

BothH₂nia



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BothH₂nia goes Oulu & Raahе 5.–6.5.2022

This is a presentation given at the event BothH₂nia Goes Oulu & Raahe on 5.–6.5.2022.

BothH₂nia is a network of operators interested in hydrogen. The objective of the network is to create a Nordic hydrogen cluster around the Baltic Sea, beginning with the Bothnian Bay. BothH₂nia strengthens the position of the north in the European hydrogen industry!

BothH₂nia invites all businesses, research institutes, investors, municipalities and cities to roll up their sleeves for a greener future.

Please notice that the presentation has been modified to comply with the Accessibility Directive. In case for need the original material, please contact Minna Näsman (minna.nasman@both2nia.com).



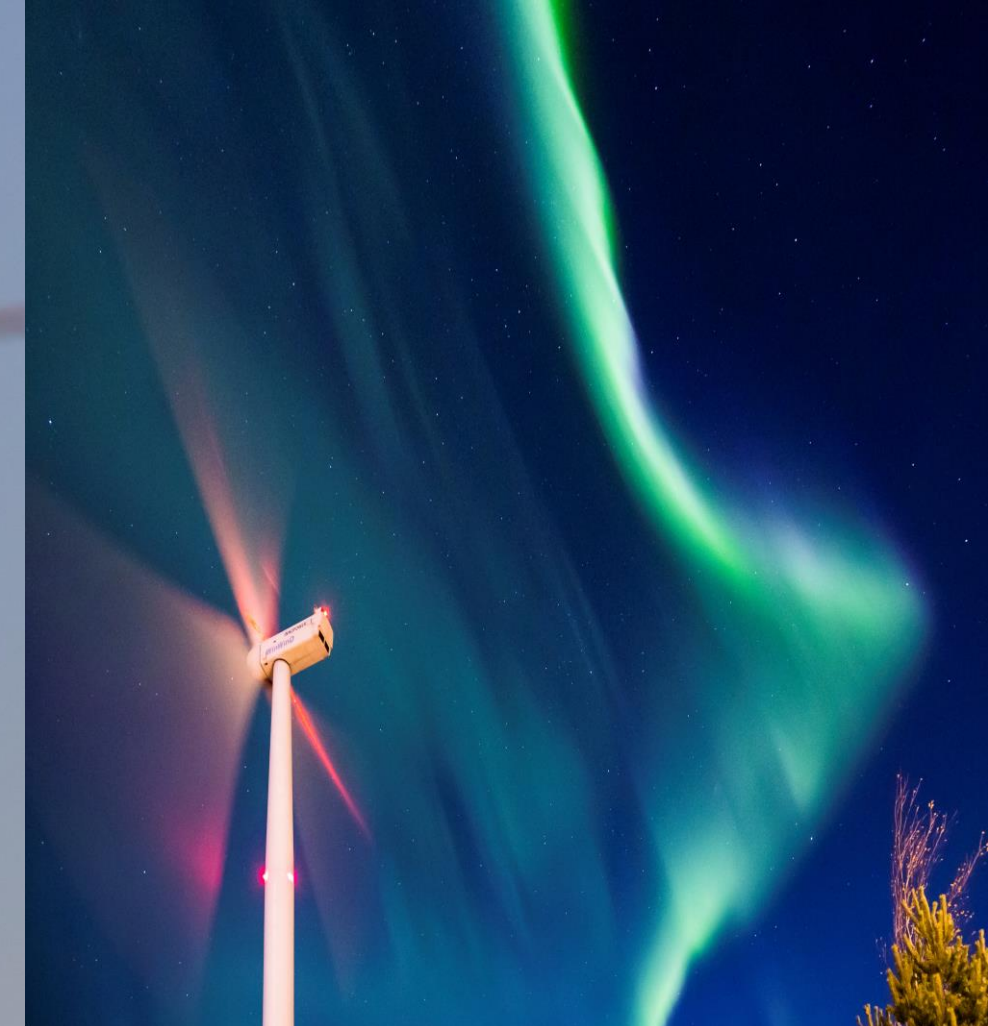
BotH2nia goes Oulu 5.5. & Raahel 6.5.

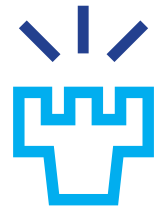
Electrofuels, Hydrogen and Biomethane in Transport

UOulu 5.5.2022

Prof. Riitta L. Keiski

University of Oulu, Faculty of Technology, Environmental and Chemical Engineering



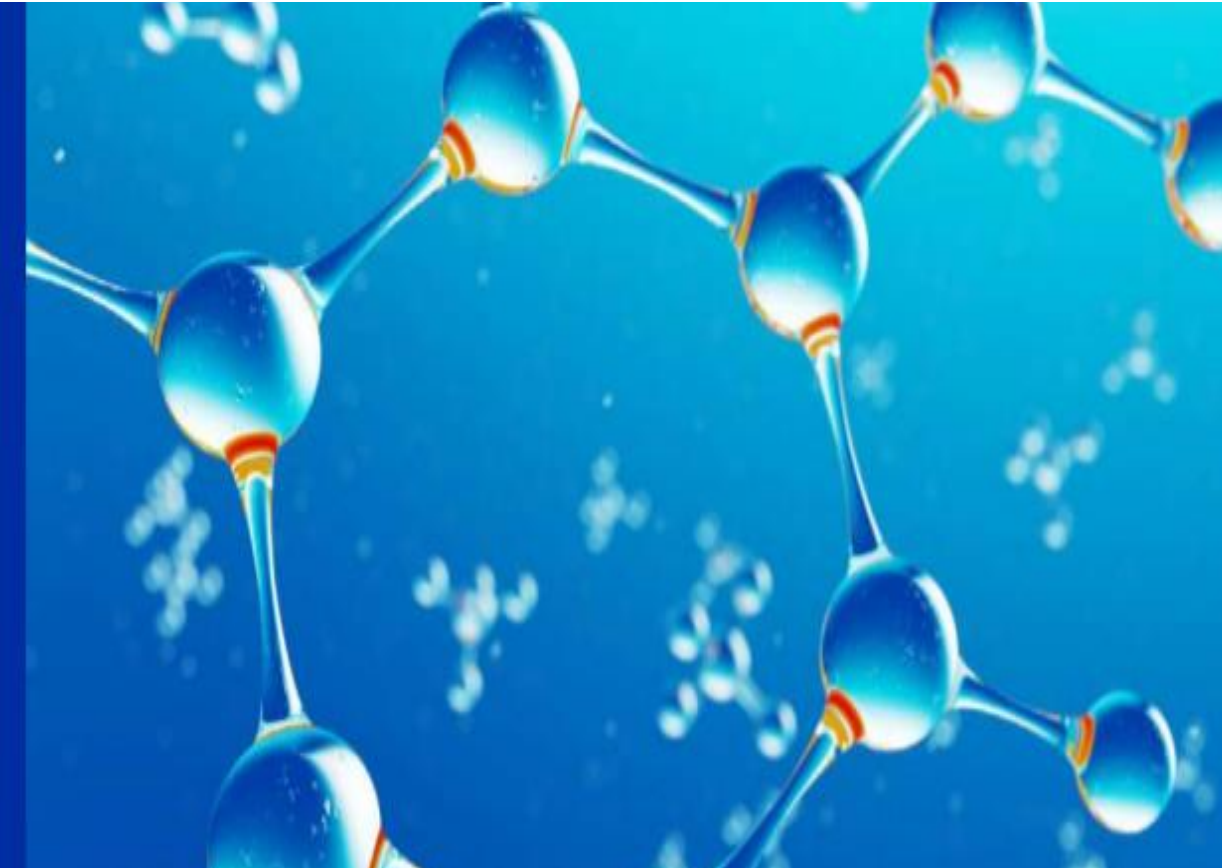


Hydrogen as an Enabler of Energy Transition

- **Good wind resources** (offshore/onshore) allow the increase in the production of renewable electricity, essential for the production of low-carbon hydrogen
- **A fairly strong electricity grid** to support increased transmission of power
- **A full and working value chain for hydrogen**
- Decades of **experience in large-scale industrial use of hydrogen**
- **A natural gas pipeline** to store and carry hydrogen
- **Cost-effective transport of hydrogen by trucks**, as much higher total vehicle mass is allowed in Finland, compared to the rest of Europe
- The large heavy long-distance transport sector offers a case to study the **possibility of hydrogen-powered fuel cells** to act as a zero-emissions power source (lower unit weight compared to battery electricity)
- **Large refinery and biofuel industry** – clean hydrogen to fulfil the Renewable Energy Directive
- **A major steel manufacturing company** willing to reform the steel-making process - about **30% increase in today's hydrogen production and use**
- Hydrogen offers for Finland great opportunity to create wide range of new businesses throughout the entire hydrogen value chain

Can Finland increase clean hydrogen production and use?

NATIONAL HYDROGEN ROADMAP for Finland

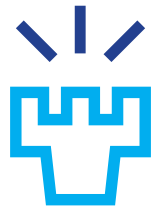


Business Finland

Juhani Laurikko, Jari Ihonen, Jari Kiviaho, Olli Himanen, Robert Weiss, Ville Saarinen, Janne Kärki, Markus Hurskainen

Six areas in clean hydrogen:

- **Hydrogen production**
- **Hydrogen transmission & distribution**
- **Industrial applications of hydrogen**
- **Hydrogen for mobility**
- **Hydrogen for energy**
- **Residential applications of hydrogen**



Hydrogen as an Enabler of Energy Transition

→ Industry, **Transport**, Buildings, Electricity generation (Power-to-XH₂-to-Power) and TRLs

Hydrogen as an Enabler of Energy Transition – The role of CO₂

→ H₂ + CO₂: **Synthetic fuels and fuel additives** (via MeOH and Fischer-Tropsch syntheses)

→ N₂ + H₂ → **NH₃** + CO₂ → **Urea** → **fuels, fuel additives** and fertilizers

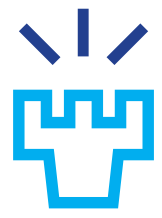


Electrification of Transport & Use of Electrofuels, Gaseous fuels, Biofuels

10.3.2022 CLC Transportation: Saara Jääskeläinen, Ministry of Transport and Communications
https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/163258/LVM_2_021_15.pdf?sequence=1&isAllowed=y

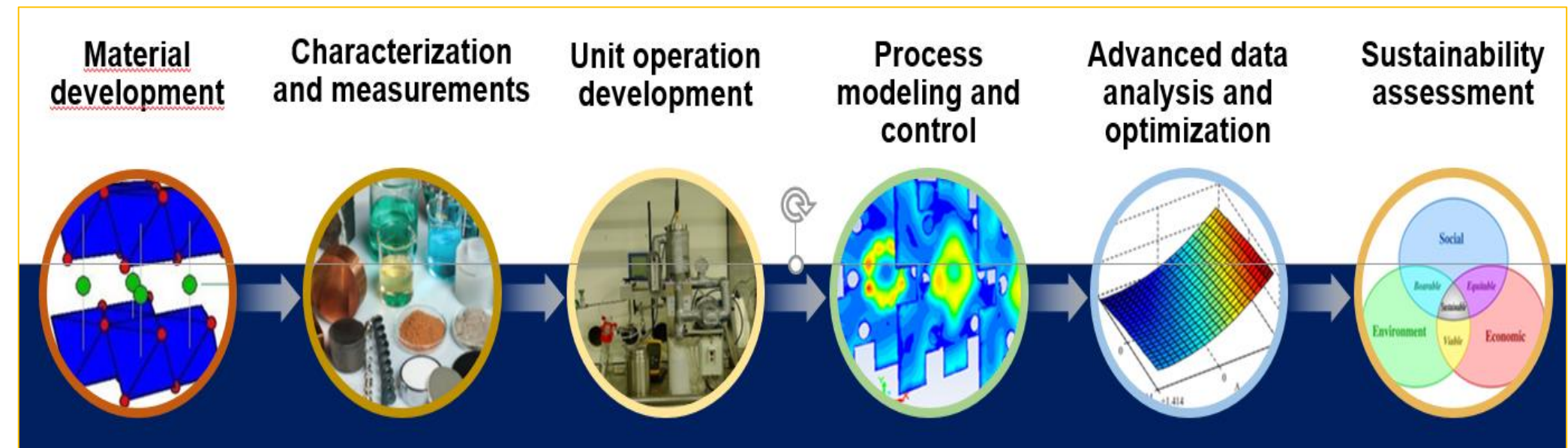
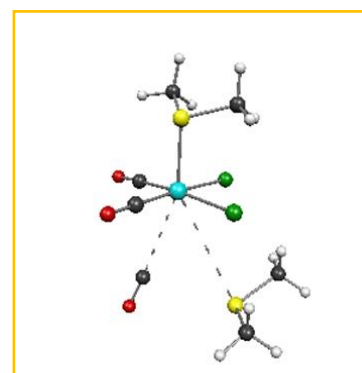
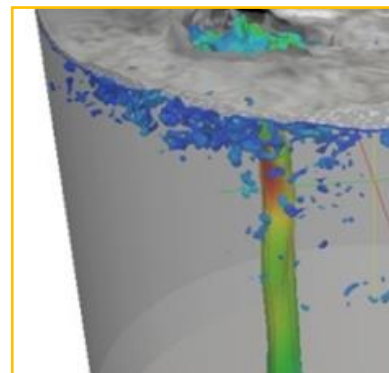
Roadmap to fossil-free transport : Government resolution on reducing domestic transport's greenhouse gas emissions (6.5.2021):

- **By 2030**, Finland will reduce emissions from domestic transport by at least 50 per cent compared to the 2005 level
- The aim is to achieve an **entirely fossil-free transport sector by 2045**
- Principles for aviation and water traffic
- **Roadmap with three phases with aids and incentives**
- **1st phase: Aids and incentives, reduction of CO₂-emissions by 0.4 – 0.5 Mtn**

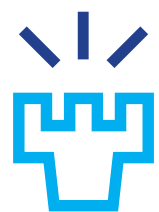


Research Profile and Approach at ECE

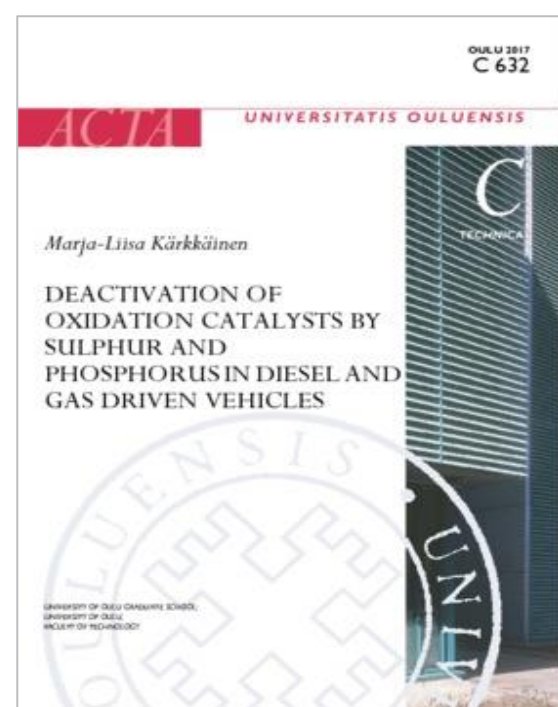
- Combines basic and applied research, and collaboration between sectors and disciplines
- H₂ and Biofuels production and use, Emission abatement in transport and industry, CO₂ utilization, Energy technologies, Energy efficiency, Intelligent energy systems



- **Materials development & characterization**
 - *(Photo)catalysts, adsorbents and membranes for hydrogen production, P2X, emissions abatement and utilization including CO₂*
- **Unit operations and production processes design** for Clean production
 - *Design of unit operations and production processes for H₂, biofuels and chemicals production*
- **Process modelling and simulation**, from DFT to DEM and CFD), process control
 - *Models for fuel cells, H₂ and biofuels production processes, catalysts & separation processes design*
- **Advanced data analysis and optimization**
 - *Data fusion and AI to select e.g., catalysts, to aid sustainability assessment and to speed-up e.g., design of production process*
- **Sustainability assessment, and assessment tools and criteria development**
 - *Assessing biobased resources, unit operations and production processes, use of catalysts and critical materials, products*



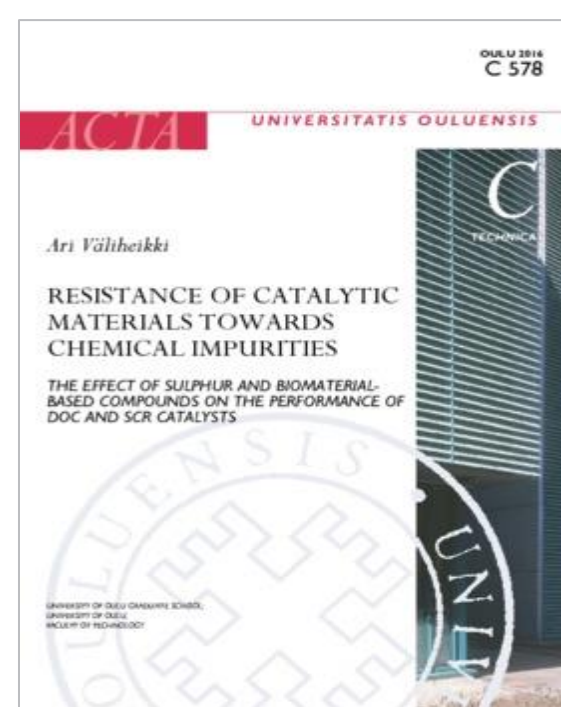
Doctoral Theses Related to Biofuels and Emission Control in Transport



Marja Kärkkäinen's doctoral thesis, 2017:

- Diesel and gas driven vehicles and the role of impurities existing in biofuels on the catalytic abatement units

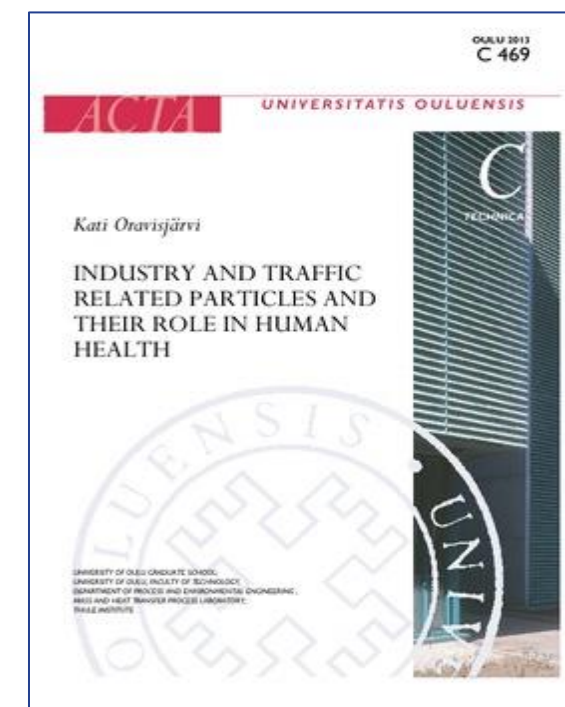
Phosphorus (P) and sulphur (S) originating from biofuels



Ari Väliheikki's doctoral thesis, 2016:

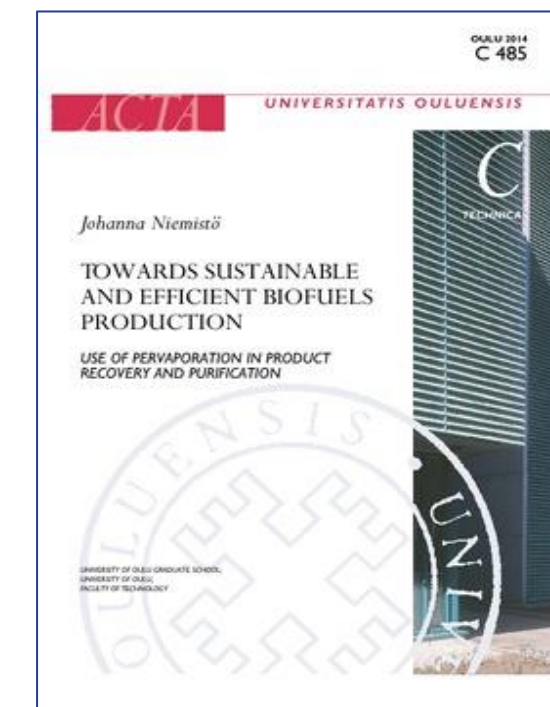
- Diesel driven vehicles and the role of impurities existing in biodiesel on the catalytic abatement unit (catalytic oxidation, SCR and particulate filter)

Potassium (K), sodium (Na), phosphorus (P) and sulphur (S) in biofuels



Kati Oravisjärvi, 2013:

- Industrial and traffic related particles and their role in human health. Acta, Technica C 469, PhD thesis. Oulu 2013, University of Oulu, Faculty of Technology. 154 pp.



Johanna Niemistö, 2014:

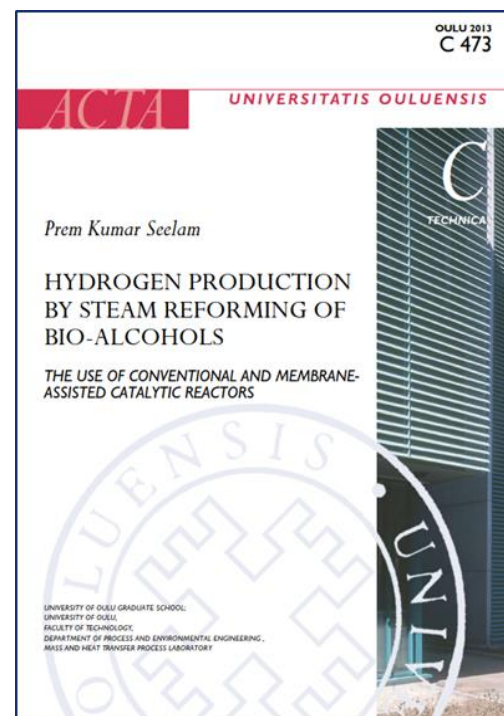
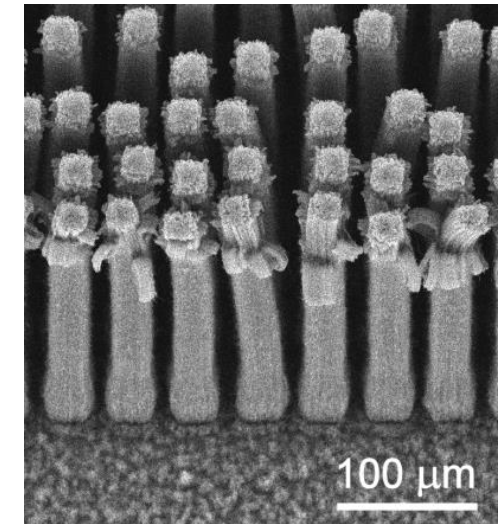
- Towards sustainable and efficient biofuels production – Use of pervaporation in product recovery and purification. Acta, Technica C 485, PhD thesis. University of Oulu, Faculty of Technology. 121 pp.



How to Produce H₂? – Research since 2007

Reforming, WGSR, Partial oxidation & (Photo)catalysis and Sustainability in Hydrogen Production

- Use of hydrogen carriers, industrial side streams, organic load in WWs, biomass in H₂ production
- Use of novel reactors, H₂-selective membranes and CNT catalysts



Prem Kumar Seelam, 2013:

Hydrogen production by steam reforming of bio-alcohols. Acta, Technica C 473, PhD thesis. Oulu 2013, University of Oulu, Faculty of Technology. 123 pp.



CO₂ Research

- **Over 100 possible conversion pathways identified**
- **Only a few routes at commercial level**

Source: Bazzanella, A. & Krämer, D. 2019. Technologies for sustainability and climate protection – Chemical processes and use of CO₂. Dechema

Source: Chauvy, R. & De Weyrald, G. Energy Technology 2020, 2000627

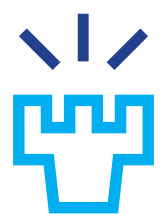


Our target:

Secondary CO₂ as a raw material for valuable chemicals/ products inside the company that produces CO₂, e.g., oil, chemical, power, pulp and paper, and metallurgical industry

Chemical utilization of CO₂ has been an active research theme in ECE since 2003

- **Use of CO₂ in chemicals and fuels production and parallel to biomass (H₂ source) utilization**
- **CO₂ as a solvent in catalytic reactions, e.g., ScCO₂**
- **Use of CO₂ in mining industry beneficiation processes (grinding and flotation)**
- **Simulation and predictive optimization of supercritical CO₂ extraction processes (batch and continuous operating modes)**
- **Sustainability assessment and criteria development for CO₂ utilizing processes**



Fossil Free Biohydrogen and Clean Energy from Biogas - GREENE

1.7.2021 – 30.6.2023



- Supports the **hydrogen economy**, self-sufficiency and **local energy production** and contributes to the **carbon neutrality 2035 target** in Finland.
- Development of a new **thermochemical method** that utilizes biogas in the production of fossil-free biohydrogen.
- Enables the utilization of **biogas in hydrogen production** in an atom- and energy-efficient way and promotes low-emission, flexible and efficient decentralized energy production.
- **Contents:**
 - **Reactor design** (pre-treatment, reactor, analytics and automation),
 - **Development and testing of carbon-resistant and sulphur-tolerant catalysts**, and
 - Pilot-scale equipment **construction ja testing**

Docent Esa Muurinen, Docent Satu Pitkäaho, UOulu Environmental and Chemical Engineering Research Unit
www.oulu.fi/environmentalengineering/greene

Prof. Riitta Keiski, UOulu, Faculty of Technology, Environmental and Chemical Engineering Research unit





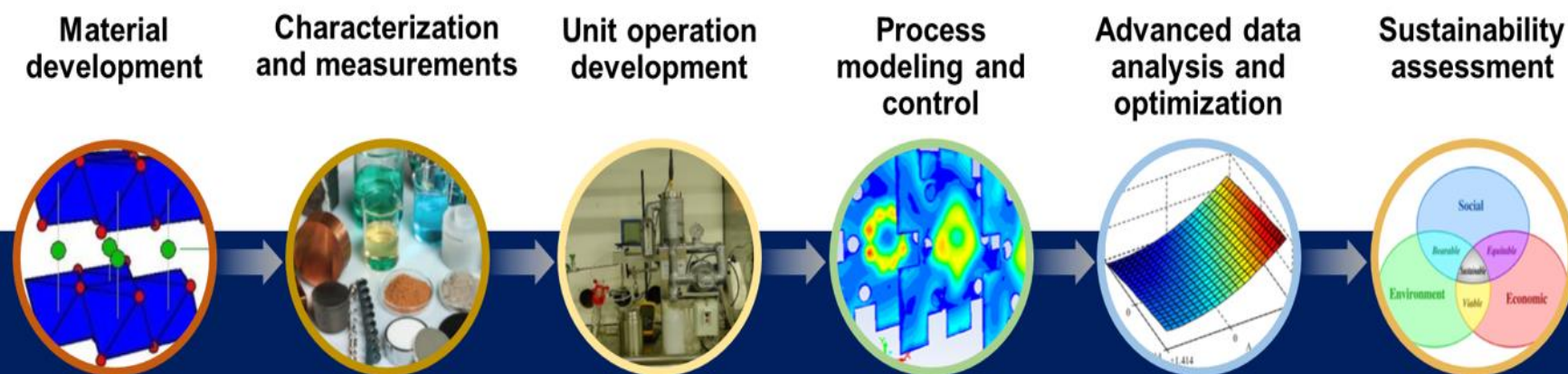
Many thanks!

Thanks to Doc. Mika Huuhtanen, Doc. Satu Pitkäaho, Doc. Satu Ojala and many other researchers in our unit!

Environmental and Chemical Engineering Research unit, ECE
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Environmental and Chemical Engineering



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