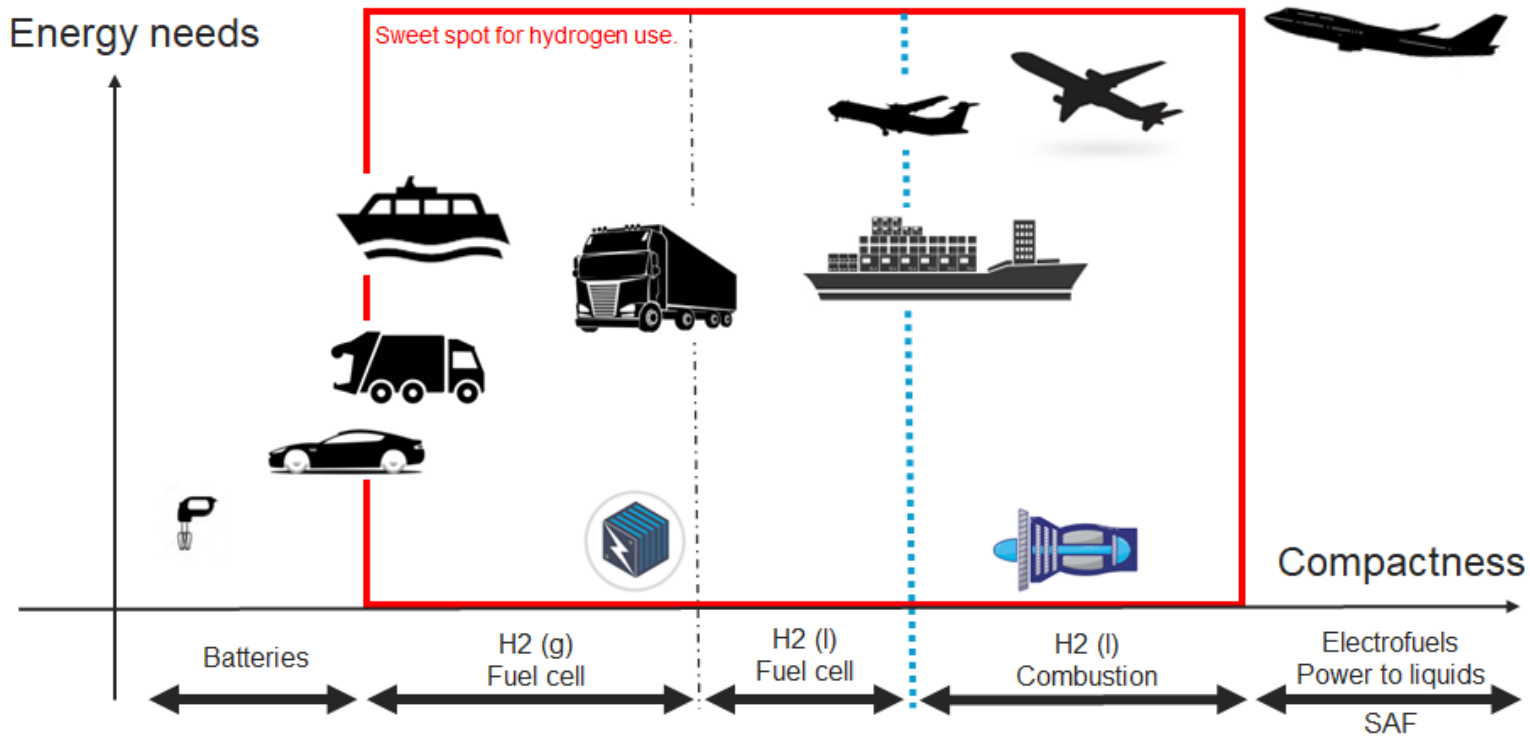
Technologies and innovations for a future sustainable hydrogen economy

https://www.chalmers.se/centrum/techforh2/

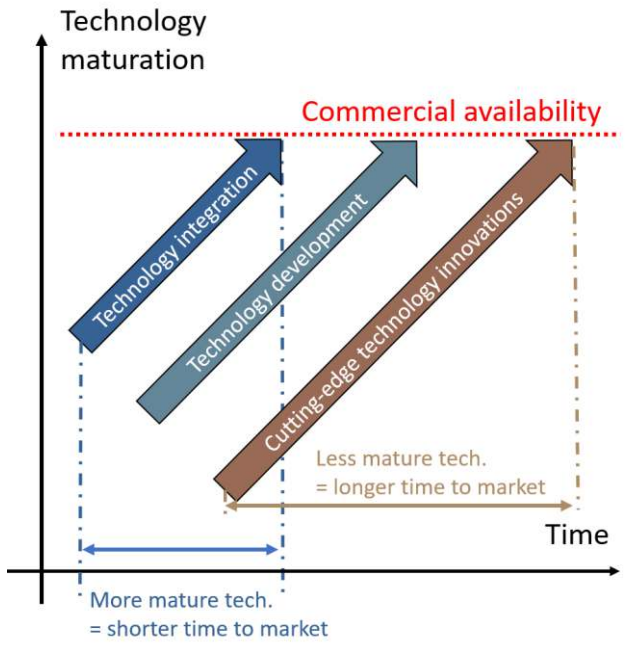
TechForH2 – our vision

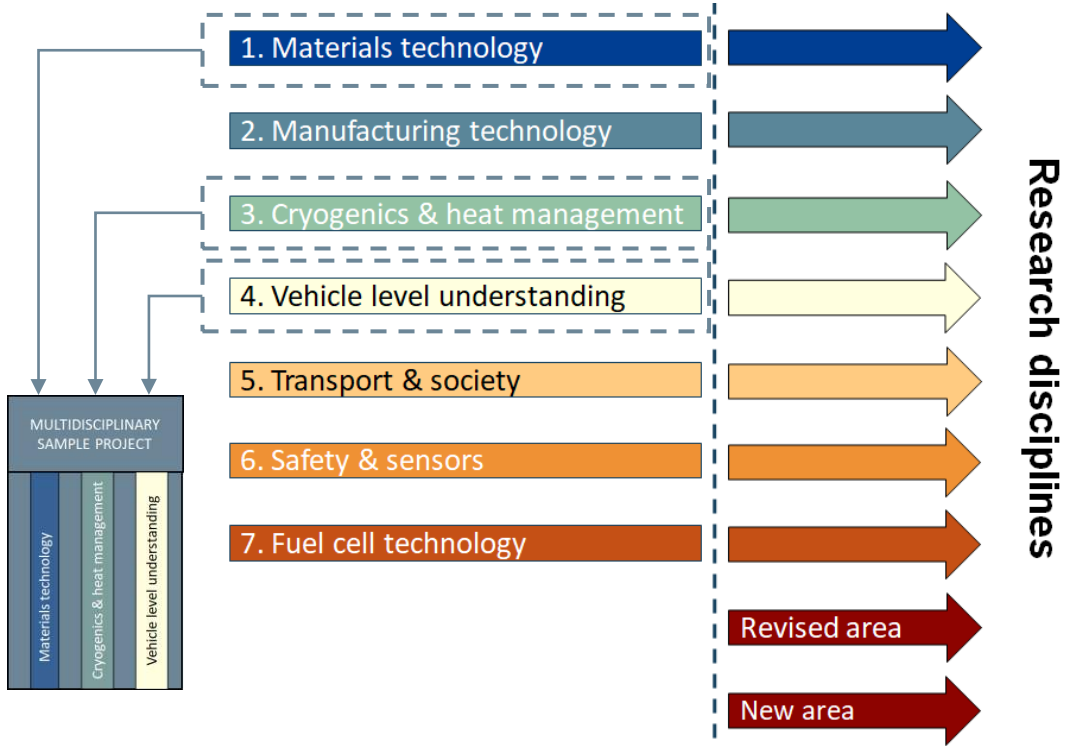


TechForH2 is an internationally leading excellence center for application driven multidisciplinary hydrogen research with focus on heavy transport that accelerates the transition to a sustainable energy system by building on national strengths for global impact.

- Wide research disciplines with hydrogen and heavy transport relevance
  - Disciplines are building blocks for multidisciplinary research areas

- Focus on technology integration
- Rapid transition!
- Successful transition!

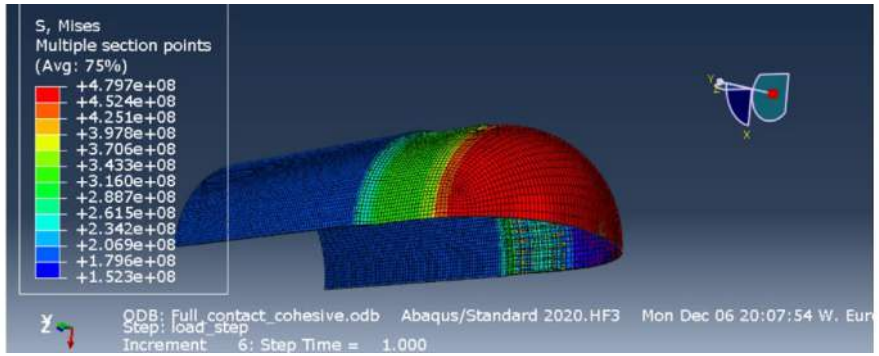




Example: sensor integration, heat management,, tank- fuel system, safety, fuel cells and vehicle integration, long term technology potential

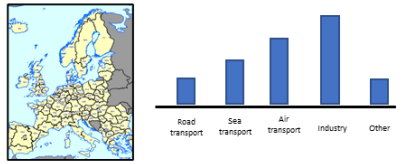
Our multidisciplinary research areas

1. Lightweight composite storage solutions for cryogenic hydrogen
2. Additive manufacturing for hydrogen fuel supply systems
3. Nanoplasmonic hydrogen sensor maturation
4. Fuel cell development and integration
5. The future of hydrogen – societal challenges



Stress analysis of a liner-less CFRP tank for liquid hydrogen storage

Scenarios for demand for hydrogen for transport and industry in different regions



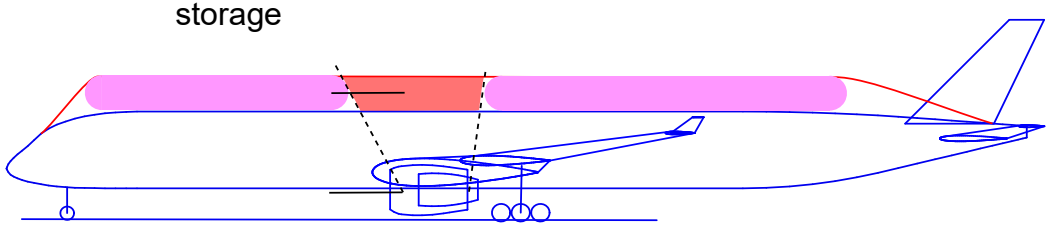
Technical performance

Investment cost

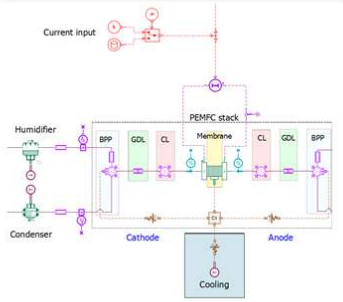
Centralised vs decentralised

Domestic production vs import

Scenarios for hydrogen production, storage and distribution in different regions

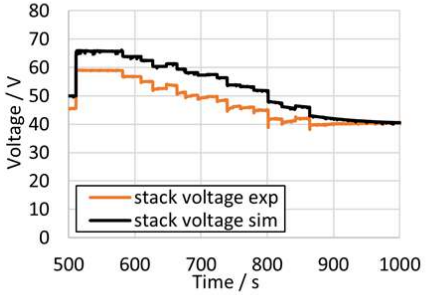


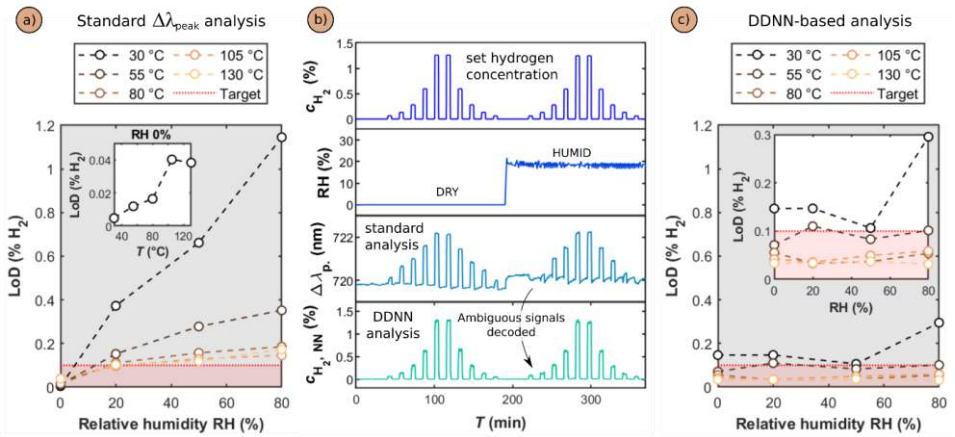
Fuel cell modeling

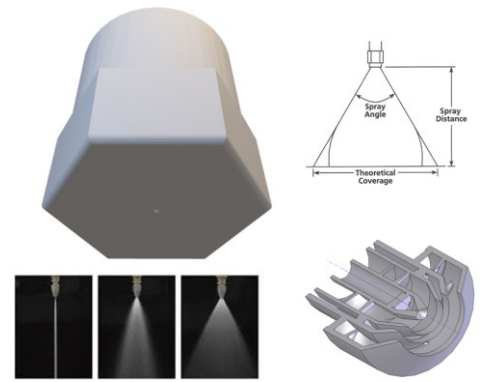


SIEMENS | Simcenter Amesim 2022.1

Preliminary results







Hydrogen fuel nozzle and fuel spray

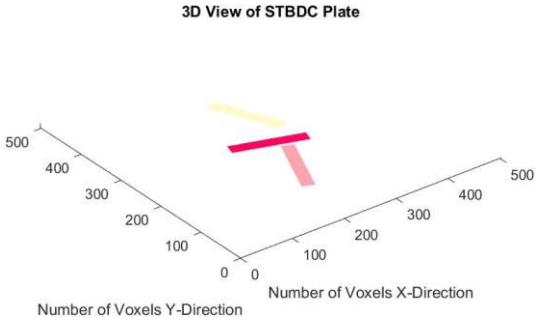
1. Lightweight composite storage solutions for cryogenic hydrogen

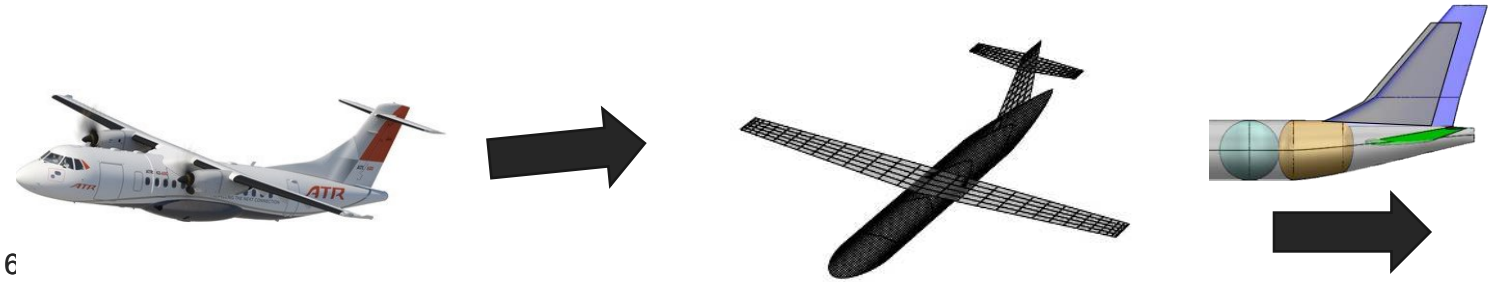
Tomas Grönstedt tomas.gronstedt@chalmers.se

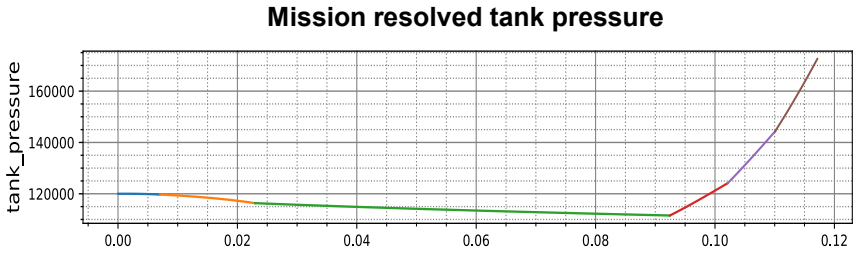
Martin Fagerström martin.fagerstrom@chalmers.se

Composite technology for lightweight solutions of cryogenic/pressurized hydrogen

- Develop **efficient and reliable computational methods** for analysis of thin-walled, liner-less, composite tanks from thin tapes (thickness down to 20 mm) ➔ multiscale modelling
  - Efficient FEM formulations to accurately model the **effects of tape distributions on the mechanical performance of tanks, adhesive joints, material models and design criteria**
- Develop conceptual design tools for hydrogen aircraft and propulsion systems
  - 19 and 50 passenger, electric-prop aircraft & PEM fuel cell stack. Liquid hydrogen for Nordic market







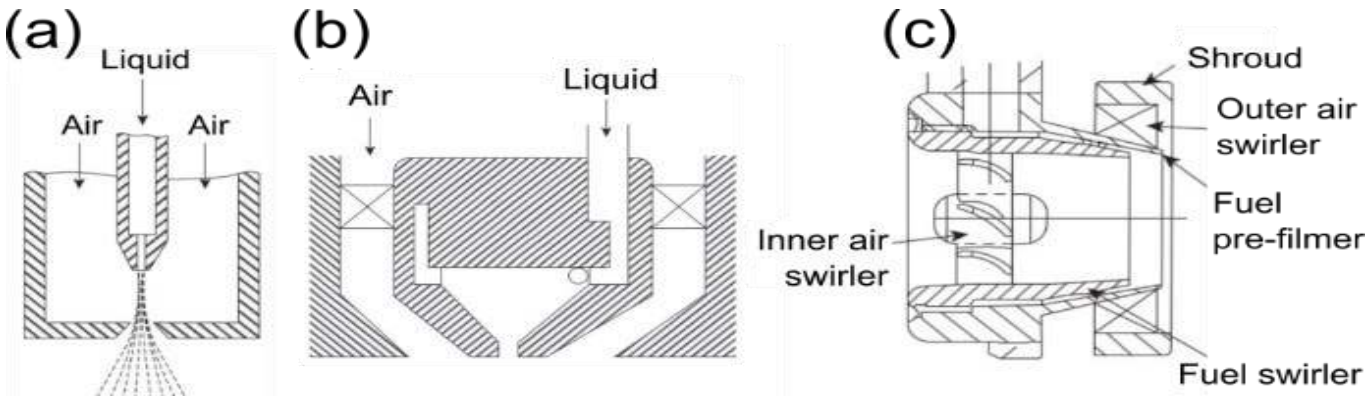
2. Additive manufacturing for hydrogen fuel supply systems

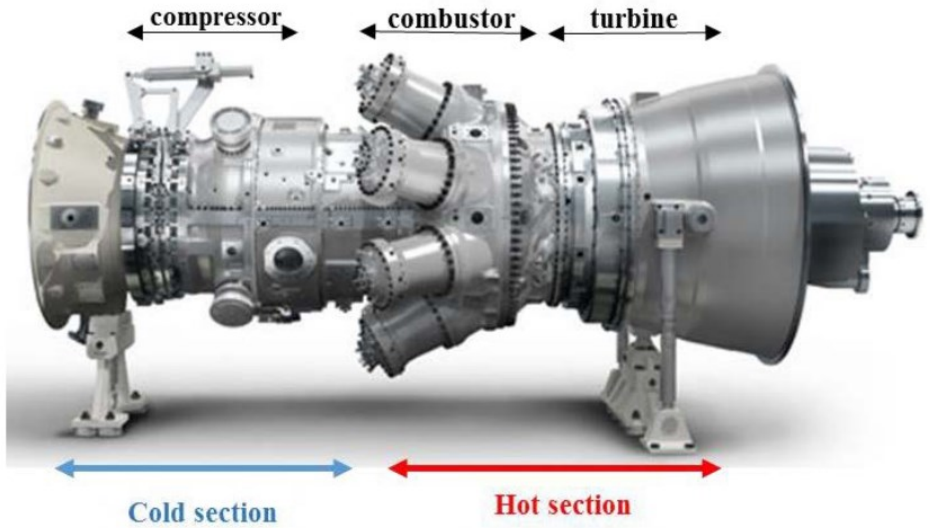
Emmy Cao yu.cao@chalmers.se

Lars Nyborg lars.nyborg@chalmers.se

Metal additive manufacturing for hydrogen fuel supply systems

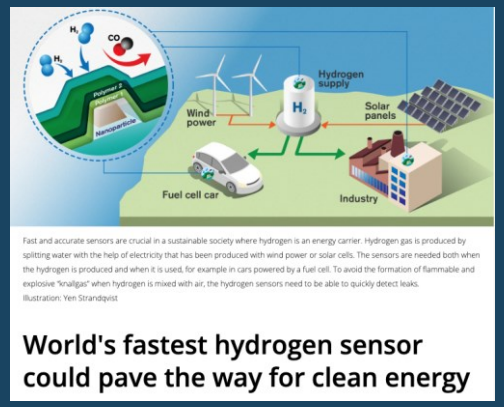
- To develop novel approach to produce fuel nozzle
- To optimize AM-processes for intended metal parts
- To establish process parameter and quality control
- To manufacture prototype demonstrator

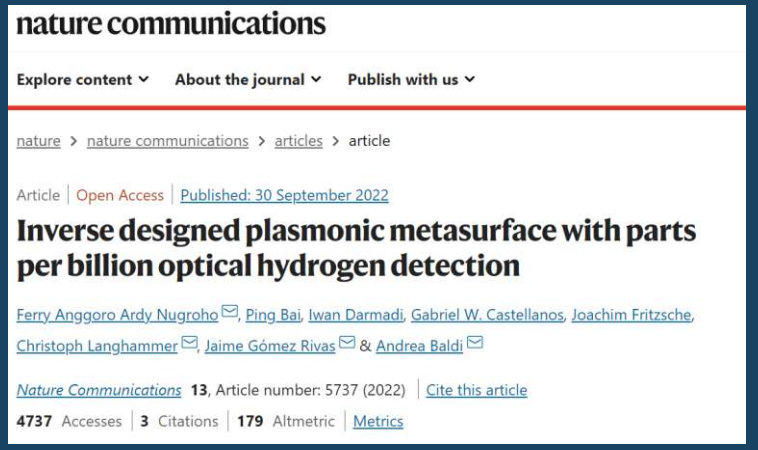




3. Nanoplasmonic hydrogen sensor maturation

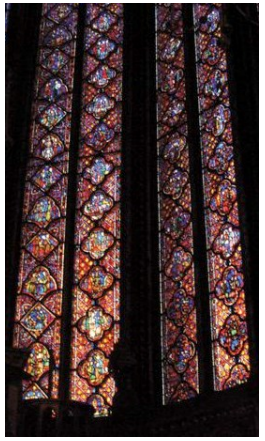
Christoph Langhammer clangham@chalmers.se

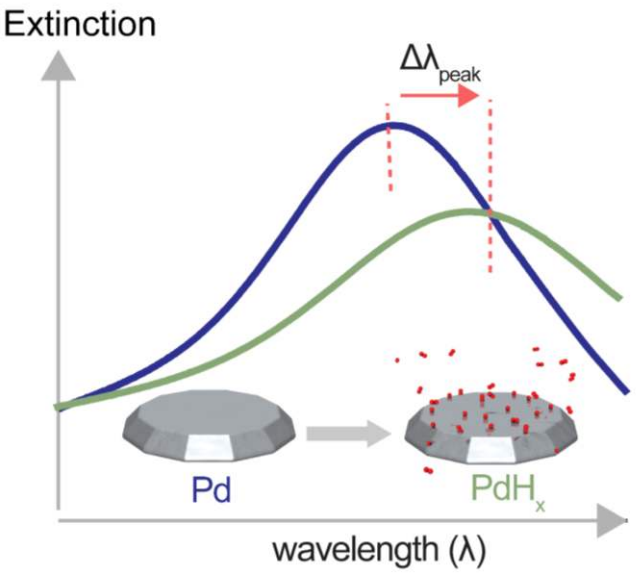


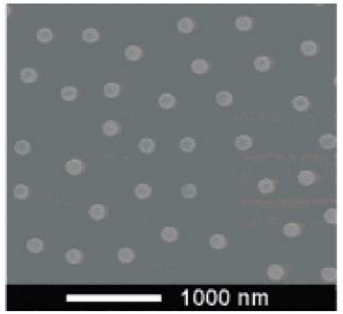


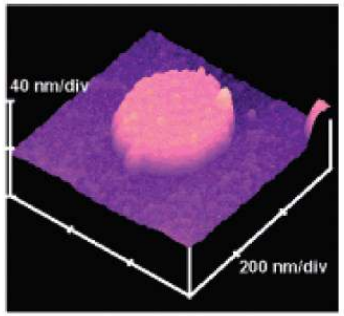
Nanoplasmonic sensors

- No single current sensor meets US department of energy H2 sensor performance targets for stationary and mobile safety sensor applications!
- Insplorion/Chalmers nanoplasmonic sensor promises
  - ultrafast response in the sub-second range that can detect hydrogen concentrations in the low ppm/ppb range in air
  - high pressure hydrogen environments, to develop stable sensor operation at widely varying relative humidity conditions,
  - to facilitate long-term (years) stable sensor operation without significant deactivation/ageing/sensitivity loss,
  - provide reduced sensor cross-sensitivity to other molecular species.



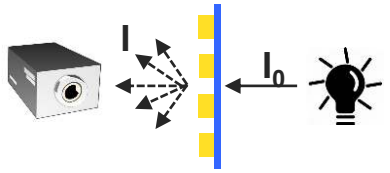






Scheme 1. US DoE Performance Targets for Stationary and Automotive Hydrogen Safety Sensors[5]

	Dynamic range [vol.%]	Detection limit [vol.%]	Response/ recovery time [s]	Accuracy [%]	Power consumption [W]	Lifetime	Ambient temperature [°C]	Ambient pressure [kPa]	Ambient humidity [%]
Stationary	≤ 4	≤ 4	< 30 / < 30	± 10	N.A.	3 - 5 years	-50 to +50	80 to 110	20 to 80
Automotive	≤ 4	0.1	< 1 / < 1	± 5	< 1	6000 hours	-40 to +85	62 to 107	0 to 95



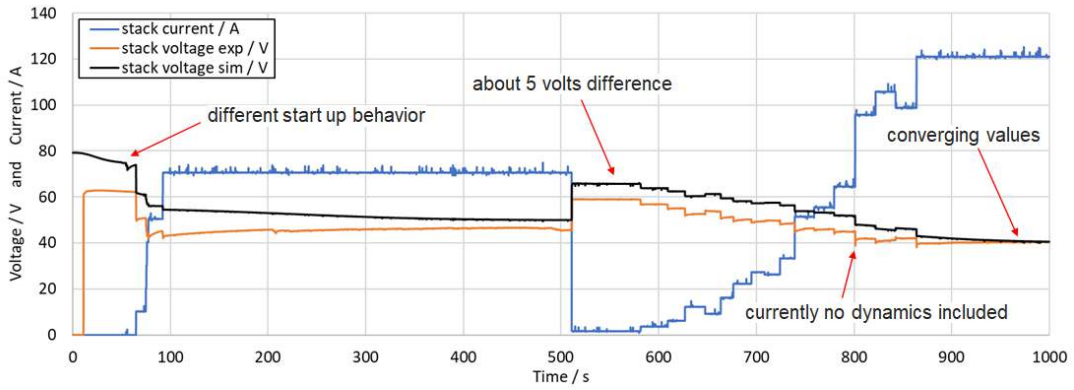
4. Fuel cell development and integration

David Sedarsky sedarsky@chalmers.se

Anna Martinelli anna.martinelli@chalmers.se

- Develop model that combines the mass flow and **heat dissipation** of an **active cooling system** to the **temperature dependent behavior of the PEMFC electrochemistry and heat transfer** within a physics-based stack model.
- Integrate and **test** a selection of component **deterioration** models, **FC system control** for faster time-response, **startup/shutdown optimization**
- Develop new materials concepts for proton conduction at high temperatures (80-200 °C)

First validation with 5 kW experimental data → Matching well in trends without fine tuning



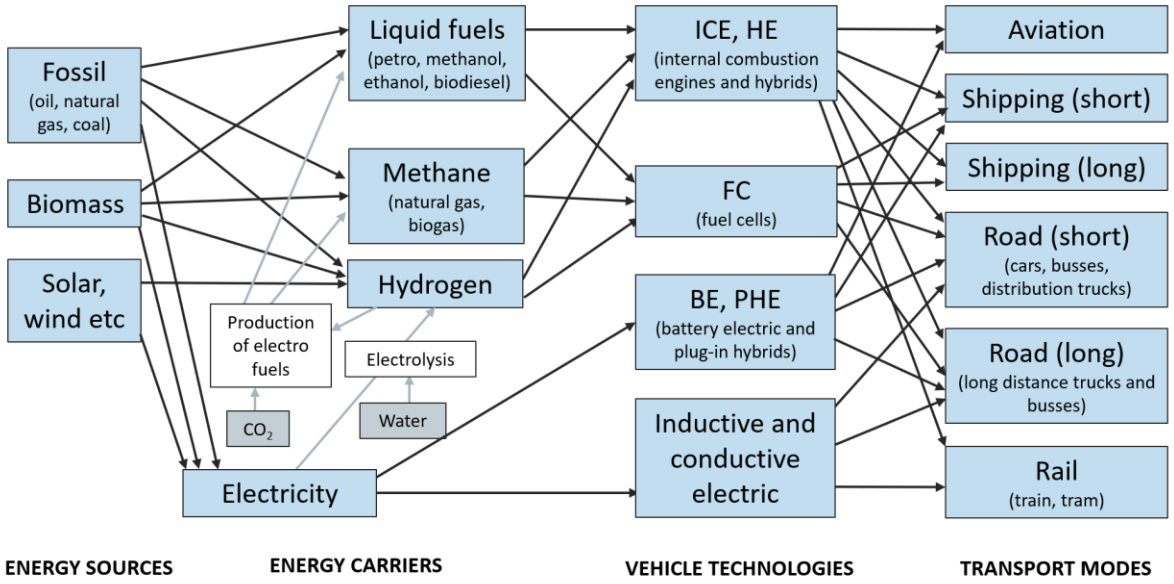
5. The future of hydrogen: societal challenges

Maria Grahn maria.grahn@chalmers.se

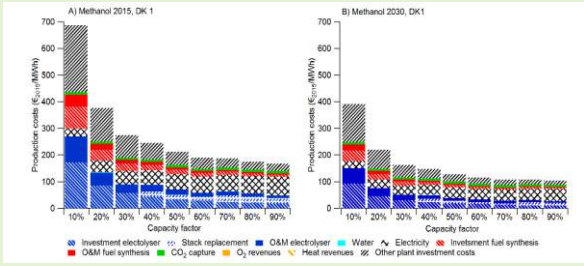
Selma Brynolf selma.brynolf@chalmers.se

The future of hydrogen

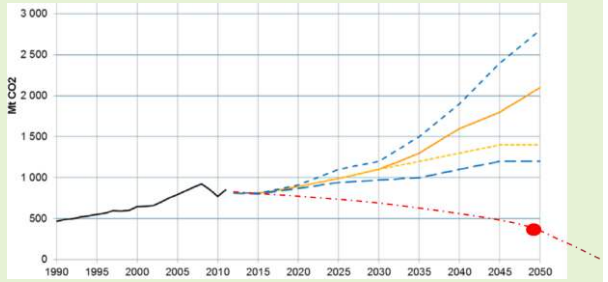
- Assess research questions from different aspects using a range of evaluation methods,
  - Identify the best suited well-known tools (developed at Chalmers and elsewhere)



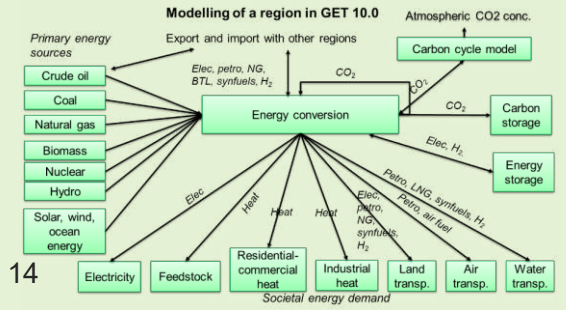
Techno-economic assessment (TEA)

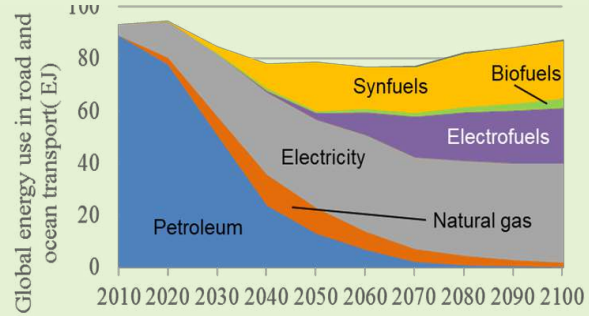


Scenario development



Global energy systems modelling





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