LITHUANIAN ENERGY INSTITUTE

R&D activities on hydrogen in Lithuania

Darius Milčius

October 2022,

WHO WE ARE

BRIEF HISTORY OF THE LEI

- Founded **in 1956** as Institute of Energy and Power Engineering.
- **1992** Lithuanian Energy Institute.
- Since 2019 we are members of RTO.Lithuania (together with other 3 partners.

RTO LITHUANIA

TODAYS MAIN MISSIONS:

- Fundamental and applied energy-related research and innovations;
- Conceptual and methodological basis for energy sector planning;
- Delivery of competent experts for energy related research

MESSAGE

LEI performs research in **energy field** for **State, Industry and Public**

LEI in brief

- **230** Employees
- **130+** Scientists & researchers
- **37** PhD students
- **10** scientific laboratories
- **12.700** sqm of lab facilities
- **10+ MEUR** R&D infrastructure
- **8+ mio. Eur** annual revenue

R&D competencies

RESEARCH ON ENERGY TECHNOLOGIES

- Nuclear fission and fusion
- RES (wind, biomass)
- H2 energy (generation, storage, fuel cells,)
- Combustion and Plasma technologies

THERMAL ENGINEERING & METROLOGY

- Thermal physics
- Gas & Fluid dynamics
- Metrology

ENVIRONMENTAL ENGINEERING

- Hydrology
- Combustion and Plasma technologies
- Environmental impact assessment

MATERIALS SCIENCE

- Materials synthesis
- Materials analysis (surface, bulk)

ENERGY SYSTEMS AND ECONOMY

- Energy economy
- Energy systems modeling, smart grids

Projects

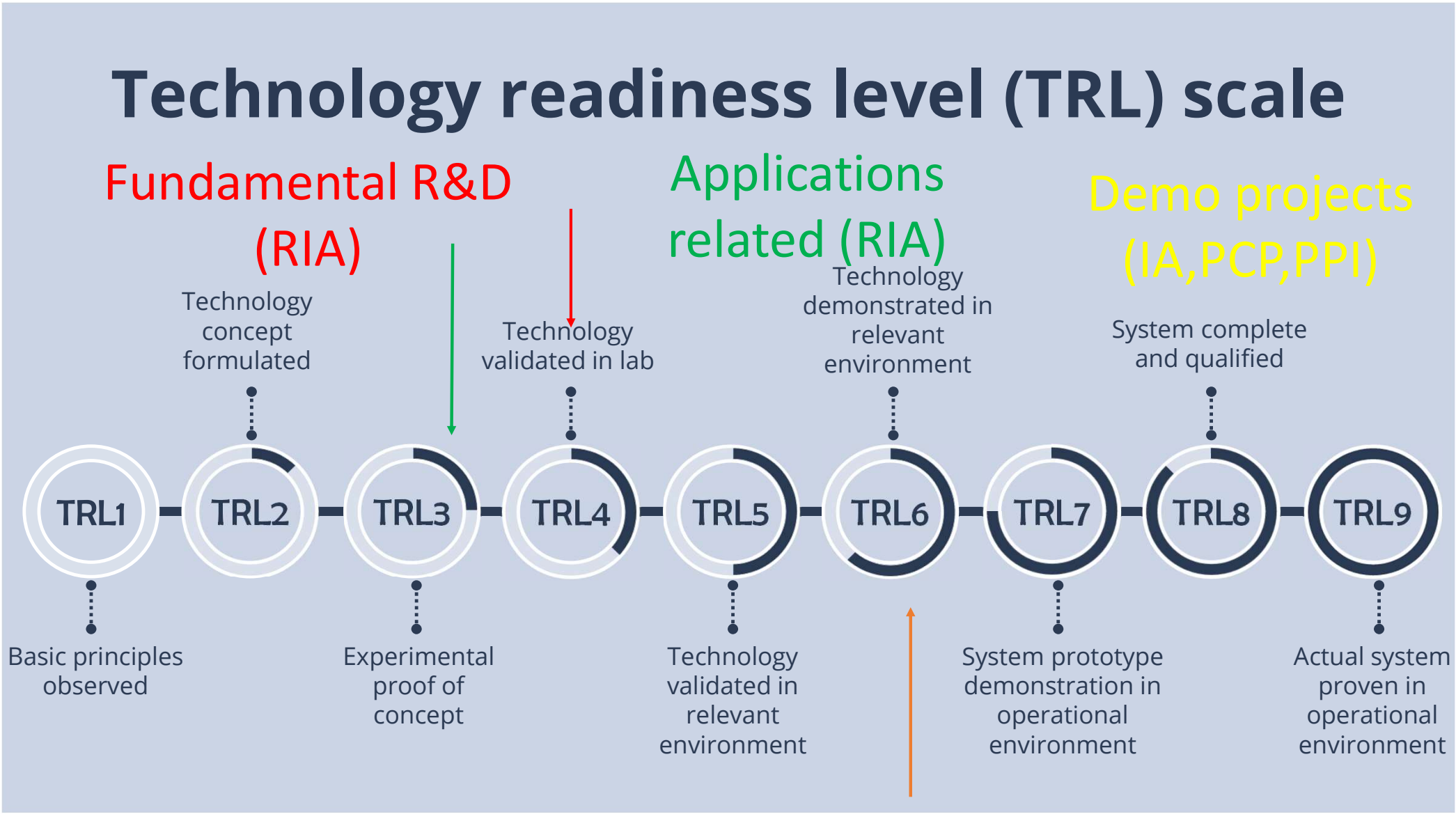
- 26 funded H2020 projects in:
  - EURATOM – 15 (1 – coordinator)
  - Secure, Clean and Efficient Energy – 9 (1 – coordinator)
  - Spreading Excellence and Widening Participation – 1 (coordinator)
  - Cross-cutting activities – 1.

22 proposals in Horizon Europe:

  - 8 – EURATOM (1 – LEI coordinator). **5 projects (1 – LEI coordinator).**
  - 11 – CL5 (D2, D3, D4; 2 – LEI coordinator). ***1 project in the negotiation phase***
  - 2 – Widening thematic
  - 1 – ERC starting grant (passed the 1st threshold).

- Other projects & initiatives:
  - LIFE (3 proposals in LIFE-2021 call – 1 in negotiation phase)
  - *eDIH (European Digital Innovation Hub) –* ***in the negotiation phase***
  - INTERREG
  - NERP
  - …

Technology readiness level (TRL) scale



R&D activities on hydrogen in Lithuania

Lithuanian Energy Institute:

Hydrogen production using Al, Mg_2NiH_4 hydrolysis reactions

Materials development for solid state hydrogen storage

The use of metal hydrides in production of synthetic fuels

Green Hydrogen Demonstration Site

Vilnius University:

Sintering and electrical properties of oxygen conducting solid electrolytes for SOFC.

Vilnius Gediminas Technical University:

Modelling and experimental research on CNG/H_2 fuel mixture use in a spark ignition internal combustion engines

Kaunas University of Technology:

Formation, research and application of multi-functional thin films structures and nanocomposites for Solid Oxide and Proton Conductive Fuel Cells.

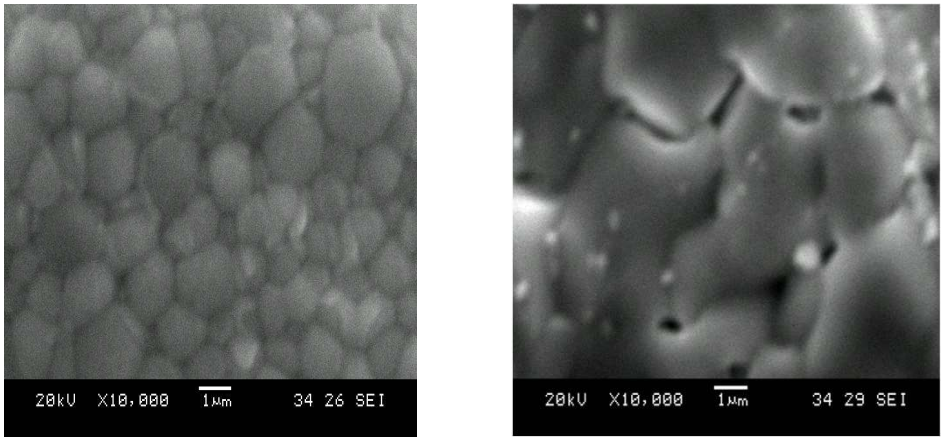
Vytautas Magnus University:

Research in Social science on the role of renewable energy prosumers in implementing energy justice theory and energy security on regional/national level.

R&D activities on hydrogen at Vilnius University

Main contact person:
Prof. dr. Feliksas Antanas Orliukas
„Nanoionics“ laboratory, Institute of Applied Electrodinamics and Telecomunications,
Faculty of Physics,
Vilnius University
antanas.orliukas@ff.vu.lt

Laboratory is focused on the transport of lithium and sodium ions, oxygen vacancies and protons in solid state electrolytes. Superionic materials can be applied in many electrochemical devices: solid oxide fuel cells (SOFC), solid-state batteries, gas sensors, memristors etc. It is necessary to understand the charge transport in these materials.



SEM images of $Ce_{0.9}Gd_{0.1}O_{1.95}$ ceramics sintered from powder with S_{BET} = 158.03 m^2/g (a) and S_{BET} = 6.44 m^2/g (b); Temperature dependences of total ionic conductivity of YSZ ceramics with different BET

Changes in properties of scandia-stabilised ceria-doped zirconia ceramics caused by silver migration in the electric field. Mosiałek, M., Socha, R.P., Bożek, B., ...Dudek, M., Lach, R. Electrochimica Acta, 2020, 338, 135866

Crystal growth, structural and electrical properties of (Cu1-xAgx)7GeS5I superionic solid solutions. Studenyak, I.P., Pogodin, A.I., Kokhan, O.P., ...Kežionis, A., Orliukas, A.F. Solid State Ionics, 2019, 329, pp. 119–123

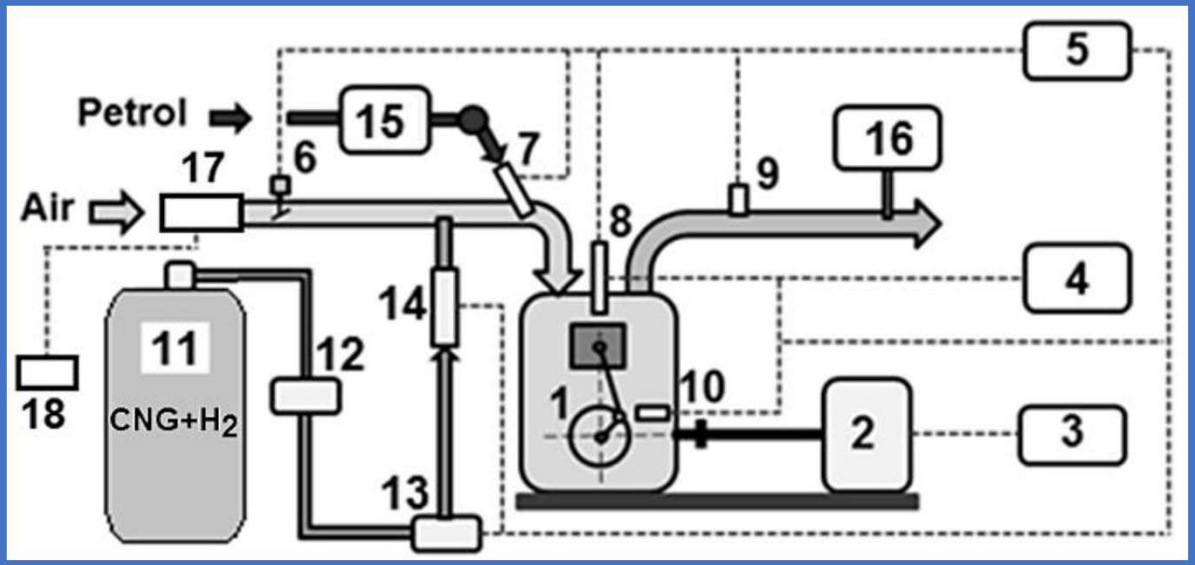
Composite cathode material LSCF-Ag for solid oxide fuel cells obtained in one step sintering procedure. Mosiałek, M., Michna, A., Dziubaniuk, M., ...Wyrwa, J., Orliukas, A.F. Electrochimica Acta, 2018, 282, pp. 427–436

R&D activities on hydrogen at Vilnius Gediminas Technical University

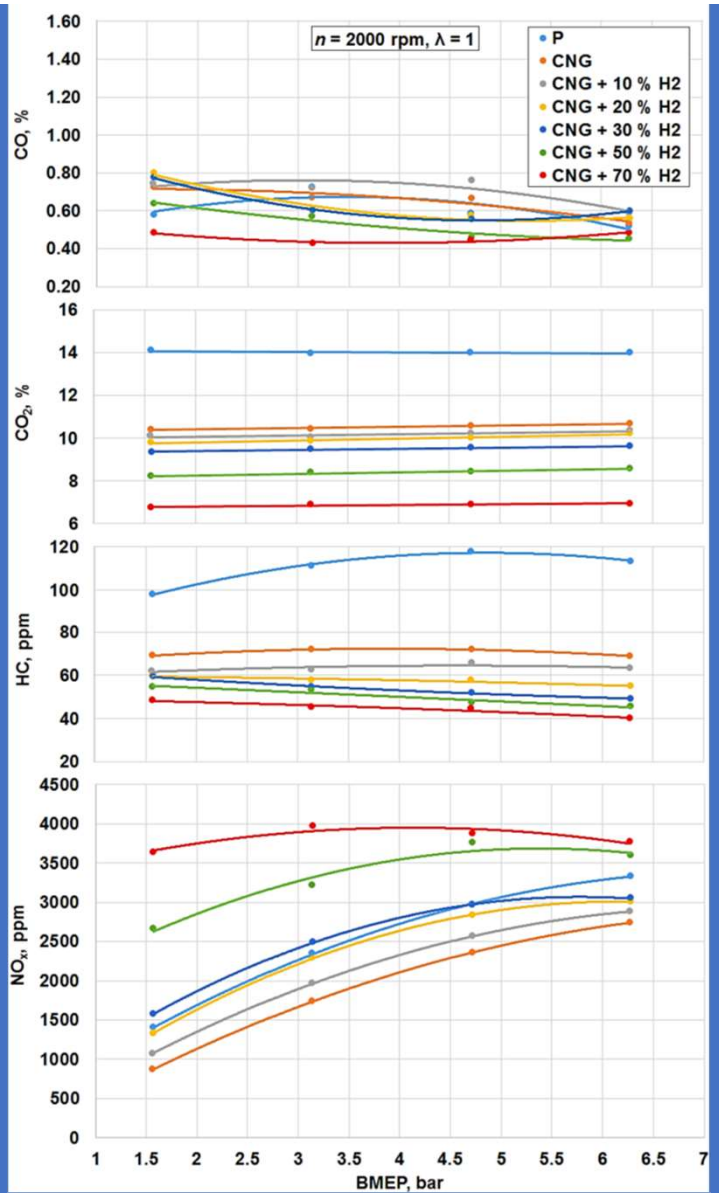
Main contact person:
As. prof. dr. Saugirdas Pukalskas
Faculty of Transport Engineering
Vilnius Gediminas Technical University
saugirdas.pukalskas@vilniustech.lt

Experimental research

Research of CNG / H_2 fuel mixture use in a spark ignition internal combustion engine



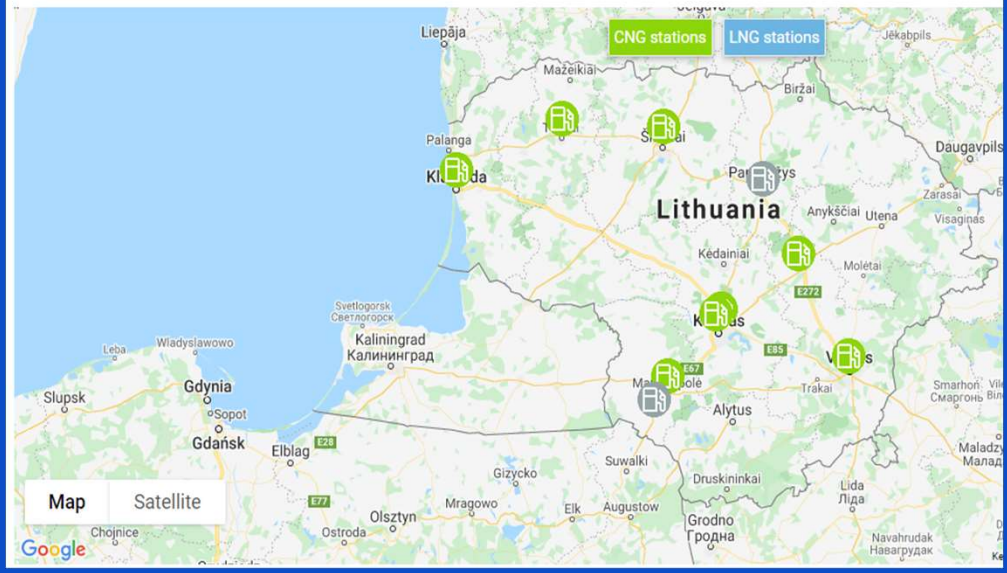
Schematic of engine stand testing equipment for CNG/H_2 fuel mixtures investigation: 1 – SI engine *Nissan HR16DE*; 2 – engine load stand *AMX 200/100;* 3 – load stand electronic control unit; 4 – equipment for registration of pressure in the cylinder *LabView Real Time*; 5 – engine electronic control unit *MoTeC M800*; 6 – throttle control servo-motor; 7 – petrol injector; 8 – spark plug with integrated pressure sensor *AVL ZI31*; 9 – wideband oxygen sensor *Bosch LSU 4.9*; 10 – crankshaft position sensor; 11 – natural gas and hydrogen fuel mixtures cylinder at 200 bar pressure; 12 – gas mass flow meter *RHEONIK RHM015*; 13 – high pressure reducer from 200 bar to 1.5 bar; 14 – gas injector; 15 – petrol consumption metering device *AMX 212F*; 16 – exhaust gas analyser *AVL DiCOM 4000*; 17 – air mass flow meter *Bosch HFM 5*; 18 – air mass flow meter indication monitor



HYDROGEN TECHNOLOGIES FOR VEHICLES ALREADY IN USE IN LITHUANIA!

The buses of the Marijampole, Telsiai and Ukmerge bus fleets use up to 10% of hydrogenated natural gas.

The map of UAB SG dujos natural gas (CNG/LNG) filling stations in Lithuania



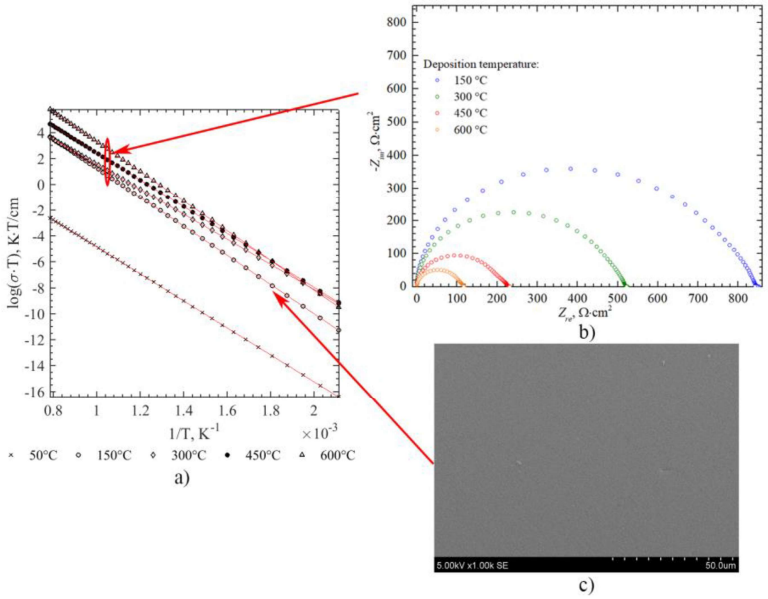
R&D activities on hydrogen at Kaunas University of Technology

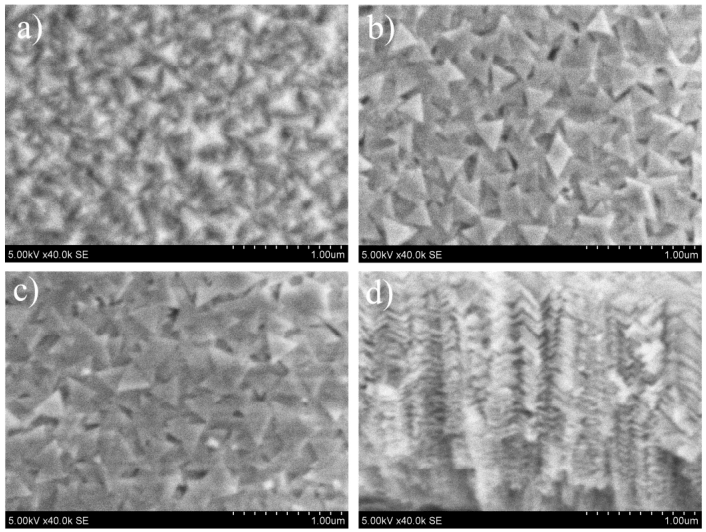
Main contact person:

Prof. dr. Giedrius Laukaitis
Kaunas University of Technology,
Faculty of Mathematics and Natural Sciences,
Department of Physics
giedrius.laukaitis@ktu.lt

Research on SOFC and PCFC:

- Formation of thin-film solid oxide structures and their investigation (YSZ, SDC, GDC, ScSZ, etc).
- Formation and investigation of thin film proton conduction ceramics (LaNbO, BCO, BCY, BZO, BZY, BZCY, etc.).

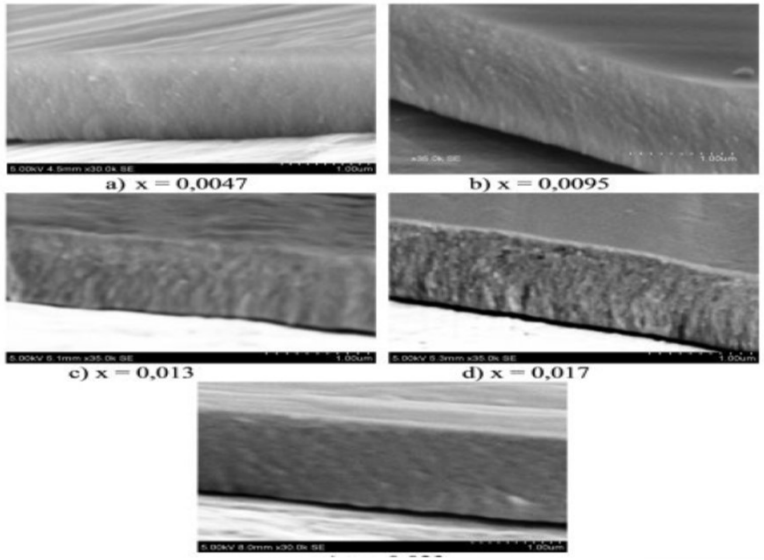


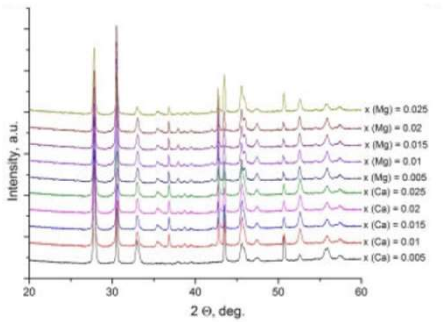


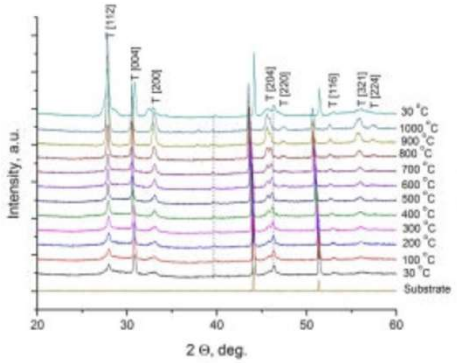
Patent. LT 6354 B. 2017-01-25. Structure and formation of ion-conductive and catalytically active membranes

Research Projects:

- 01.2.2-LMT-K-718-01-0071, K7180171, Investigation of mass transfer and catalytic processes in single-chamber solid oxide hydrogen fuel cells, (2017-12-20 ÷ 2021-12-19).
- P-LL-18-82, LL183, Formation of the Proton Conducting Fuel Cells and their Components (ProFC) (2018-10-01 ÷ 2022-09-30).
- VP1-3.1-ŠMM-07-K-02-064, Formation of the Proton Conducting Fuel Cells and their Components (ProFC), (2012 ÷ 2015-12-31).







More detailed information - https://en.ktu.edu/research/research-at-divisions/rg_formation-research-and-application-of-multi-functional-thin-film-structures-and-nanocomposites/

R&D activities on energy storage (including hydrogen) at Vytautas Magnus University

Main contact persons:

Prof. dr. Julija Kirsiene; Faculty of Law; julija.kirsiene@vdu.lt

Prof. dr. Juozas Augutis; Energy Security Research Centre; juozas.augutis@vdu.lt

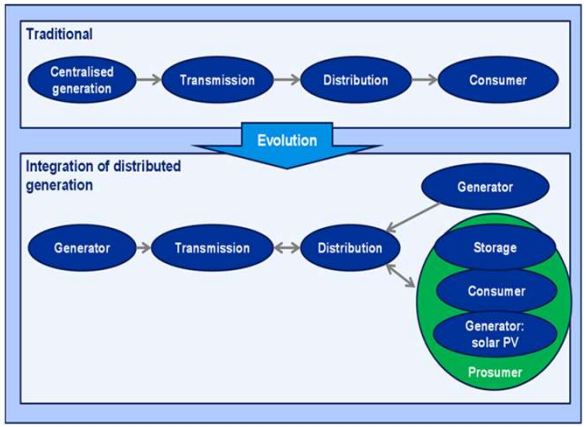
Research in Social science on the role of renewable energy prosumers in implementing energy justice theory

The role of the prosumer as a market player can be analyzed in terms of implemented technological solutions, economic assessment, environmental impact, and legal regulation requirements. One of the main aim of research is to investigate the importance and compatibility of energy prosumers with energy justice theory in the context of European Union (EU) law.

Milčiuvienė S., Kiršienė J., Doheijo E., Urbonas R. [LEI], Milčius D. [LEI]. The Role of Renewable Energy Prosumers in Implementing Energy Justice Theory. Sustainability. Basel, Switzerland: MDPI, 2019, Vol. 11, 5286, p. 1-16. ISSN 2071-1050.

Aleksiejuk-Gawron J., Milčiuvienė S., Kiršienė J., Doheijo E., Garzon D., Urbonas R. [LEI], Milčius D. [LEI]. Net-Metering Compared to Battery-Based Electricity Storage in a Single-Case PV Application Study Considering the Lithuanian Context. In: Energies. MDPI, 2020, Vol. 13, No. 9, 2286, p. 1-5. ISSN 1996-1073.

http://www.idistributedpv.eu/



Energy security on regional/national level.

ESRC is seeking to build theoretical principles of energy supply security evaluation, scientifically validate the criteria of energy security, prepare and develop evaluation methodologies for technical, economic, geopolitical and other consequences of possible energy disturbances in rapidly changing energy market.

Augutis J., Krikštolaitis R., Martišauskas L., Urbonienė S., Urbonas R., Ušpurienė A. B.. Analysis of energy security level in the Baltic States based on indicator approach. Energy. Elsevier, 2020, Vol. 199, 117427, p. 1-13. ISSN 0360-5442.

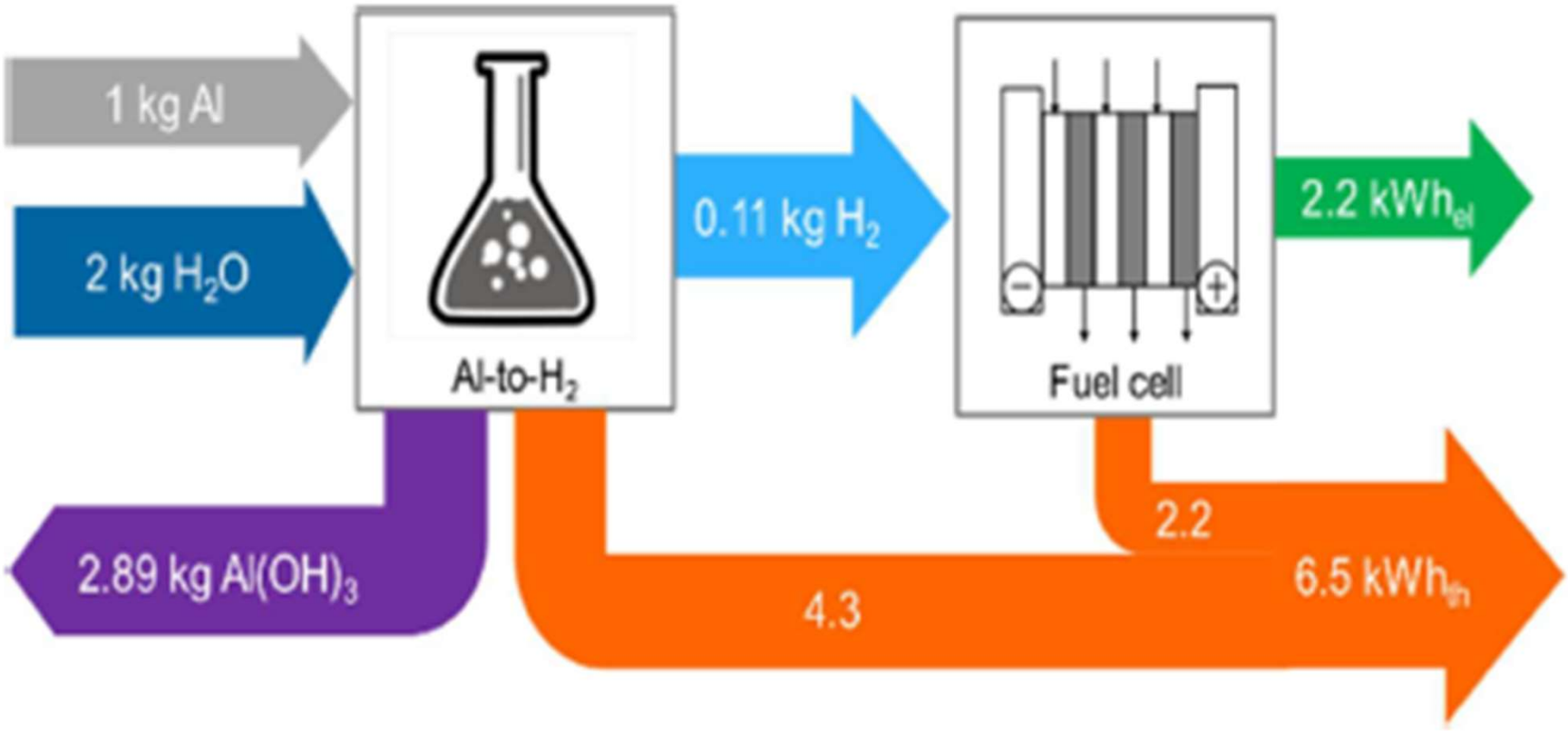
LIETUVOS ENERGETIKOS INSTITUTAS
http://www.lei.lt

R&D activities on hydrogen at Lithuanian Energy Institute

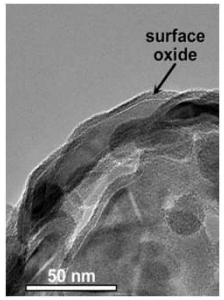
Main contact person:

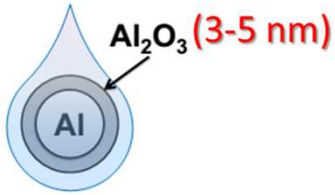
dr. Darius Milčius
Center for Hydrogen Energy Technologies
Lithuanian Energy Institute
darius.milcius@lei.lt

Al hydrolysis: energy balance

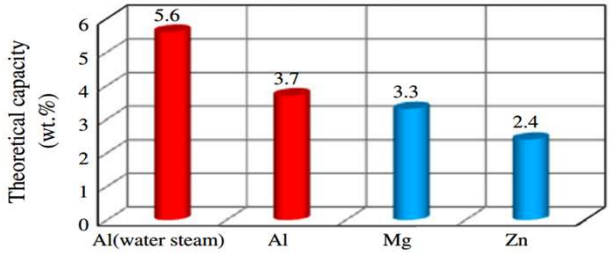


Hydrogen production as it needed: direct reaction of Al with water



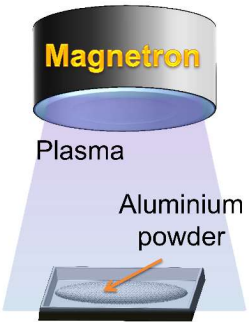


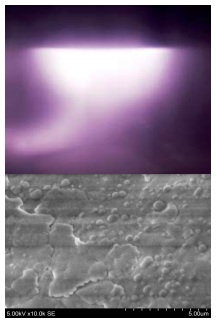
$$2Al + 6H_2O \rightarrow 2Al(OH)_3 + 3H_2$$

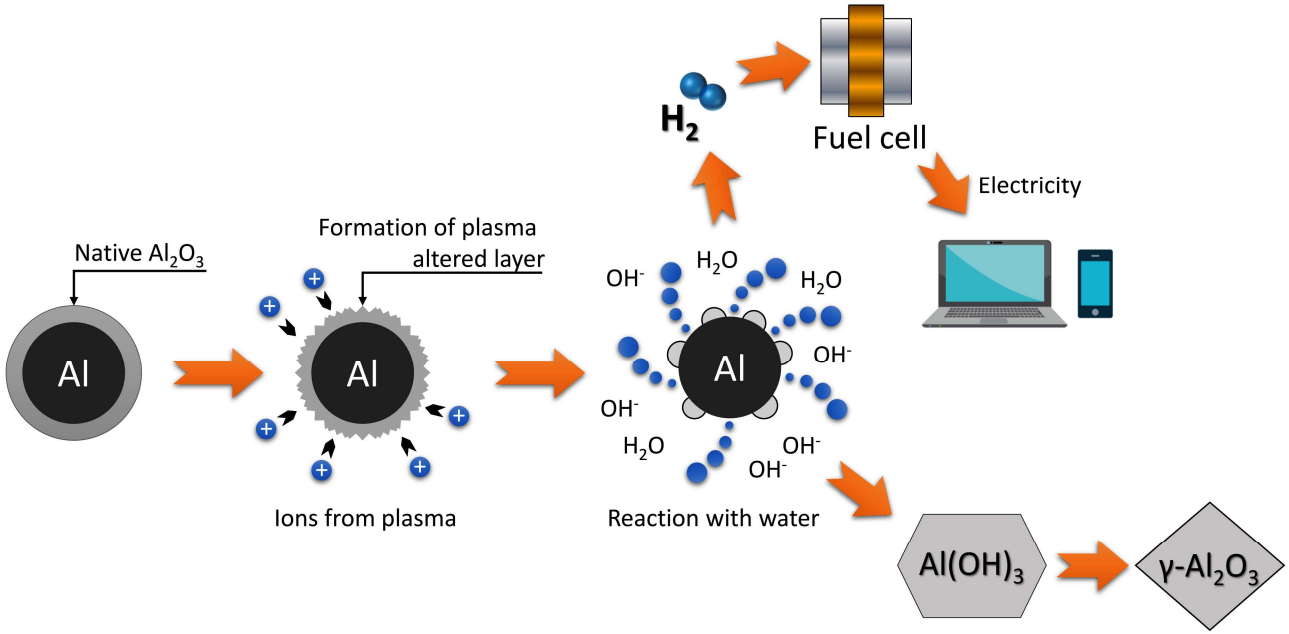


Wang H., Leung D.Y.C., Leung M.K.H. Energy analysis of hydrogen and electricity production from aluminum-based processes. *Applied Energy*, 2012, Vol. 90, no. 1, p. 100–105.

Gas plasma treatment



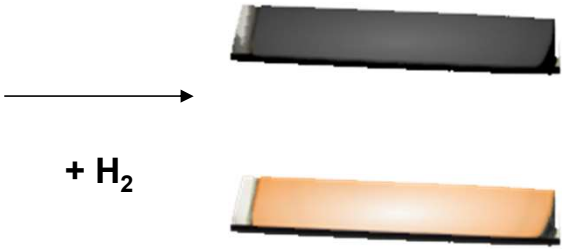


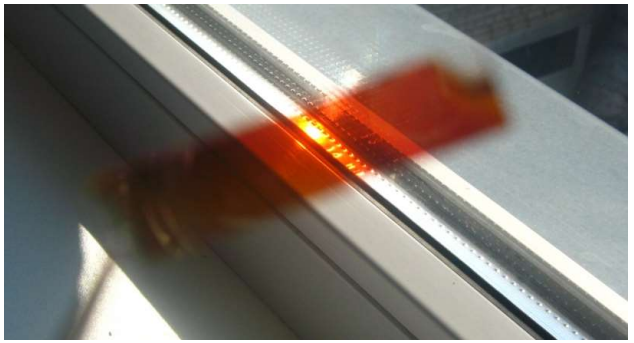


Milcius et.al. Patent application: PCT/IB2018/0522123

Mg_2NiH_4 thin films for hydrogen storage, production, smart windows, bio-fuels applications

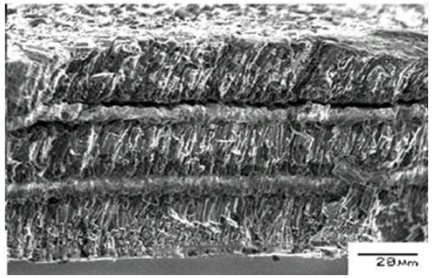
Mg_2Ni

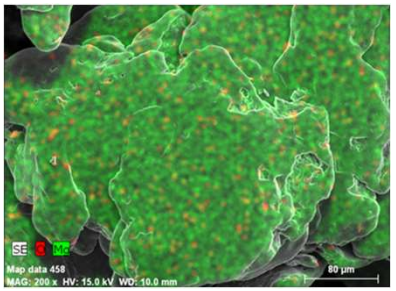




Mg_2NiH_4

MgH2-Ni-MgH2 layered systems.

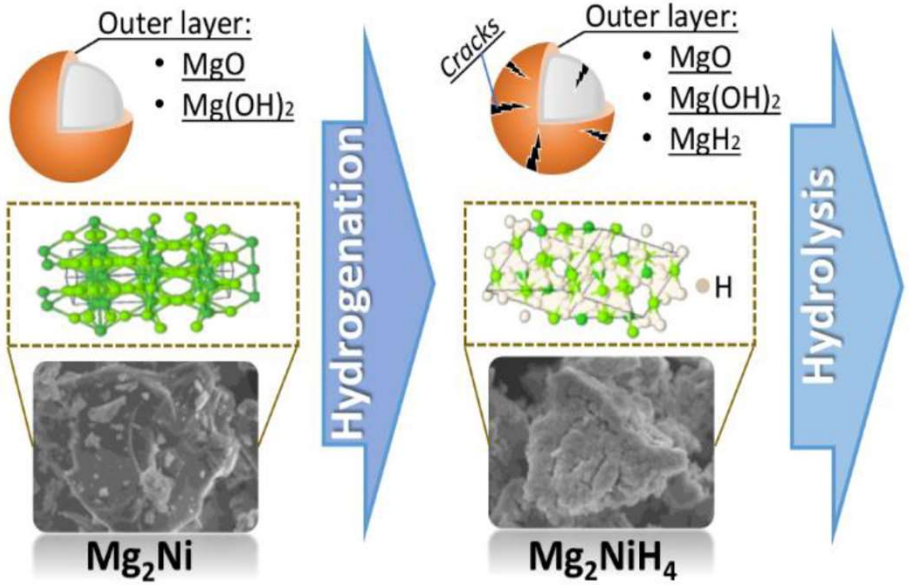


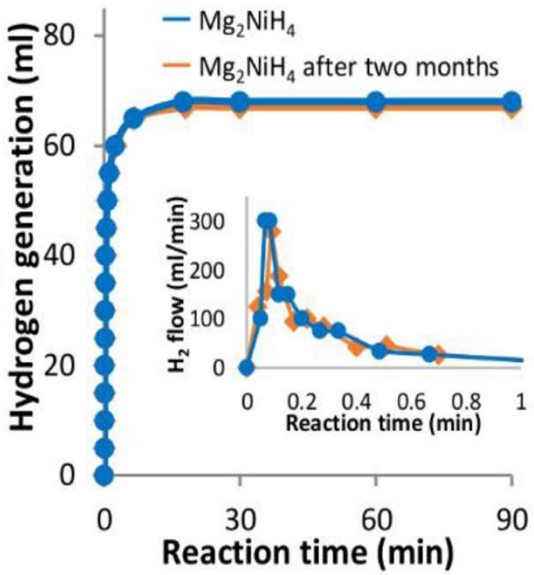


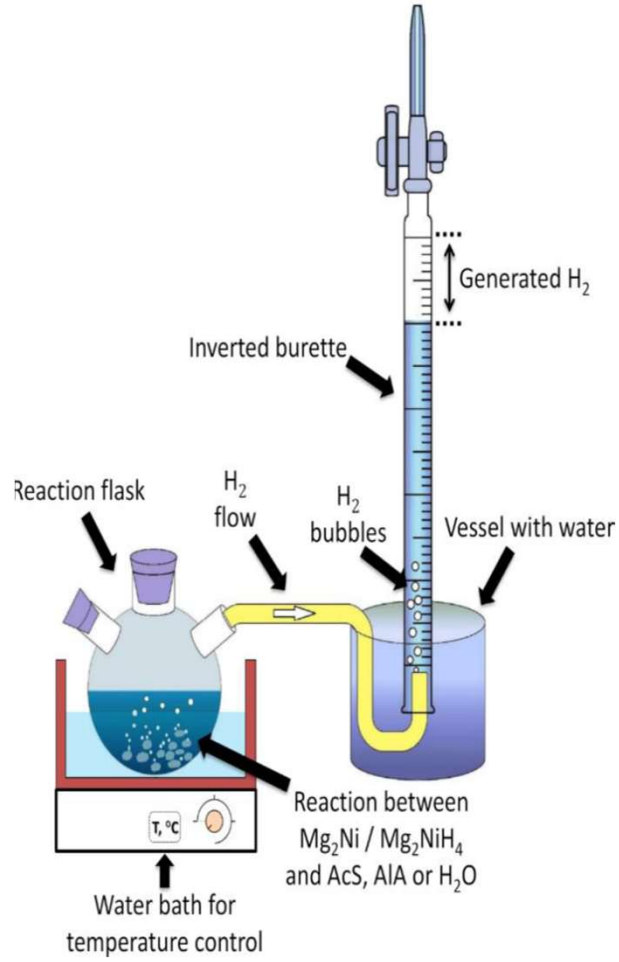
1. Wirth E., Milčius D., Filiou C., Noreus D. Exploring the hydrogen sorption capacity of Mg-NI powders produced by the vapour deposition technique // International journal of hydrogen energy. ISSN 0360-3199. 2008. Vol. 33, Iss. 12, p. 3122-3127.

Collaboration with Stockholm University, Department of Materials and Environmental Chemistry

Hydrogen generation kinetics via hydrolysis of Mg2Ni and Mg2NiH4 powders





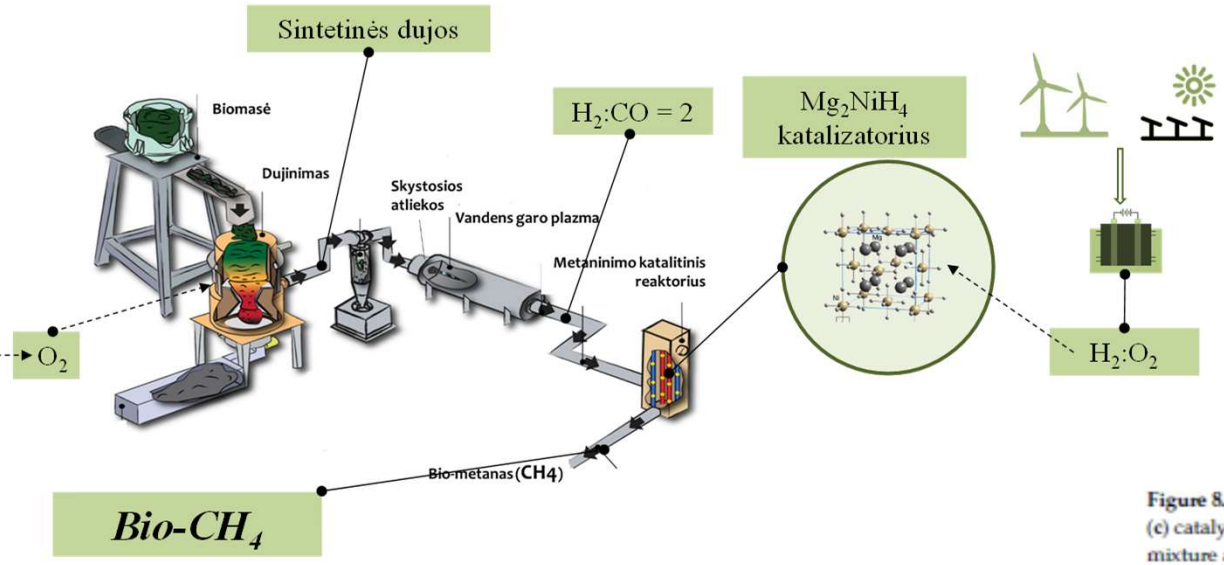


Milcius et. al. Method of hydrogenation of metals and their alloys. European Patent Office. Patent number : 10478001.0-2111.

The use of metal hydrides in production of synthetic fuels

Mg_2NiH4 – as Sabatier reactions catalyst and hydrogen source

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$$



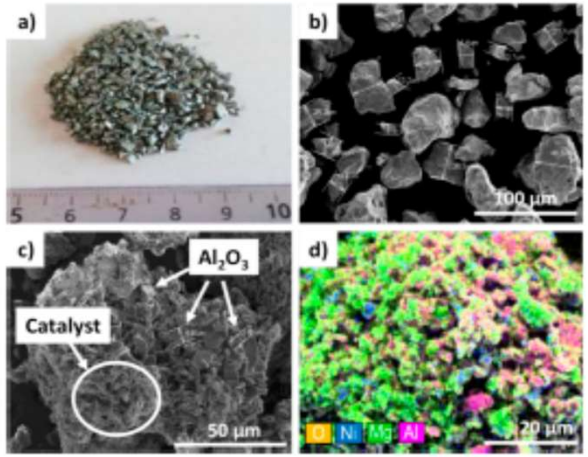
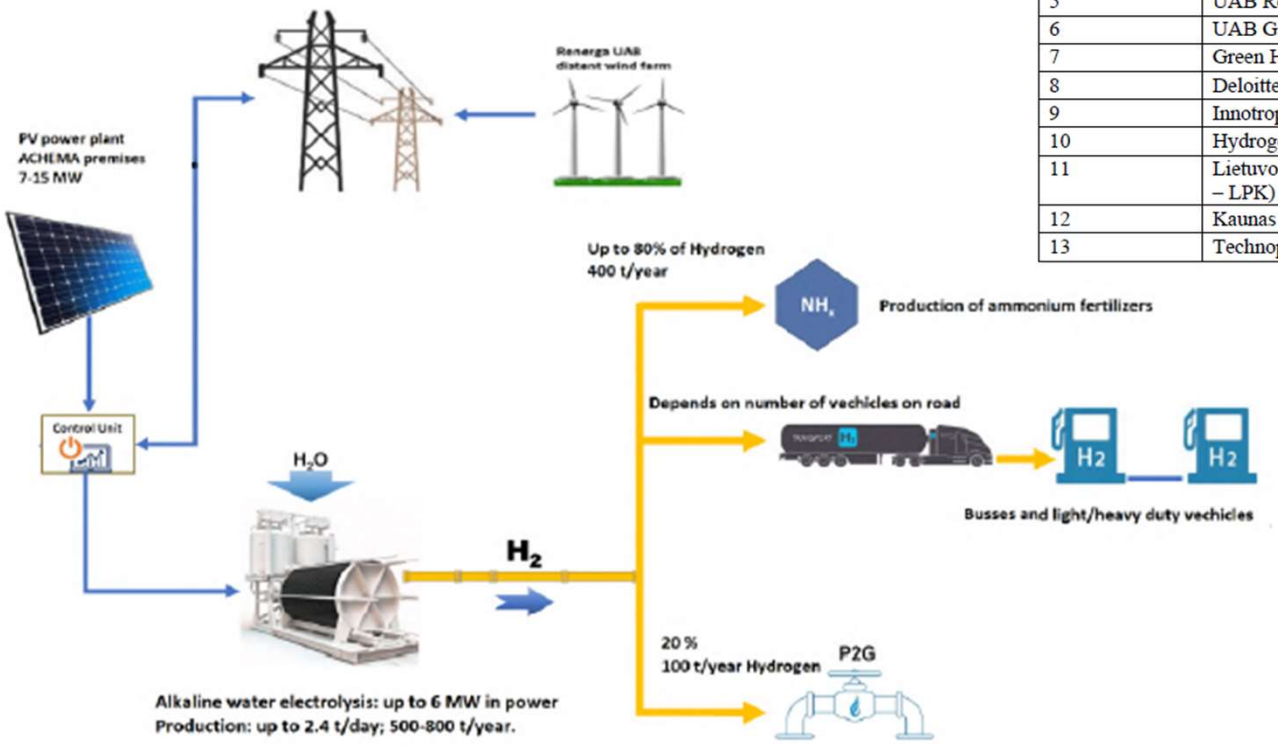


Figure 8. Optical and SEM images: (**a**) as received Mg_2Ni alloy grains, (**b**) Mg_2Ni grains after grinding, (**c**) catalyst–Al_2O_3 mixture after methanation test, and (**d**) EDS elemental mapping of catalyst–Al_2O_3 mixture after methanation test.

Lelis M. [LEI], Varnagiris Š. [LEI], Urbonavičius M. [LEI], Zakarauskas K. [LEI]. Investigation of Catalyst Development from Mg2NiH4 Hydride and Its Application for the CO2 Methanation Reaction In: Coatings. Basel: MDPI, 2020, vol. 10 (12), 1178, p. 1-15. ISSN 2079-6412.

Small Scale Hydrogen Valley

TOPIC ID: HORIZON-JTI-CLEANH2-2022-06-02 (SUBMITTED 20/09/2022)



List of participants

Participant No.	Participant organisation name	Country
1 (Coordinator)	Lietuvos Energetikos Institutas (Lithuanian Institute of Energy – LEI)	LT
2	Vytauto Didžiojo Universitetas (Vytautas Magnus University – VDU)	LT
3	AB Achema (Achema)	LT
4	AB Amber Grid (AG)	LT
5	UAB Renerga (Renerga)	LT
6	UAB Gaschema (Gaschema)	LT
7	Green Hydrogen Systems A/S (GHS)	DK
8	Deloitte Consulting SLU (Deloitte)	ES
9	Innotrope SAS (InnoT)	FR
10	Hydrogen Energy Association (HEA)	LT
11	Lietuvos Pramonininkų Konfederacija (Lithuanian Confederation of Industrialists – LPK)	LT
12	Kaunas University of Technology (KTU)	LT
13	Technopianti SRL (TP)	IT

Thank you for attention