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HYDROGEN ECONOMY

Finland’s goal is to become the European leader in the hydrogen economy

SUOMI
FINLAND

Contents

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1 KEY POINTS AND MAIN MESSAGES

- Finns see hydrogen produced with renewable energy as a key to mitigate climate change while promoting sustainable economic growth.
- Finland's goal is to become the European leader in the hydrogen economy in the entire value chain.
- The Finnish Government's resolution on hydrogen (09.02.2023) says the country has the potential to supply 10% of EU's emissions-free hydrogen in 2030.
- Finland's strengths are its solid energy infrastructure, world-class technology and a highly talented pool of professionals.
- Large-scale hydrogen production requires a significant amount of clean electricity. Finland has a huge potential for new renewable power generation, particularly wind. By 2030 the wind power industry aims to have 30 TWh of annual wind power production, covering 30 per cent of our electricity consumption.
- Clean hydrogen can be produced from water through electrolysis powered by renewable energy. The abundant fresh water from Finland's thousands of lakes and rivers are a valuable resource for electrolysis, splitting water into hydrogen and oxygen.
- Finland's other competitive advantages include predictability of the operating environment and seamless permitting and land use planning.
- The Finnish hydrogen industry is well placed to serve the international market. Major domestic and international companies are already working with hydrogen in Finland.

2 HOW TO PORTRAY FINLAND?

Position Finland as able to be a leader of the emerging hydrogen economy.

Highlight Finland's huge potential for wind power and high level of knowhow in industrial hydrogen use and production.

Profile Finland as a place international partners come to develop hydrogen solutions.

3 ELEVATOR PITCH

Hydrogen has the potential to be a revolutionary source of clean energy. It can be used as a clean energy source making it valuable for sectors and processes where utilizing other solutions is particularly challenging, such as steel and maritime transport.

Finland has the potential to be a leader in the future hydrogen economy: Finland is a stable, high-tech society with expertise in heavy industry, public-private collaboration and innovation.

Currently hydrogen is used by Finnish companies to refine petroleum, treat metals and produce fertiliser. Due to their experience, Finnish industries already possess the knowhow, technology and infrastructure to use hydrogen.

Clean hydrogen can be produced from water through electrolysis powered by renewable energy. Electrolysis requires an enormous amount of energy. Finland's long coasts and tracts of uninhabited land make it perfect for affordable wind power. Finland also has a diversified source of zero-emissions energy production, including biofuels and new nuclear plants.

There are also opportunities to integrate hydrogen with other industrial sectors to maximise cost efficiency. For example, "waste" heat from industrial production is valuable in district heating networks, while bio-CO_2 from forestry can be coupled with clean hydrogen to produce carbon-neutral chemicals and materials.

The public and private sectors in Finland are working together to advance the hydrogen economy, not just domestically but also internationally. The Finnish Government sees that by 2030 Finland has the potential to produce a tenth of all emissions-free hydrogen in the EU.

Finnish companies and universities are seeking international partners and investors to help develop hydrogen innovations and scale them up world-wide. For international experts working in the field of hydrogen economy, Finland is a great place to live and work and has also been consistently ranked as the happiest country in the world.

4 BACKGROUND

Finland's hydrogen ambition

- Finland is committed to become carbon-neutral by 2035, an ambitious target which requires considerable support and agreement across society. The Finnish state has recognised the role of clean hydrogen and is actively supporting its development and application, as well as encouraging foreign investments.

- Finland's goal is to become the European leader in the hydrogen economy in the entire value chain.

- Finland can be a global leader in hydrogen economy due to existing abilities as well as public and private commitments.

The potential hydrogen economy

- Hydrogen has the potential to be an affordable, abundant and accessible form of clean energy. When it is produced with zero-emission electricity it will contribute to a carbon-neutral society. In particular, hydrogen will be critical in sectors where emissions are hard to abate.

- Hydrogen is versatile. It can be used as a fuel as well as a method to store and transport energy. It can also be used in industrial processes, replacing fossil-based materials.

- As a fuel, hydrogen can be used in fuel cells or in combustion engines in various forms. It can be part of synthetic fuels like petrol, diesel or methane, which are made from captured CO_2 and renewable hydrogen. Hydrogen can also be used in gas engines, which are common in the maritime and energy sectors.

- Hydrogen is a way to store and transport energy. The Power-to-X process converts energy into a more useful form, such as hydrogen.

- In industrial applications, hydrogen can be used to refine petroleum, produce fertilizer and process foods. Several projects in Finland are developing ways to replace coal with hydrogen in the iron ore reduction process to make steel.

Finland's strengths in hydrogen economy

- Hydrogen production requires clean electricity and water, which are available in Finland. Finland has enormous potential for wind power, which is being rapidly expanded.

- Finland possesses high-tech, committed industrial companies covering the whole hydrogen value chain.

- Finland has a highly educated workforce, including in engineering and software, which are needed in developing hydrogen solutions.

- Collaboration between sectors and public-private actors is active in Finland. Domestic and foreign universities, corporations and research institutions often work together to develop solutions.

- Sector coupling offers efficiency and additional value to hydrogen projects in Finland. These include district heating, combined heat and power and energy intensive industries.

- Authorities have fostered a stable operating environment and common-sense regulations to improve predictability and the ease of doing business.

Keep in mind

- The hydrogen economy is a new and rapidly developing sector. It is recommended to verify the latest key figures as they change quickly.

- Much work is necessary to realize hydrogen's full potential. For example, a critical part of Finland's plan is to significantly expand wind energy production. For exporting, hydrogen transmission infrastructures should be developed. In the large scale use of hydrogen, the safety issues must be taken into account as hydrogen is flammable and can cause fires and explosions.

5 FACTS AND STATS

Global

- In the IPCC climate scenarios, hydrogen is mentioned as one tool needed to mitigate climate change in order to achieve the objectives of the Paris Agreement.
- European Commission sees renewable and low-carbon hydrogen one way to help decarbonizing the EU and reducing EU emissions by at least 55% by 2030.
- In 2021 the global demand for hydrogen was about 94 million tonnes, equivalent to the energy in 993 supertankers filled with oil. The main uses are in petroleum refining, ammonia and methanol production, and iron and steel production.
- The IEA expects global demand to reach 180 million tonnes by 2030. Half of the demand in 2030 will come from new applications in heavy industry, power generation and the production of hydrogen-based fuels.

Finland

- In 2020 dedicated hydrogen production was about 4.7 – 5.0 TWh. This is equivalent to about 7.5% of Finland's total electricity production.
- The largest use for hydrogen in Finland is oil refining and biofuel production (88%), followed by industrial chemicals (7%) and mining and ore refining (5%).
- At the end of 2022, there were 1 393 installed wind turbine generators, with a combined capacity of 5 677 MW. They generated 14,1 % of Finland's electricity consumption in 2022.
- FWPA is expecting that Finland will have aproximately 100 TWh of annual onhore wind power production and 100 TWh of annual offshore wind power production in 2040.

6 HYDROGEN COMPANIES WORKING IN FINLAND

Hydrogen Cluster Finland maintains a diverse member list including companies and industry groups and where they fit on the hydrogen value chain.

The below companies are a selection to illustrate the breadth and depth of hydrogen expertise in Finland. This list is not exclusive.

ABB – a multinational technology leader in electrification and automation

AFRY – international engineering and consulting for all parts of the hydrogen value chain

Blastr – a Norwegian startup planning a €4 billion green steel plant in Inkoo

Fingrid – Finland's transmission system operator

Flexens – owned by a group of Finnish research institutions and specialises in energy systems, the bioeconomy and circular economy

Fortum – energy company involved in several hydrogen projects across Europe

Gasgrid – Finland's gas transmission network operator who leads several hydrogen transmission network projects

Gasum – a Nordic energy company specialising in gas

Hycamite – a Finnish startup developing processes to produce clean hydrogen and carbon by decomposing methane

Kemira – expert in industrial chemicals and currently is the largest producer of hydrogen from electrolysis in Finland

Neste – oil refining and fuel company which is rapidly transitioning to cleaner fuels; they are the largest producers of renewable diesel and jet fuel in the world and are active leaders in hydrogen projects

P2X Solutions – startup in green hydrogen and Power-to-X solutions

Solar Foods – an innovative startup which combines clean hydrogen with carbon dioxide, water and other ingredients to feed microbes, thus creating an edible protein as a food ingredient

SSAB – largest steel sheet manufacturer in the Nordics, has developed HYBRIT technology to make steel with fossil-free electricity and hydrogen which will be used in their Raahe plant

ST1 – best known for their petrol stations, ST1 is also the largest wind power producer in Finland

UPM – a major global forestry corporation and one of Finland's largest hydrogen users at their biofuels refinery in Lappeenranta

Valmet – an industrial company with expertise in energy and forestry, have flow control solutions for Power-to-X processes such as green hydrogen

Wärtsilä – global energy and maritime company, have successfully run hydrogen blends and 100% hydrogen in their gas engines

7 NOTABLE PROGRAMMES AND GROUPS

Business Finland

At the time of writing Business Finland does not have any specific hydrogen projects, but they do have others where hydrogen could play a role, such as decarbonising cities, sustainable manufacturing and decarbonising the maritime sector. If in doubt, you can contact them and they will research what programmes could be applicable.

CLIC Innovation – Energy Systems

CLIC Innovation is a non-profit open innovation cluster in the bioeconomy, circular economy and energy sectors. They have considerable experience in hydrogen projects.

GREENRENEW

LUT heads this major research platform to develop cost-efficient Power-to-X technologies. A particular focus is the coupling of energy and industry with green hydrogen and CO_2.

Hydrogen Cluster Finland

Hydrogen Cluster Finland is a network of companies and industry groups that facilitate joint ventures, information sharing and promotion of the hydrogen economy.

VTT

Hydrogen technologies and fuel cells are one of the focus areas at the Finnish state-owned applied research company. They are specialists in collaboration between companies and academia, turning ideas into businesses.

8 POSSIBLE SITES TO VISIT IN FINLAND

Hydrogen Cluster Finland maintains an interactive map of the different hydrogen projects throughout Finland. This could be helpful to plan agendas for visiting delegations. Below are a few other ideas.

- **Lappeenranta** – St1 has a power-to-methanol project not far from UPM's biorefinery and green hydrogen production. Lappeenranta University has expertise in hydrogen research and innovation.

- **The University of Oulu** is one of the driving forces in the Hydrogen Research Forum Finland. Members include eight major Finnish universities and VTT.

- **Neste's Porvoo plant** – Neste is running a feasibility study for green hydrogen production.

- **SSAB Raahe** – SSAB's Raahe steelworks is being transformed into a minimill with electric arc furnaces. It replaces coal in the iron ore reduction process with hydrogen.

- **Tecoil in Hamina** – produces and uses green hydrogen for their own operations.

- **Wärtsilä's Vaasa campus** – includes the Smart Technology Hub where they co-create sustainable solutions in the maritime and energy sectors. They have engaged in several hydrogen projects.

9 FOR SOCIAL MEDIA

@CLICInnovation
@Business Finland
@Cleantech Finland
@Ministry of Economic Affairs and Employment
@VTT Finland

#teamfinland #sustainability #greenhydrogen #cleanenergy #hydrogeneconomy

You need wind to create #greenhydrogen, and Finland has enormous potential for #windpower.

#Renewables can create #hydrogen through electrolysis. The heat from the process isn't waste in Finland, but a valuable resource in our district heating network.

Got a great business idea about #hydrogen? Come to the happiest country on Earth – Finland – and let's talk about #sustainability and innovation.

10 FOR FURTHER INFORMATION

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11 TOOLS AND MATERIALS

National Hydrogen Roadmap for Finland

Business Finland produced this document in 2020.

A systemic view on the Finnish hydrogen economy today and in 2030 – Our common playbook for the way forward

Hydrogen Cluster Finland released this white paper in 2021.

Hydrogen Cluster Finland website

Hydrogen Cluster Finland's website is one of the best sources for additional information. It is updated relatively frequently.

Finnish Wind Power Association website

Statistics and information about wind power projects in Finland.

Enabling cost-efficient electrification in Finland

Created by the Finnish Innovation Fund Sitra, a public thinktank, this publication details Finnish decarbonisation, including the role of hydrogen. A particular noteworthy part of the study is the low cost and high capacity of wind power in Finland.

Government adopts resolution on hydrogen – Finland could produce 10% of EU's green hydrogen in 2030

Ministry of Economic Affairs and Employment press release (9.2.2023).

Hydrogen economy: Opportunities and limitations (2022)

Publications of the Government´s analysis, assessment and research activities 2022:41. Publisher: Prime Minister's Office.