White paper — 9 / 2021

H2 cluster FINLAND

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

Hydrogen Cluster Finland

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1. Executive summary

Hydrogen is enjoying an unprecedented era of attention and popularity growth. In Europe, with the recently proposed "Fit for 55" package, the political will is present to invest tens of billions of euros of collective national and EU public funds in developing a continent-wide hydrogen economy, with applications ranging from industrial hydrogen production and use to transport, heating, and energy storage. On top of these investments, come enormous infrastructure needs for electricity grids, gas pipelines, and transport refueling systems. All these investments will create a huge and rapidly growing demand for related technology products and services. It is clear that a new fundamental sector of industry and business is in the making, and Finland should take part in its development.

So far, hydrogen has not played a central role in Finnish industry or our economic landscape. However, partly by chance and partly as a legacy of our energy-intensive industry and world-class technology sector, we currently possess a clean, smart, and robust power system, cost-effective renewable electricity resources, comprehensive and solid energy infrastructure, world-leading technology companies as well as a highly talented professional pool, which are all key requirements for success in the construction of a hydrogen economy.

On this basis, when going further into the 2020s and towards carbon neutrality in 2035, we must leverage our strengths to the maximum and create a world-leading hydrogen ecosystem in Finland that maximally draws investments to Finland and enables a significant increase in global Finnish hydrogen technology exports. This will not only help us reach our own climate targets and strengthen our economy by creating a brand-new export industry with tens of thousands of high-value adding jobs, but it will also support other nations around the world in their battle against climate change by offering a concrete role model. We have all that it takes for the Finnish hydrogen economy to be globally significant.

To get there, we must now define a common and shared Finnish hydrogen integration and acceleration plan based on a shared systemic vision and implement it with the same pragmatic, predictable, and long-term policies that have helped create the desirable and stable investment environment that Finland is today. We must secure the most cost-competitive clean electricity in Europe by utilizing all our clean electricity resources and potential to the fullest, over the whole country and its sea areas. We must introduce pragmatic regulation to facilitate the creation of demand and scaling for the hydrogen economy. Funding must also be provided to enable Finnish competence to be built in hydrogen value chains in the fields of research and education, in schools and universities as well as in the many companies innovating and already building their business on hydrogen.

This whitepaper is a collective effort by members of Hydrogen Cluster Finland and presents decision makers with a system-level vision as well as concrete actions to kick-start and build a prosperous hydrogen economy in Finland. This is a call to action.

Glossary

Green – "Green" typically refers to many things renewable, but it also indicates environmentally sustainability and a lack of emissions (such as nitrogen oxides, sulfur, volatile organic compounds and particles). When discussing electricity, the technical term "renewable" is more commonly used than the term green, but green hydrogen refers to hydrogen produced in a renewable manner, i.e., predominantly based on renewable electricity, although it may also be based on biogenic input.

Clean – "Clean" is used to depict anything low-carbon or carbon-neutral and also generally free of emissions. In terms of electricity, clean refers to both renewable and nuclear power. Clean hydrogen includes all forms of low-carbon or carbon-neutral production: in addition to renewable hydrogen, also so-called blue hydrogen, i.e., fossil hydrogen where CO2 is captured during the production process or electrolytic hydrogen based on nuclear power.

2. Introduction

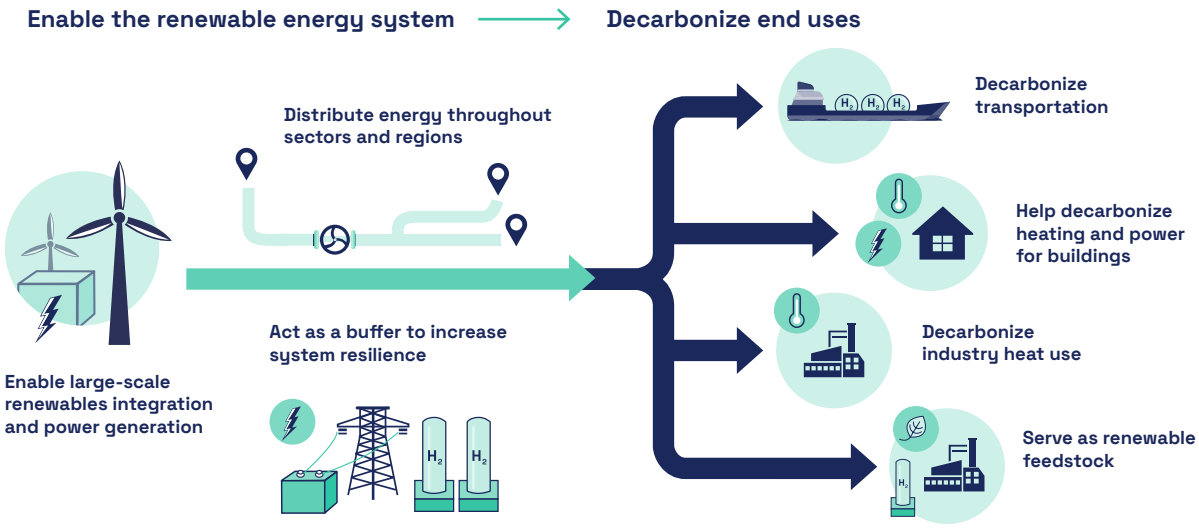
Finland has set the extremely ambitious target of reaching carbon neutrality by 2035, as the first industrialized country in the world and well ahead of many other nations. This target positions Finland as the global trailblazer of the green transition and creates a fruitful innovation environment for cutting-edge technological development and the piloting of new solutions on a societal scale.

The key to achieving climate neutrality is replacing fossil fuels and raw materials in society with solutions essentially based on clean electricity. In Finland, new renewable electricity will, to a large extent, be based on a massive increase in the generation and use of wind power, for which Finland offers one of the best and most cost-competitive environments.

Hydrogen will play a key role in this transition: it allows replacement of fossil fuels and raw materials with synthetic, sustainable alternatives derived from the use of clean electricity. This will help decarbonize transportation and industry and allow the replacement of coal in some hard-to-decarbonize industrial processes, such as steel making. Hydrogen also acts as an energy carrier as well as energy storage in integrated energy networks and so can help compensate for inbalances in weather-dependent power generation.

In this paper, we briefly describe the role hydrogen can play in the transition towards a sustainable energy system and how Finnish industry and society could benefit through embracing new technologies and business opportunities related to hydrogen. Our aim is to build on our core resources of clean electricity, our competencies, and a systemic approach to the formation of a new integrated export industry comparable to the Finnish forest industry or ICT business ecosystems. If successful, this will lead to substantial growth in Finnish exports and the creation of tens of thousands of high value new jobs, while at the same time contributing to Finland becoming the first carbon neutral industrialized society in the world.

ROLE OF HYDROGEN AS ENABLER OF THE ENERGY TRANSITION



Source: FCH JU 2019, p. 19: https://www.fch.europa.eu/sites/default/files/Hydrogen%20Roadmap%20Europe_Report.pdf

2.1 Hydrogen in many forms

Hydrogen is a versatile substance. It can be produced in several and used in even more ways. Because the use of hydrogen does not produce any GHG (Green House Gases) emissions, in the frame of a sustainable energy system it is important to understand how the hydrogen is produced. Due to low GHG emissions in electricity generation already today, Finland has a great opportunity to produce clean (ie. low-carbon) hydrogen.

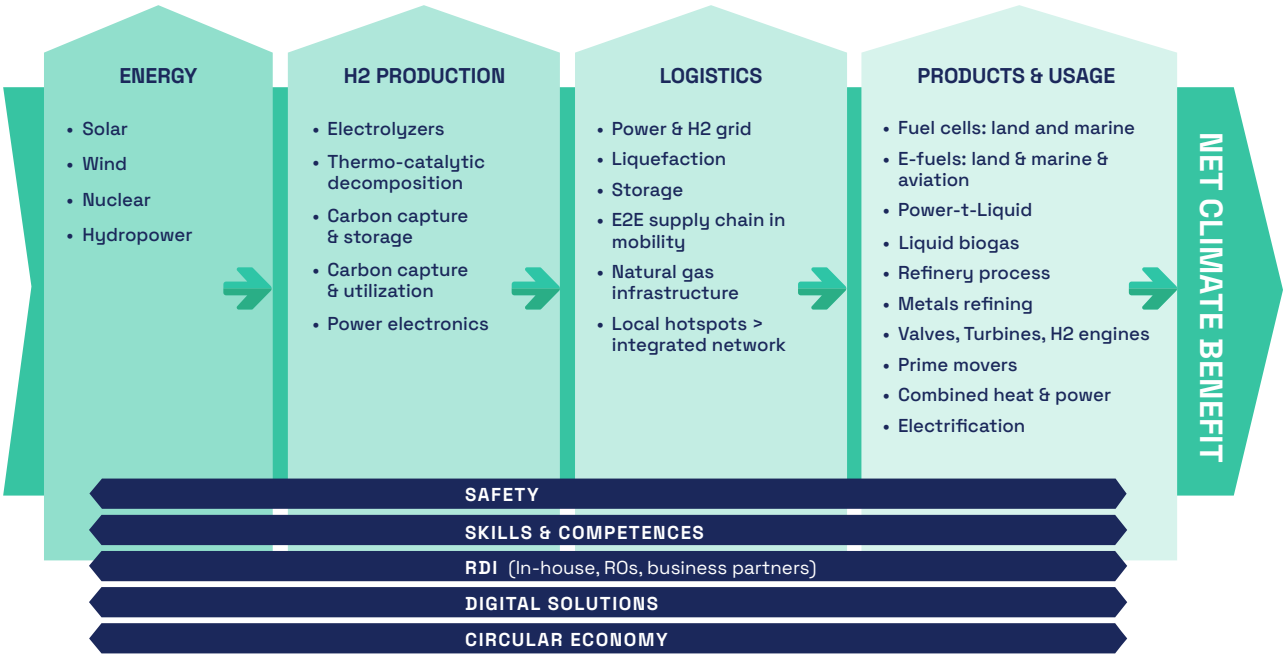
Currently most of the hydrogen used in the industry is produced from fossil raw materials such as natural gas, resulting in high CO2 emissions. This form of hydrogen is labelled "grey", "brown" or "black" hydrogen based on which fossil raw material is being used (natural gas, coal or oil, respectively). Going forward, we need to shift the production to clean forms of hydrogen, particularly renewable, "green" hydrogen produced using renewable electricity. This will be the predominant form of hydrogen to be used in Finland.

In addition to renewable electricity, clean hydrogen can also be produced using nuclear electricity (resulting in so called "pink" hydrogen), by capturing and storing the CO2 that is byproduct of fossil hydrogen (the result being "blue" hydrogen) or by methane pyrolysis where carbon is captured in solid state (resulting in "turquoise" hydrogen). In Finland the CO2 capture and storage (CCS) route is of limited interest because the country does not possess great opportunities for the permanent storage of CO2. Nevertheless, also blue hydrogen is relevant in Finland for quickly reaching significant reductions in emissions of currently existing hydrogen production during the transition period towards large-scale renewable production.

2.2 The Finnish hydrogen value network

How do we introduce clean hydrogen in the Finnish energy system and industries so that the overall value for the Finnish society is maximized? We define the hydrogen value network broadly: it encompasses building and operating physical infrastructure such as production and distribution of clean electricity, production, transportation and storage of hydrogen, and its further processing and use in

FINNISH HYDROGEN VALUE CHAINS



various ways. Parallel to the physical value chains centered around clean electricity and hydrogen, we highlight the importance of technology, digitalization and ICT sectors, and the need for financing and public-private collaboration. These competencies and capabilities need to be intertwined into a network of interconnected stakeholders, and coordinated to achieve maximum value for the Finnish society.

While developing the hydrogen value network domestically, increased attention needs to be paid to take full advantage of the new opportunities in EU and globally. Finland has strong technology and process industries featuring globally leading companies that can scale the novel solutions and related products and services to world-wide distribution. By doing so, the carbon handprint of the Finnish actions will be multiplied on the world-wide scale and the value network of the Hydrogen Cluster Finland extends to collaboration with partners globally. This will lead also to high value adding jobs being created in Finland and related exports adding a brand-new industry to deliver Finnish export growth. We have an opportunity to build hydrogen value chain based on clean electricity to a new foundation for Finnish economy, parallel to forests and high-tech industries.

3. Finnish strengths in the hydrogen economy

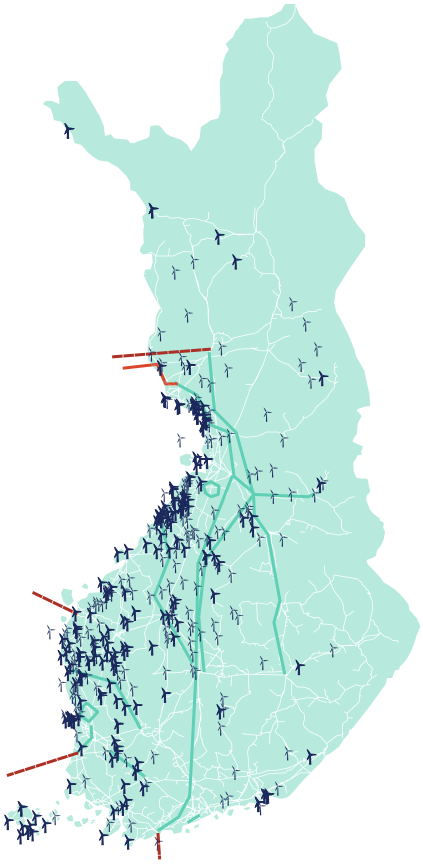
Finland has certain core strengths which place us in a unique and highly competitive position when creating value with a hydrogen economy:

3.1. A robust and clean electricity system as a basis for clean hydrogen expansion

Unlocking the opportunities of clean hydrogen is essentially tied to the good availability of reliable, low-cost, clean electricity. This is also Finland's main competitive edge – our geography and the current infrastructure enable the rapid and massive scaling of cost-effective onshore wind power. In addition, Finland has shallow coastal waters that are well suited to further cost-effective expansion with offshore wind power.

Current wind-power grid-connection inquiries to Fingrid amount to close to 100 GW of additional capacity (2020, installed capacity approx. 2 GW). In addition, publicly known projects currently at various stages of planning total 21 GW of additional capacity. As a benchmark, Finland's total power generation capacity (including all forms of generation) was around 16 GW in 2020. The growth projection is therefore very strong.

The Finnish national electricity transmission grid is already highly robust, and, as a result, the whole country forms one power market area. Due to the high penetration of electricity use in residential heating and regulations mandating reliable electricity distribution, grids are also modern and dependable compared to most other

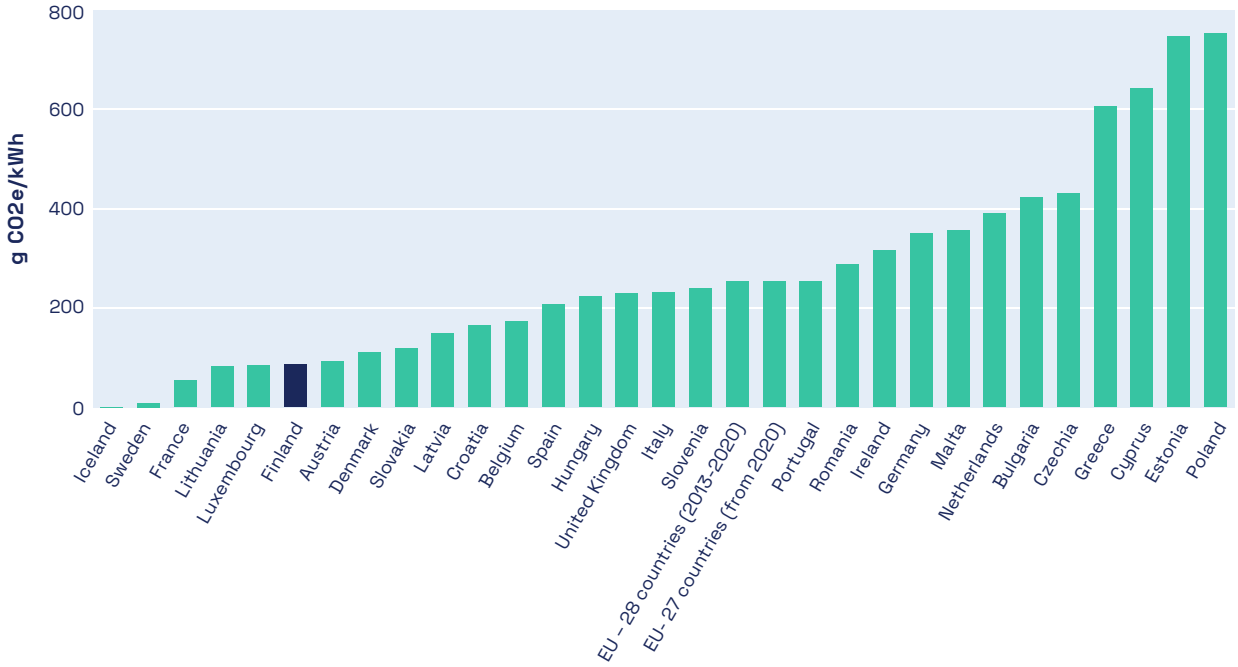


Wind power and the Finnish electricity system
Source Ethawind: https://www.ethawind.com/suomen-tuulivoimapuistot/

countries. Supported by planned further investments as well as further improvements in digitalized monitoring and control, our grids will be able to accommodate the expansion in transmitted volume and will enable the accurate measurement of such factors as the renewability and emission rates of the electricity transmitted. This measurement and accounting process is critical for creating optimal added value from renewable electricity.

Finally, based on the long-term pragmatic energy policy adopted in Finland, the country possesses a significant and growing amount of non-renewable clean electricity generation capacity, i.e. nuclear power, to supply power needs when renewable electricity is not available. Based on these factors, the Finnish electricity generation mix already features one of the lowest emissions factors, 89 kg CO2/MWh, in Europe (2019 data), and this will further improve with the rapid increase of renewable and nuclear clean power generation in the coming years.

INTENSITY OF GHG EMISSIONS IN EUROPEAN ELECTRICITY GENERATION



Source: https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-6#tab-googlechartid_googlechartid_chart_111_filters=%7B%22rowFilters%22%3A%7B%7D%3B%22columnFilters%22%3A%7B%22pre_config_date%22%3A%5B2019%5D%7D%3B%22sortFilter%22%3A%5B%22index_2019%22%5D%7D

3.2 A stable, high-tech society with unique competencies as the basis for a hydrogen ecosystem

Finland is a high-tech society with unique societal competencies. Our technology industries and highly educated talent pool offer a strong basis for addressing complex systemic challenges. We are experts in designing, building, and integrating complex industrial systems, and our digitalization, ICT, and cyber security capabilities are world-class. Culturally, Finland is a high-trust society: Finns keep their word, and actions, once agreed, are implemented. All this forms the basis for attracting further talent and investment to Finland by offering a stable, innovative, low risk investment environment for piloting and scaling-up cutting-edge hydrogen-related technologies.

In the following sections, we take a brief look at the different Finnish competencies relevant to the hydrogen value chain.

3.2.1 Technology industries

We possess strong energy, intelligent machinery, and Information and communication technology (ICT) sectors with world class companies. Finnish technology competencies cover the entire energy value chain: the generation of clean electricity, power electronics and power conversion technologies, control and optimization of energy distribution systems, energy and process industry equipment, end-to-end digitalization and related consulting, and the design and engineering services required for turn-key project deliveries. Through the implementation of integrated, optimized systems and the export of related products and services, the Finnish technology sector is already creating a significant carbon handprint all over the world. The hydrogen sector provides Finnish technology companies with yet another direction for expansion and further impact.

3.2.2 Process industries

In recent decades, strong renewal has occurred in Finnish process industries. The forest industry has shifted its focus from paper to packaging and pulp grades and invested in the development of totally new forms of forest biomass-based products, such as biofuels, chemicals, and new fibers for clothing. Our former national oil company has reinvented itself as the world's leading refiner of renewable diesel. Our innovative process industry is supported by strong Finnish technology companies developing the required novel process technologies. Such capability for continuous renewal is both necessary and a strength when seeking to seize business opportunities based on renewable hydrogen.

3.2.3 Energy Industry

The Finnish energy industry features both advanced local utilities engaged in local circular economy activities together with innovative local communities, as well as companies operating in several European countries and advancing the sustainable energy system transition on a European scale. In recent years, our power transmission and distribution system operators have invested substantial capital in improving the resilience of the power distribution infrastructure, and the adoption of new technology has placed Finland at the forefront of the digitalization of energy infrastructure. This creates a strong backbone for the energy sector expansion required to seize the opportunities presented by hydrogen.

3.2.4 Effective public-private collaboration

Finland has been at the forefront of European open-energy-market development. The power market was deregulated years ago by separating electricity distribution network operations, which form a natural monopoly, from the open electricity market. The robustness of the system has been further developed by collaboration between market participants. One example is the emergence of various auxiliary services markets offering additional revenue potential for market participants that can provide flexibility to the system. A similar development has more recently occurred with the separation of gas grid infrastructure operations from the related energy market, forming a new open market platform for gases that can now be further extended to cover hydrogen.

To achieve the safety-related excellence required for a flourishing hydrogen economy, we could mirror the development seen in the nuclear power industry: Finnish industrial companies together with the public Radiation and Nuclear Safety Authority (STUK) constitute a world-renowned reference point for how public and private sectors can collaborate to build a safe and sustainable industry. Hydrogen Cluster Finland together with TUKES (the Finnish Safety and Chemicals Agency) should aim to accomplish the same for hydrogen-related value chains.

3.2.5 Innovation capabilities

The Finnish innovation system combines research at public universities and research institutes with active collaboration with industry. This is supported by public co-innovation programs and funding

instruments managed by Business Finland, targeting rapid commercialization of cutting-edge research results to form new export innovations. Many companies active in Hydrogen Cluster Finland participate in such co-innovation projects. By taking advantage of existing capabilities and networks and ensuring further investment in innovation, Finnish hydrogen value chains can form a new export industry ecosystem, and the resulting innovation landscape will also attract foreign venture capital investments to further boost growth. This development has already been seen in the ICT and gaming industries, where in recent years Finland has attracted the most venture capital investment of any Europen country in relation to the size of its economy.

3.3 Extensive sector coupling opportunities to integrate hydrogen across industries and energy sectors for optimum cost efficiency

Many industrial sites in Finland offer good infrastructure for efficiently integrated production of hydrogen and e-fuels[1], allowing the production process to be connected to the robust power grid, abundant water resources, and biogenic CO2-sources from, e.g., biomass boilers, pulp mills, or biogas plants, while also providing the potential to utilize by-product renewable heat and oxygen.

3.3.1 District Heating systems and CHP

Finland is the coldest country in Europe, resulting in the highest annual heating demand of any European country. Of this heating demand, 46% is supplied by around 200 district heating networks and produced by CHP (combined heat and power) plants. In larger cities, over 90% of heating demand is supplied by district heating. Finland's comprehensive heating infrastructure combined with the sustained need for heat create an excellent opportunity to utilize the heat produced as a side stream of clean hydrogen applications. This will improve the commercial viability of clean hydrogen production while simultaneously helping to further decarbonize the heating system (by substituting the burning of CO2-emitting fuels with heat generated with clean electricity).

Sector coupling with heating systems also offers opportunities for balancing the electricity grid, as the excess electricity from renewable generation can be converted and stored as hydrogen and/or heat for later use. Existing CHP plants will also provide additional opportunities for grid balancing when they can be converted from heat-demand-based operating profiles to an operating regime fully optimized for sector coupling.

3.3.2 Energy intensive industries

Finnish industry is dominated by energy intensive process industries, e.g., the forest industry (pulp, paper, other biorefining), mining, metals and chemical processing. These industries will use clean hydrogen and direct electrification to decarbonize their own operations and create totally new streams of business. When they do so in an intelligent way, the in-built energy storages in the processes can be unlocked through sector coupling to balance energy networks and compensate for market volatility.

3.3.3 Bio-CO2 and clean water

In Finland, a specific opportunity is offered by the many condensed sources of biogenic CO2 that are currently a wasted side stream of flue gases from pulp mill recovery boilers and biomass burning

[1] E-fuels are synthetic drop-in fuels, such as synthetic gasoline, diesel, kerosene, or methane, which are made from captured CO2 and renewable hydrogen.

CHP plants. When coupled with clean hydrogen, this bio-CO2 can be utilized to produce fully sustainable, carbon-neutral products, such as fuels, chemicals, and materials. Compared to countries that lack access to similar green CO2 sources, this opportunity places Finland at a distinct advantage as a location for the long-term sustainable production of renewable e-fuels and chemicals.

Another key advantage for building a successful hydrogen economy is the abundant clean fresh water resources provided by our tens of thousands of lakes and rivers across the country. Furthermore, forest industry sites and CHP plants, where flue gas washers already produce side streams of purified water, provide readily available sites for the deployment of water electrolysis for hydrogen production outside the commonly utilized water infrastructure.

3.3.4 Ports and zero-emission marine logistics

The Finnish marine cluster is the world leader in developing the technologies, products, and solutions needed for zero emissions ports and marine operations. Hydrogen and synthetic fuels are required for decarbonizing the longer routes, where battery powered electrification of ships is not a viable option. Sector coupling at ports, by offering services with electricity/hydrogen/synthetic fuels for ships and linking the necessary shore-side facilities to municipal energy networks, offers another excellent sector-coupling opportunity in Finland.

4. Weaknesses to address

4.1 Lack of shared vision on the societal role of the Finnish hydrogen economy and bold action to support it

Most European countries have defined their hydrogen related strategies – some already years ago – and many are now implementing them with substantial concrete investment decisions, both public and private. For example, Sweden recently announced its revised strategy and is pursuing the necessary policies and public/private investment to support expansion. Similarly, Denmark has published an ambitious plan to construct artificial energy islands in the North Sea, to be owned and operated as a public-private joint venture partnership. This development is currently scaling up rapidly to become a global platform business. This time, instead of missing the boat, we must ensure that we swiftly adopt a common Finnish vision and begin implementing it right away.

This whitepaper aims to contribute to the creation of a shared vision by offering the common views of industry players and concrete policy recommendations derived from those views.

4.2 Still no commercialization of some core competencies/technologies

Finland still lacks competence in some strategic technology areas due to a lack of industrial activity in those sectors. For example, low-temperature electrolysis – the current de-facto renewable hydrogen production technology – is not yet within the skillset of any established Finnish company. There is, however, a good base of knowledge on the required technologies in research institutes, universities, and start-up companies. Consequently, local technology expertise in hydrogen production must be further developed and strategic partnerships created to acquire the necessary competencies and capabilities. A key opportunity is offered by the integration and optimization of entire processes, plants, and sector coupled systems, including the related business model innovation.

4.3 Small country, lack of funds, distant location

Finland's location on the periphery of Europe would be a disadvantage if we were to remain in the low value-added part of the hydrogen business. Transporting hydrogen or electricity requires major investments in the related transport grid infrastructure, and the value added by Finnish know-how would be low if we were merely to export clean energy as electricity or hydrogen. Therefore, we should make a virtue out of a necessity by concentrating on developing high value-added technologies, solutions, and P2X[2] products that are more cost-effective to export and that create high value local jobs and attract foreign investment to Finland. Close collaboration with the neighboring Nordic countries to build regional "hydrogen hubs" is also a logical way to address this disadvantage.

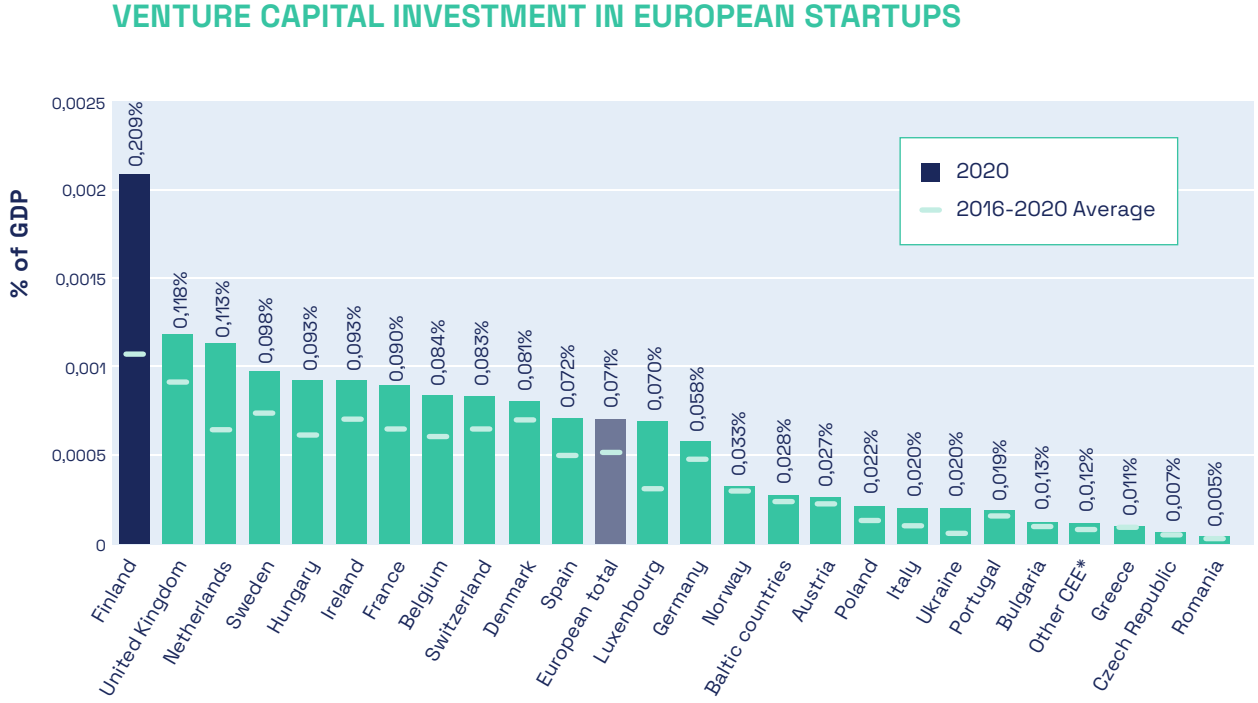
The transition to green electrification and a hydrogen economy requires significant amounts of additional capital. In Europe, the focus of the discussion has recently been public support for hydrogen projects, for example via currently planned IPCEI or RRF fund allocations or hydrogen-specific national programs. This puts small countries such as Finland in a weaker position than larger economies who can allocate much larger public funds to their projects.

The funding discussion nevertheless misses the point that public funds can only cover less than 10% of overall capital needs, while the remainder is to be funded with private equity. The most effective way to address the lack of capital is therefore to make Finland the most attractive location for (foreign) private investment.

A similar development has previously been witnessed in the ICT and gaming industries, where today Finland is the most attractive country for venture capital investment in Europe and where the high-tech industry is attracting top talent from all over the world. In addition to venture capital funding for start-ups, Finnish wind power and the electricity distribution grid infrastructure have received major capital contributions in recent years from foreign institutional investors who favor investments with predictable low-risk returns.

We must aim to repeat this model for the integrated hydrogen economy.

[2] P2X or Power-to-X refers to processes and technologies which convert clean electricity to carbon-neutral or carbon-negative fuels, chemicals, and materials able to replace today's fossil counterparts.



Source: https://paaomasijoittajat.fi/en/ie_2020_en/

5. Roadmap and recommendations

5.1 Target state for the Finnish Hydrogen Economy by 2030

By 2030, Hydrogen Cluster Finland companies will deliver global solutions for building a carbon neutral society. This goal is based on the Finnish hydrogen value chain becoming the most advanced in the world and Finland achieving carbon neutrality by 2035 as the first industrial country in the world.

Concretely, this target state can be characterized in the following way:

- Clean electricity will be abundantly available in Finland at the most competitive price in Europe
- Finland will be a major exporter of carbon-neutral Power-to-X products
- Finnish hydrogen technology know-how and solutions will be at a world-class level, resulting in major export growth for technology products and services
- 10,000+ high value new jobs will have been created in the Finnish hydrogen value chain
- The carbon handprint of Finnish exports will be many times greater than Finnish net emissions (baseline 2018 level)
- Systemic added value will be maximized with extensive sector integration through the use of renewable by-product heat and the intelligent digitalization of assets

- Finland will attract the most investment (relative to GDP) in the hydrogen economy in Europe, both for the integrated infrastructure of the hydrogen value chain and for technology companies and their research, development, and innovation activities
- Finland will be "the place to be" for the top talent in the hydrogen economy, attracting the best people from all over the world

5.2 Getting there – waypoint 2025

In order to reach the ambitious target state for 2030 described above, the work must begin immediately. As an interim target for 2025, it necessary to reach the following key waypoints:

- Establishment of the clearest and most cost-competitive regulation for all aspects of the hydrogen economy, from renewable power generation to the use of hydrogen as transport fuel and from environmental permits for Power-to-X plants to regulatory treatment of sustainable synthetic materials;
- Introduction of clear rules that support the utilization of our key strengths at the core of the hydrogen economy, e.g., our bio-CO2 resources and our district heating infrastructure;
- Correction of key technology weakness and construction of a strong overall knowledge base supporting leadership in the hydrogen domain at a global level.

By 2025, the forerunners of the Finnish hydrogen sector should have begun operation and Finland should be recognized by, for example, the European Commission and the IEA as a role model nation in the integrated handling of the transition to a sustainable energy system incorporating hydrogen deployment. Finland's renewable electricity generation capacity and its digitalized energy transmission grids will provide the world's best technical environment for renewable hydrogen production and business.

Supported by clear long-term regulation, several further hydrogen projects will be under construction, thereby scaling-up the industry. Commercial utilization of bio-CO2 will have begun and, through selected pilot activities, Finland will be recognized as the spearhead of the green transition towards carbon neutrality within the European hydrogen ecosystem. A healthy cohort of Finnish hydrogen experts will have graduated from local schools to support the development of a domestic hydrogen technology industry, in both start-ups as well as established corporations. As a prominent manifestation of our innovation environment, Hydrogen Cluster Finland will be well represented at SLUSH.

5.3 Immediate actions

To reach the target state of establishing a new hydrogen-based export industry in Finland by 2030, Finland must establish a pragmatic, cost-competitive, yet systematic and coordinated, regulatory basis and operating environment for commercial actors to invest and operate in Finland. We must accelerate the deployment of renewable electricity and clean hydrogen applications, and the regulatory framework must create a clear domestic market for hydrogen technologies and products based on clean hydrogen, thus providing a healthy launchpad for export business.

It is recommended that the following actions be started immediately:

5.3.1 Agreement on a shared national vision for hydrogen economy and kick-starting its implementation with RRF-backed investment

We need to create a solid, long-term national vision and related plans for seizing the hydrogen opportunity. This involves agreeing on shared targets and introducing investment and operating subsidies together with the required regulation to support the rapid implementation of the necessary

investments. A similar development has previously been seen with, for example, wind power and biofuels. The strategy must be coupled with Finnish climate policy and targets for emission reduction as well as renewable energy deployment, as a hydrogen economy is an irreplaceable part of the overall value network delivering carbon neutrality to Finland by 2035.

Implementation of the national strategy must be clearly supported by the government and its long-term continuity over multiple elective terms must be ensured to provide predictability for private investors. A clear lead role and co-ordination responsibility must be assigned to one of the ministries to prevent confusion over roles and responsibilities hampering the swift implementation of the strategy.

Special emphasis must be immediately placed on building readiness for participation in European funding programs, such as the hydrogen IPCEI, Innovation Fund, and hydrogen-specific allocations within the Green Deal and EU recovery programs and national funding.

What	Who	By When
Define Finnish Hydrogen integration & acceleration plan based on shared vision	Ministry of Economic Affairs and Employment (MEAE) together with Hydrogen Cluster Finland	30 October 2021
Define & publish funding criteria for RRF allocations in line with the above	MEAE and Business Finland	30 October 2021
Award first projects	Business Finland	31 December 2021
Define lead ministry and its co-ordination mandate	Finnish Government	31 December 2021

5.3.2 Defining and implementing a sector integration strategy including the planning of integrated energy networks

The opportunities presented by hydrogen must be incorporated into the long-term development plans of the Finnish national and local energy transmission and distribution grids, and these plans should be synchronized between the relevant actors. The national hydrogen strategy should integrate electrolyzers, hydrogen storages, hydrogen mobility, pipelines and other logistics, fuel cells, and Power-to-X production facilities with the planning of the Finnish and Nordic energy networks (gases, electricity, heat). For example, investment in hydrogen pipelines could enable efficient local and cross-border energy transport and storage, though investment levels would require clarification in order to optimize them vis-à-vis the other options. Finally, we should introduce plans for the expansion of cross-border energy transmission capacity, in particular in the north of Finland, towards Sweden and Norway to begin building an integrated regional Nordic hydrogen network. Ultimately, the aim should be to connect with Continental Europe, as there will be a major need for clean hydrogen, and this infrastructure would allow Finnish companies access to European storage capabilities. Finland should lead this effort.

Potential end-users of hydrogen energy over different sectors must be included immediately in the strategic planning of the hydrogen economy. End-users are the key to quickly materializing plans into projects. For example, marine ports and airports could be developed as potential hydrogen hubs in the strategy. Mechanisms supporting preparation phases (feasibility studies, basic engineering projects) in hydrogen projects should be introduced to de-risk and accelerate project initiation and development.

What	Who	By When
Revise Finnish national power and gas grid development plans, including the current vision for a hydrogen backbone transmission system	Fingrid and Gasgrid together with Hydrogen Cluster Finland companies	2022
Engage Nordic governments to co-ordinate the action plans for the Nordic hydrogen infrastructure	Ministry of Economic Affairs and Employment together with Hydrogen Cluster Finland companies	2022
Create an overall vision of Finnish energy grid development and integration to support energy system flexibility	Power grid (TSO/DSOs), gas grid, heat, and utility companies together with Hydrogen Cluster Finland	2023

5.3.3 Removing obstacles to further acceleration of green electricity and hydrogen investment

Renewable electricity

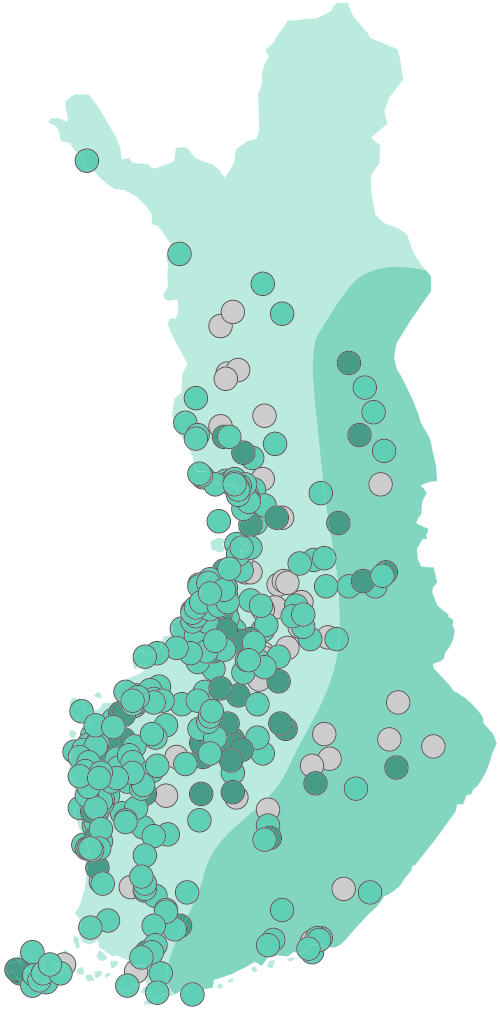
Currently, wind power cannot be developed in Eastern Finland or the Gulf of Finland due to issues related to interference with defense surveillance radar systems and consequent Finnish Defence Force objections. This issue must be urgently addressed through allocation of additional specific public funding in conjunction with the currently planned renewal of air surveillance radar systems. Relatively minor additional investment could allow the issue to be addressed, thus unlocking the development of wind power in sparsely populated parts of the country close to existing process industry plants where hydrogen would be produced and used. This investment would pay for itself if the additional costs were levied to private investors through build permits, and it would also reduce the required additional investment to transfer clean electricity from North-West Finland to consumption points in Southern Finland.

Unlocking investment

The government should assume the key task of unlocking private investment. Legislation should create a stable, predictable and low-risk investment environment. This can be achieved by creating markets for new products (regulation), increasing costs for fossil solutions (regulation), offering direct subsidies or equity investments, or providing guarantees (risk reduction) for investors.

The guarantee option would tie less funds from public budgets. Guarantees would also reduce investors' risk of losses, in turn attracting private equity from institutional investors and lowering the cost of re-financing for those investors. Lower and

UNTAPPED WIND POWER EXPANSION POTENTIAL IN EASTERN FINLAND



Source: https://tuulivoimayhdistys.fi/tuulivoima-suomessa/kartta

more limited risk would entice institutional investors to invest in projects in Finland rather than in other countries and could at least partially replace the need for direct public subsidies. Over a wisely chosen portfolio of projects, guarantees would also balance the risk to the government, for example through the capping of returns for guaranteed projects. We already have well established mechanisms for guaranteeing large projects (such as the construction of cruise vessels), which could be extended to pilot projects in the implementation of green electrification and the hydrogen economy.

What	Who	By When
Create a solution model for the particular national interests that are limiting deployment of new wind power in Eastern Finland and the Gulf of Finland	Finnish Defence Forces, Ministry of Defence, together with Ministry of Economic Affairs and Employment	31 December 2021
Design and establish a Finnish Clean Hydrogen guarantee instrument	Finnvera	Design 2021 New instrument opened 2022

5.3.4 Securing pragmatic regulation to enable the rapid scaling of the hydrogen economy

We must quickly develop the necessary approval processes and resources for the smooth deployment and installation of hydrogen technology and renewable power generation and hydrogen-production assets. We must secure the lead in clean electricity generation and transmission. Above all, we must enable the use of wind power and clean grid electricity in continuous industrial H2 production. Special attention should be paid to ensuring the cost competitiveness of clean hydrogen-based end products when they are produced through inter-sector collaboration. Leading European hydrogen countries are currently driving development through hydrogen valleys where various private and public initiatives come together in a regional context. We should also aim to optimize the value of hydrogen by-products and job creation by utilising, for example, waste heat to decarbonise district heating across Finland, capturing and utilising CO2 in hydrogen-derivative chemicals and fuels, and building additional value as flexibility and storage for energy markets. Finland should aim to become a leader in the application of flexible EU-regulation in a local context and engage the research community in the development of best-of-class regulation to enable the growth of new industries.

What	Who	By When
Defend use of all clean electricity for production of clean hydrogen, including ability to use adequately clean grid-based electricity during hydrogen scale-up period	Finnish government supported by Hydrogen Cluster Finland	2022
Create an incentive program to increase demand for clean hydrogen and its by-products (e.g., carbon contracts for difference). Focus on creating hydrogen hubs	Finnish Government	2022
Nominate a national body for wind power and hydrogen permitting co-ordination	Finnish Government	2021
Set a maximum time for permit decisions (including possible appeal processes) on regional land use and environmental permit plans for wind power and hydrogen projects	Finnish Government	2022

5.3.5 Prioritization of national public investments and procurement to create demand for climate-neutral, sustainable applications

Prioritization of public national investments and procurement can secure initial market "seed" demand and open the market for clean hydrogen-based products and solutions.

What	Who	By When
Introduce system-level climate impact as one mandatory criterion for public procurement (to support the national climate objective of 2035)	Finnish government	2022
Transition the national emergency resilience policy from emergency inventories of fuels towards building capability for sustainable, domestically produced, clean hydrogen-based alternatives	Finnish Government in conjunction with the current Energy and Climate policy renewal	2022

5.3.6 Introduction of a systematic program for creating the required competencies

Finland must create and strengthen its world-class expertise in hydrogen-related technologies and business. New skills, competencies and capabilities are required in all jobs and companies of all sizes. More strategic collaboration between companies, research institutes, universities, and vocation-

al education and training institutes is necessary for industrial piloting and the demonstration of new hydrogen technologies and applications, building flagship research infrastructure, and establishing study programs for training experts (also in the relevant regulatory, environmental, legal, commercial, and safety aspects of the hydrogen economy, in addition to new technologies). Increased public funding is required to enhance the development of an internationally competitive, renewable hydrogen industry in Finland.

What	Who	By When
Launch a targeted long-term program (min. 5 years) for hydrogen economy business and technology development.	Business Finland	H1/2022
Identify key competence and capability development needs and plans for the hydrogen value network and implement them accordingly. Ensure that Finnish RDI and education and training budget allocations provide funding for this.	Hydrogen Cluster Finland together with universities and research institutes. Ministry of Education and Culture Ministry of Economic Affairs and Employment	H2/2021
Initiate and maintain the development of an internationally competitive renewable hydrogen industry as a key objective for government investment support while increasing Finnish RDI investment towards the 4%-of-GDP target by 2030.	Ministry of Economic Affairs and Employment	2022

6. Call to action

This whitepaper represents Hydrogen Cluster Finland's long needed and thoroughly prepared first position on how the Finnish hydrogen economy should be developed. This is the start, and a call for both public and private actors across sectors to collaboratively develop an entirely new form of industry and business in Finland. Let us leverage this opportunity to the fullest for the sake of our economy and the global environment.

Hydrogen Cluster Finland members are ready and eager to take on the challenge.

White paper – A systemic view to the
Finnish Hydrogen economy today and in 2030
– Common playbook for the way forward

Hydrogen Cluster Finland
– Business for clean planet

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