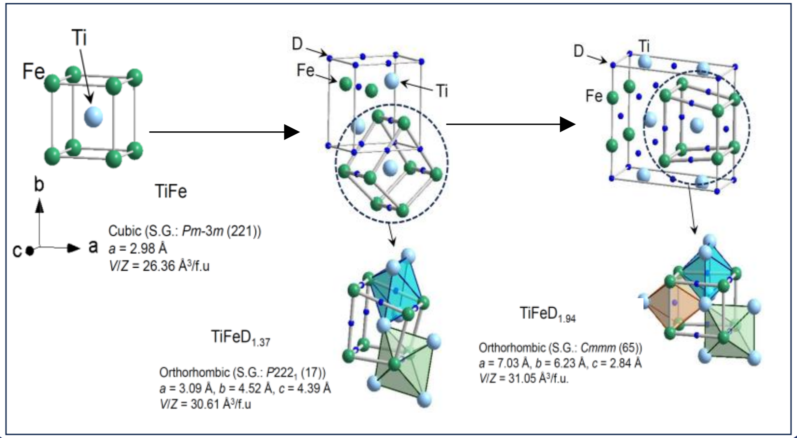
Pressure-Composition-Temperature (PCT)



Data_Analysis_Algorithms



H_2-Storage_Mechanisms: Metal-Hydrides



IFE Institute for Energy Technology
Universitetet i Stavanger
URLABS

Abhishek Banerjee

Affiliation(s): ***University of Stavanger (UiS)***

Related projects: ***Hydrogen som Energibærer, Equinor***

Short Bio

- ***Masters (Ms) in Materials Physics from Norwegian University of Science and Technology (NTNU), Norway.***
- ***Currently pursuing PhD in Physics and Mathematics, from University of Stavanger (UiS).***

Estimated progress of the PhD project:

Just started ... | < 50 % | > 50 % | Almost done ☺

Publications/Conferences

- *Deciphering Atomic Structure and Hydrogen Sorption Kinetics and Uptake of TiFe-Nb doped Metal-Alloys utilizing Combined Techniques: Synchroton PXRD and EXAFS Techniques. **Banerjee, A.**, Deledda, S. and Zavorotynska, O. (2023) 'Research Exchange Program (REP)', Oral Talk. Tokyo: Shibaura Institute of Technology (SiT), 22nd Aug–3rd Nov, 2023.*
- *Deciphering Atomic Structure and Hydrogen Sorption Kinetics and Uptake of TiFe-Nb doped Metal-Alloys utilizing Combined Techniques: Synchroton PXRD and EXAFS Techniques. **Banerjee, A.**, Deledda, S. and Zavorotynska, O. (2023) 'Gordon Research Conference (GRC) - Hydrogen Metal System', Poster Presentation, Les Diablerets, 25th June-30th June, 2023.*
- *Sharma, A., Foppen, J. W., **Banerjee, A.**, Sawssen, S., Bachhar, N., Peddis, D., & Bandyopadhyay, S. (2021). Magnetic Nanoparticles to Unique DNA Tracers: Effect of Functionalization on Physico-chemical Properties. Nanoscale Research Letters, 16(1), 1-16. [24]. https://doi.org/10.1186/s11671-021-03483-5.*

ESRF
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Supply Chain Losses and Quality Degradation for Large-Volume Hydrogen Transport Chains

Ingrid Marie Stuen

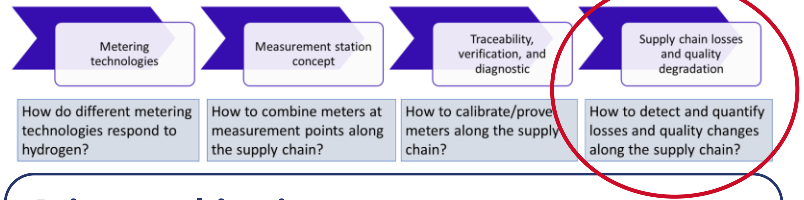
Affiliation: *University of Bergen*

Related projects: HyMe, HyValue

- PhD candidate in measurement science at the Department of Physics and Technology
- Background in physics

Introduction

My PhD project is part of the HyMe, “Reliable metering for the hydrogen supply chain”, research project. Our focus is on metering in large-volume supply chains with transfer of hydrogen gas in pipelines.



Primary objective

- How to detect and quantify losses and quality changes along the supply chain

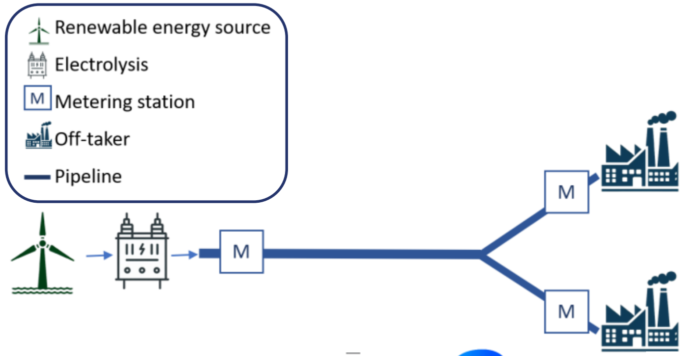
Secondary objectives

- Identify high-risk nodes for loss and quality degradation
- Mass and energy balance

Mass balance in hydrogen networks

- A pipeline network has measurement stations at each entry and exit point measuring gas flow and composition
- These measurements can be used to monitor the mass balance in the system
- A measured imbalance can be due to measurement errors or hydrogen loss/leakage in the network

Simple hydrogen network:



Estimated progress of the PhD project:

Just started ... | **< 50 %** | **> 50 %** | **Almost done ☺**

Ongoing work

- Challenges and Considerations in Hydrogen Gas Flow Metering: Implications for Accurate Energy Calculation and Custody Transfers
- Monitoring of Hydrogen Gas Grids: Losses and Uncertainty

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Computational Fluid Dynamics Simulations of Cryogenic Storage Tanks

Introduction

To minimize boil-off losses during large-scale storage and transport of liquid hydrogen (LH_2), accurate prediction of evaporation rates and boil-off temperatures is essential.

In my PhD, I use Computational Fluid Dynamics (CFD) to simulate how natural convection influences evaporation and thermal stratification inside LH_2 tanks. Heat ingress through the tank insulation drives convective flow in the gas phase, enhancing heat transfer to the liquid surface and accelerating evaporation.

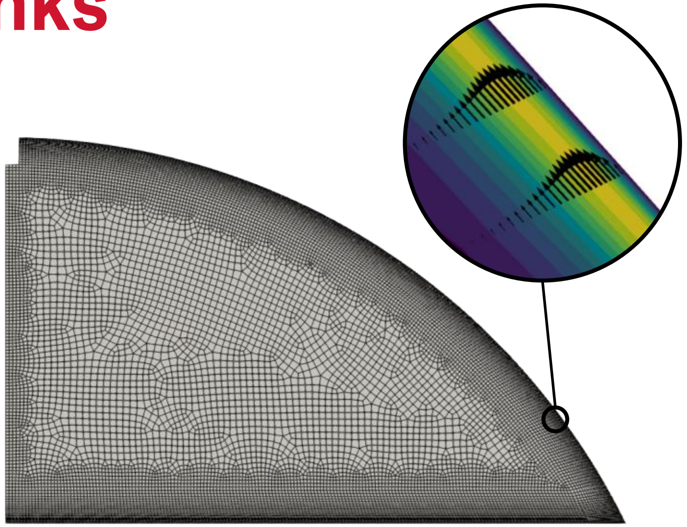
These flows are highly transient, can transition to turbulence, and span a wide range of spatial and temporal scales. Due to the cost and safety challenges of detailed LH_2 experiments, CFD can be a valuable tool to predict flow behaviour under various conditions.

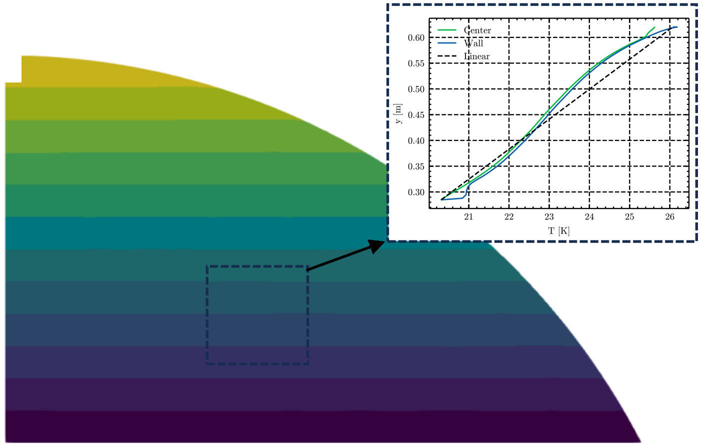
Primary objective

- Use CFD (OpenFOAM) to predict evaporation and thermal stratification in LH_2 storage tanks

Secondary objectives

- Use CFD to improve accuracy of heat transfer correlations in thermodynamic models of larger tanks
- Use two-phase direct numerical simulations to model effect of wall superheat on phase change during sloshing conditions.





Johan R. Espelund

Norwegian University of Science and Technology,
Sintef Energy Research
Supervisor: Corinna Schulze-Netzer (NTNU)
Co-supervisors: Åsmund Ervik (Sintef), Svend Tollak Munkejord (Sintef), Luca Brandt (Politecnico di Torino)

- 2022: MSc Mechanical Engineering (NTNU) – CFD simulations of heat exchangers
- 2022-2023: Master of Science at Sintef Energy Research (CFD, heat exchanger modelling)

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺

Publications

- Espelund, J., Gjennestad, M., Blakseth, S., & Netzer, C. (2024, November). Assessment of turbulence models for evaporation and stratification in cryogenic storage tanks. In *APS Division of Fluid Dynamics Meeting Abstracts* (pp. J32-001). (conference presentation)

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NTNU
Department of Energy and Process Engineering

SINTEF

Magnetocaloric Metal-oxides for Efficient H_2 Liquefaction

Introduction

- Storage and transportation of H_2 are key challenges in the hydrogen value chain.
- Liquefaction by cooling down to 20 K (-253 °C) is a promising solution, but highly energy intensive with today's technology.
- Magnetocaloric cooling uses magnetic materials and strong magnetic fields to achieve an up to 50 % higher energy efficiency.

Primary objective:

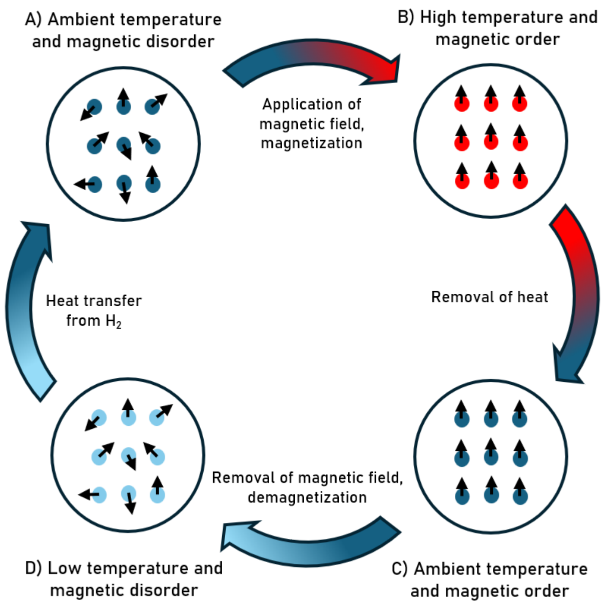
To identify and optimize promising materials for magnetocaloric H_2 liquefaction

Secondary objectives:

- Identify design principles for magnetocaloric materials
- Find viable and scalable production methods

Magnetocaloric cooling principles

- Transitions between ordered and disordered magnetic states are used to store potential/thermal energy
- Application or removal of an external magnetic field is used to trigger these transitions, leading to cooling or heating of the material.



Josef Kosler

Affiliations: University of Oslo, Institute for Energy Technology

Related projects: HYDROGENi

Research interests: energy materials, structural characterization and optimization, hydrogen liquefaction, magnetocaloric materials

Background: Nanoscience and materials chemistry

Estimated progress of the PhD project:

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Project future

- Varying composition and structural defects:
  - Optimize the cooling temperature range
  - Maximize cooling effect (J/kg)

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HYDROGENi

Experimental reservoir physics for underground hydrogen storage (UHS) in porous media

RAYMOND MUSHABE

Affiliation(s) : University of Bergen

Related projects: Centre for sustainable subsurface resources (CSSR-NORCE)

PhD fellow at UiB

MSc. Reservoir engineering from NTNU, Trondheim

BSc. Petroleum geoscience and production from MAK, Uganda

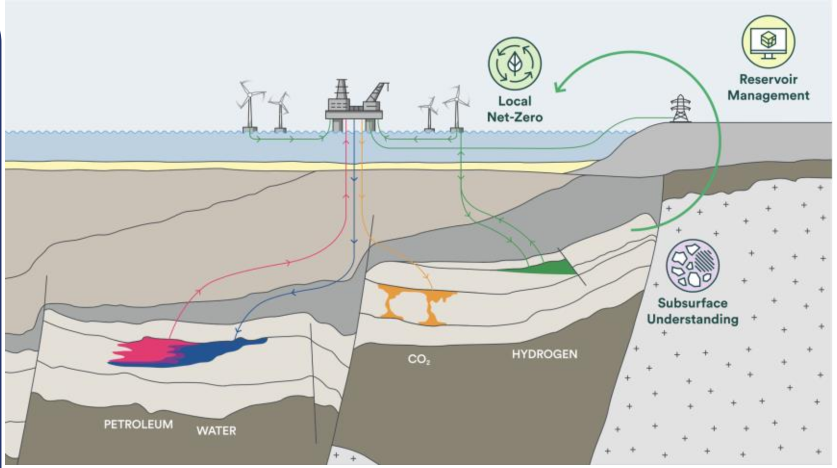
ramus8091@uib.no

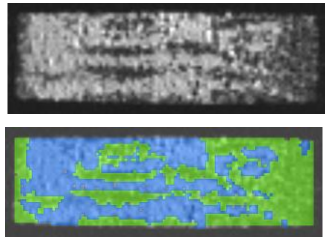
Introduction

The efficiency of hydrogen recovery in short- and long-term cyclic operations of underground hydrogen storage (UHS) within porous media is a crucial factor for successful implementation.

However, various factors can hinder hydrogen recovery, including structural and capillary trapping, dissolution in water, microbial consumption, and ineffective recovery strategies. The objective of my research has been to explore how microbial consumption impacts the efficiency of short-cycle hydrogen recovery.

To achieve this, I have developed a sand pack methodology to simulate hydrogen storage in a sandstone reservoir containing bacteria in formation water (brine). I have measured hydrogen consumption and analyzed its impact on reservoir rock properties, particularly storage capacity, fluid flow, and distribution.





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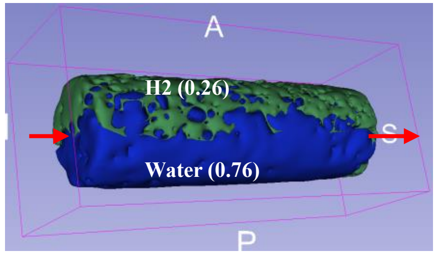

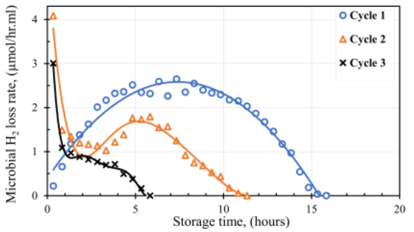

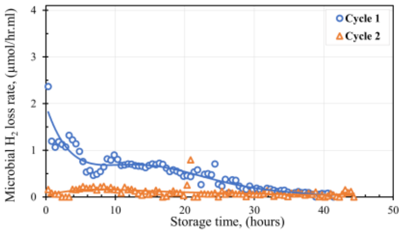

Primary objective:

Core scale quantitative assessment of porous media hydrogen loss by microbial activities using modern visualization methods.

Project goals:

1. Develop an experimental methodology to study hydrogen loss in porous media due to microbial activities.
2. Quantify in-situ hydrogen loss kinetics due to microbial activities and its effect on porous media properties
3. Provide quality laboratory data to validate a fully coupled numerical model that simulate short cycle cyclic hydrogen storage in porous media

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺

Publications (in the pipeline)

- Experimental study of microbial hydrogen consumption rates by Oleidesulfovibrio alaskensis in porous media
- Impact of specific surface area on anaerobic microbial hydrogen consumption by a sulphate reducer: A sand pack study
- In-situ quantification of hydrogen loss due microbial consumption using MRI imaging
- Predicting ultimate hydrogen production and residual volume during cyclic underground hydrogen storage in porous media using machine learning

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Centre for Sustainable Subsurface Resources

NORCE

Underground Hydrogen Storage in Porous Media

Sadegh Ahmadpour

Affiliation(s): PhD in University of Stavanger (UiS)

- Ph.D. Candidate in Underground Hydrogen Storage
- MSc. in Petroleum Engineering from UiS

Introduction

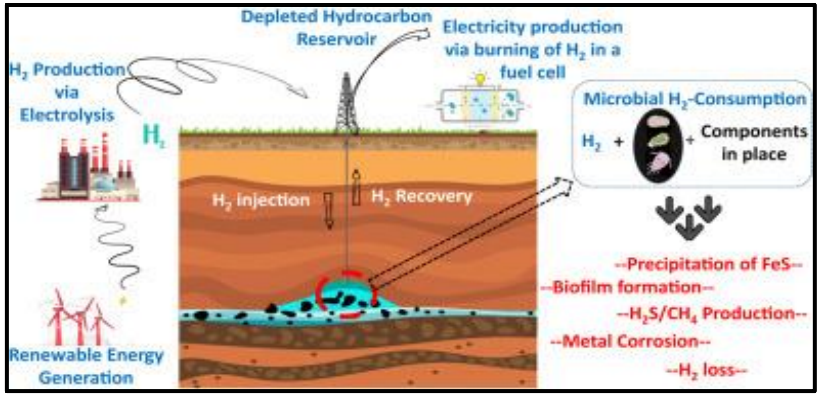
Storing hydrogen in depleted hydrocarbon reservoirs where the infrastructures are already built is a promising and safe solution to contribute to future hydrogen value chain. Porous geological settings can provide huge capacity for hydrogen storage. In order to store hydrogen in a safe and efficient way, the interaction of hydrogen with minerals, and residual fluids are necessary.

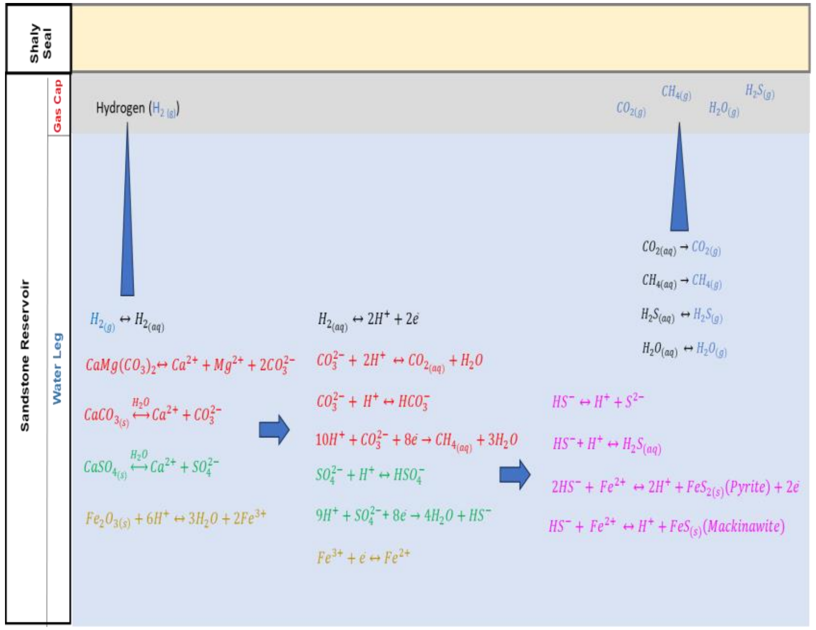
GUIDELINES

Existence of microorganisms without the need of light or oxygen in geological setting has created an opportunity for them to consume hydrogen by microbial activities. The products of these biochemical reactions, e.g., H_2S are undesirable and can be toxic and fatal. In addition, the size of hydrogen molecule is extremely small that might diffuse through caprocks, adjacent formations, or into the formation water. The diffusion of hydrogen in the formation water is the primarily mechanism for the geochemical and biochemical reactions. In addition, the reaction between pyrite (mineral) and dissolved hydrogen might occur at temperature above 100 °C leading to the production of H_2S in the storage site.

Primary objective

- Biochemical reactions
  - Evaluation of microbial activities in contact with excess hydrogen
- Diffusion and Dispersion of Hydrogen
  - Evaluation of hydrogen loss through diffusion and dispersion
- Geochemical Reactions
  - Investigation of the interaction between hydrogen and minerals





Estimated progress of the PhD project:

Just started ... | < 50 % | > 50 % | Almost done ☺

Publications

- Ahmadpour, Sadegh, Raoof Gholami, and Mojtaba Ghaedi. "Density driven flow in CO_2 storage sites: A new formulation for heterogeneous layered porous media." *Fuel* 381 (2025): 133721.
- Ahmadpour, Sadegh, and Raoof Gholami. "Hydrogen sulfide in underground hydrogen storage sites: Implication of thermochemical sulfate reduction." *Deep Underground Science and Engineering* (2025).

Magnetocaloric Hydrogen Liquefaction

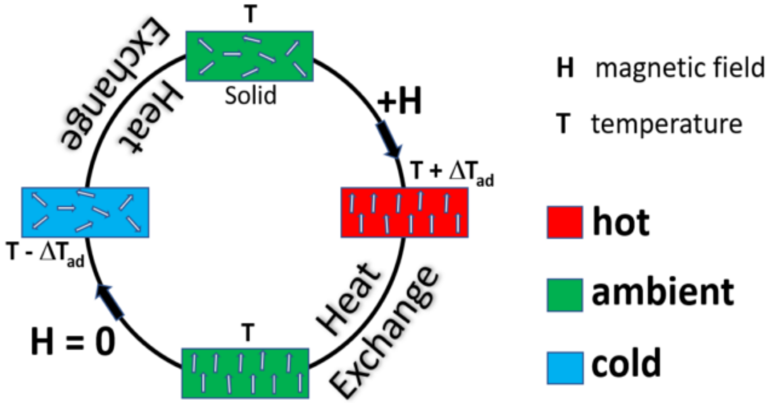
Vilde G. S. Lunde

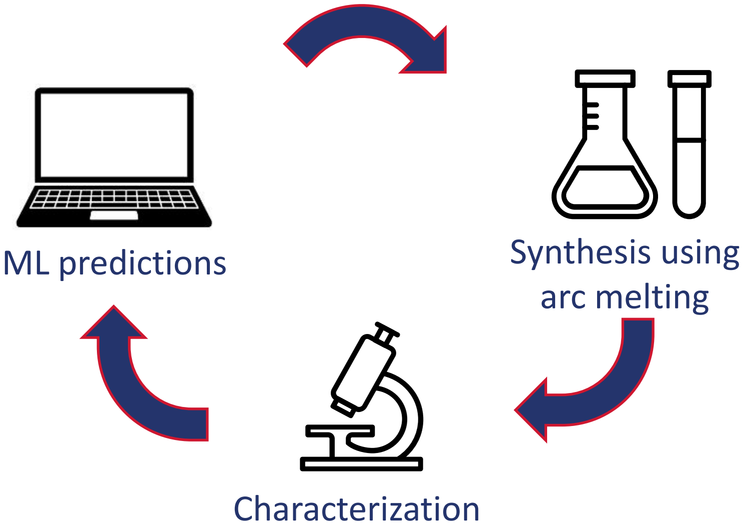
Introduction

Conventional refrigeration uses vapor compression-expansion technology, which suffers high cost, high complexity, and energy inefficiency as one approaches the liquefaction point of hydrogen (-253 °C).

Magnetocaloric hydrogen liquefaction (MCHL) is a promising alternative, utilizing the heating and cooling of specific materials upon undergoing magnetization and demagnetization, respectively. The largest MCE occurs at the magnetic transition temperature of the material.

Theory and Method:





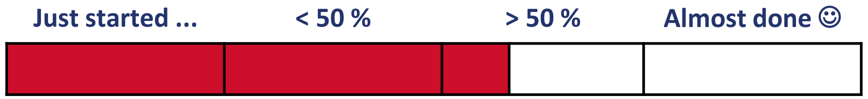
Affiliation: Institute for Energy Technology & University of Oslo

Related projects: LIQUID-H "Hydrogen Liquefaction with Caloric Materials"

Master's degree in Nanotechnology with a specialization in Nanotechnology for Materials, Energy and the Environment from NTNU (2018-2023).

PhD candidate at the Department for Hydrogen Technology at IFE (2023-2026).

Estimated progress of the PhD project:



Primary objective
- Develop magnetocaloric materials for hydrogen liquefaction

Secondary objectives
- Reduce the critical raw material content (>50%)
- Use machine learning to predict the magnetic transition temperature for new materials

Institute for Energy Technology

UiO

Topical Area 4: Applications

Name (affiliation)	Title of PhD project
David Zilles (NTNU)	Experimental study of low-carbon fuel injection and combustion in marine engines
Duc Duy Nguyen (NTNU)	Combustion of ammonia and hydrogen fuel mixtures in marine engine
Giulia Collina (NTNU)	Loss prevention and maintenance modelling for hydrogen-based industry
Giulia Fede (NTNU)	Digital twin for integrated production and maintenance planning in hydrogen-based process industries
Hederson Nascimento (NTNU)	Novel Vacuum Insulation Concepts for Large-Scale Liquid Hydrogen Storage

Experimental study of low-carbon fuel injection and combustion in marine engines

Introduction

Ambitious goals of the International Maritime Organization envision a decarbonization of the international shipping industry until 2050. New synthetic fuels such as Ammonia (NH_3) and Methanol (CH_3OH) are promising options to reduce green-house-gas emissions from marine internal combustion engines. Their thermophysical properties deviate strong from conventional compression ignition fuels resulting in slow reaction kinetics. These can be improved by dual fuel injection strategies, injecting small amounts of high reactive fuels as ignition and combustion promotion.

Primary objective

Identify and determine injection parameters supporting a retrofit of current marine engines with low-carbon NH_3 and CH_3OH.

Secondary objectives

- Characterize experimentally the dual fuel combustion of NH_3/CH_3OH (main injection) and various ignition promoters (pilot injections) in a constant volume combustion chamber.
- Identify the maximum practical NH_3 and CH_3OH energy share for various pilot fuels to reduce ignition time and increase reliability of combustion.
- Determine the best injection timings and spray interaction between main and pilot injections.

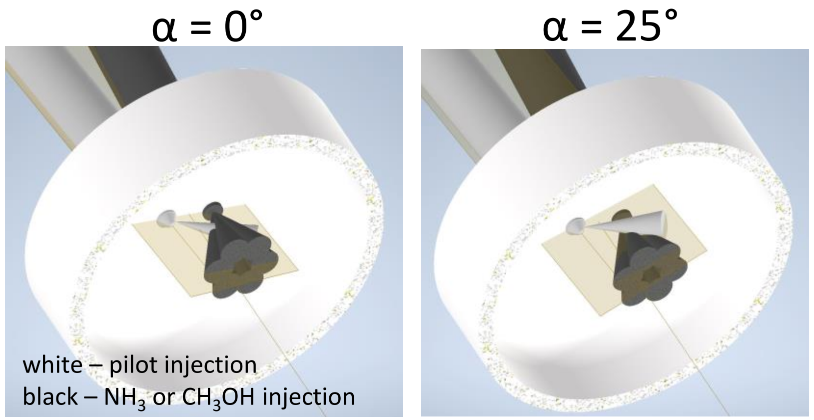


Fig.1: Spatial plume interaction controlled by pilot injector rotation α.

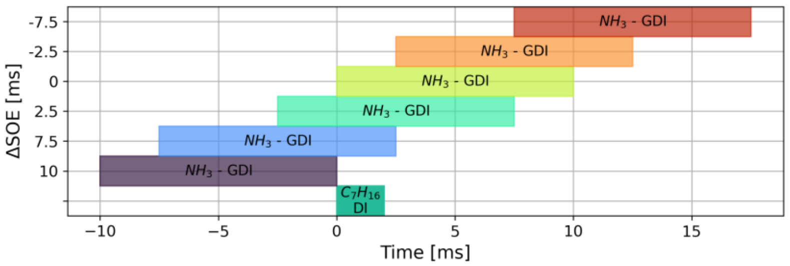


Fig.2: Temporal plume interaction ΔSOE – relative start of injection exemplary for ammonia main and heptane pilot.

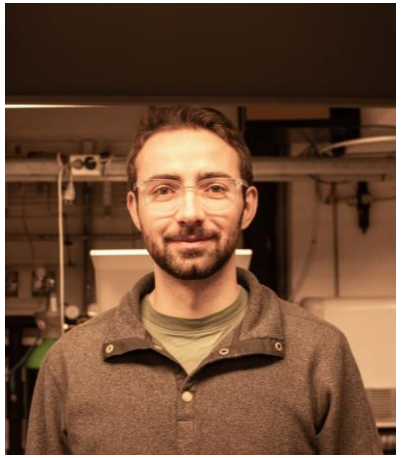
David Zilles

Affiliation: NTNU, Institutt for marin teknikk (IMT)

Master of Science degree in Automotive Engineering from TU Ilmenau, Germany. Specialization in internal combustion engines development and production.

Member of the ComKin work group at EPT, NTNU and HySchool.

Passion for green shift in industry, experimental design, Norwegian friluftsliv, road cycling and running.



Estimated progress of the PhD project:

Just started ... **< 50 %** **> 50 %** **Almost done ☺**

Publications

Oftedahl, Live; Zilles David. (2023) Flytende ammoniakk og methanol kan bli fremtidens drivstoff. (Blog entry)

HySchool.no

Norwegian Research School on Hydrogen and Hydrogen-Based Fuels

NTNU
Department of Marine Technology

NTNU – Trondheim
Norwegian University of Science and Technology

Combustion Kinetics Group

Combustion of ammonia and hydrogen fuel mixtures in marine engine

Introduction

This Ph.D. is part of the HYDROGENi project (https://hydrogeni.no/).

In alignment with international maritime organization zero emissions target, the need for alternative renewable fuels is increasingly vital. Hydrogen and ammonia with should be a solution for decarbonisation the marine sector. Ammonia may be thought of as a hydrogen vector, essentially a molecularly bound method to store and transport hydrogen.

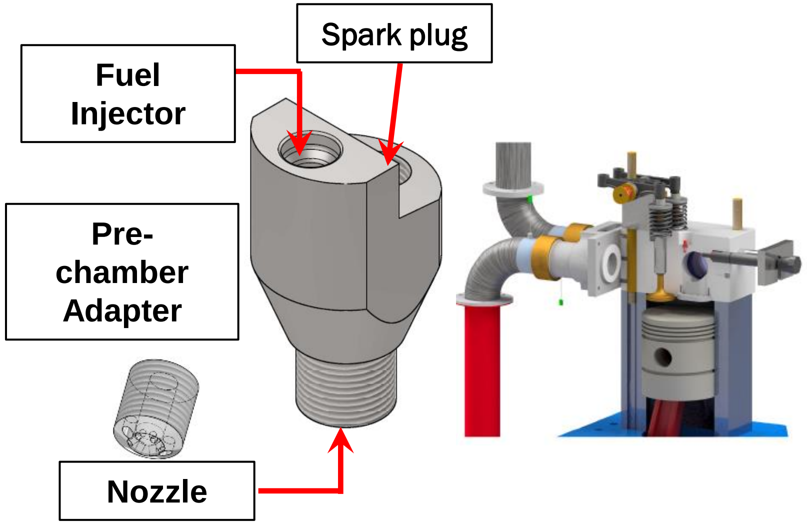
To utilise ammonia as a fuel it may need to be mixed with hydrogen to ensure efficient and complete combustion.

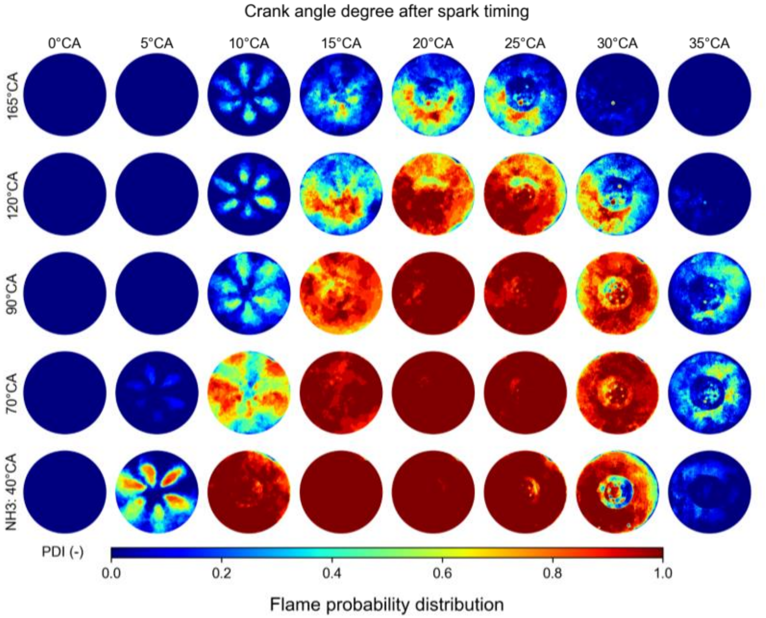
Primary objective

- Design a new pre-chamber to use in an optical engine to ignite ammonia.
- Determine suitable fuel mixtures for high efficiencies and low emission.

Secondary objectives

- Develop an LCA model to evaluate the environmental impact of the system.





Duc Duy Nguyen

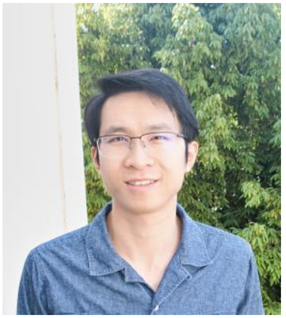
Affiliation(s): Norwegian University of Science and Technology

Related projects: FME – HYDROGENi

Supervisor: David R. Emberson (NTNU)

Co-supervisor: Eilif Pedersen, James W.G. Turner (KAUST)

I originally had a career in industry, spending 5 years working as project engineer. Before moving to NTNU, I have served as a graduate researcher at the CCRC at KAUST in Saudi Arabia, and KIMM in Korea. I hold a Master's degree in Mechanical Engineering from University of Science and Technology in Korea.



Estimated progress of the PhD project:

Just started … | **< 50 %** | **> 50 %** | **Almost done ☺**

Publications

- Ducduy Nguyen, et al. "Life cycle assessment of ammonia and hydrogen ..." International Journal of Hydrogen Energy (2025).
- Ducduy Nguyen, and James WG Turner. "Towards carbon-free mobility: ..." International Journal of Engine Research (2024)
- Renston, JF, Ducduy Nguyen, et al. "Advanced Biomass Conversion…", SAE 2024-01-2449
- Ducduy Nguyen; et al. "Pre-Chamber Ignition…". EPHyC (2024)

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Norwegian Centre for Environmentfriendly Energy Research
FME HYDROGENi
SINTEF
IFE Institute for Energy Technology
NTNU Kunnskap for en bedre verden

Loss Prevention and Maintenance Modelling for Hydrogen-based Industry

Description

This Ph.D. is part of the H2GLASS project (*https://h2-glass.eu/*).

To achieve net-zero emissions by 2050, the glass industry must undergo complete decarbonization. The H2GLASS project aims to develop the necessary technology stack to enable 100% hydrogen combustion in glass manufacturing, ensuring the required product quality, and manage this safely.

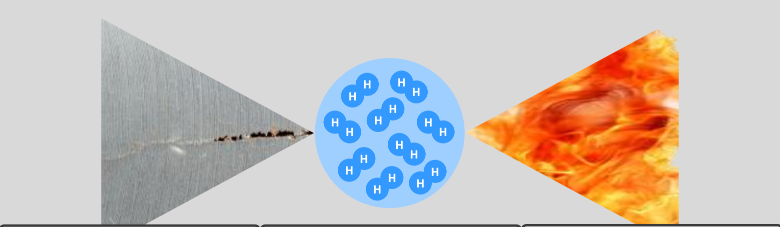
Primary objective

Guarantee safe design and operability of emerging hydrogen-based industry

Secondary objectives

- Loss of integrity analysis: models and sensors for H2 applications
- Safe design for emerging H2 industry
- Risk-based inspection and maintenance model development

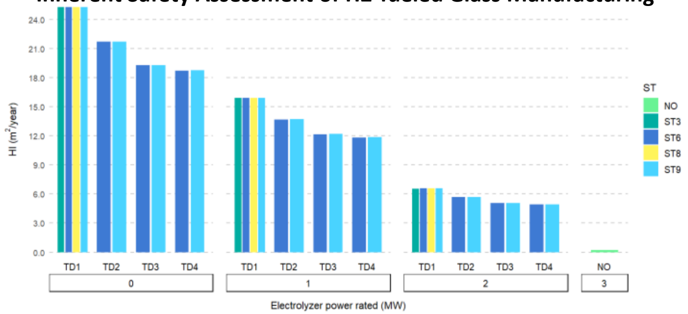
Hydrogen monitoring framework



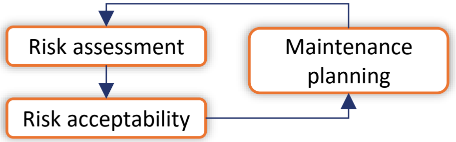
Material degradation monitoring and detection	Leak monitoring and detection	Flame monitoring and detection
- Ultrasonic techniques - Acoustic emission techniques - Electromagnetism testing - Visual testing	- Catalytic - Resistance based - Work function based - Optical - Acoustic - Pd Nanoparticles-based	- Thermal heat detector - Optical fibre detector - UV detector - UVIR detector - MIR detector

Data collection to improve maintenance planning

Inherent Safety Assessment of H2-fueled Glass Manufacturing



Integrating in the RBM approach:



Giulia Collina

PhD candidate at NTNU – Norwegian University of Science and Technology and UniBO – University of Bologna

H2GLASS - advancing Hydrogen (H2) technologies and smart production systems TO decarbonise the GLass and Aluminium SectorS

- Master's degree in Chemical and Process Engineering – University of Bologna (2020-2023)
- Bachelor's degree in Chemical and Biochemical Engineering – University of Bologna (2017-2020)

Estimated progress of the PhD project:

Just started ... | < 50 % | > 50 % | Almost done ☺

Publications

- Collina G., et al., (2025). Multi-stage monitoring of hydrogen systems for improved maintenance approaches: an extensive review, International Journal of Hydrogen Energy, 105, 458-480.
- Collina G., et al., (2024). Hydrogen in Glass Sector: A Comparison between Risk-Based Maintenance and Time-Based Maintenance Approaches, *IFAC-PapersOnLine*, *58*(8), 109-114.

TA4 – Applications
TA5 – Safety

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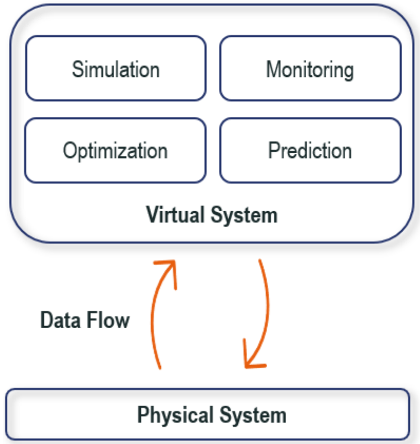
H2GLASS DECARBONISING OUR FUTURE

NTNU | Norwegian University of Science and Technology

Digital Twin for integrated production and maintenance planning in hydrogen-based process industries

Introduction

Green hydrogen presents a promising solution for decarbonizing energy-intensive process industries like glass, aluminium, and steel. The EU-funded initiative H2GLASS, which supports this research, aims primarily to demonstrate the feasibility of hydrogen adoption in the glass sector. However, transitioning to hydrogen comes with some challenges, including the lack of hydrogen-related infrastructure in manufacturing plants and the need to ensure a continuous and reliable hydrogen supply for industrial furnaces while maintaining safe operations. To facilitate this transition, Digital Twin (DT) technology has been identified as a valuable tool for supporting production and maintenance planning decisions. Given the strong interdependencies between these tasks, an integrated approach to decision-making can enhance overall performance. With its real-time synchronization capabilities and ability to provide a unified view of manufacturing processes, DT has the potential to improve collaborative decision-making, ultimately enabling a more efficient transition to hydrogen-based manufacturing.



Digital Twin concept

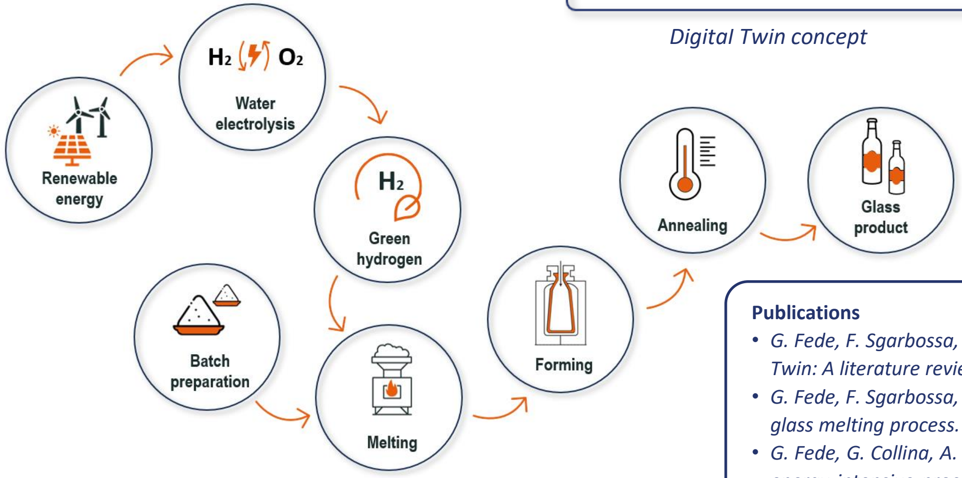
Primary objective

Investigate the benefits of integrating production and maintenance planning using DT in hydrogen-based process industries.

Secondary objectives

With reference to hydrogen-based process industries:

- Develop a multi-objective model for physical system design that considers production and maintenance performance indicators.
- Develop a simulation model to identify key factors influencing production and maintenance planning decisions.
- Develop a DT-based framework for joint production and maintenance planning.



Hydrogen-based glass manufacturing process

Giulia Fede

Norwegian University of Science and Technology (NTNU)

Related projects: H2GLASS - advancing Hydrogen (H2) technologies and smart production systems TO decarbonise the GLass and Aluminium SectorS

- *PhD candidate at the Department of Mechanical and Industrial Engineering (NTNU)*
- *MSc in Management Engineering – Analytics for Business at Politecnico of Milano (2021-2023)*
- *BSc in Management Engineering at Politecnico of Milano (2018-2021)*

Estimated progress of the PhD project:

Just started ... **< 50 %** **> 50 %** **Almost done ☺**

Publications

- *G. Fede, F. Sgarbossa, N. Paltrinieri. (2024). Integrating production and maintenance planning in process industries using Digital Twin: A literature review. IFAC-PapersOnLine, 58 (19), 151-156. https://doi.org/10.1016/j.ifacol.2024.09.124*
- *G. Fede, F. Sgarbossa, D.F. Silva, G. Collina. (2025). A model-based approach to hydrogen supply scenarios for decarbonizing the glass melting process. Accepted for 11th IFAC Conference on Manufacturing Modelling, Management and Control (MIM 2025)*
- *G. Fede, G. Collina, A. Tugnoli, M. Bucelli, D.F. Silva, F. Sgarbossa. (2025). Hydrogen supply scenarios for the decarbonization of energy-intensive process industries considering costs, safety and environmental performance: A multi-objective model-based approach. To be submitted to Safety Science.*

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NTNU | Production Management Research Group - LOGISTICS 4.0 LAB -

Co-funded by the European Union

H2GLASS DECARBONISING OUR FUTURE

Novel Vacuum Insulation Concepts for Large-Scale Liquid Hydrogen Storage

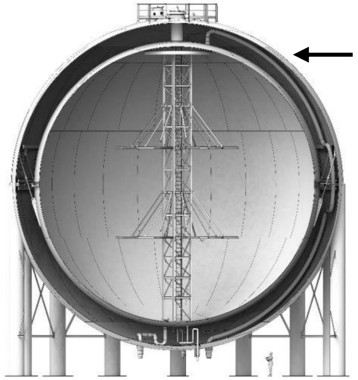
Hederson Nascimento

Affiliation: Norwegian University of Science and Technology (NTNU)

Related project: Novel Insulation Concepts For Liquefied Hydrogen Storage Tanks (NICOLHy)

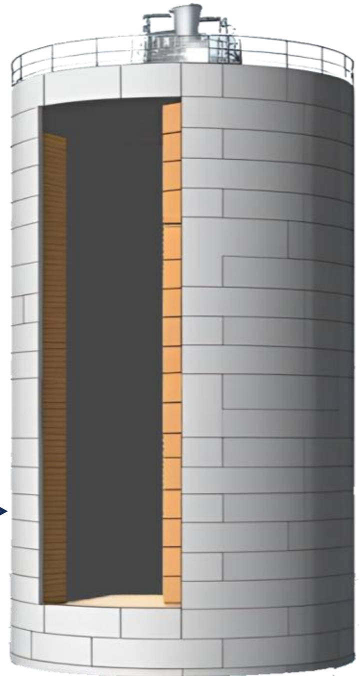
Introduction

Cryogenic storage of liquid hydrogen (-253°C) presents significant challenges due to extreme temperature differences, leading to thermal deformations and mechanical stresses. Traditional insulation solutions struggle to balance thermal efficiency, mechanical integrity, and manufacturability. This project investigates novel vacuum insulation concepts for large-scale liquid hydrogen storage assessing their potential.



State-of-the-art ≈ 4,700 m^3

[1] J.Fesmire 2021



Volume Targets: 40,000 m^3 - 200,000 m^3

[1] doi:10.1088/1757-899X/1240/1/012088

Primary objective

Evaluate the thermomechanical performance of novel vacuum insulation concepts under cryogenic conditions.

Secondary objectives

- Optimize material and structural performance.
- Develop a simulation framework to simulate real-world cryogenic conditions.
- Ensure practical feasibility.

I am a PhD student at NTNU Mechanical and Industrial Engineering Department studying the thermomechanical behavior of novel vacuum insulation concepts for large-scale liquid hydrogen storage. My research focuses on thermally induced deformations and coupled temperature-displacement effects in multi-material assemblies at -253°C. I use Abaqus/Ansys for simulations, SolidWorks/NX for CAD, and Python for automation.

Estimated progress of the PhD project:

Just started ... | **< 50 %** | **> 50 %** | **Almost done ☺**

Publications

www.nicolhy.net/Resources/Publications/

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NTNU Norwegian University of Science and Technology

NICOLHy

Clean Hydrogen Partnership

Co-funded by the European Union

Topical Area 5: Safety

Name (affiliation)	Title of PhD project
Abhishek Subedi (NTNU)	Improved modeling of socio-technical systems for hydrogen value chain
Anne Marie Lande (USN)	Mitigation of hydrogen explosions
Davide Rescigno (NTNU)	Modelling of physical phenomena in liquid hydrogen releases for safety analysis and risk assessment
Donghun Lee (NTNU)	Empirical Systems Approach for Safe Zero-Emission Transportation Systems
Leonardo Giannini (NTNU)	Risk-based inspection and maintenance for safe handling and use of hydrogen
Petar Bosnic (USN)	Experimental and numerical study of hydrogen gas explosions with a focus on deflagration-to-detonation transition

Improved modeling of socio-technical systems for hydrogen value chain

Abhishek Subedi

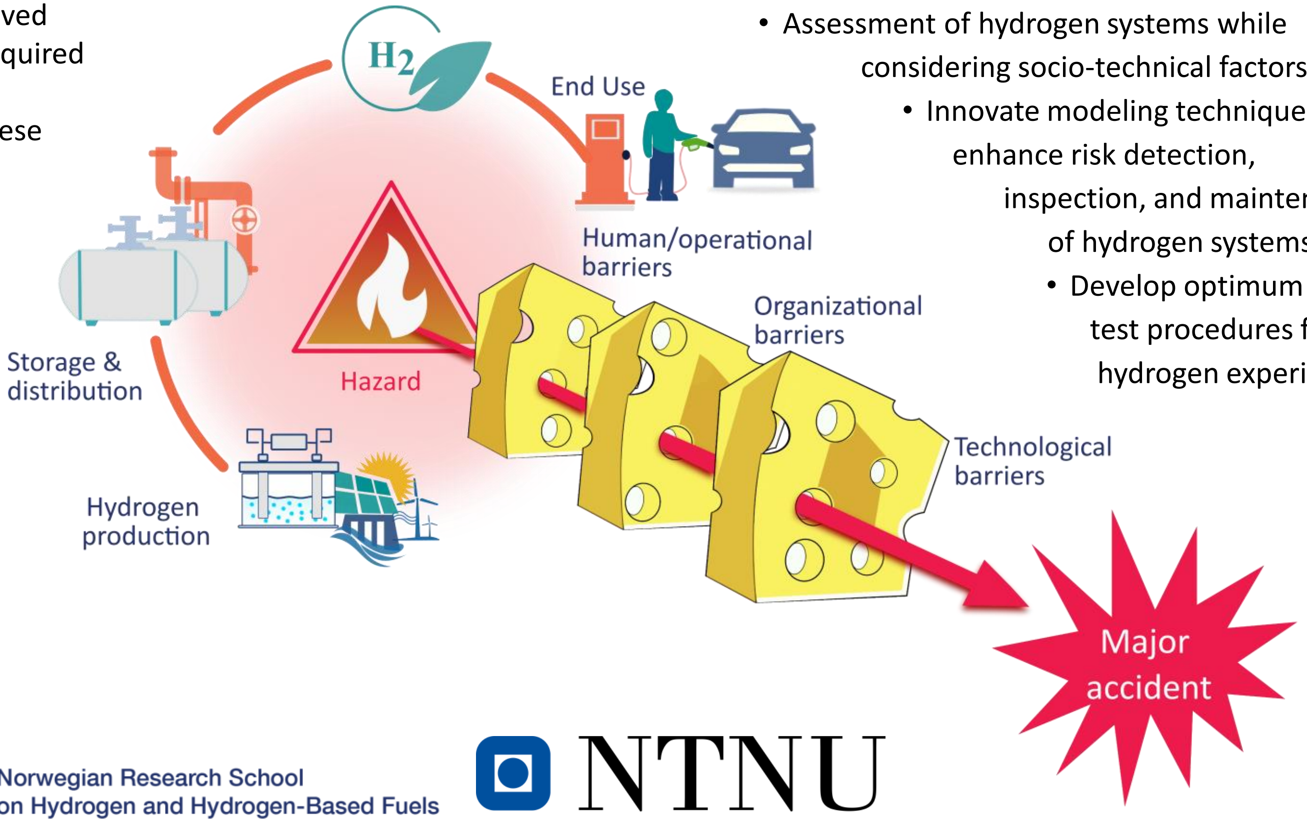
Norwegian University of Science and Technology (NTNU)
abhishek.subedi@ntnu.no

PhD candidate at Department of Mechanical and Industrial Engineering, NTNU

Master by Research (Hydrogen Safety) from Kathmandu University (2022/23)

Introduction

Hydrogen technologies offers a sustainable solution to climate change problems, but its systems must be safe. Hydrogen systems are complex socio-technical systems. Human or operational, organizational along with technical aspects plays a crucial role in preventing catastrophic events as safety barriers. However, thorough study & improved modeling is required for properly quantifying these factors.



Research Gap and Objectives

Available knowledge	Gap	Expected knowledge
Safety barrier analysis methods are insufficient for complex hydrogen systems	Consideration of the safety barriers as socio-technical systems	Safety barriers to be assessed as socio-technical systems (STS).

Objectives:

- Assessment of hydrogen systems while considering socio-technical factors.
- Innovate modeling techniques to enhance risk detection, inspection, and maintenance of hydrogen systems.
- Develop optimum & safe test procedures for hydrogen experiments

Estimated progress of the PhD project:

Just started ...	**< 50 %**	**> 50 %**	**Almost done ☺**
■	■		

Status and Publications

2024-Feb

Research article
Functional resonance analysis method for emerging risks in hydrogen handling: An analysis of an experimental test
S. I. Pezeshki, A. Subedi, T. Gogiyev, A. Falegnami, F. Ustolin, and N. Paltrinieri
Journal of Safety and Sustainability

H_2 Safety Training Modules
Modular training courses & material for safe operations of H_2 heating processes
A. Subedi and N. Paltrinieri
HyinHeat Project

2025

Review article
Reframing Safety Barriers as Socio-Technical Systems: A Review of the Hydrogen Sector
A. Subedi, M. Bucelli, and N. Paltrinieri
**Submitted*

Book Chapter
Barrier management for hydrogen
A. Campari, A.J.N. Akel, A. Subedi, and N. Paltrinieri, Chapter 9, Sushy Project

Conference Paper
Introducing socio-technical safety barriers for hydrogen systems
A. Subedi, G. Collina, and N. Paltrinieri
**Submitted*

2026

2027-Feb

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NTNU

Mitigation of hydrogen explosions

Introduction

Hydrogen is considered to be an important part of the energy supply of the future and a major driver of the green shift. However, hydrogen is a highly explosive gas. Therefore, safe use of hydrogen is an important research topic.

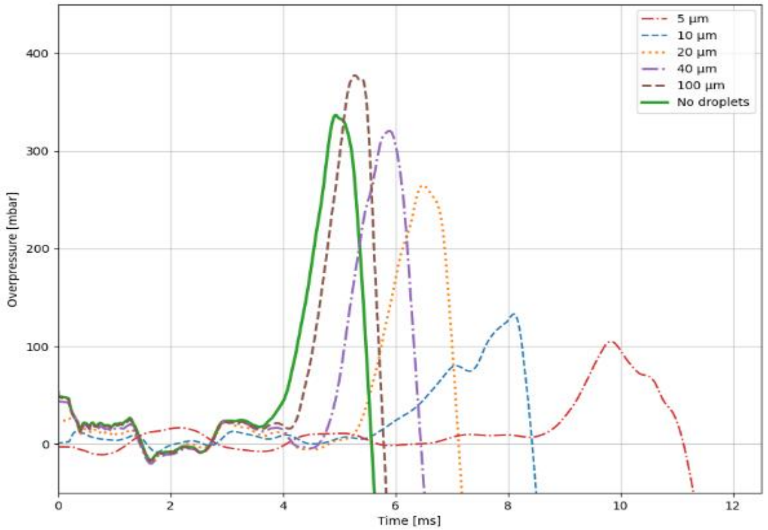
Water spray systems are a possible active fire protection method for mitigation of hydrogen explosions. If water spray is released when leakage of hydrogen is detected, it might prevent explosion pressure build-up. However, models of this are generally not validated, and more research should be conducted. Studies have shown divergent results because of the complex flow of gas explosion interacting with water droplets.

Primary objective

- The main objective is to determine the effect of a distribution of water droplet sizes (polydisperse) on a hydrogen explosion in a computational fluid dynamics (CFD) simulation compared to a monodisperse assumption.

Secondary objectives

- The Open-Source CFD simulation software OpenFOAM and the chemical kinetics software Cantera will be used for the simulations.
- As part of the research project, water droplet injection in the post-flame region will also be investigated.



In the submitted conference paper for ISFEH 2025, monodisperse water spray in a premixed lean hydrogen-air deflagration was modeled in OpenFOAM. The aim was to investigate how droplets of different sizes affect the deflagration pressure and velocity. The model is 2D, the solver is multicomponentFluid, the turbulence model is k-epsilon and the combustion model is Partially Stirred Reactor. The premixed gas cloud is modeled as Eulerian and the water droplets as Lagrangian particles. First, the numerical combustion model was validated against experimental data. Then, droplet sizes ranging from 2-100 µm were injected into the model to explore the effect on flame position and overpressure. The overpressure results are shown in the figure above and revealed that the droplets in the range of 2-40 µm had a mitigating effect on the deflagration, with droplets sized 2-10 µm being the most effective. Droplets sized 5-10 µm increased the flame propagation time and increased the overpressure significantly, while the smallest droplets of 2 µm prevented ignition. Droplets sized 100 µm did not have a mitigating effect, but slightly increased the overpressure.

Anne Marie Lande

PhD Research Fellow, Ministry of Education and Research Position

Affiliation: University of South-Eastern Norway (USN)

Process Safety, Combustion and Explosions Research Group (USN)

Supervisor: Joachim Lundberg (USN)

Co-supervisors: Knut Vågsæther (USN)

& Mathias Henriksen (USN)

- BSc in Mechanical Engineering from Høgskulen på Vestlandet (HVL)
- MSc in Process Technology from USN
- Experience with CFD on both Master's Thesis and Research Project

Estimated progress of the PhD project:

Just started ... **< 50 %** **> 50 %** **Almost done ☺**

Publications

- A. M. Lande, J. Lundberg and M. Henriksen, "Modeling Monodispersed Water Droplets in Hydrogen Deflagration Using OpenFOAM ," The International Seminar on Fire and Explosion Hazards (ISFEH), Rome, Italy, 2025
- A. M. Lande and J. Lundberg, "Summary of mechanisms of water droplets in hydrogen deflagration," Nordic Flame Days 2023, Trondheim, Norway, 2023

Modelling of Physical Phenomena in Liquid Hydrogen Releases for Safety Analysis and Risk Assessment

Introduction

Hydrogen is an energy resource that could play a key role in global decarbonization. However, its use, especially in liquid form (LH2), presents several critical challenges. When LH2 is released into the environment, part of it rapidly **vaporizes**, while some may reach the ground, forming an **LH2 pool** that subsequently evaporates and might ignite. Additionally, the extremely low boiling point of liquid hydrogen can cause the **solidification** of **oxygen** and nitrogen from the surrounding air, potentially **enriching** the flammable **hydrogen-air mixture with oxygen**. Therefore, the **loss of containment** in LH2 storage systems due to accidental scenarios can have severe consequences, which must be prevented.

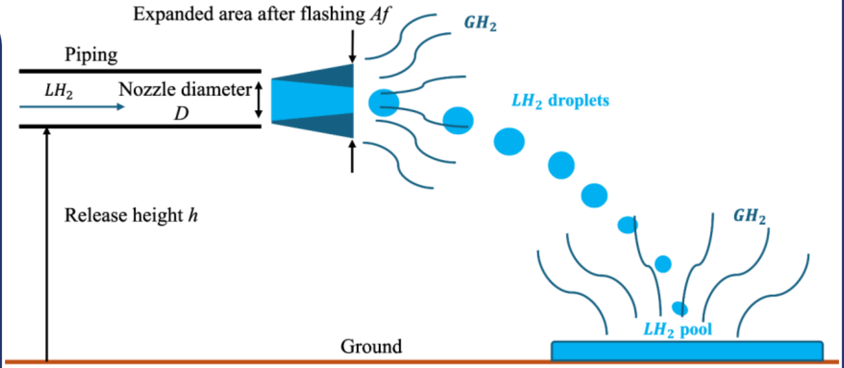
Primary objectives

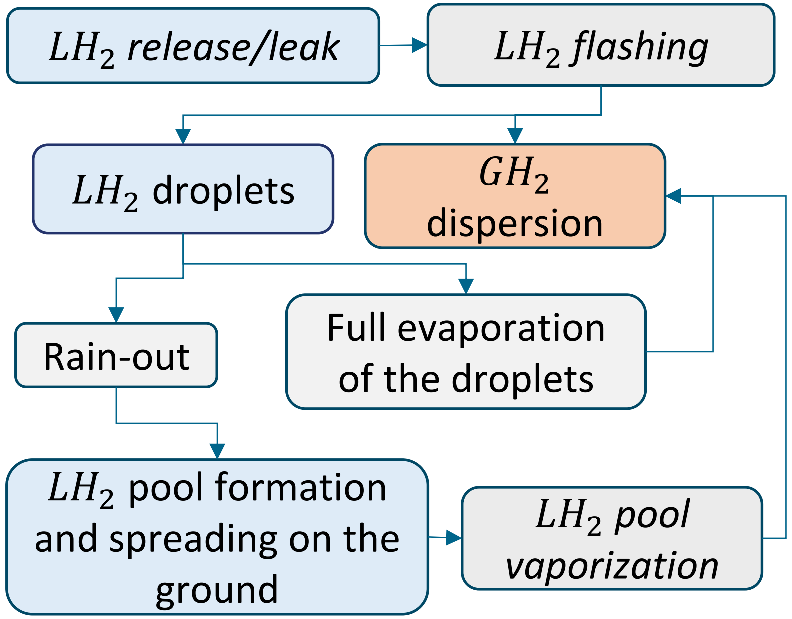
Modelling of:

- LH2 rainout
- LH2 pool formation, spreading, and vaporization
- Oxygen enrichment phenomena and condensed-phase explosions due to phase changes in air components during an accidental release of LH2

Secondary objective

- Investigate the behavior of thermal insulation material and its integrity when in contact with LH2 due to a loss of containment





Davide Rescigno

PhD candidate at NTNU – Norwegian University of Science and Technology

Related projects: **FME Hydrogeni**

- MSc. in Mechanical Engineering – University of Bologna
- BSc. in Mechanical Engineering – University of Salerno

Estimated progress of the PhD project:

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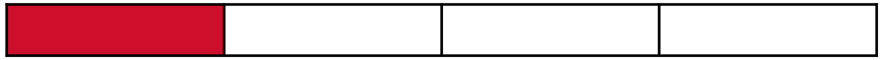

Publications (planned)

- Modeling of Accidental Liquid Hydrogen Spills and Rainout
- Validation of a Semi-Empirical Model for LH_2 Pool Spreading and Vaporization

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HYDROGENi

Empirical Systems Approach for Safe Zero-Emission Transportation Systems

Introduction

The global push for zero-emission transportation systems using hydrogen, ammonia, batteries, and methanol brings promising environmental benefits but also complex safety challenges. Current research primarily addresses individual fuel safety, leaving a gap regarding interactions between multiple alternative fuels operating simultaneously. This project addresses this gap by developing an empirical, integrated safety analysis approach using STPA and risk assessment methodologies.

Objectives

- Collect and analyze accident data involving alternative-fuel vessels and vehicles.
- Perform detailed interaction analysis using STPA and Dynamic Risk Assessment methods.
- Develop practical safety protocols and guidelines based on identified risks.

Systems Theoretic Process Analysis (STPA)

STPA is a safety analysis methodology developed to identify potential hazards and assess risks in complex systems.

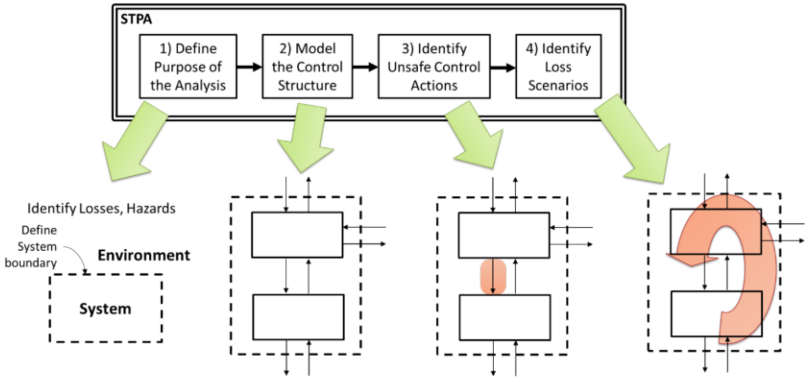
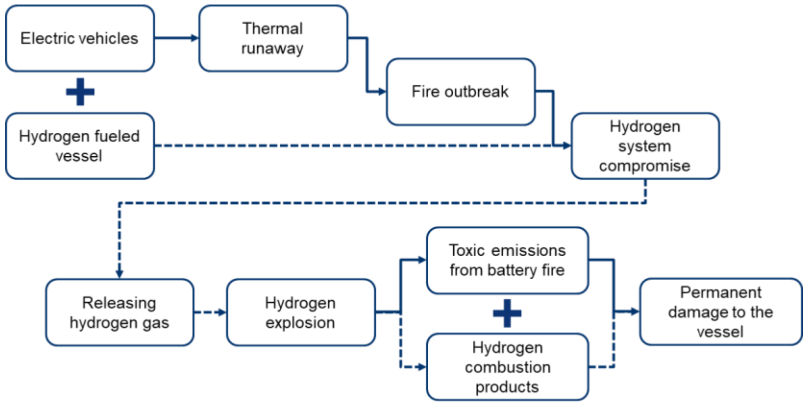


Figure 2.1: Overview of the basic STPA Method



Donghun Lee

NTNU(Norwegian University of Science and Technology)
PhD candidate, donghun.lee@ntnu.no

PhD candidate: RAMS group, Mechanical and Industrial Engineering, NTNU

Researcher: RAMS group, Mechanical and Industrial Engineering, NTNU

Master's degree: Naval Architecture and Ocean Engineering, INHA University

Bachelor's degree: Naval Architecture and Ocean Engineering, INHA University

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺

Publications

- A Study on Multi-ship Avoidance System for Unmanned Surface Vehicles Using the Quaternion Ship Domain and Collision Risk Index, 2025, Journal of Ocean Engineering and Technology
- Human Reliability Analysis for Fishing Vessels in Korea Using Cognitive Reliability and Error Analysis Method (CREAM), 2024, Sustainability

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Kunnskap for en bedre verden

Risk-Based Inspection and Maintenance for Safe Handling and Use of Hydrogen

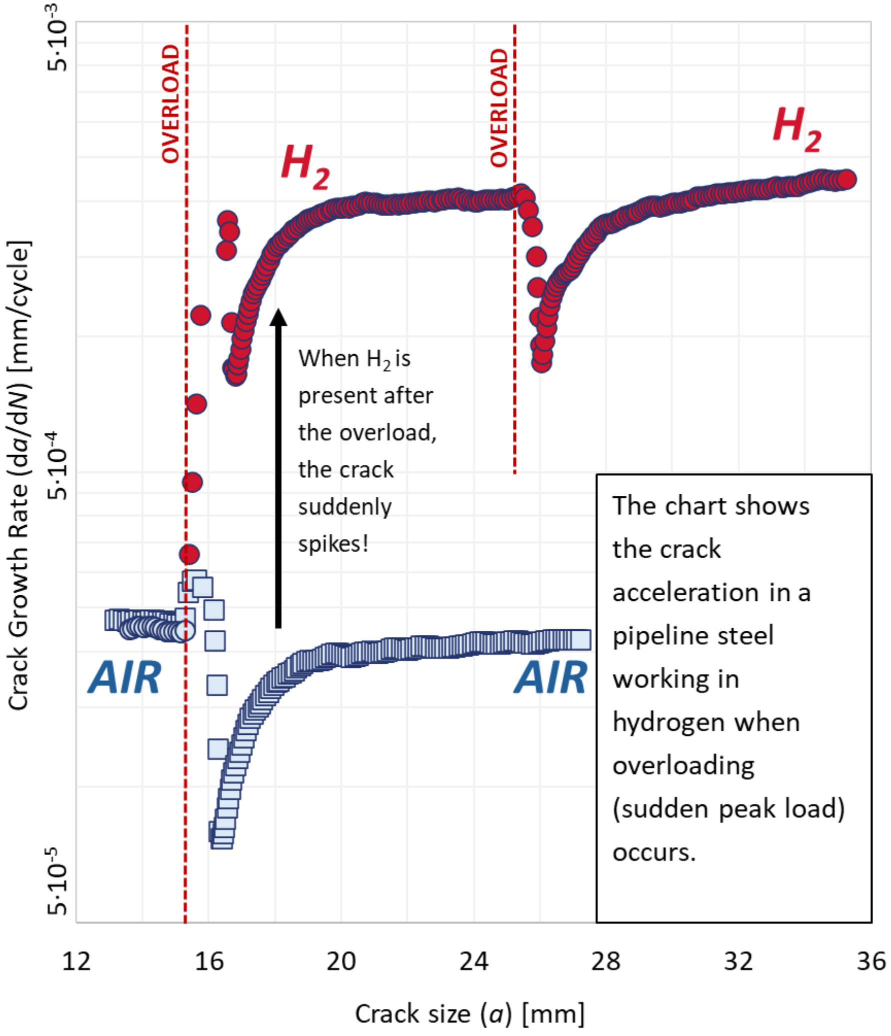
Introduction: My project focuses on development and optimization of inspection procedures for hydrogen systems and hydrogen degradation in metals. The shown work deals with the hydrogen-induced fatigue crack acceleration in a pipeline steel, which is relevant for material integrity and safety assessment.

Primary objective

- Developing optimal inspection planning for hydrogen systems considering material integrity.

Secondary objectives

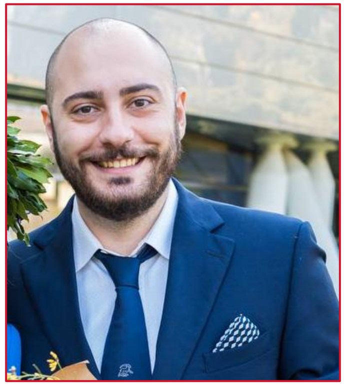
- Optimizing inspection programs through cost-effectiveness analysis.
- Investigating hydrogen-enhanced fatigue in pipeline steels (*focus of this year Hyschool presentation!*)



Leonardo Giannini

Affiliation = NTNU

Related projects: *SH2IFT-2*



Hi! I am Leonardo Giannini, I am an energy engineer, and my background includes the design of energy systems, power plants and hydrogen technologies. To this end, I am completing a Ph.D. program at NTNU on inspection of H_2 systems with a focus on material integrity. I am at the last year, so wish me luck! ;)

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺

Publications:

- Embrittlement, Degradation and Loss Prevention of Hydrogen Pipelines, MRS Bulletin, 2024.
- Peer-Reviewed Conference Papers: see

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NTNU ENERGY Team Hydrogen

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SH2IFT II

Experimental and Numerical Study of Hydrogen Gas Explosions with a Focus on Deflagration-to-Detonation Transition

Introduction

The global shift to ***low-carbon energy*** is vital for addressing ***climate change***, with ***hydrogen*** playing a key role in the deep ***decarbonization*** of sectors such as electricity production, industrial manufacturing, and transportation. However, ***accidental explosions*** remain a major ***safety*** concern in hydrogen systems, potentially causing severe damage or loss of life. Understanding the physics of such events is essential for implementing safety measures. Since large-scale testing is expensive and resource-intensive, ***Computational Fluid Dynamics*** (CFD) offers an effective alternative for ***assessing explosion consequences***.

Objectives and Methods

- ***Experimental***: Conduct ***systematic experiments*** on gas ***explosions*** using homogeneous ***hydrogen-air*** mixtures in a ***lab-scale*** explosion channel to study ***DDT.***
- ***Numerical***: ***Develop*** a ***numerical solver*** within the ***OpenFOAM*** framework that accurately ***simulates DDT*** on relatively ***coarse computational meshes***.

Research Results

OpenFOAM solver: ***MMXFoam***

Combustion Model:

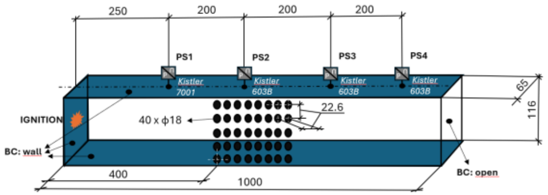
$$\frac{\partial(\rho b)}{\partial t} + \nabla\cdot(\rho\mathbf{u}b) - \nabla\cdot\left(\frac{\mu_t}{Sc_t}\nabla b\right) =$$

$$= \begin{cases} \rho_u S_u \Xi|\nabla b|, & \tau < 0.99, \\ \rho\frac{1-b}{\Delta t} & \tau \geq 0.99. \end{cases}$$

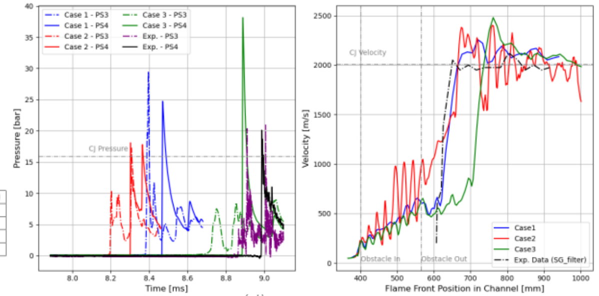
DEFLAGRATION
AUTO-IGNITION
DETONATION

$$\frac{\partial(\rho\tau)}{\partial t} + \nabla\cdot(\rho\mathbf{u}\tau) - \nabla\cdot\left(\frac{\mu_t}{Sc_t}\nabla\tau\right) = \frac{\rho}{t_{\mathrm{ind}}}$$

(a)



(b)



Case	Mesh	AMR	Base/Min. Mesh (mm)	Run Time (h)	DDT	$p_{3,max}$ (bar)	$p_{4,max}$ (bar)
1	26 152	Yes	2 / 0.5	21	Yes	29.5	24.7
2	116400	No	1 / 1	40	Yes	17.3	18.1
3	26 152	Yes	2 / 1	5	Yes	9.0	38.1
4	26 152	No	2 / 2	0.75	No	6.4	6.6

(c) (d)

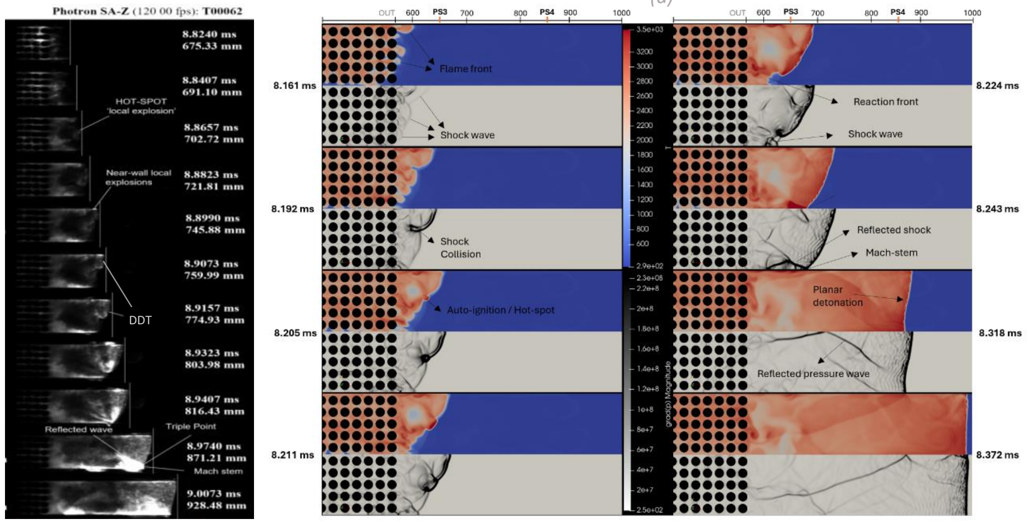


*Figure: **DDT Study** - (a) Explosion Channel (b) p-t and v-x plots, (c) experimental and (d) numerical results Case 2*

Petar Bosnic

Affiliation: **University of South-Eastern Norway** (USN)

Related projects: **FME HYDROGENi**

Supervisor: **Knut Vågsæther** (USN), *Co-supervisor:* **Mathias Henriksen** (USN)

Mechanical Engineer with a Master's degree from the University of Split, Croatia and currently pursuing a ***Ph.D.*** in ***hydrogen safety*** at the ***University of South-Eastern Norway*** (USN). My research focuses on the ***physics and dynamics of hydrogen gas explosions***, employing both ***experimental*** and ***numerical*** analysis to enhance the safety of hydrogen systems. With expertise in ***computational engineering***, ***simulations***, and ***testing***, I develop and implement ***consequence analysis tools*** to enhance ***safety***.

Estimated progress of the PhD project:

Just started ... | < 50 % | > 50 % | Almost done ☺

Publications

- Bosnic, P., Henriksen, M., Bjerketvedt, D., & Vaagsaether, K. (2025). *Modeling of Flame Acceleration and DDT in Open-Ended Channel with Homogeneous Premixed H_2-Air Mixture*. The 30th International Colloquium on the Dynamics of Explosions and Reactive Systems (ICDERS), Ottawa, Canada.
- Bosnic P., Henriksen M., Vaagsaether K. *Flame acceleration and DDT of homogeneous premixed hydrogen-air mixture in obstructed channel: A numerical study using OpenFOAM*. European PhD Hydrogen Conference 2024.
- Penga Z., Tolj I., Bosnic P. et al. *Combined numerical and experimental analysis of liquid water distribution inside PEMFC flow fields*. World Hydrogen Energy Conference 2022.