Green hydrogen, has commission put all the eggs in a one basket ?

Lithuanian Embassy's Hydrogen Seminar

Helsinki 20.04.2021

By: Kimmo Siira

Finnish Energy

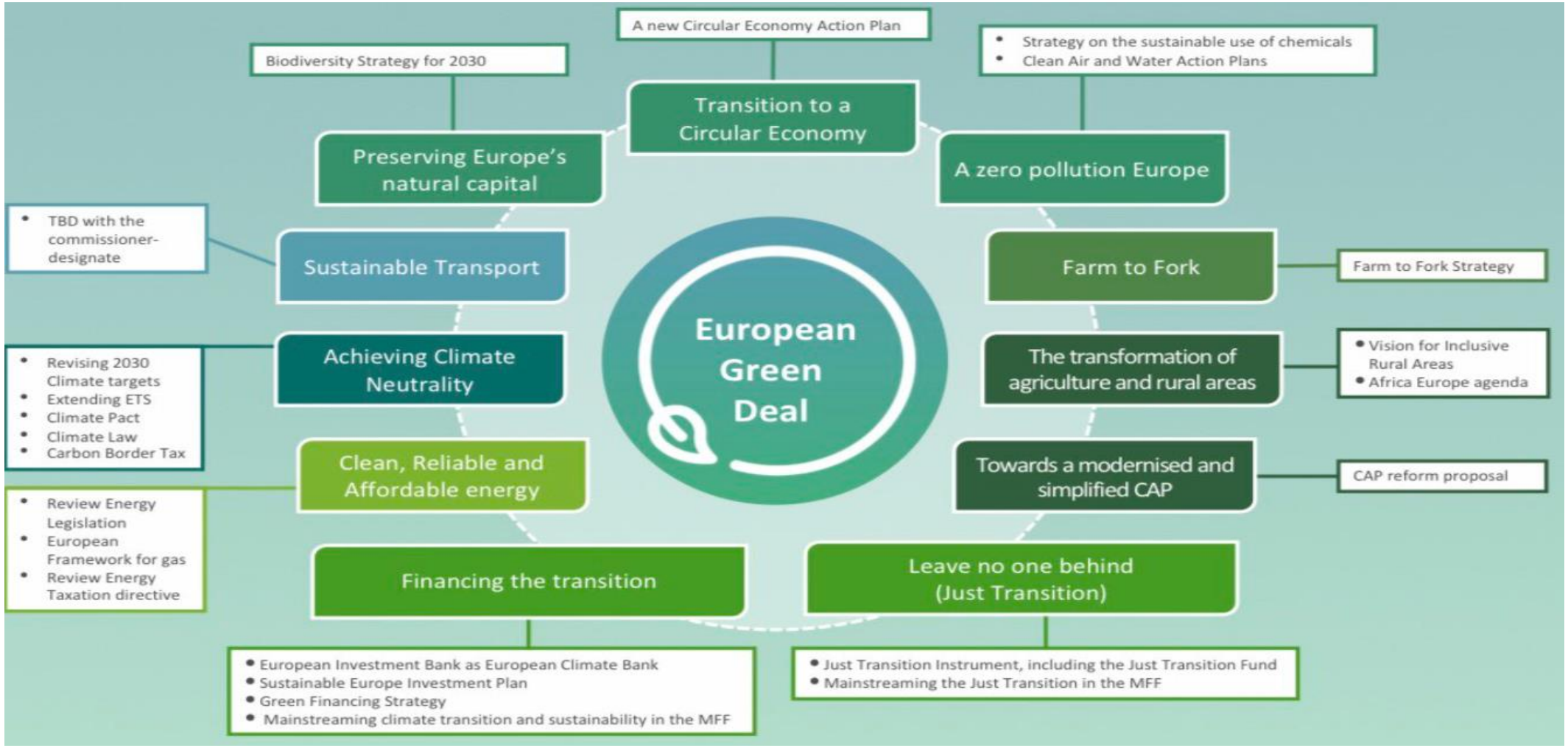
This is Hydrogen…

- Hydrogen is the chemical element with the symbol H and atomic number 1. With a standard atomic weight of 1.008, hydrogen is the **lightest element** in the periodic table. Hydrogen is the **most abundant** chemical substance in the universe, constituting roughly 75% of all baryonic mass.[7][note 1] Non-remnant stars are mainly composed of hydrogen in the plasma state. The most common isotope of hydrogen, termed *protium* (name rarely used, symbol ^{1}H), has one proton and no neutrons.
- Industrial production is mainly from steam reforming natural gas, and less often from more energy-intensive methods such as the **electrolysis of water**.[10] Most hydrogen is used near the site of its production, the two largest uses being fossil fuel processing (e.g., hydrocracking) and ammonia production, mostly for the fertilizer market. Hydrogen is problematic in metallurgy because it can **embrittle many metals**,[11] complicating the design of pipelines and storage tanks.[12]
- Hydrogen gas is **highly flammable**. It forms **explosive mixtures with air** in concentrations from 4–74%[15] and with chlorine at 5–95%. The explosive reactions may be triggered by spark, heat, or sunlight. The hydrogen autoignition temperature, the temperature of spontaneous ignition in air, is 500 °C (932 °F).[16]

This is Hydrogen to EU Commission…

- The European Green Deal is the plan to make the EU's economy **sustainable**
  - 100 mio t CO2 abetment by 2030 by using H2
  - Additional CO2 reductions from renewable energy increase
- Europe needs a new **growth** strategy that will transform the Union into a modern, resource-efficient and competitive economy
  - 170.000 jobs just in H2 electrolyze production
  - Renewable energy development and production
  - Infrastructure development
  - R&D increases
  - Power to X
  - Potential for **over 1 million new jobs**
- Turning climate and environmental challenges into opportunities…. by using **green hydrogen**

It all starts with the Grean Deal

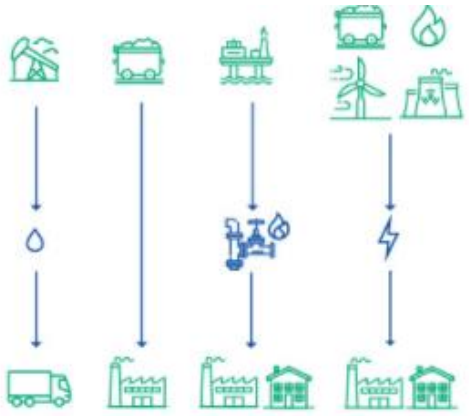


Grean Deal's linkage to ESI strategy

" This strategy will profoundly reform the European energy system. We are designing a more efficient and integrated system that links energy sources and infrastructure to support decarbonization and build a climate neutral EU by 2050. It will help to build modern infrastructure, make European industry more sustainable and competitive, create jobs, and provide clean energy for citizens"

Energy system today;

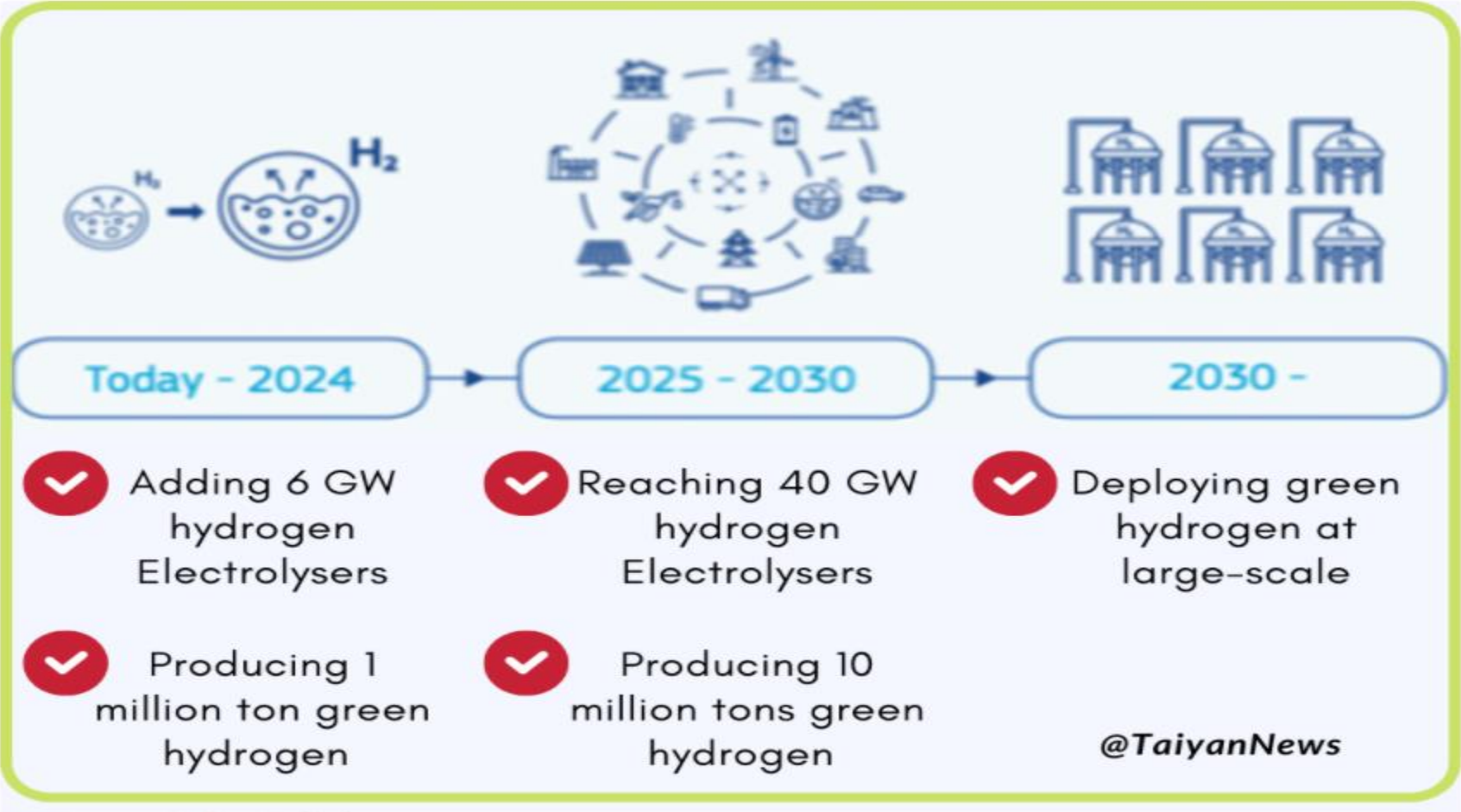
- Flows into on direction
- Linear
- Wasteful



Energy system in the near future;

- Flows into multi directions
- Producers, consumers and prosumers creating the markets
- Reducing wasted resources and saving money

Hydrogen is not a hoax… there is now a road map



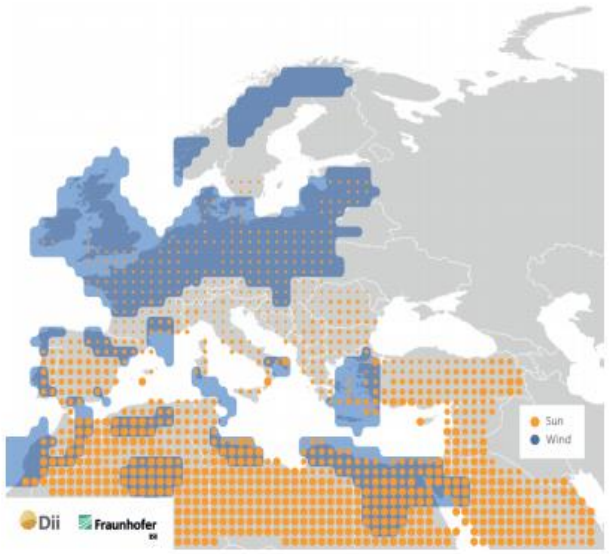
Where ESI strategy has an impact?

Ongoing and upcoming legislative proposals (2020 and 2021)

- Revision of TEN-E Regulation (by end of 2021)
- REFUEL Aviation and Fuel Maritime Initiative (By end of 2020)
- Revision of the State Aid Framework (by 2021)
  - Currently State aid rules are relaxed by until summer 2021
- Revision of the TEN-T Regulation (by 2021)
- Revision of the Alterative Fuels Infrastructure directive (by 2021)
- Revision of the Industrial Emission Directive (2021)
- Revision of the Energy Taxation directive (expected by Q2 2021)
- Revision of the gas legislative framework, “Gas Directive” (2021)
- Revise of the CO2 emission standards for cars and vans (proposal by June 2021)
- Revision of the Energy Efficiency Directive (June 2021)
- Revision of the Renewable Energy Directive (June 2021)
- New Common Agricultural Policy (2021 onwards)
  - EU Methane strategy by oct 2020

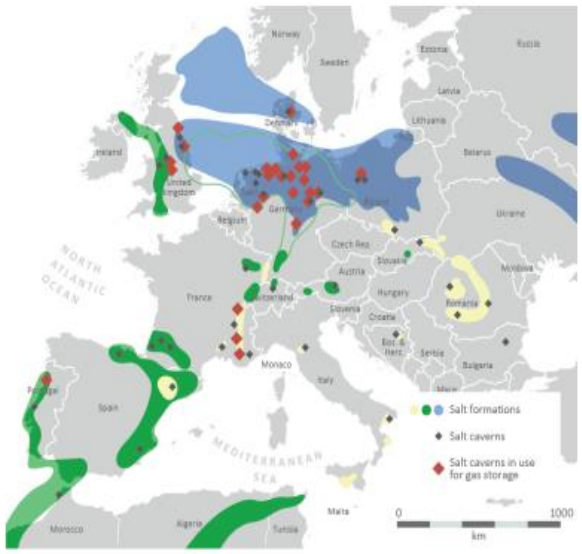
It started with a vision of 2x40 GW Hydrogen production

Solar/wind resources



Hydrogen backbone

Salt Caverns

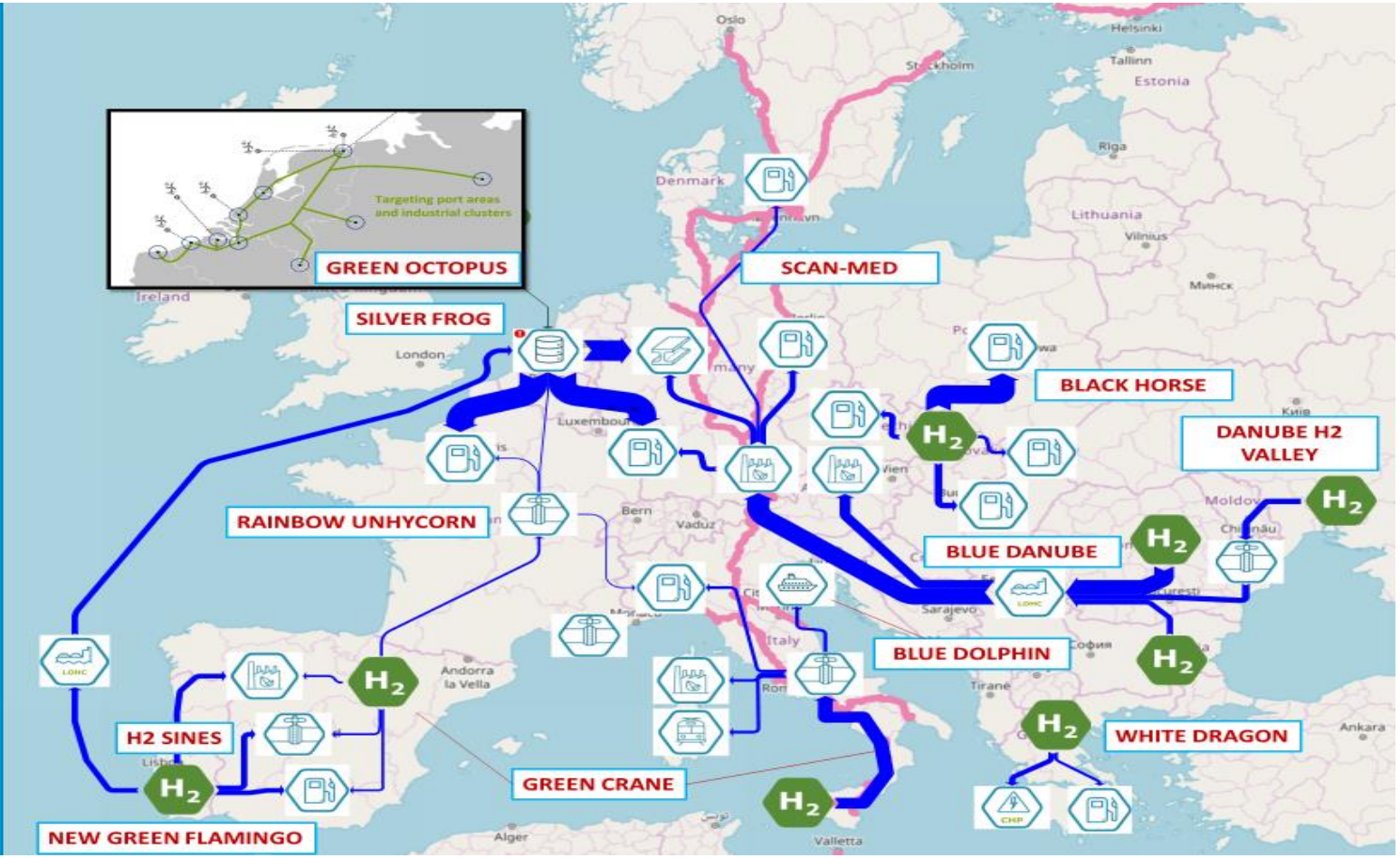


Geographical funding need estimations:

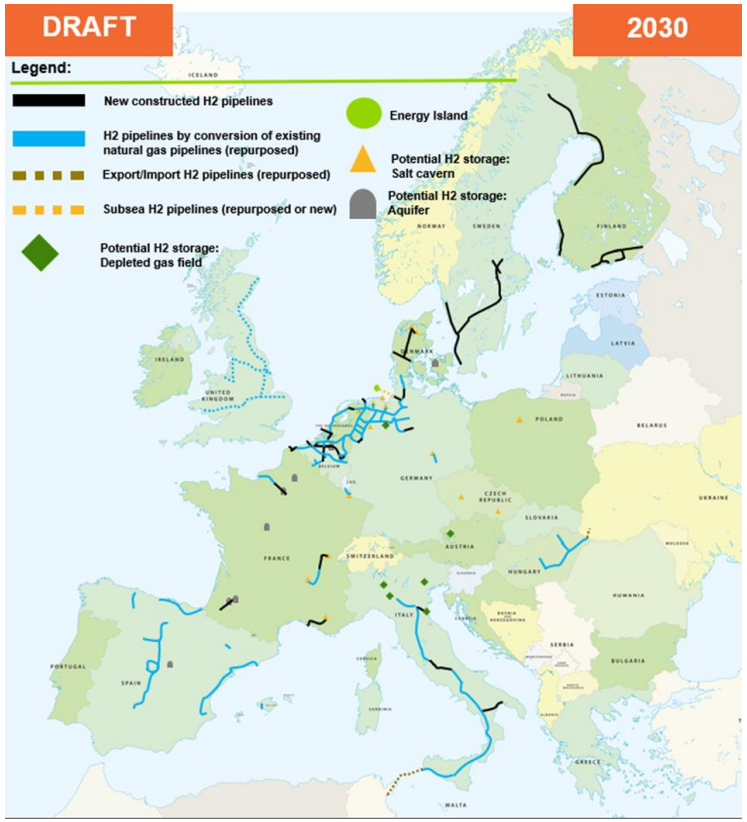
- **EU 40 GW of Electrolysers worth 95 billion € combined, including renewable energy production investments**
- **Ukraine 10 GW of Electrolysers worth 20 billion € all included**
- **North Africa 30 GW of Electrolysers worth 72 billion € all included**

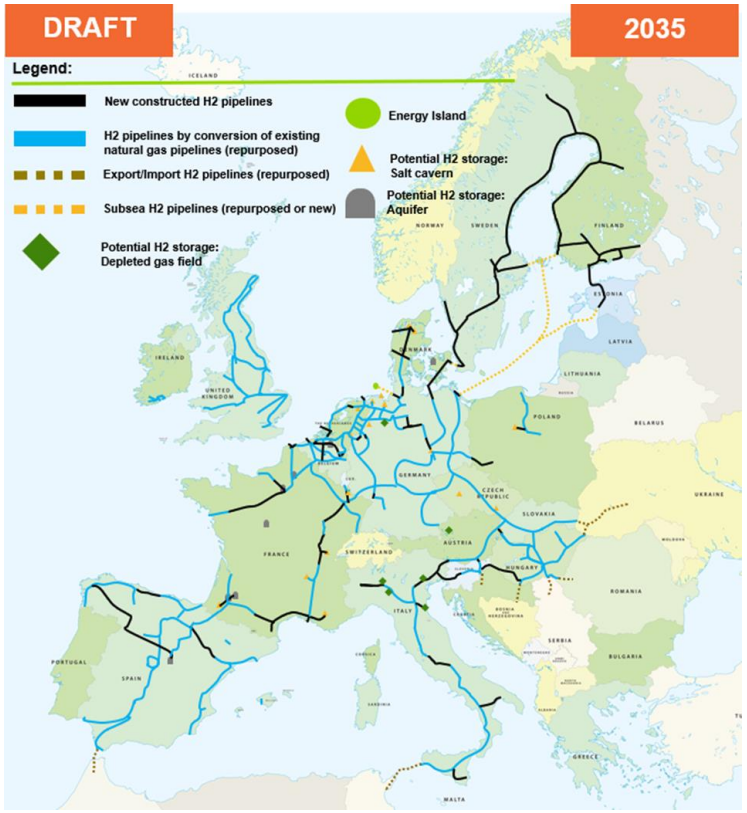
Things are developing fast… after 6 months

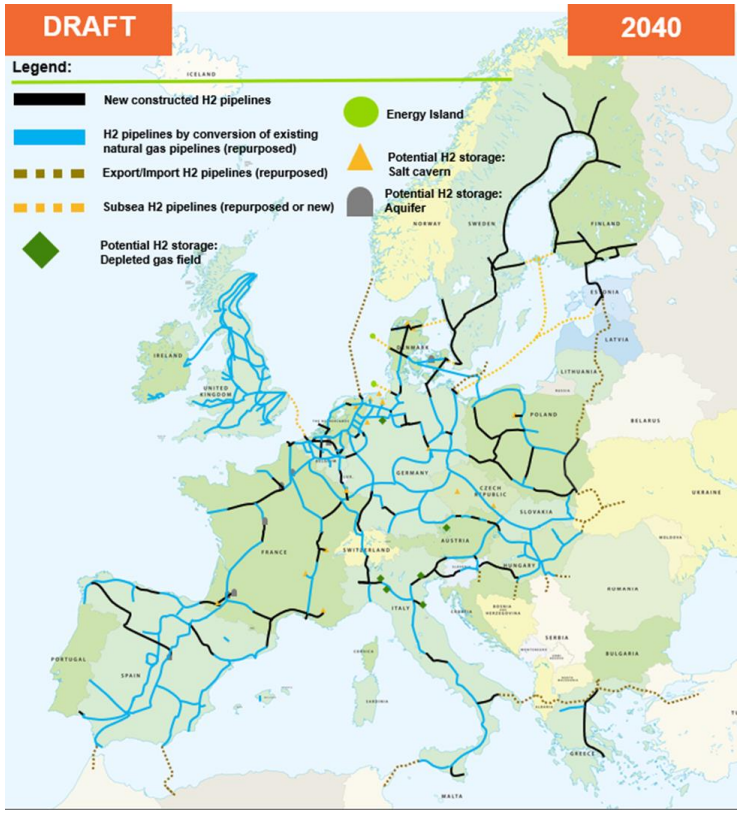
Large scale up integrated projects covering multiple EU Member States



Hydrogen backbone, TSO's vision of hydrogen future





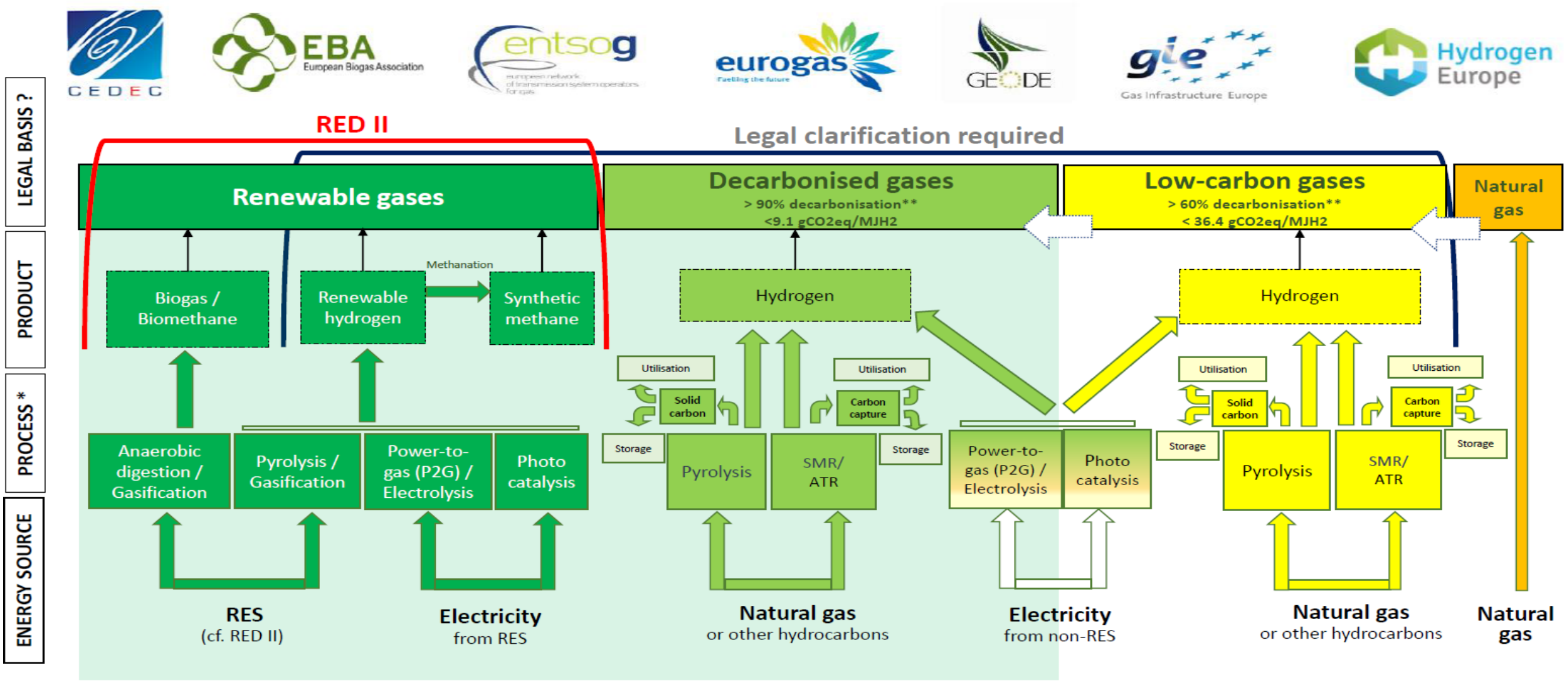


- Hydrogen backbone will eventually be 37 000 km covering 11countries
- Investments costs estimated 41-78 billion € (ref. EU's estimation of hydrogen investment needs > 400 billion €)
- Pipeline would utilize 68% of existing natural gas pipeline ja 32% new build special for hydrogen

And there is now money to spend…

- Germany looking to invest 7+2 billion € on green hydrogen by 2030
- Netherland has a 9 billion € “hydrogen valley” program
- Portugal 7 billion € h2 plans until 2030
- France 7 billion € hydrogen program
  - Looking to link with Germany
  - Overall investments into green energy policies around 100 bio € by 2030
- Hydrogen Europe estimates spending needs by 2030
  - Electrolysers 26,2 billion €
  - Off-shore wind 44,7 billion €
  - On-shore wind 37 billion €
  - Solar PV 28,2 billion €
  - Existing H2 production with carbon capture storage / utilization 20 billion €
  - Coal gasification with CCSU(Poland, Hungary, Romania and Bulgaria specific) 12 billion€

And where it all started to go wrong…



Disclaimer:

* This overview is based on existing processes and known technologies and evidently does not preclude any other existing process or new technological developments.

** The GHG reduction is calculated on the BAT 91 gCO2/MJH2 derived from CertifHy and could be replaced by a comparable threshold pending confirmation of the methodological basis for CertifHy.

And now we have all colors of rainbow…

Summary of current situation

- Commission has a hydrogen road map, but do not know how to execute the plan
- Theoretically there are plenty of funding possibilities, but how it will be distributed?
- Discussions are still on higher level and lagging concrete actions
- EU is making this more of a political agenda rather than economical or energy policy
- Baltics are moving slowly towards hydrogen
  - Scandinavia and Baltics have an advantages to become a H2 player
    - Relatively cheap electricity mix
    - Fresh water available
    - Existing infrastructure
    - Heat has a price, so location is a key
- NGOs are heavily involved as there is so much money to be spend
- There are significant delays….just trying to define green hydrogen seems to be impossible
- **Hydrogen is not an end game, but rather an enabler to energy transition**

Grean Deal and hydrogen directs all commission’s current workload

- Energy
- Environment
- Mobility and transport
- Regional policy and the low-carbon economy
- Sustainable finance
- Industrial policy
- Trade and sustainable development
- International cooperation and development
- Research and innovation on climate change
- Sustainable development goals

What about Baltics?

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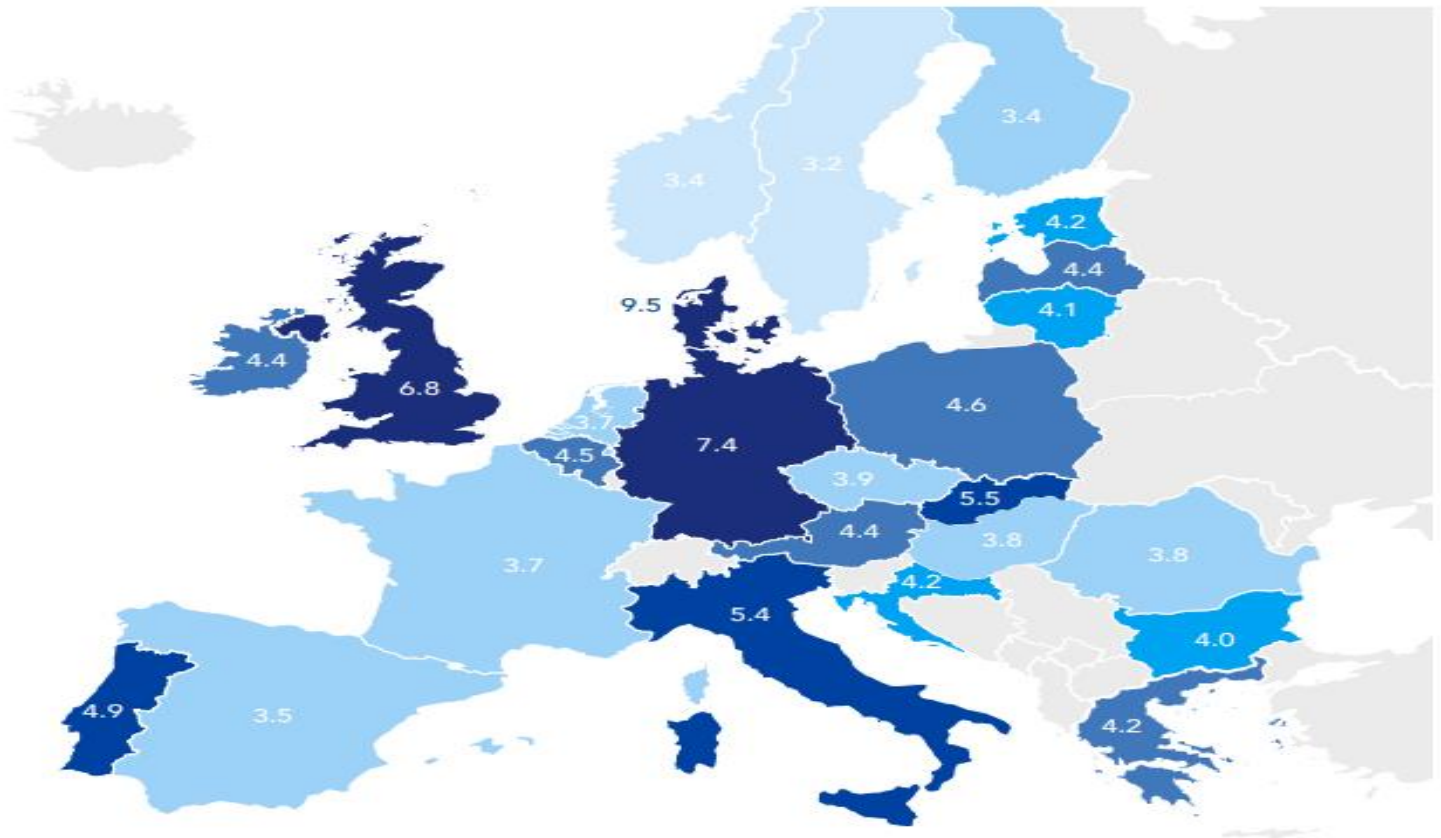
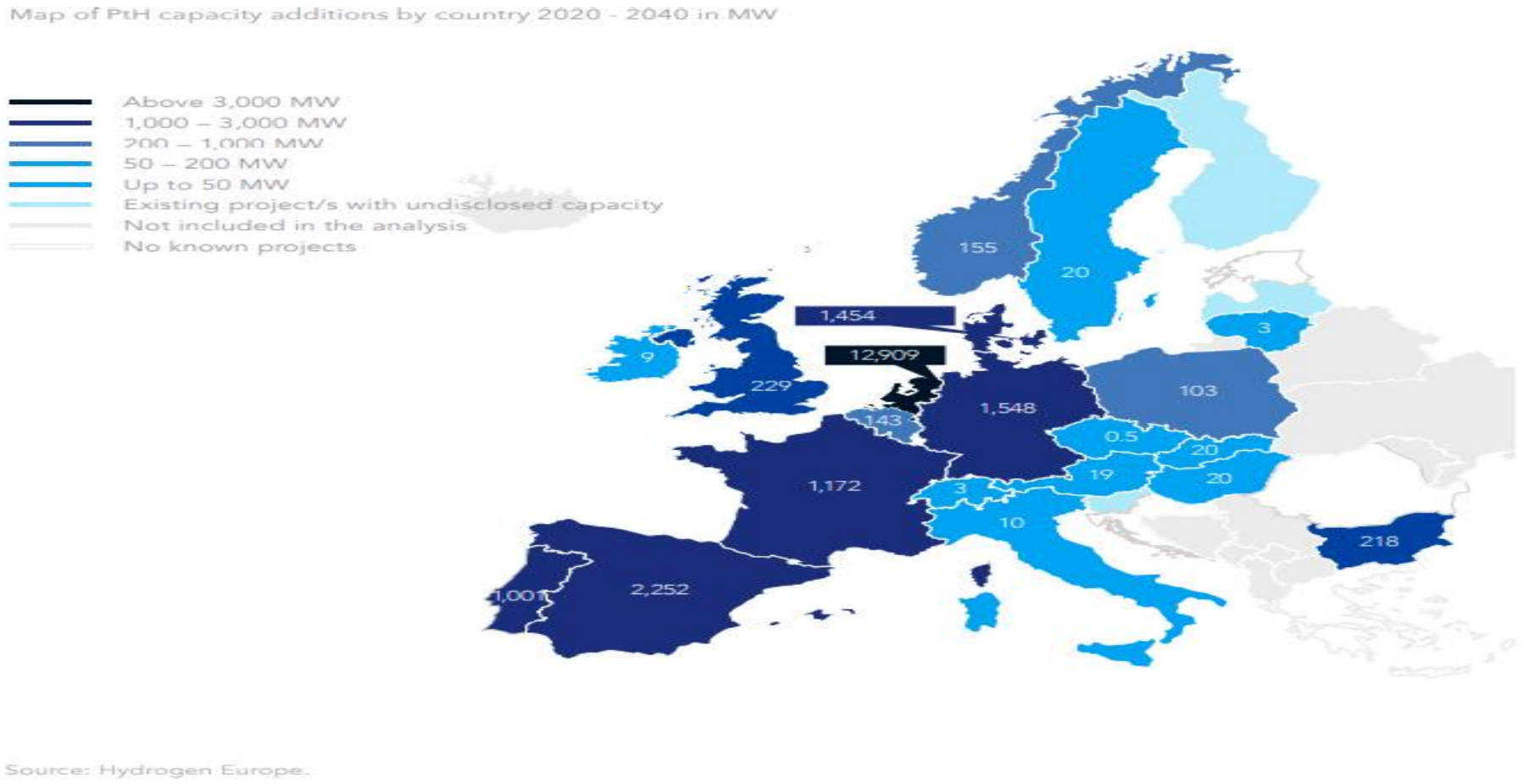
Hydrogen costs / country

Map of grid connected electrolysis hydrogen production costs in the EU in 2019



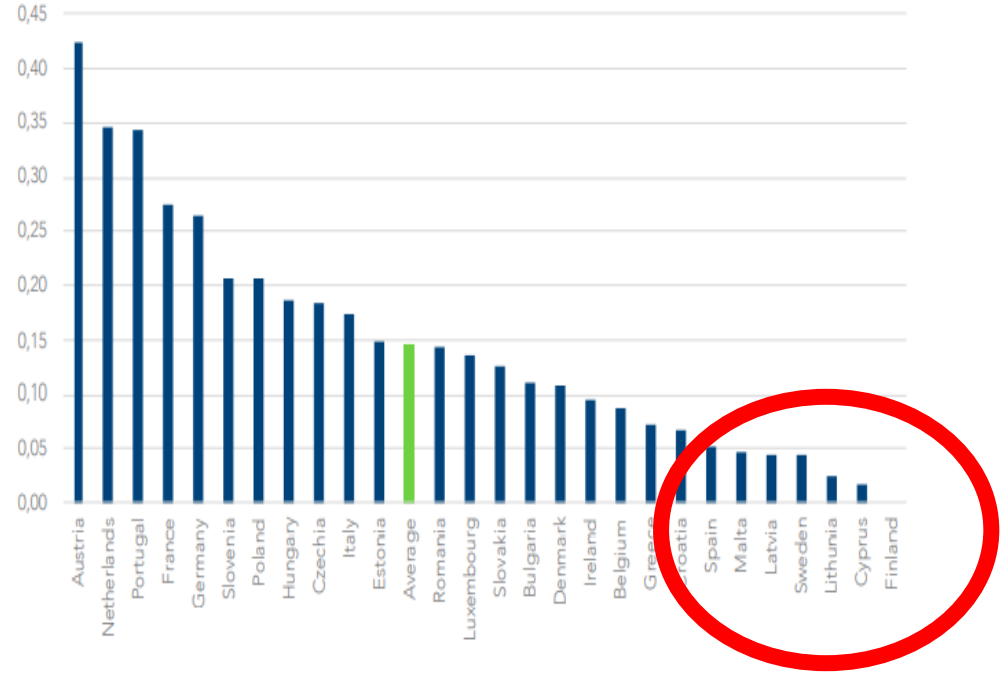
Source: Hydrogen Europe.

Yet Finland and Baltics are falling behind



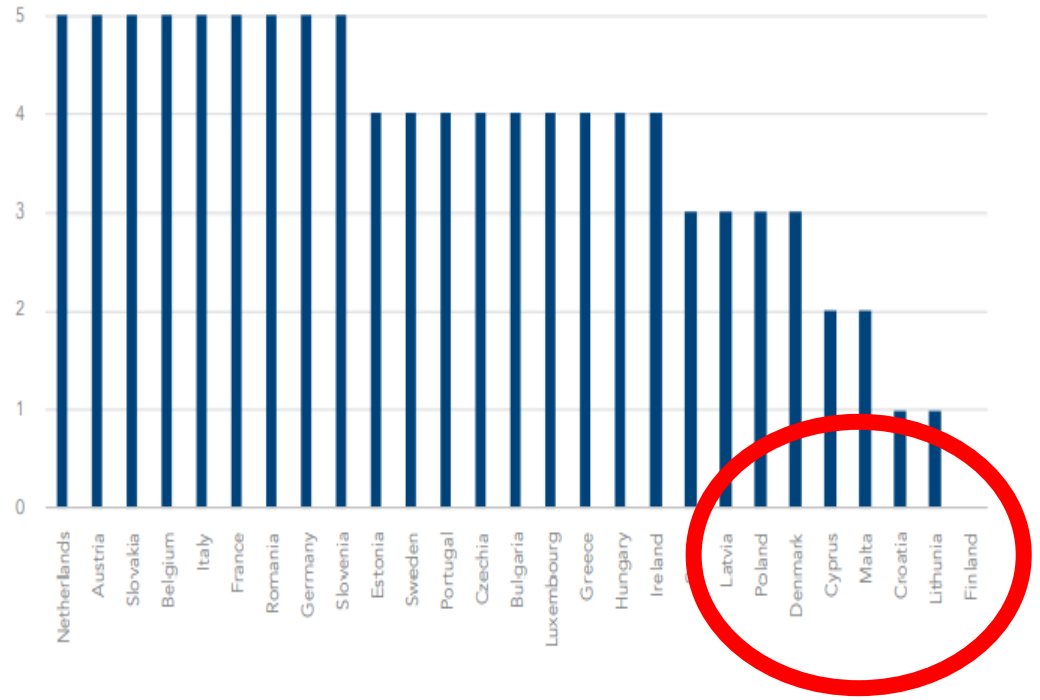
EU countries' NECP including hydrogen

Ratio of hydrogen mentions per NECP page per Member State



Reading key: The 0.15 average ratio (in green) means that a hydrogen mention appears every 6 to 7 pages on the average NECP.

Number of hydrogen applications tackled per Member State in their NECP



What is happening in Finland

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National Hydrogen Cluster

Developing hydrogen economy through collaboration

Hydrogen Cluster – Steering Group

OUTI ERVASTI, NESTE
- Chair
- outi.ervasti@neste.com

MARKO JANHUNEN, UPM
- marko.janhunen@upm.com

SAKARI KALLO, SSAB
- Workgroup 2, Innovation and investment projects
- sakari.kallo@ssab.com

MATTI MALKAMÄKI, AURELIA TURBINES
- Workgroup 3, EU Networking
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MIKKO MUONIOVAARA, FORTUM
- mikko.muoniovaara@fortum.com

OLLI SIPILÄ, GASGRID
- Workgroup 4, Operating environment and regulation
- olli.sipila@gasgrid.fi

SIMO SÄYNEVIRTA, ABB
- Workgroup 1, How will Finland differentiate
- simo.saynevirta@fi.abb.com

MIKAEL WIDESKOG, WÄRTSILÄ
- mikael.wideskog@wartsila.com

Operating Model and Work Groups 2021

Steering Group – chair Outi Ervasti, Neste

Cluster meetings – 30 companies and industry associations

- Common interests, focus areas, working groups, financials
- Stakeholder group and collaboration meetings

How will Finland differentiate

Simo Säynevirta, ABB

- System level energy efficiency optimisation
- Competitive solutions and capabilities
- Value networks, collaborations, IPCEI

Innovation and investment projects

Sakari Kallo, SSAB

- Summary of Hydrogen projects in Finland
- Linkage to EU Hydrogen IPCEI projects
- R&D and investment financing
- Recovery Package

EU-networking

Matti Malkamäki, Aurelia Turbines

- ECH2A Roundtables
- Hydrogen IPCEI preparations at EU-level
- BothH_2nia - project
- EU-affairs and information sharing

Operating environment and regulation

Olli Sipilä, Gasgrid

- Combined view from the cluster company
- Evaluation on impacts of the coming regulation and taxation
- Cluster statements

Secretariat

BothH_2nia – the hydrogen bay of the North

Large industrial H_2 users

- SSAB, LKAB, Kokkola Industrial Park, Kemira, ...

Multiple bio-product plants

- GHG-neutral CO_2

Renewable energy available

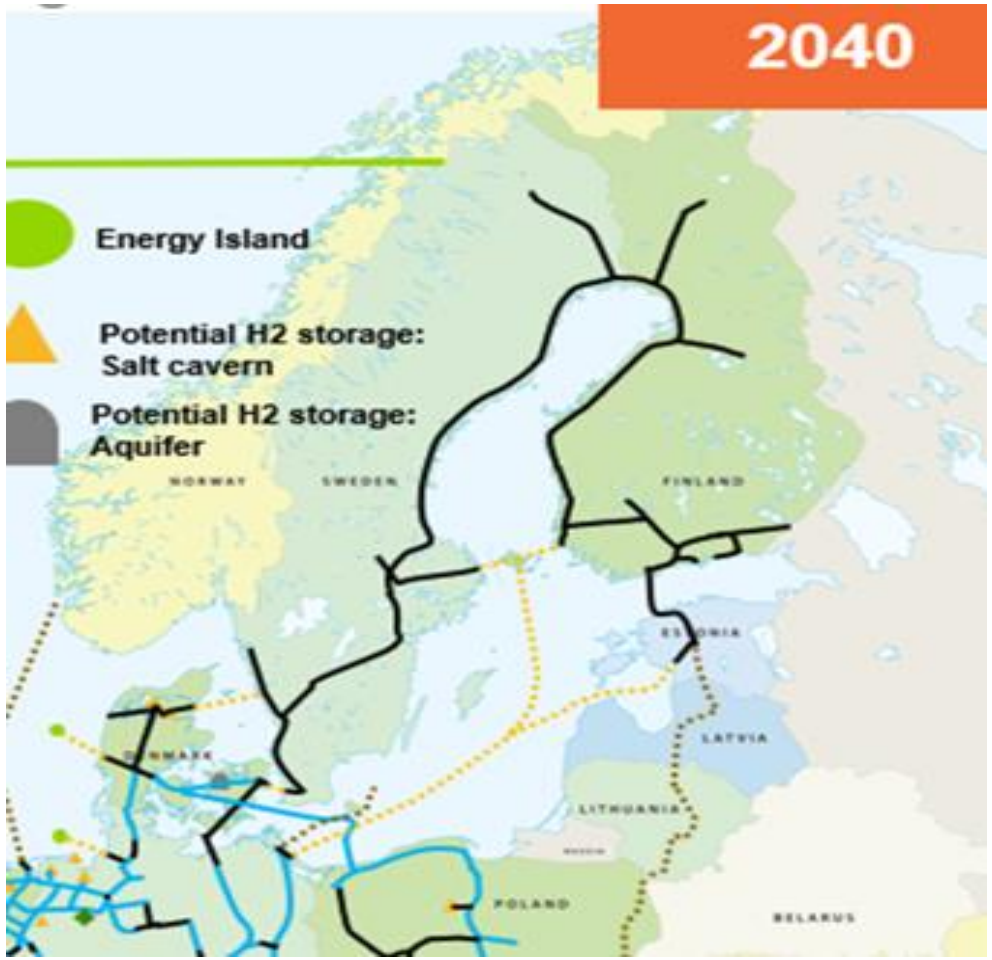
- Up to 10 GW of new off-shore wind capacity planned
- Lots of hydropower and biomass

New nuclear plants as back-up

- OL3, Pyhäjoki, total 2.8 GW

Developed infrastructure

- Stable power grid, joint market
- >15 industrial harbours
- H_2 grid proposed (see line)



Access to Central European Markets

- Germany, Poland, Denmark, Netherlands...

Public-Private -cooperation

- Very close cooperation compared to most other areas
- Good examples of successful cross-border projects

Active projects on-going

- Nordic Arc / Hydrogen Bay - projects

National H_2 clusters

- Swedish H_2 Development Center
- Finnish H_2 Cluster

Cooperation within EU

- ECH2A
- Hydrogen Europe

EU financing possibilities

- EIC / EASME
- IPCEI
- EIB / EIF / RRF,...

Both$_2$nia – what's next?

Open collaboration

- Everyone can refer to the brand
  - Helps in the search for financing, etc.
- All needed parties invited on board
  - From cities & municipalities to companies
  - National gas and electricity grid companies
  - Local district heating network companies
  - Legal framework, financiers
  - Universities, associations
  - International partners, governments, etc.
- Theme groups established as needed
  - To enhance collaboration and communication

Finnish kick-off 23.4. 10:00-12:00


Finnish Energy in a nutshell

We represent Finnish energy

Personnel

37

Finnish Energy

15

Adato Energia Oy

The energy sector employs

about **15,000**

people

268

members

60

cooperation members

Over EUR **2** billion

in annual investments

→

about **40**%

of all investments by industry

Big changes

Carbon neutrality and renewables

"Challenging because investments are made in the long term, but the operating environment changes rapidly."

Global competition

"A market viewpoint – we must think that competition is in society's interests. There are markets of different sizes, not only the domestic market in Finland."

Digitalisation

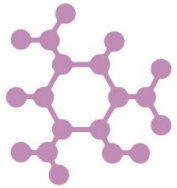
"For how long will the energy companies dominate the field? Major ICT companies are coming."
"New technological innovations change the disciplines."

The rise of customers

"The customer's role increases."
"..demand more: information, they are well-informed, they want to know about emissions, to do things independently. This will become more pronounced."

Big changes

Carbon neutrality and renewables



Digitalisation

Global competition

The rise of customers

Vision

Finnish Energy is the most influental branch organisation in Finland, leading society towards a sustainable future without bias.

Finnish Energy's tasks

Building a climate-neutral society.

Improving the operating preconditions of its member companies.

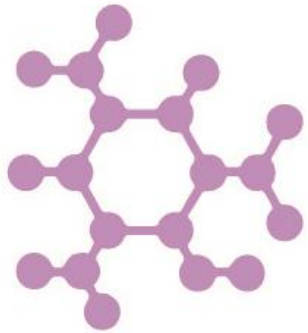
Promoting the production and use of market-based and reliable electricity and heat.

Supporting the reform of the energy sector by producing and distributing information.

This is how we do it

We undertake a reform in the energy industry in a responsible way and renew ourselves in the same process

We carefully listen to the needs and wishes of current and new members



We build partnerships transparently, are inspired by cooperation and have a broad understanding of different stakeholders.

We carry out policy advocacy in an expert and professional way, utilise the latest knowledge and are competent in the use of communication channels.

Adato – refining energy-related information

Adato Energia Oy promotes the efficiency and renewal of the operation of Finnish energy companies by organising timely training courses and events and by providing information services in support of our client companies' operations.

Energy-sector training and seminars

- 6,000 participants / year
- 1,200 expert lecturers
- At more than 20 localities each year
- Classroom & online teaching and webinars

Information services

- District heat extra
- Electricity network extra
- Energy products for end customers

Customer communications

- Electronic customer communications – internet and social media
- Customer magazines online/print
  - 720,000 customer magazines sent to home addresses
  - 150 articles per year
- Energy news

Other publications

- Sector agreements and guidelines
- Textbooks

Customer surveys of energy companies

Thank you

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Finnish Energy

Hydrogen Roadmap for Finland (until 2030)

Janne Kärki, VTT

INTRODUCTION

- Business Finland contracted VTT to prepare a national hydrogen roadmap for Finland and it was published on November 2020
- Main aim was to analyze Finland's strengths and opportunities in the entire hydrogen value chain
- Roadmap's time horizon was set to 2030

- Work is mainly based on information from public sources, but also interviews with relevant industry representatives were conducted (>80 contacts)
- Only public information and results of VTT's team judgements are presented today

Report available:
https://www.businessfinland.fi/en/whats-new/news/cision-releases/2020/national-hydrogen-roadmap-guides-finland-towards-carbon-neutrality

Green hydrogen business is taking big steps

Air Products announce $5 billion renewable hydrogen to ammonia project in Saudi Arabia

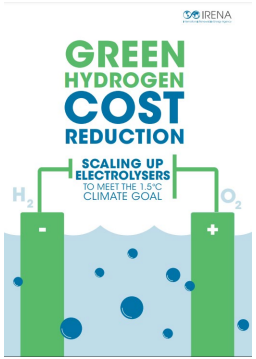
DATE POSTED: **16TH AUG 2020**

Green hydrogen: ITM Power's new gigafactory will cut costs of electrolysers by almost 40%

Feb 02, 2021

Endesa wants to invest €2.9bn in 23 hydrogen projects

Nel to slash cost of electrolysers by 75%, with green hydrogen at same price as fossil H2 by 2025



European Commission Unveils its Hydrogen Strategy

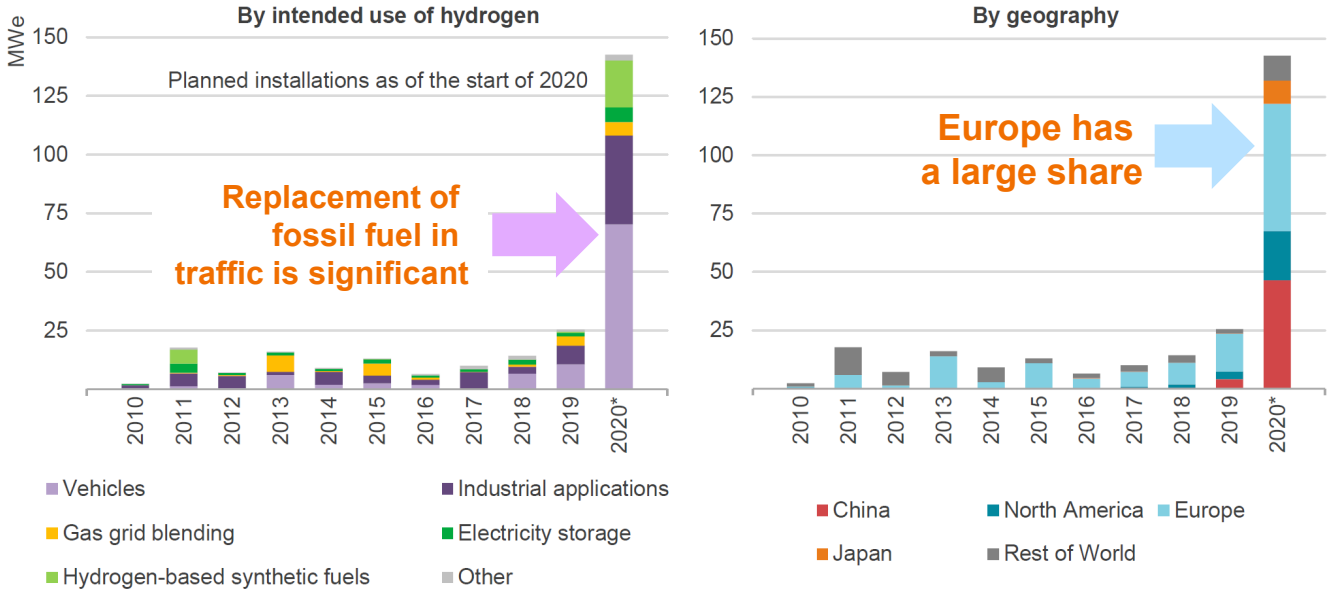
By FuelCellsWorks | July 8, 2020 | *8 min read* (1465 words)

By 2024 at least 6 GW of electrolyser capacity installed
By 2030 at least 40 GW of electrolyser capacity installed

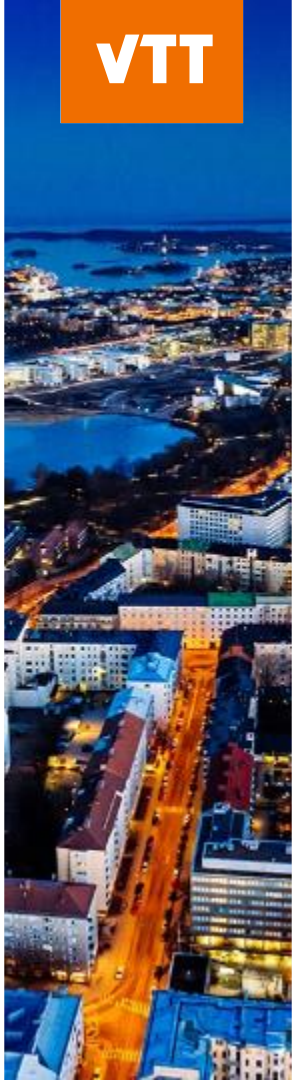
10 years of "warm-up" and now the race has begun

A record capacity of electrolysers to produce hydrogen was added in 2019, supported by vehicles in Europe and industry in China, with a far bigger wave of projects on its way

Capacity of electrolysers for hydrogen production by commissioning year, by intended use of hydrogen (left) and geography (right)

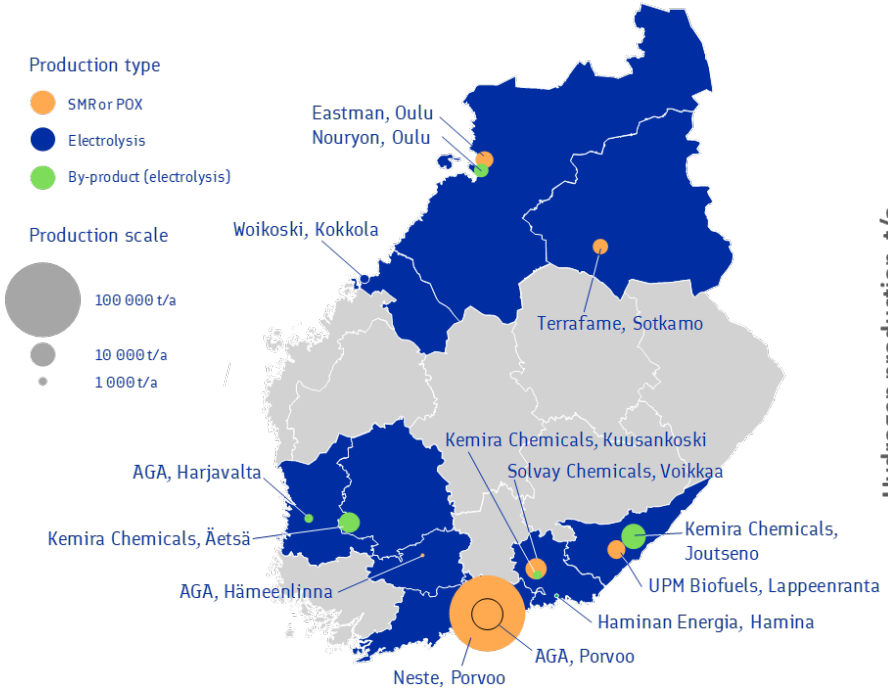


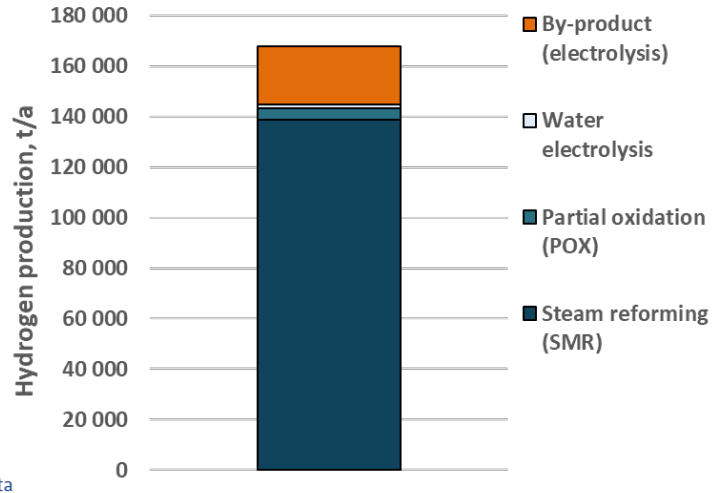
Source: IEA World Energy Investment (2020)



HYDROGEN IN FINLAND

Hydrogen in Finland – Current production and use





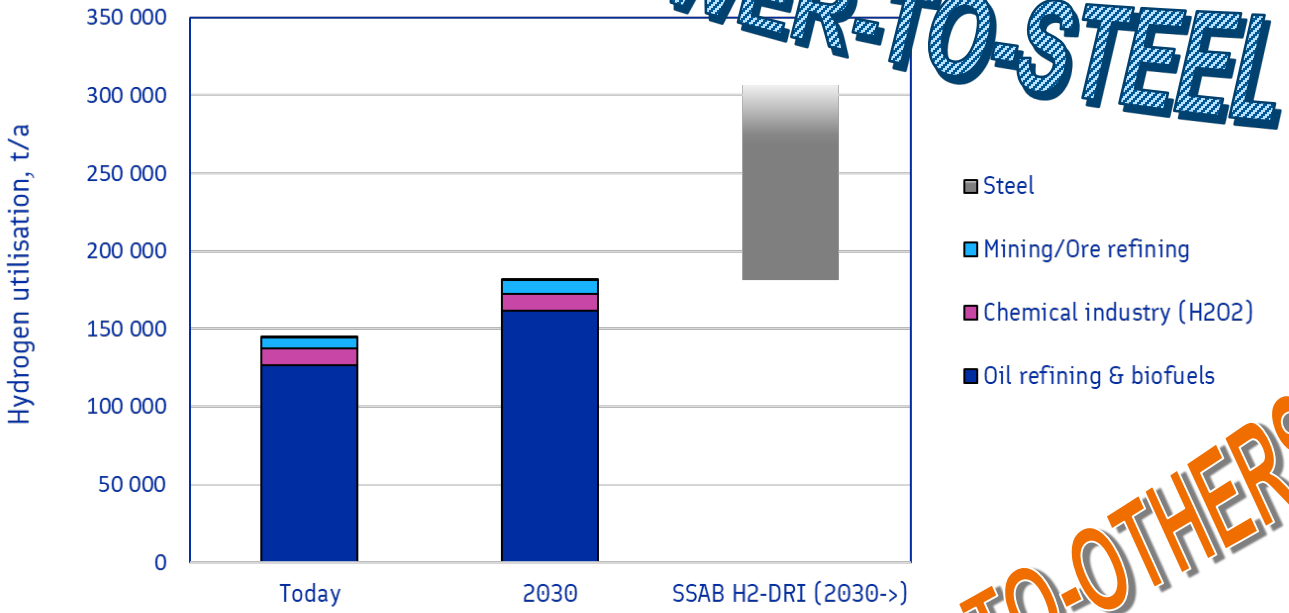
Current production and use ca. 150 000 t/a

Most potential new use of hydrogen in Finland

- Existing/enlarging production of renewable transport fuels
  - Neste/Porvoo: HVO/NEXBTL
  - UPM Kymmene/Lappeenranta: HVO/BioVerno
- Terrafame mine, Sotkamo
  - production of hydrogen sulfide (H_2S) for the ore refining process
- Direct use in heavy transport vehicles
  - Use of hydrogen fuel cells to lower transport costs in selected point-to-point logistic cases
- SSAB steel plant, Raahe (**after 2030**)
  - production of CO_2-free steel (*Hybrit* process)

Most potential new use of hydrogen in Finland

POWER-TO-STEEL



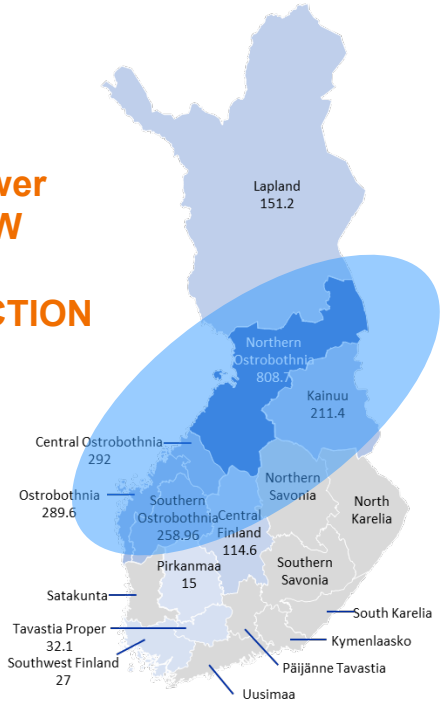
POWER-TO-OTHERS ?

NEW WIND POWER GENERATION IN FINLAND

New Wind Power Capacity in MW

IN CONSTRUCTION OR ON-LINE

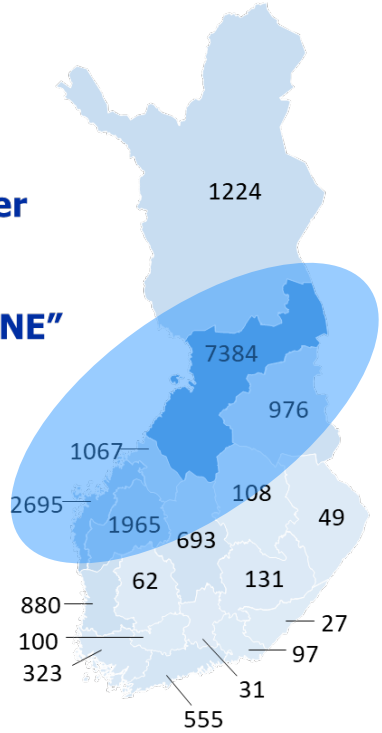
2019-2023



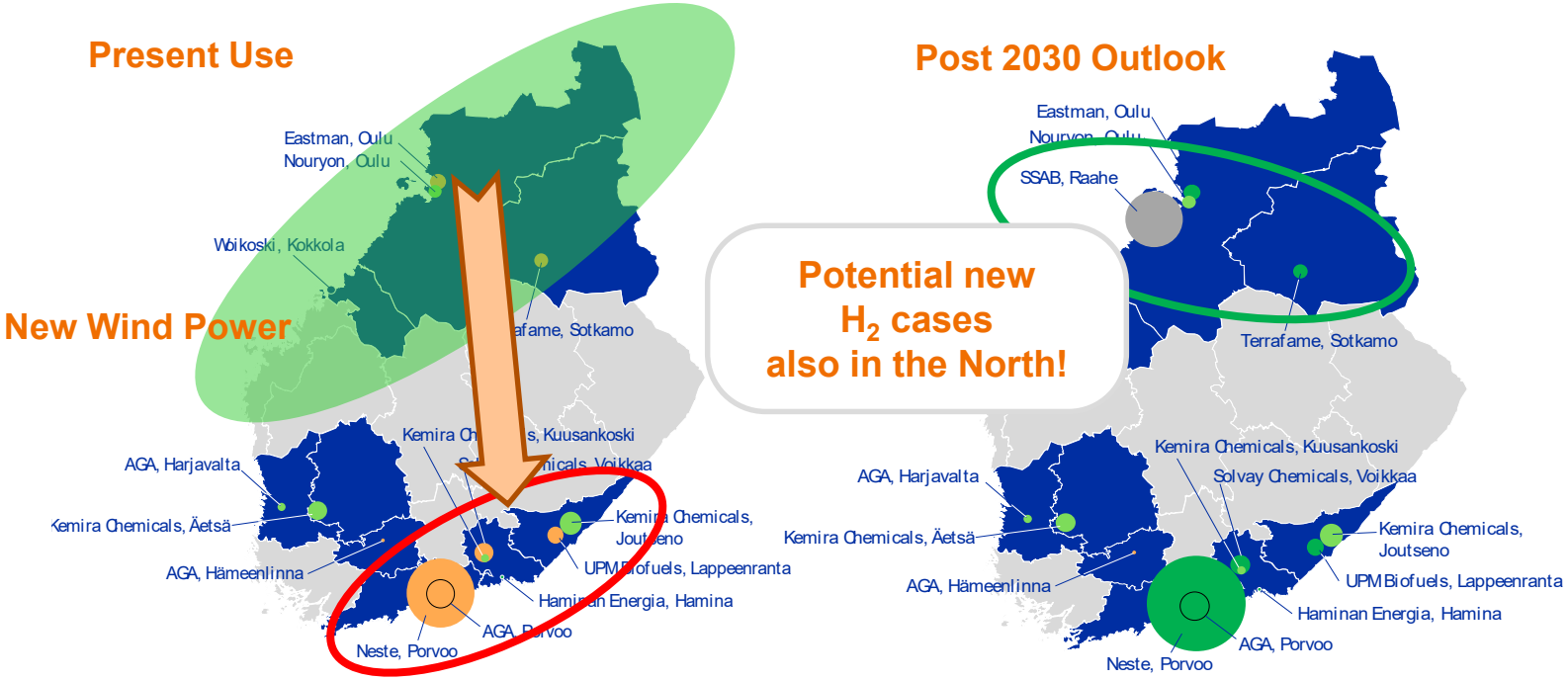
New Wind Power Capacity in MW

IN THE "PIPELINE"

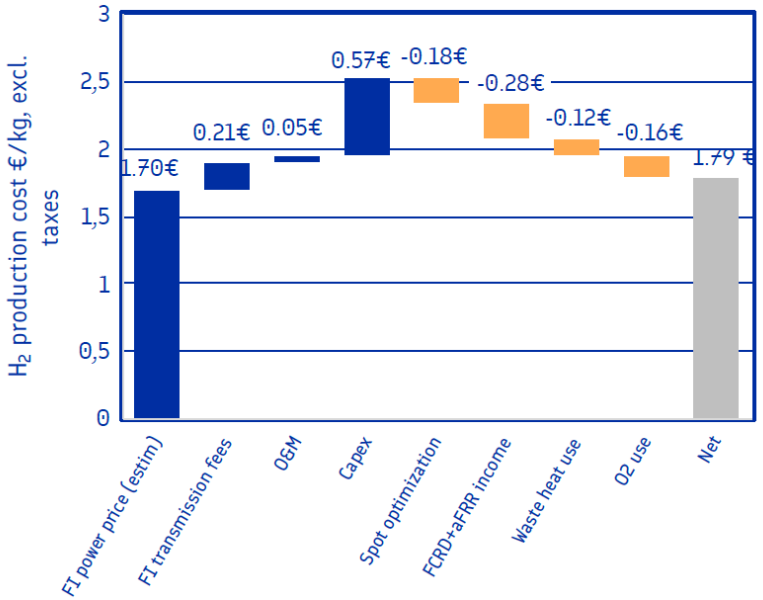
	GW
Onshore	15.8
Offshore	2.7
in Total	18.5



NEW WIND POWER GENERATION IN FINLAND



COST OF ELECTROLYTIC HYDROGEN PRODUCTION IN FINLAND?



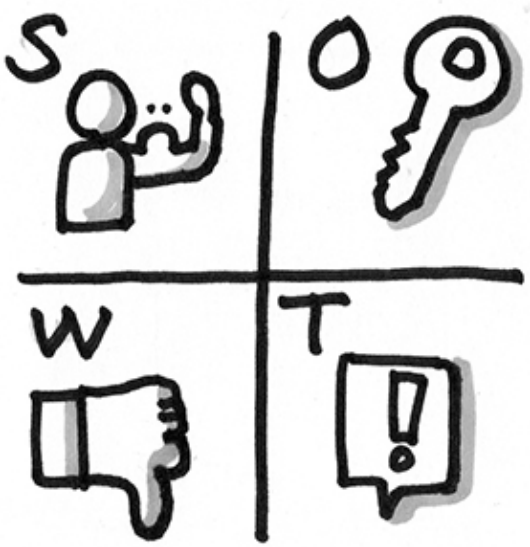
*Alkaline electrolyser based hydrogen production cost estimate based on 600 €/kW overall specific investment, 2020-2030 power price futures, transmission costs and O&M costs (blue bars) with 8000 h/a operation. With cost decrease from spot market optimization (cutting the most expensive 760 h of the year) and the extra income from grid services, waste heat and oxygen utilisation (orange bars) the total cost is around **1.8 €/kg** excluding taxes.*

The dominating cost factor in electrolysis is the cost of clean electricity. In addition, the capacity factor (operation hours) of the electrolysis is a very important aspect.

The outlook is that the specific investment cost of electrolysis will be reduced by upscaling, improving the manufacturing process (automation) and substituting high-cost materials in electrolysis technologies.

Efficient system integration of P2X side-streams (heat, steam, oxygen, grid services) are also essential in enabling profitable plant operation and business models.

HYDROGEN SWOT FOR FINLAND



SWOT FOR FINLAND – STRENGHTS & ASSETS

- Good wind resources – both onshore & offshore
- Strong and reliable electricity transmission grid
- Stable, predictable regulation framework
- Strong experience in industrial hydrogen use
- Repurposing of the present natural gas pipeline

SWOT FOR FINLAND – WEAKNESSES

- Higher electricity market price vs. Sweden & Norway
- Less hydrogen experience outside of the industry
- No hydrogen use in traffic & transportation
- No salt cavern type of formations (for hydrogen storage)

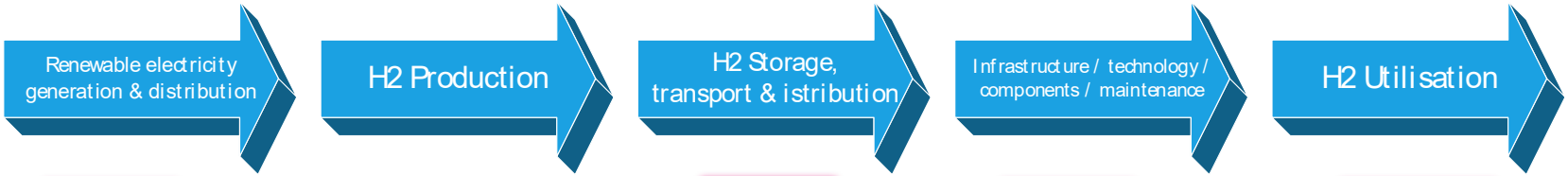
SWOT FOR FINLAND – THREATS

- Changes and/or interpretations of RED II Directive that could prove to be unfavourable for Finland
- Price of technology remains high
- Low prices for fossil fuels and CO_2 allowances
- Delayed scale-up of electrolyser manufacturing capacity

SWOT FOR FINLAND – OPPORTUNITIES

- Existing production of renewable transportation fuels
- Cost-efficient decarbonisation of existing hydrogen use
- Enabler for CO_2-free steel production
- Offers lowering the cost of logistics for industry
- Use of waste heat for district heating purposes ("CHH plants" for combined heat and hydrogen)

Value chain for hydrogen in Finland



Renewable electricity generation & distribution	H2 Production	H2 Storage, transport & istribution	Infrastructure / technology / components / maintenance	H2 Utilisation
Company A	Company D	Company H	Company M	Company D
Company B	Company E	Company I	Company N	Company S
Company C	Company F	Company J	Company O	Company T
	Company G	Company K	Company P	Company U
		Company L	Company Q	Company V
			Company R	Company W
				Company Z
				Company Y
				Company AA
				Company AB
				Company AC
				Company AD
				Company AE
				Company AF
				Company AG

KONECRANES, ABB, AGCO POWER, FINGRID, GASGRID, fortum, st1, CARGOTEC, convion, Fuel cell technology elcogen, Gasum, KONE, storaenso, KUUSAKOSKI RECYCLING, kemira, NESTE, Metsä, UPM, SSAB, Metso:Outotec, Valmet

+ *The National Hydrogen Cluster* (now about 30 companies)

…and many more

Graph: Ville Saarinen, VTT

Pan-European hydrogen network

*"The hydrogen network envisioned by European Hydrogen Backbone is a **significant opportunity for the Nordic and Baltic region**. We have large resources for clean electricity production, space, water, and the opportunity to utilize the heat generated in hydrogen production for district heating."*

Olli Sipilä, CEO of Gasgrid Finland
13.4.2021

https://gasgrid.fi/en/2021/04/13/gasgrid-finland-participates-in-envisioning-a-pan-european-hydrogen-network/

Also start-ups, ecosystems and R&D are active in Finland

P2X solutions

SOLAR FOODS

soletair power

POWER

GreenE²

BUSINESS FINLAND

And many more…

fuel

DE|CARBONATE

bio-energy BECCU for polyols based CO_2 and fuels

LUT University

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

- Finland has already a fairly well-populated value chain for hydrogen production and use
- Reliable grid and potential for new renewable electricity generation
- Strong high-tech industry in hydrogen technology
- Identified, potential large-scale targets for new hydrogen use
- Good potential to accelerate R&D&D efforts, but also some other cases suitable for public support
- Enlarging hydrogen-related domestic market is necessary

VTT

beyond

the obvious

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R&D activities on hydrogen in Lithuania and projects scaling-up

Dr. Darius Milcius
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2021

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:
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„Nanoionics“ laboratory, Institute of Applied Electrodinamics and Telecomunications,
Faculty of Physics,
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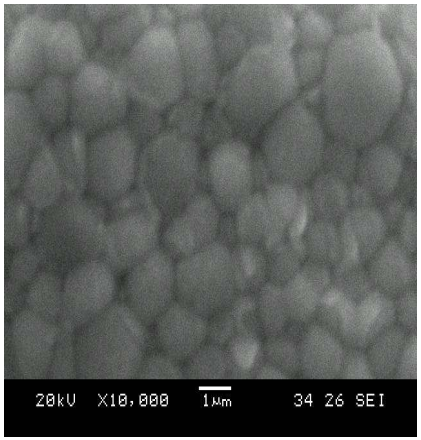
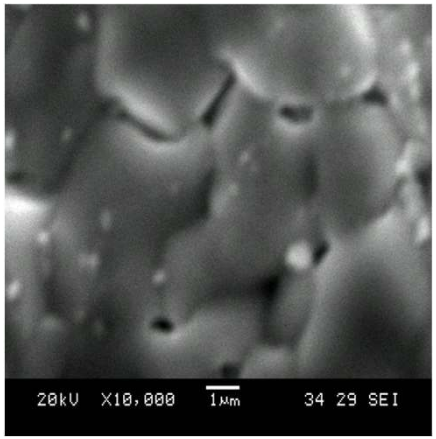
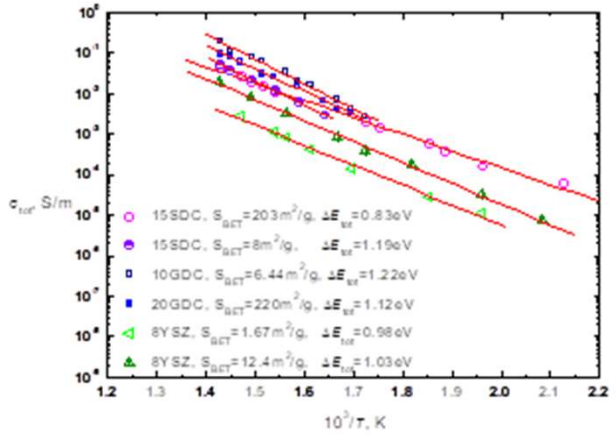
antanas.orliukas@ff.vu.lt

„Nanoionics“ 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.







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

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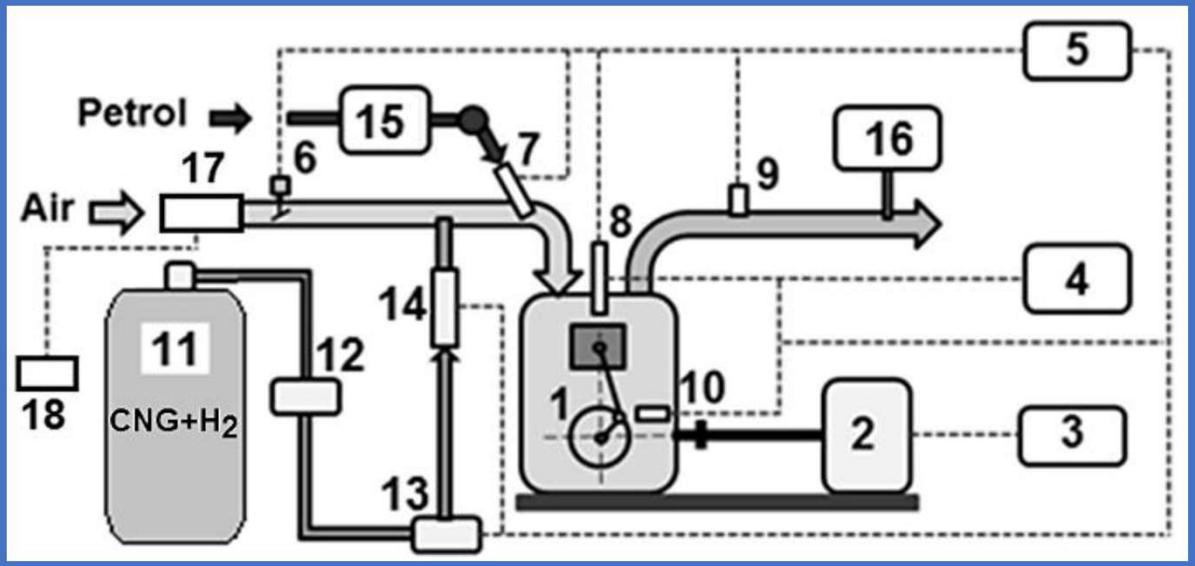
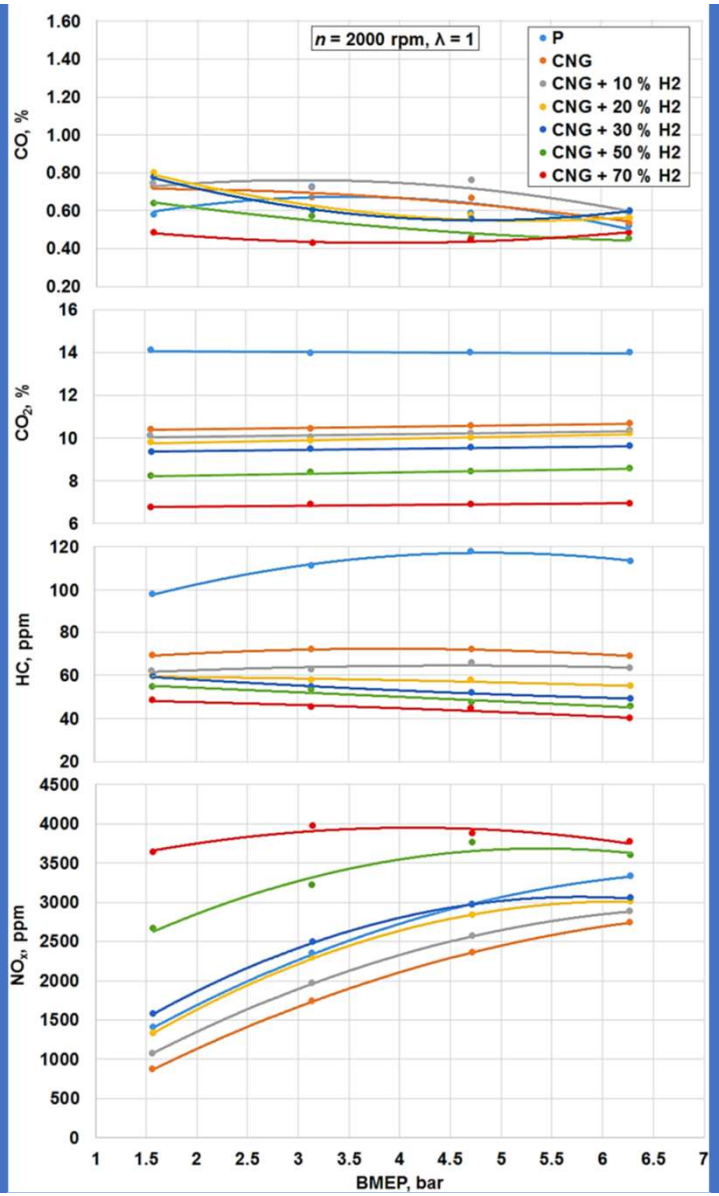
Faculty of Transport Engineering
Vilnius Gediminas Technical University
saugirdas.pukalskas@vilniustech.lt

Experimental research

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

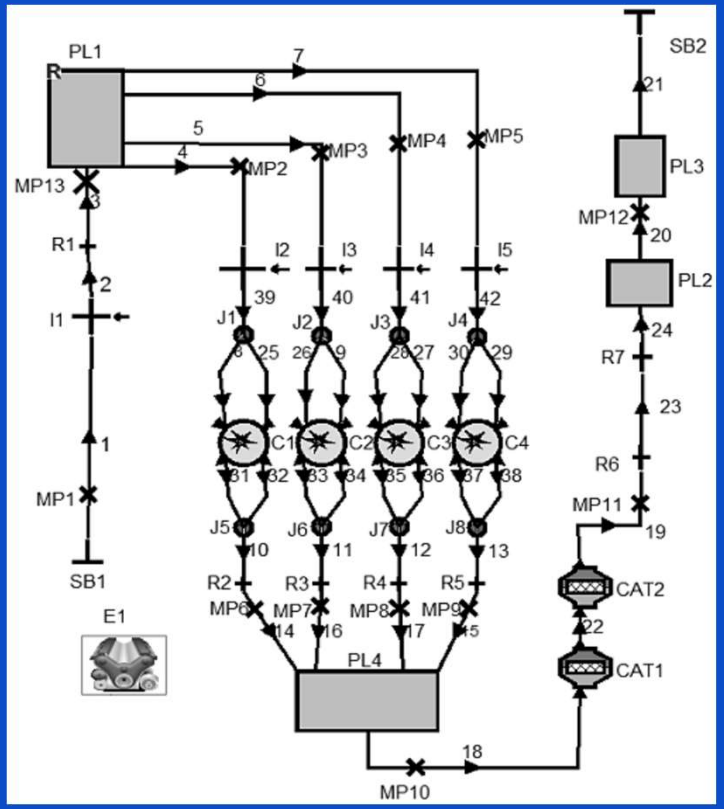


Schematic of engine stand testing equipment for CNG/H_2 fuel mixtures investigation: 1 – SI engine *Nissan HR16DE*; 2 – engine load stand *AMX 200/100;* 3 – load stand electronic control unit; 4 – equipment for registration of pressure in the cylinder *LabView Real Time*; 5 – engine electronic control 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



Engine simulation

Engine combustion analysis for CNG / H_2 fuel mixtures was performed using *AVL BOOST*



Spark ignition *HR16DE* 4 cylinder engine numerical simulation model in *AVL BOOST* environment:
SB – system boundaries; MP – measuring points;
J – junctions; I – port fuel injectors, PL – plenum,
R – restriction, CAT – catalytic converter,
E1 – engine parameters

Effect of hydrogen addition on the energetic and ecologic parameters of an si engine fueled by biogas. Pukalskas, S., Kriaučiūnas, D., Rimkus, A., ...Droździel, P., Barta, D. Applied Sciences (Switzerland), 2021, 11(2), pp. 1–17, 742

Mathematical modelling of indicative process parameters of dual-fuel engines with conventional fuel injection system. Lebedevas, S., Pukalskas, S., Daukšys, V. Transport, 2020, 35(1), pp. 57–67

Research of performance and emission indicators of the compression-ignition engine powered by hydrogen - Diesel mixtures.Juknelevičius, R., Rimkus, A., Pukalskas, S., Matijošius, J.International Journal of Hydrogen Energy, 2019, 44(20), pp. 10129–10138

R&D activities on hydrogen at Kaunas University of Technology

Main contact person:

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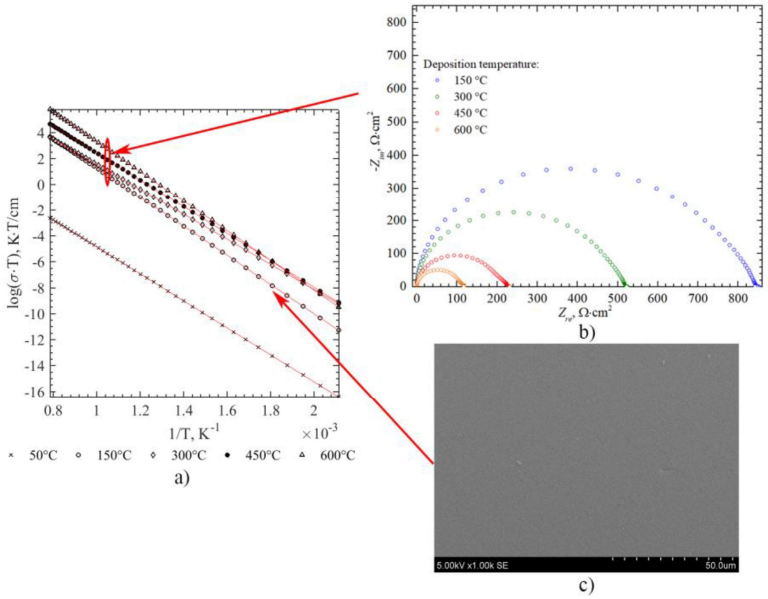
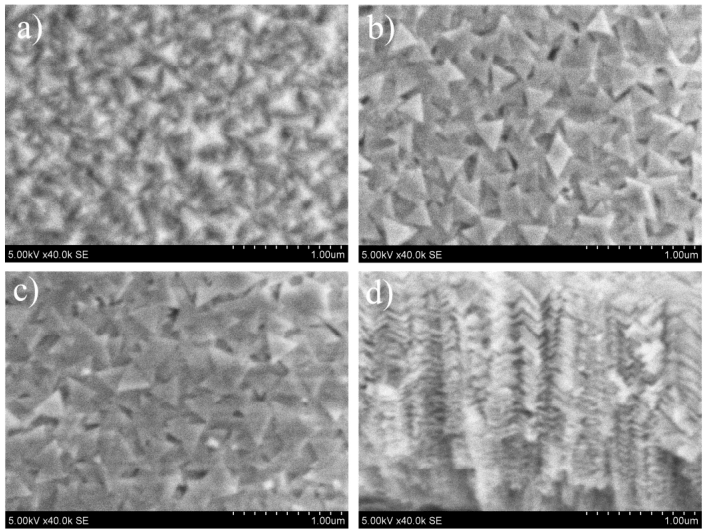
Faculty of Mathematics and Natural Sciences,
Department of Physics
giedrius.laukaitis@ktu.lt

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.).

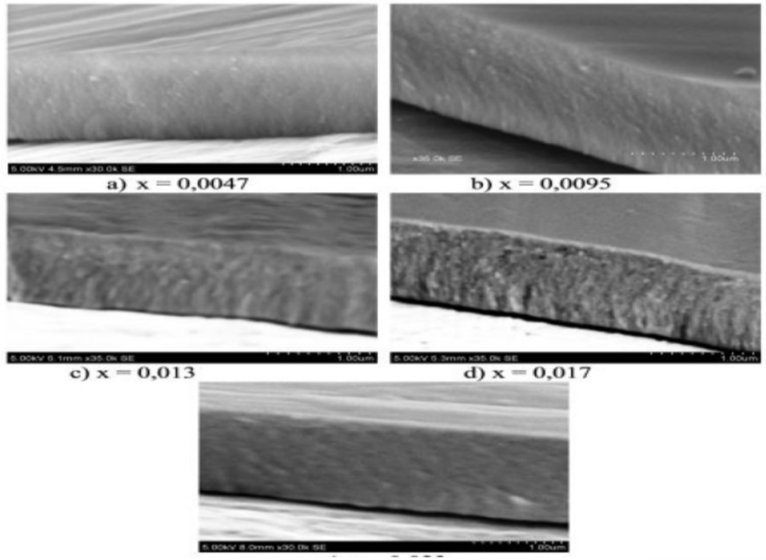


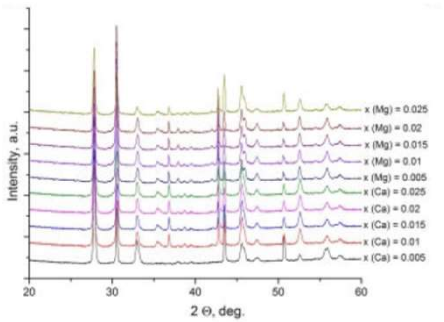


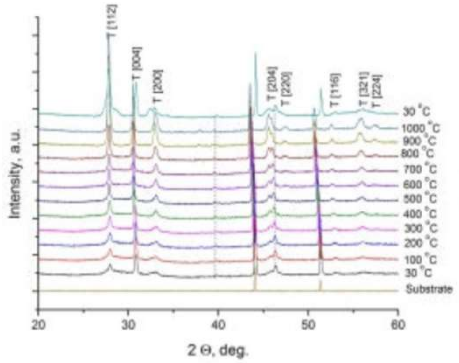
Patent. LT 6354 B. 2017-01-25. Structure and formation of ion-conductive and catalytically active membranes

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

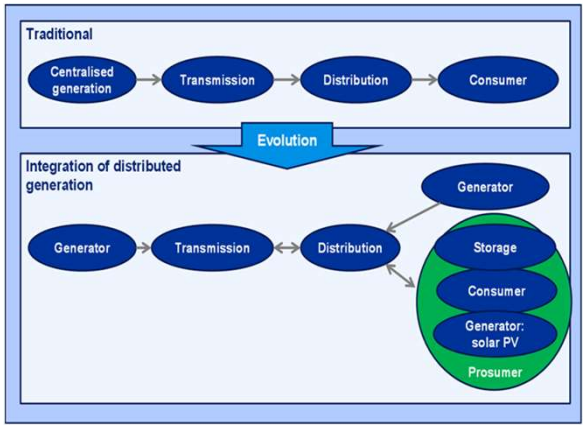
Research in Social science on the role of renewable energy prosumers in implementing energy justice theory.

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.

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R&D activities on hydrogen at Lithuanian Energy Institute

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

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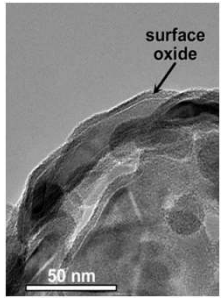
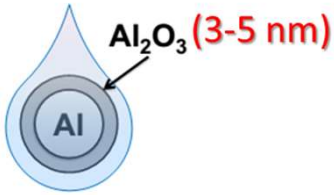
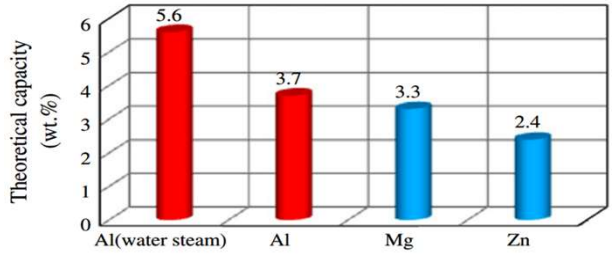
Hydrogen production as it needed: direct reaction of Al with water



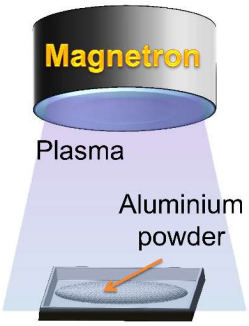


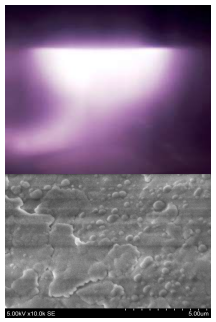
$$2Al + 6H_2O \rightarrow 2Al(OH)_3 + 3H_2$$

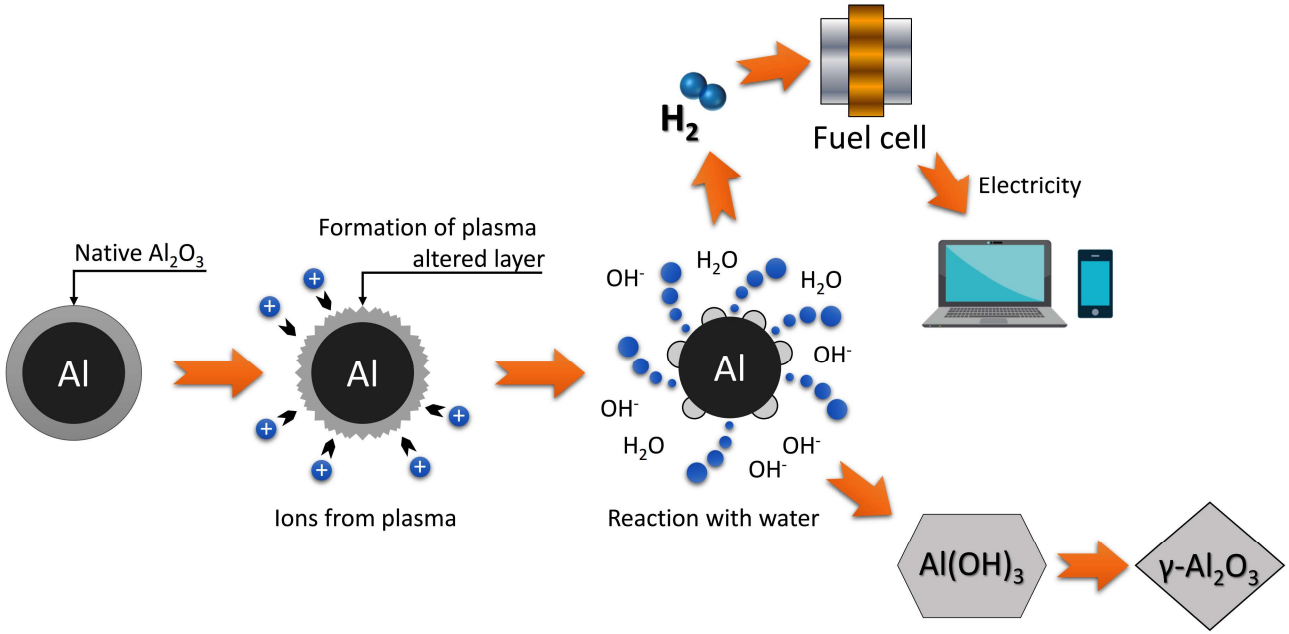


Wang H., Leung D.Y.C., Leung M.K.H. Energy analysis of hydrogen and electricity production from aluminum-based processes. *Applied Energy*, 2012, Vol. 90, no. 1, p. 100–105.

Gas plasma treatment

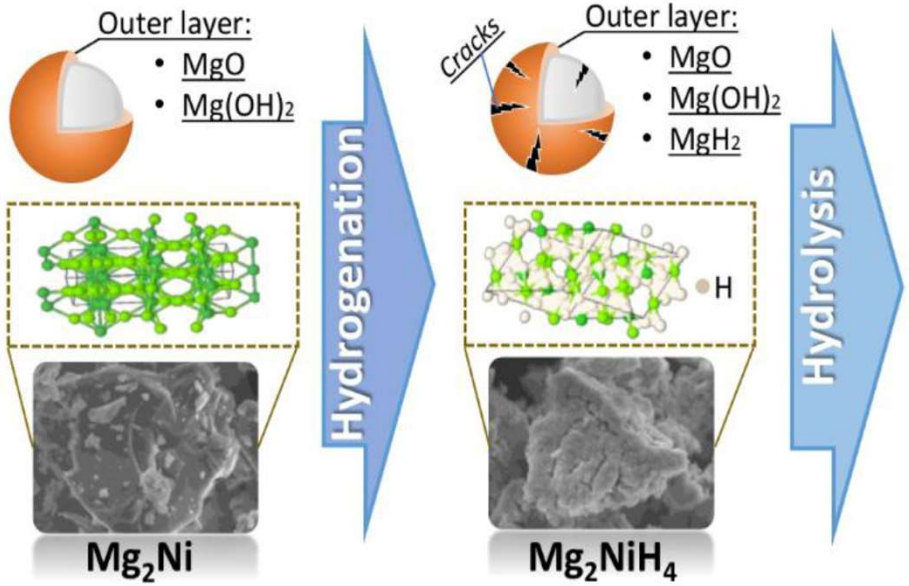


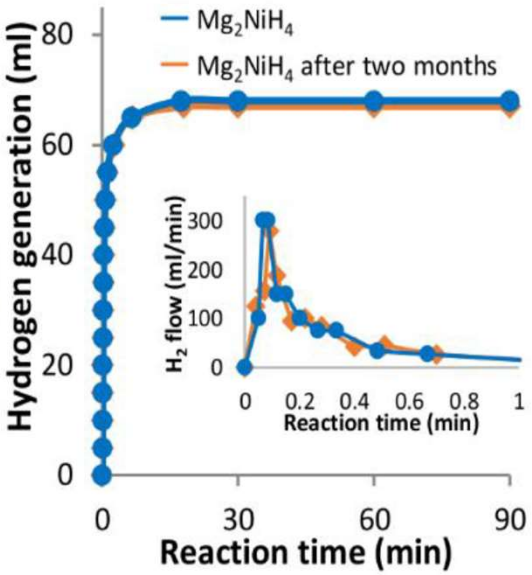


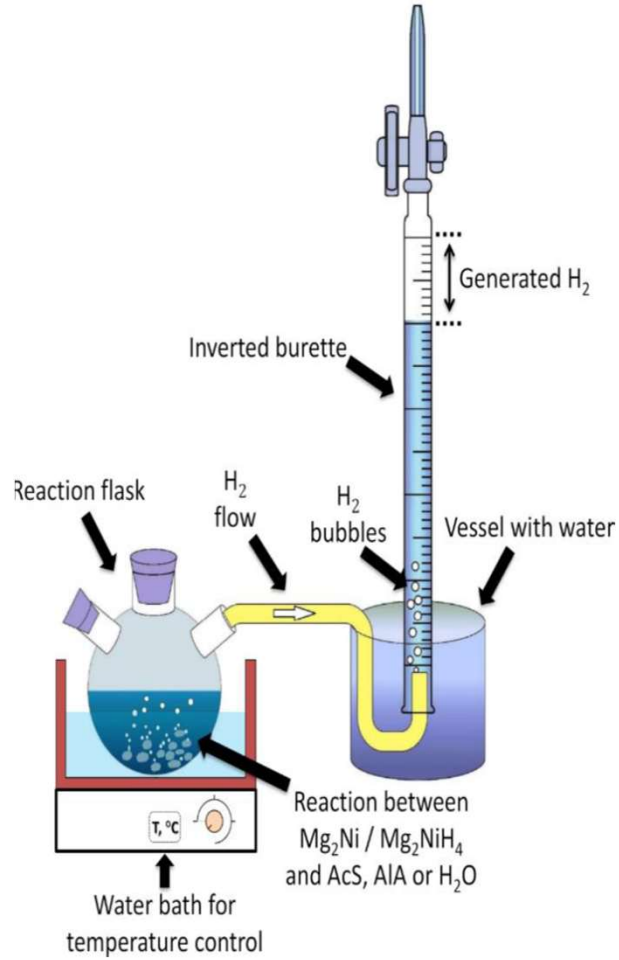


Milcius et.al. Patent application: PCT/IB2018/0522123

Hydrogen generation kinetics via hydrolysis of Mg2Ni and Mg2NiH4 powders







Urbonavicius, Varnagiris, Milcius. Submitted to Journal of Power Sources.2021

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

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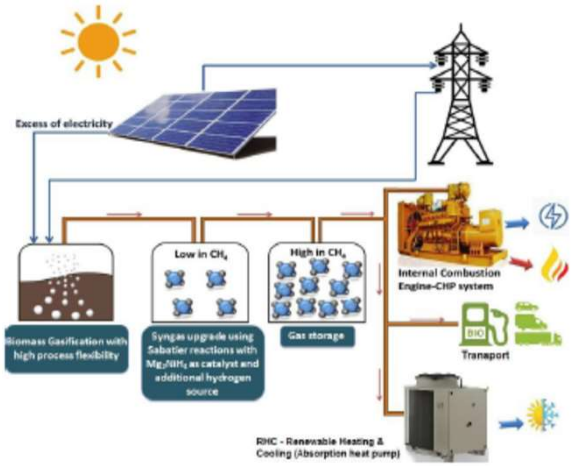
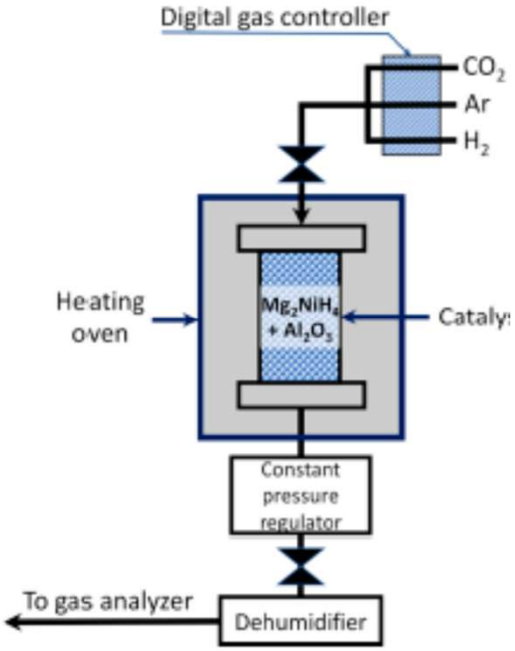
The use of metal hydrides in production of synthetic fuels

$$2Mg_2NiH_{4(s)} + CO_{2(g)} \rightarrow 0.75Mg_2Ni_{(s)} + 2MgO_{(s)} + 0.25Ni_{(s)} + 0.5MgNi_{2(s)} + C_{(s)} + 4H_{2(g)}$$

$$C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)}$$





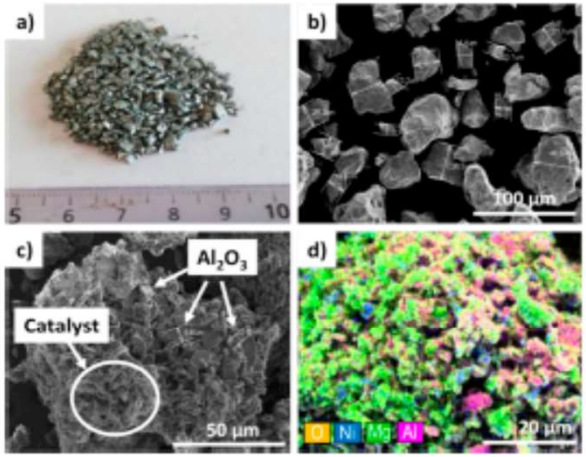


Figure 8. Optical and SEM images: (**a**) as received Mg_2Ni alloy grains, (**b**) Mg_2Ni grains after grinding, (**c**) catalyst–Al_2O_3 mixture after methanation test, and (**d**) EDS elemental mapping of catalyst–Al_2O_3 mixture after methanation test.

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.

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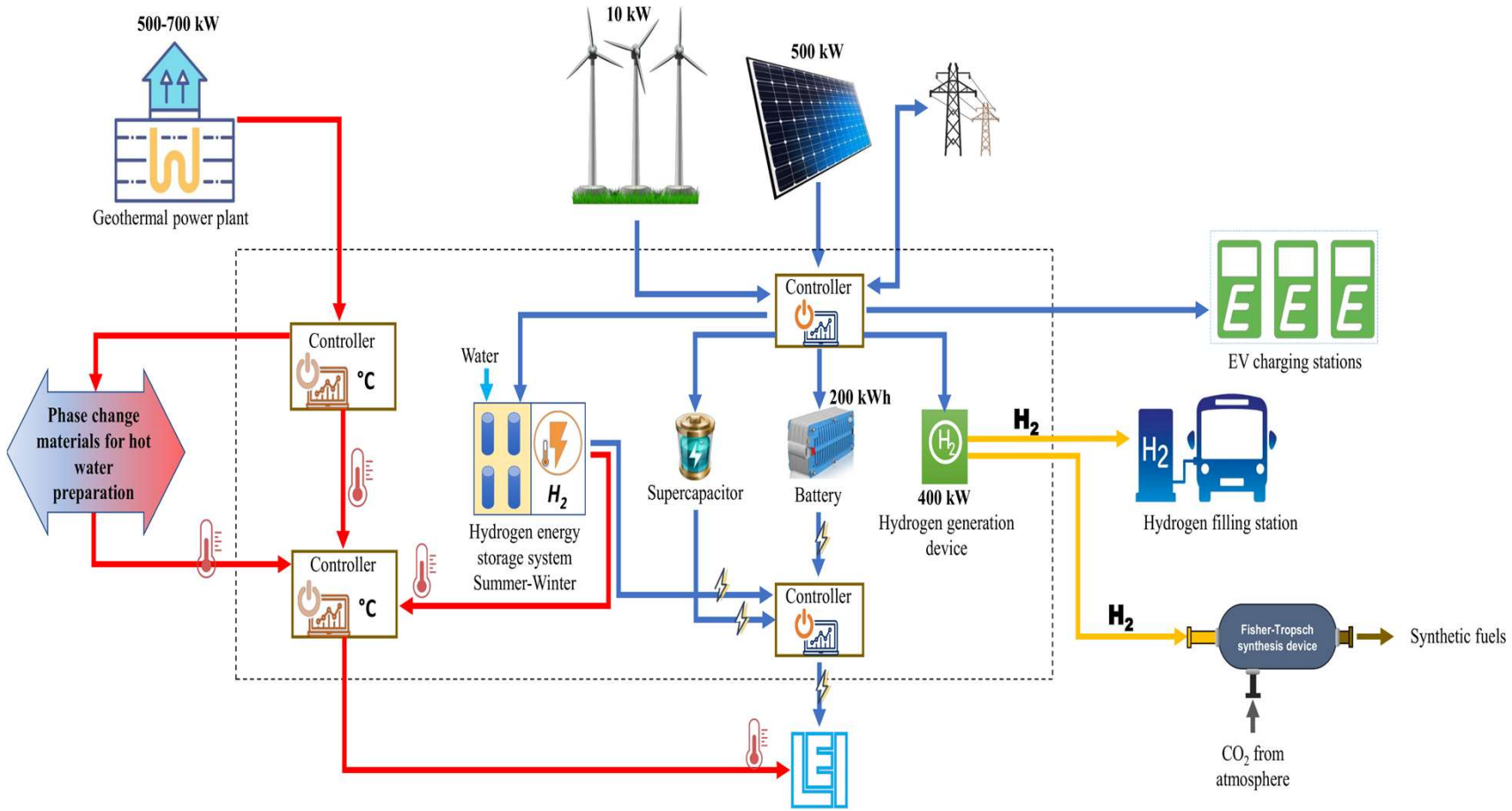
Project proposal on Green Hydrogen Demonstration Site in Lithuania



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INSTITUTAS
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Thank you for attention

ignitis group

Renewable Power to Hydrogen #EnergySmart

ignitis gamyba

Ensuring reliable energy production for the strategic national needs

Hydro, PSHP, CHP

ignitis renewables

Developing green energy in Lithuania and abroad

WIND, PV

eso

Ensuring reliable electricity and gas distribution network and empowering competition in the supply segment

ignitis

Creating easier life for energy smart businesses and homes

ignitis group

Making the world energy smart

ignitis gamyba

Ensuring reliable energy production for the strategic national needs

Hydro. PSHP. CHP

H_2 Green Hydrogen production. know-how base

ignitis renewables

Developing green energy in Lithuania and abroad

WIND. PV

H_2 Green hydrogen production

eso

Ensuring reliable electricity and gas distribution network and empowering competition in the supply segment

H_2 Green hydrogen distribution. local grids

ignitis

Creating easier life for energy smart businesses and homes

H_2 Green Hydrogen supplier. HFS

Ianitis group potential

Production and supply

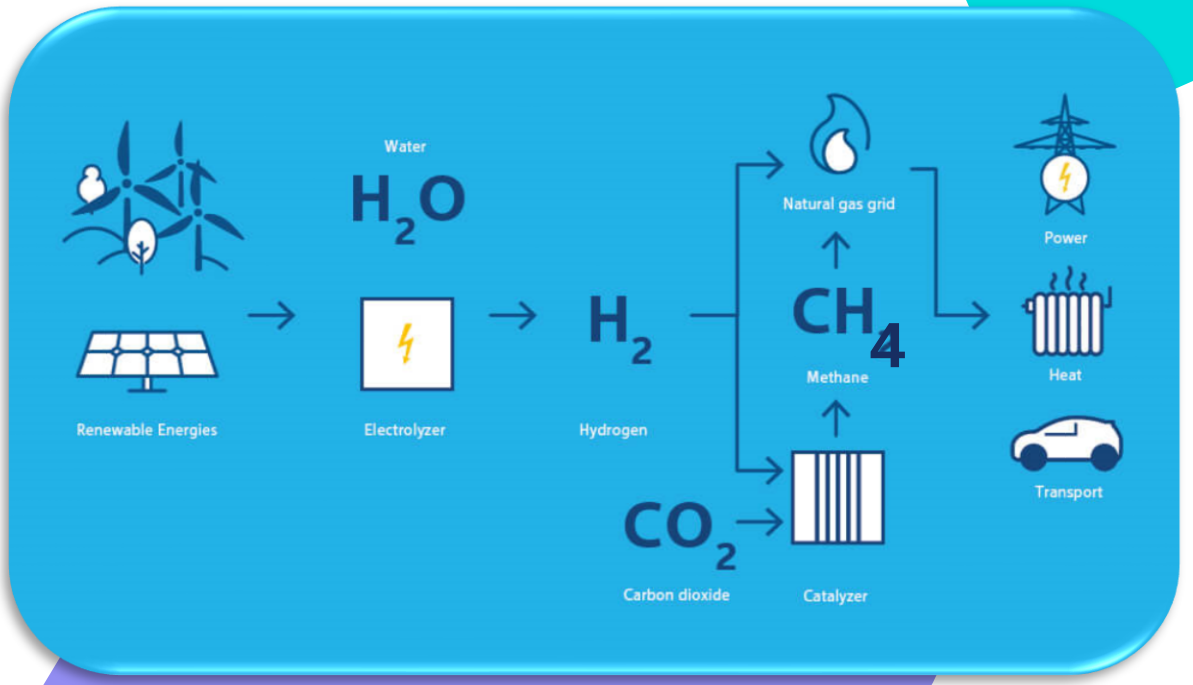
Connecting available wind park capacity for H2 production for local consumption or refueling stations.

Distribution

Connecting production facilities, utilizing blended gas mixture, enabling local H2 grids.

Capturing

Combining CCS (from WtE, CHP) with H2 for synthetic CH4.



Main sectors and challenges

Transport

Forklifts, public transport, trucks, ships

Currently - no end-customer

Challenge on infrastructure (supply of H2 + refueling station)

Synthetic fuels

CCS with combing H2 for synthetic methane production

Underground storage limited by law

Huge potential, but very limited at the moment

Gas blending

Current infrastructure is suitable

New market – green-gas certificates

Location and % limits due to grid specifics

Balancing - P2G

Estimated need for P2G balancing in 2040 – 100MW

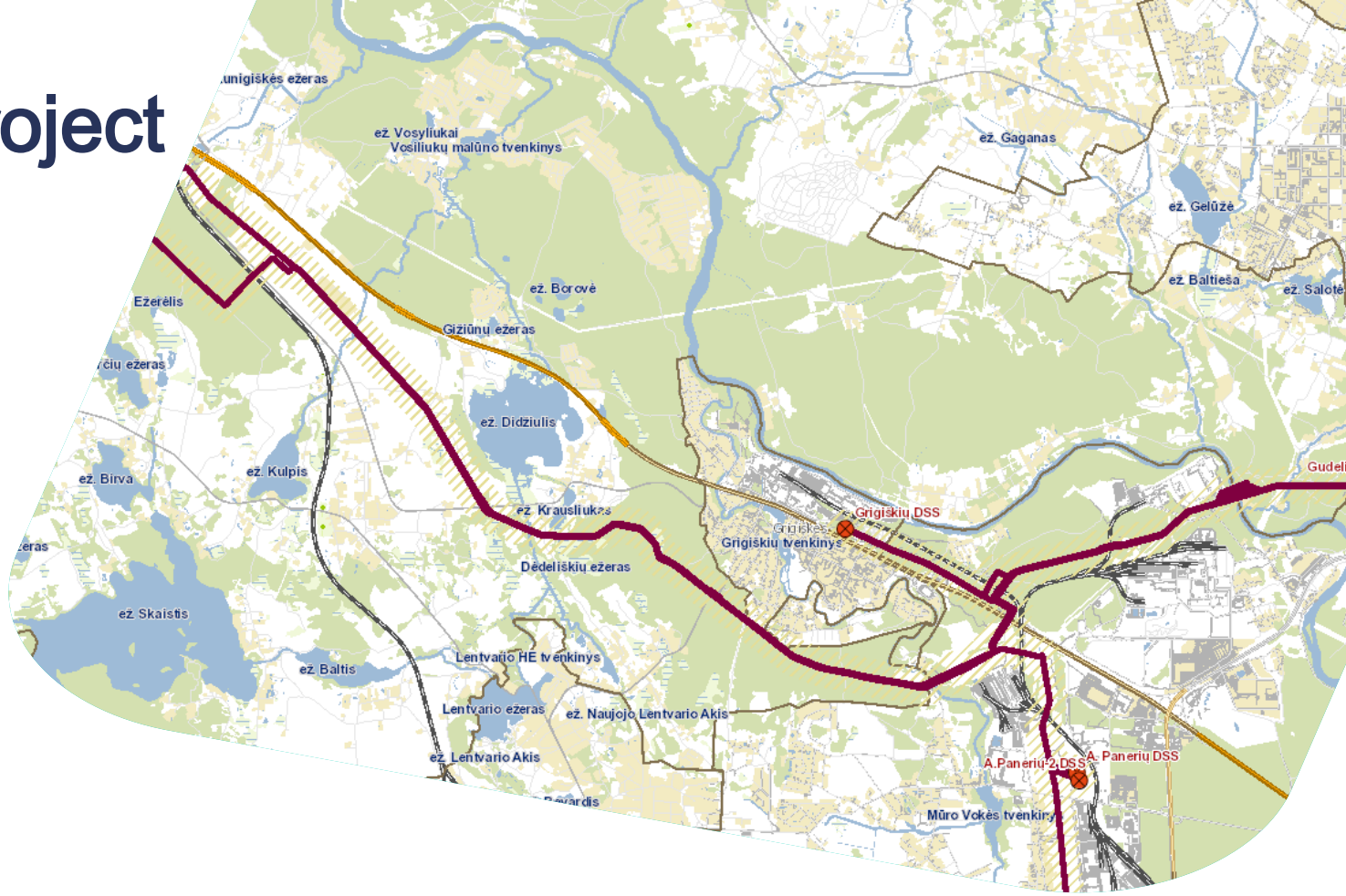
Potentially need for a storage solution

Balancing market capacities not defined

Hydrogen blending pilot project

Main facts

H2 production	„SG duios“ electrolysis unit
Additional equipment	Blender, compressor, measurement equip.
Usage	Blending with CH4 and inject to TSO grid
Location	Vilnius region
Research activities	Measurement points at TSO and DSO level, max H2 concentration evaluation



2020 Q3-2021 Q4 – agreements, specifications

2022 Q1-Q3 – procurement process

2022 Q4-2023 Q4 – equipment delivery and installation

Thank vou

ignitis group

The New Energy Landscape

Hydrogen’s role in sector coupling

Staffan Sandblom

Head of Hydrogen Development

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fortum

For a cleaner world

Staffan Sandblom

- Head of Hydrogen Development
- M.Sc. in Civil Engineering
  - Majored in city planning for sustainable societies
- 21 years in Fortum within
  - Corporate Procurement
  - Hydro Power
  - Trading and Optimization
  - IT
  - Innovation
  - Hydrogen

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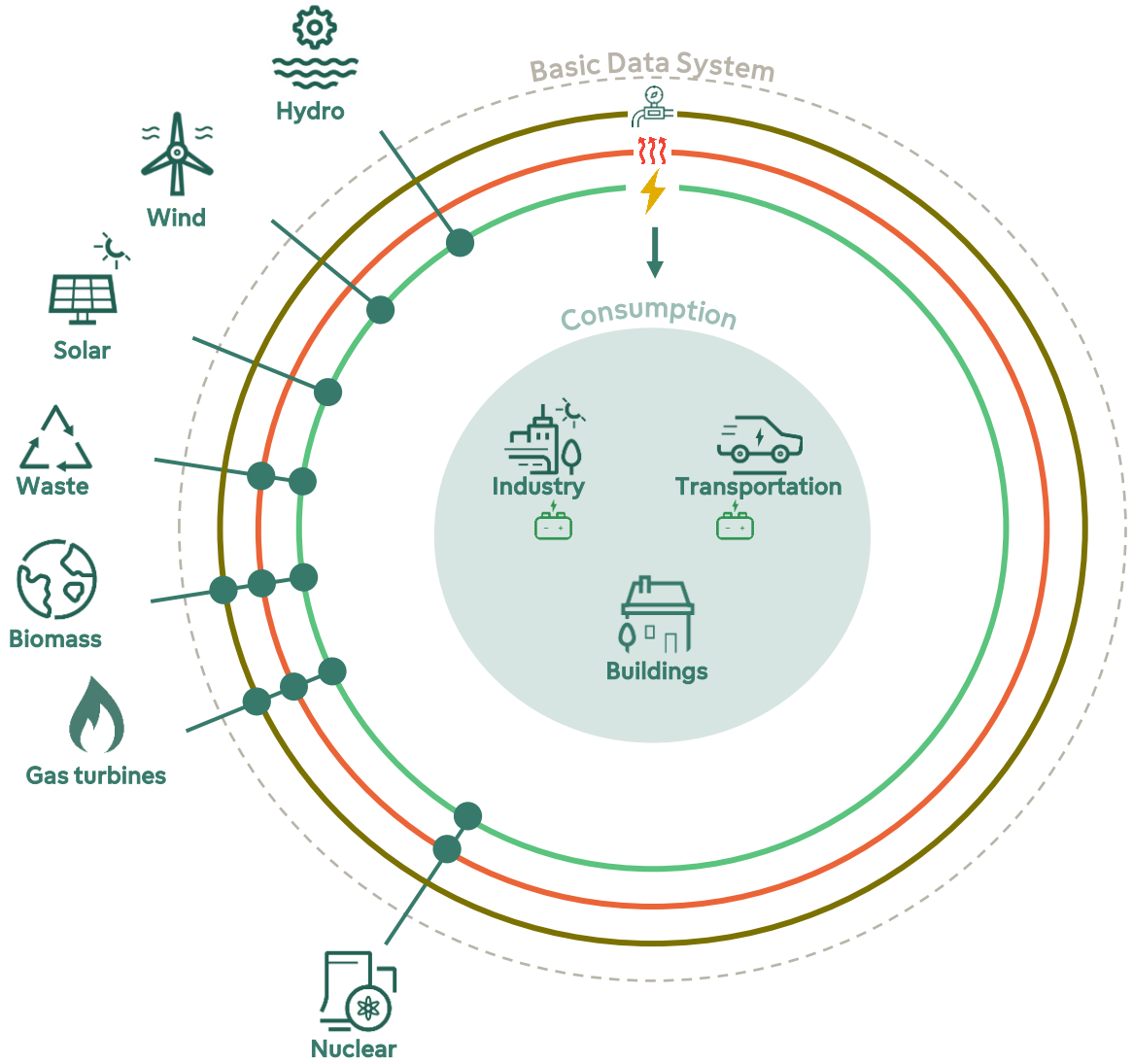
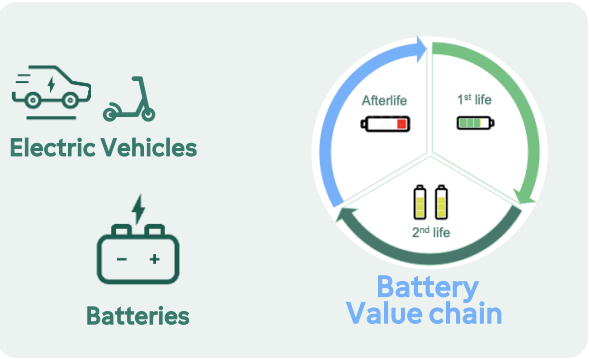
Today's Energy System

Decarbonisation and energy efficiency drives the increased need for electricity

Legend:
Natural Gas Grid
Heat network
Electricity grid



Circular Economy



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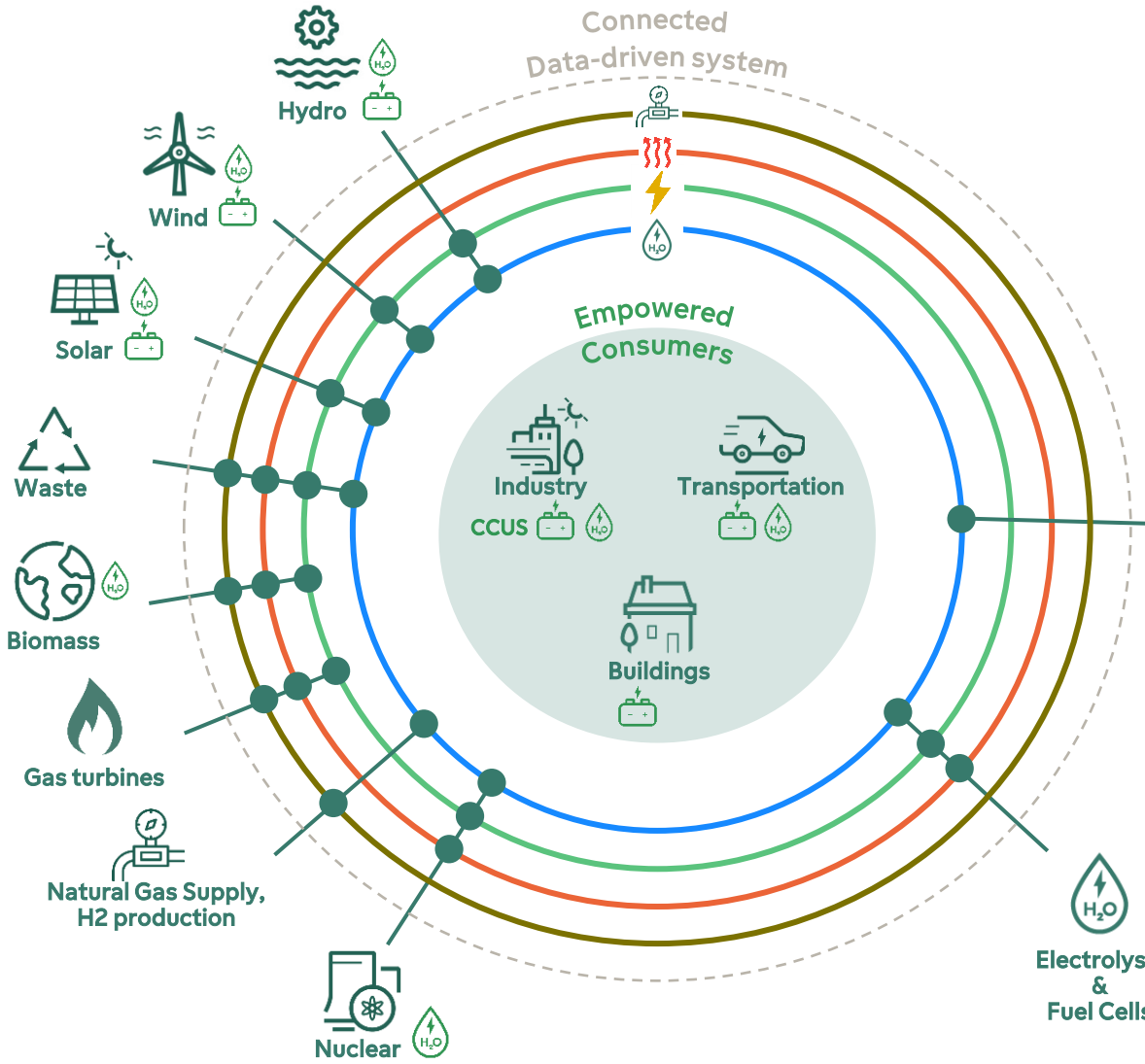
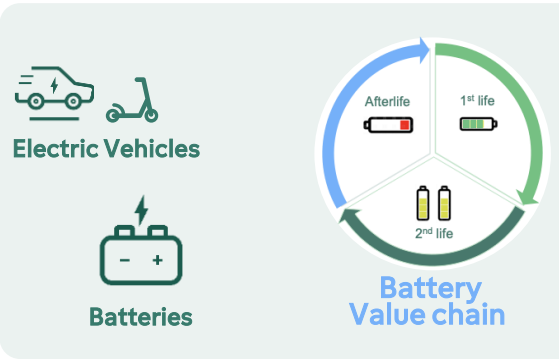
The Future Energy System

Hydrogen will play a key role ...

Legend:
Natural Gas Grid
Heat network
Electricity grid
Hydrogen





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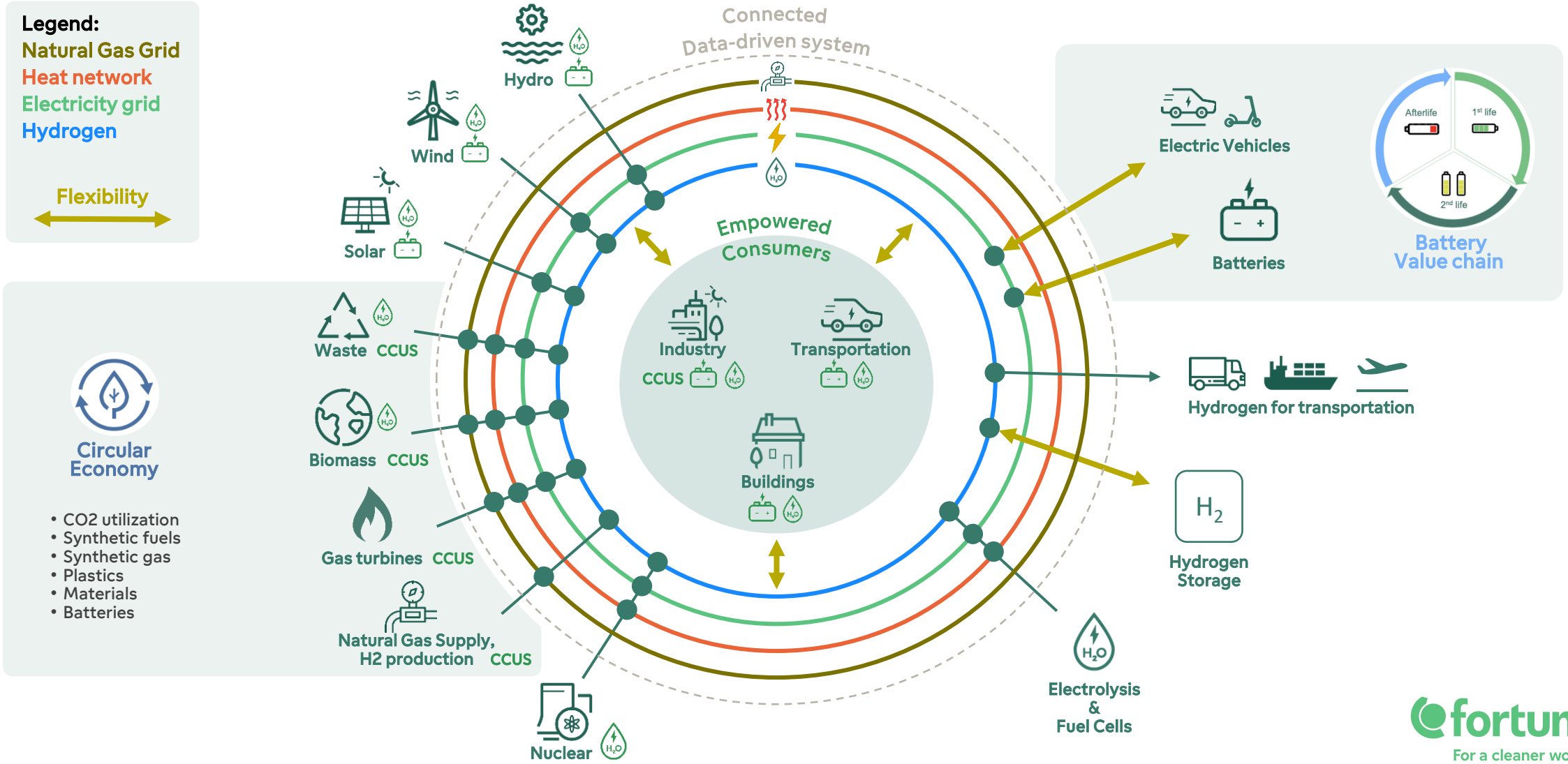
The Future Energy System

will be more complex, interconnected and sector coupled



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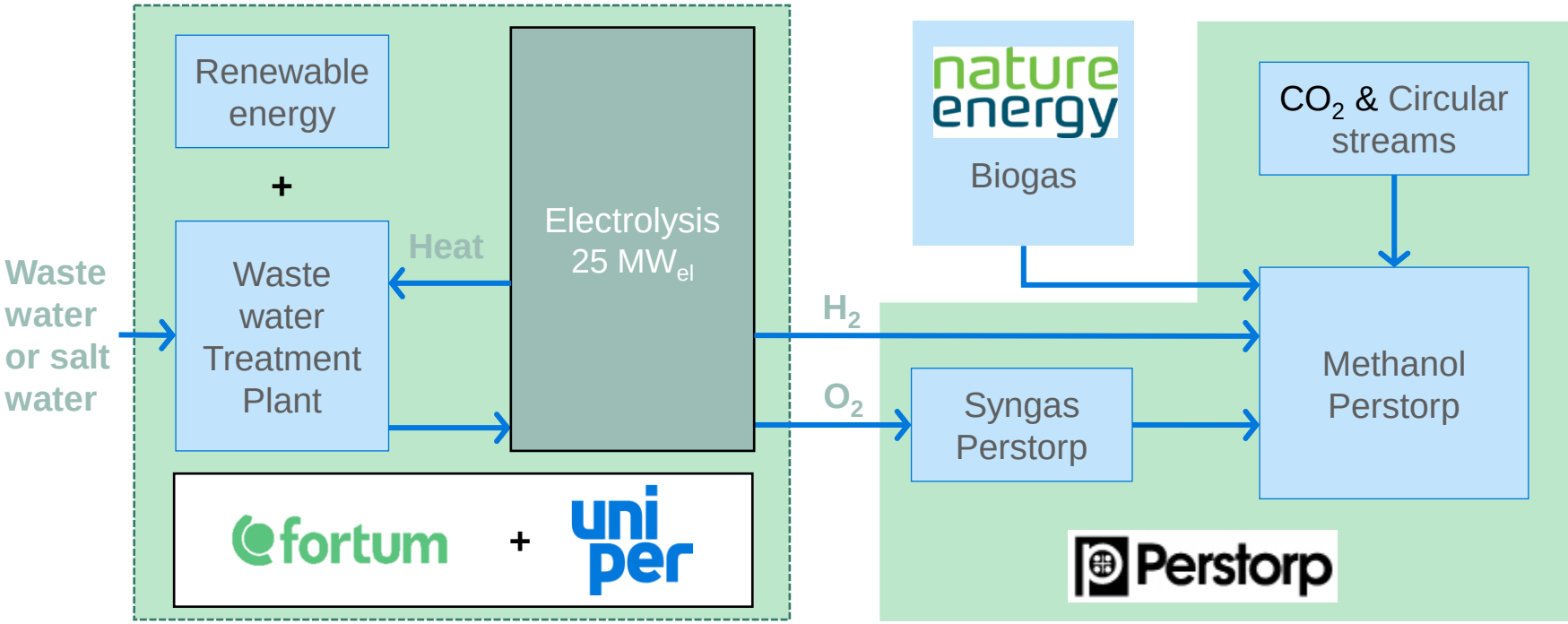
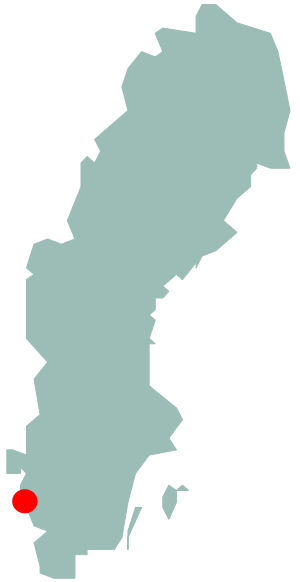
Project Air, Stenungsund, Sweden





H_2 Supply: 3500 tonnes/annum
GHG reduction*: 500 ktCO_2/annum

Project AIR aims to produce renewable methanol using renewable hydrogen, biogas, CO_2 and residue streams.
First-of-a-kind large scale commercial size demonstration of Project.
This will be the first large scale plant in the world that uses recycled wastewater to produce hydrogen.
Joint first application on 29th of October 2020 to the EU Innovation Fund.

*GHG reduction for entire project, including CCU and residue streams

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Thank You

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