H2 cluster FINLAND

Hydrogen economy roadmap for Finland: Europe’s most competitive hydrogen economy

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Abbreviations

CCU = *Carbon capture and utilisation*

CCS = *Carbon capture and storage*

RFNBO = *Renewable Fuels of Non-Biological Origin* → Renewable fuels that are not of biological origin (e.g. hydrogen e-fuels)

RED III = *Renewable Energy Directive III* (EU legislation on the promotion of renewable energy)

BECCS = *Bioenergy with Carbon Capture and Storage*

eSAF = *Electro Sustainable Aviation Fuel*

SAF = *Sustainable Aviation Fuel*

BECCU = *Bioenergy with Carbon Capture and Utilisation*

CO_2 = Carbon dioxide

H_2 = Hydrogen

Mt = Million tonnes

RRF = *Recovery and Resilience Facility* → The EU's recovery and resilience facility, which was created after the coronavirus crisis to support member states' investments and reforms. It is a one-off facility, and it will be discontinued in the next few years.

MFF = *Multiannual Financial Framework* →The EU's multiannual financial framework is a seven-year budget plan that finances EU programmes and investments. The next MFF will start after 2028 and will be a key source of long-term funding.

STIP = *Sustainable Transport Investment Plan* → The EU's investment plan for sustainable transport which aims to promote the development of infrastructure for low-emission and sustainable transport solutions, such as electricity- and hydrogen-based technologies, and reducing transport emissions as part of the green transition and the TEN-T (Trans-European Transport Network) objectives.

The Innovation Fund → An EU funding programme that supports large and innovative low-carbon projects, such as hydrogen technologies, industrial emission reductions and the energy transition.

Hydrogen bank → An initiative of the European Commission to accelerate the production and use of renewable hydrogen in the EU by providing financial incentives and competitive tendering (e.g. hydrogen price support).

CfD = *Contract for Difference* → An agreement model in which a public entity guarantees a producer a certain price ("strike price") and compensates for the difference between the market price and the agreed price, which reduces investment risk and supports competitiveness.

IPCEI = *Important Project of Common European Interest* → The EU's special funding and coordination mechanism that supports joint strategic projects of member states, such as clean hydrogen production, infrastructure and innovation, where they are important for the competitiveness and green transition of the whole of Europe.

CEF = *Connecting Europe Facility* → An EU funding programme that supports the development and interconnection of transport, energy and digital networks in Europe. It provides grants and financial instruments for infrastructure projects such as investments in ports and the distribution of alternative fuels (e.g. hydrogen).

AFIR = *Alternative fuels infrastructure directive* → An EU regulation that specifies requirements for the development of charging and refuelling infrastructure for alternative fuels (such as electricity and hydrogen). It aims to ensure a sufficient and coherent network across the EU to advance the transition to low-emission transport and a low-emission energy system.

IDB = *Industrial Decarbonisation Bank* → A financial instrument designed by the EU to support industry's transition to low- and zero-emission production methods. The bank provides strategic financing for large investment projects, such as the use of hydrogen and clean energy, and helps to reduce the risks of investments and accelerate the achievement of the industry's carbon neutrality targets.

Foreword

Our call for international collaboration

Finland aims to become the most competitive hydrogen economy in Europe in the coming years. The purpose of this roadmap is to define the path to achieving this highly ambitious goal. While the roadmap focuses on the Finnish operating environment and identifies concrete measures for Finnish stakeholders, our most important message is the need for international collaboration.

Therefore, we invite all our European and international partners to work towards the same goal of enabling a prosperous hydrogen economy. Hydrogen economy value chains are never local – they are always international and therefore benefits of investments are shared across companies and geographies.

Our mission is to work towards an operating environment that enables hydrogen economy investments to materialize to the benefit of all of Europe.

Finland possesses significant competitive advantages in establishing a prosperous hydrogen economy. You will find thorough analysis of the competitive Finnish operating environment in the roadmap in the coming pages. However, as a small nation, Finland has limited domestic market for green and low carbon hydrogen and their derivative products. Therefore, we rely on the European Union framework for creating markets through energy and climate policies that set out the direction for EU's climate protection, energy independence, resilience, and related policies.

Hydrogen is Freedom

The slogan of Hydrogen Cluster Finland sends out a strong message: hydrogen can become a key enabler of new European industrial prosperity in the coming decade, and free our continent from relying on outside energy sources. Hydrogen Cluster Finland is committed to working with you towards this goal.

A successful hydrogen economy can only be built with European-wide collaboration.

Please join us in this mission. Hydrogen is Freedom.

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1. Introduction

Finland's goal is to become Europe's leading high-value hydrogen economy. This can be achieved through determined cooperation and bold solutions. A strong hydrogen economy ecosystem creates significant economic value, increases well-being and strengthens Finland's climate handprint globally. From the point of view of security of supply, domestic hydrogen production and the related value chains are critical to securing the needs of industry and the energy system even in exceptional situations.

Hydrogen Cluster Finland, which consists of approximately 90 companies and operators in the hydrogen economy, promotes investments, strengthens the ecosystem and supports the growth of the national economy, climate goals, competitiveness and national preparedness. Achieving this goal requires joint efforts and the utilisation of strategic strengths from companies, the state and other actors.

The Government Programme, "A Strong and Caring Finland," outlines Finland's role as a key player in the hydrogen economy and aims for a 10% share of the EU's clean hydrogen production and use. The Energy and Climate Strategy also sees hydrogen as a key solution for achieving carbon neutrality and the energy transition of industry. This roadmap is based on the Hydrogen Cluster Strategy (2023), which identifies growth potential and concretises the vision into ambitious actions. The roadmap has been drawn up in close cooperation between the business members of Hydrogen Cluster Finland, and it reflects the shared vision and commitment of the operators in the sector to the development of the hydrogen economy in Finland.

Success requires input at all levels – from local to global – in a synchronised and ambitious manner. The different sectors of the hydrogen economy must progress hand in hand: renewable electricity production, market building, plant investments, infrastructure, innovations, technologies and the availability of biogenic carbon dioxide. Growth must be based on the principles of circular economy and sustainability criteria from the very beginning. The roadmap sets out measures to combine these elements and accelerate the development of the hydrogen economy.

Let's build the future of Finland and the hydrogen economy together.

2. Abstract

The hydrogen economy can be the cornerstone of Finland's sustainable growth and security of supply. Success requires bold and strong cooperation and rapid action, with each actor playing their own role. This hydrogen economy roadmap leads the way and presents concrete steps: market development, growth in clean electricity production, investments in hydrogen and downstream products, as well as the capture of biogenic carbon dioxide, innovation and technological development – they all go hand in hand.

The hydrogen economy is not created solely on market terms, but demand is created by regulation that guides users to switch to clean hydrogen and hydrogen-based fuels through obligations and incentives. EU-level mandates and distribution obligations are critical and must be transposed into national legislation ambitiously. In addition to Finland, large member states, such as Germany and Spain, must take a leading role in the implementation of regulation in order to create a market and realise investments.

In addition to scaling up simultaneously in different sectors, it must be implemented boldly, wisely and quickly in order to achieve the desired share of the hydrogen market in Finland. In 2025–2030, a foundation will be laid for expertise and market creation as well as industrial-scale investments by learning from pilot programmes and developing new solutions together. The distribution obligations defined by the regulation will create demand in the fields of aviation, shipping, industry and road transport. After 2035, mandates will grow rapidly, and scaling must anticipate this well in advance.

In addition to physical infrastructure, the growth of the hydrogen economy also requires digital capabilities that enable the coordination of value chains, the functioning of market mechanisms and reliable decision-making across sectoral boundaries. These capabilities must support both national security of supply and the functioning of the Europe-wide market.

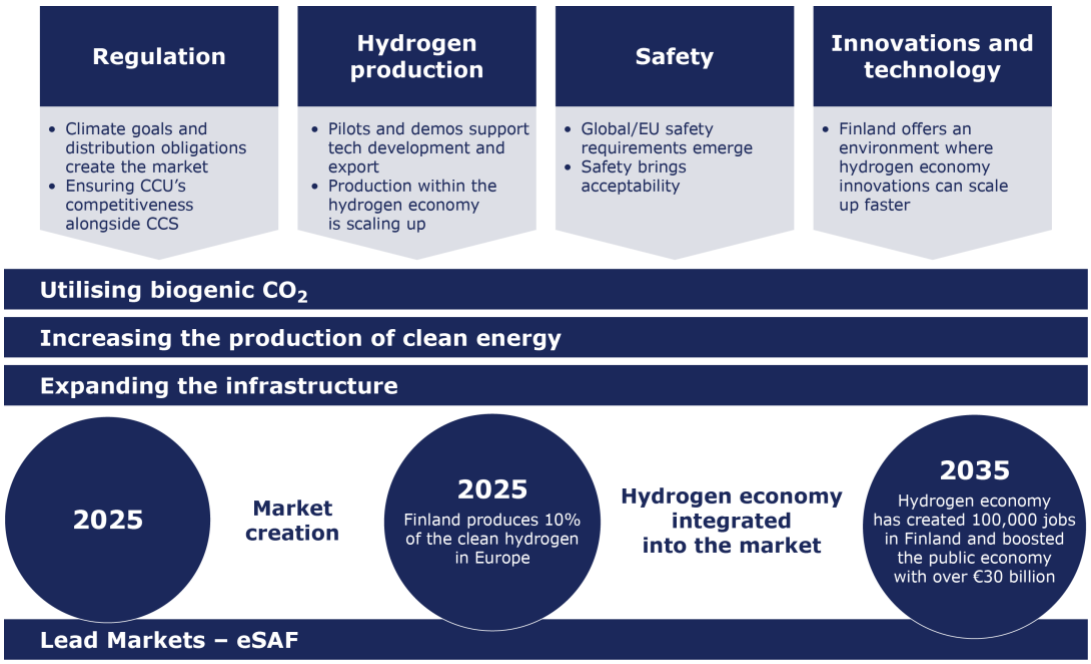

Figure 1. Pillars of the Hydrogen Economy Roadmap

Market growth requires encouraging and enabling regulation and adherence to agreed climate targets, mandates and penalty payments. The mandates set at the EU level for hydrogen and hydrogen-based fuels, as well as the end products based on them, must be transposed into national legislation, and the regulatory gaps must be filled. Especially with regard to the recovery and use of biogenic CO_2, Finland must create the necessary incentives and mandates to promote its use.

The EU's Lead Market Initiative creates lead markets for new innovative and low-carbon products and technologies. The aim is to create demand for strategic solutions so that they reach commercial maturity first in Europe and then spread globally. This is a key part of the EU's Clean Industrial Deal strategy, linked to the EU's 2050 climate neutrality targets. The European Commission is preparing a set of legislative criteria for certain sectors to promote the use of green and low-carbon hydrogen, for example in the steel and chemical industries.

The Lead Market approach promoted by Hydrogen Cluster brings together actors enabling hydrogen production and further processing from different perspectives – from technology developers to financiers, end users and legislators – to accelerate concrete investments in Finland and technology exports. With the help of this model, Finland can become a pioneer by developing new technological export products and attracting investments, concentrating its efforts on the markets that will be the first to be created by regulation. For this reason, the

"**eSAF lead market task force**" for aviation fuel, catalysed by Hydrogen Cluster, will make the first move, inviting other end-use sectors to follow suit, activating actors in the value chain and creating new markets.

Measures highlighted in the roadmap

The table below summarises the measures that emerged from the roadmap. Most of these are very ambitious and require quick and bold action, as well as a long-term commitment to the agreed goals. However, we must start now in order to implement this roadmap, which emphasises Finland's pioneering status, and the goals of the hydrogen economy.

Table 1 Summary of measures

PROCEDURE	LIABILITY	THE ROLE OF HYDROGEN CLUSTER
REGULATION AND MARKET CREATION		
Ensure that Finland's relative competitive position is maintained and that green hydrogen remains within the EU's targets.	Finnish Government, companies	Hydrogen Cluster brings the perspective of companies to the discussion and influences future legislation.
Extend the transition period for the temporal correlation of RFNBO regulation until 2035 and examine the necessity of hourly correlation.	EU, Finnish Government, Ministry of Economic Affairs and Employment (TEM)	Hydrogen Cluster brings companies' perspective to the discussion and influences future legislation.
Enable the use of nuclear PPAs in the production of low-carbon hydrogen.	EU, Finnish Government, TEM	Hydrogen Cluster brings companies' perspective to the discussion and influences future legislation.
Ensure that the distribution and use obligations of road, sea and air transport and industry are adhered to, and that a proposal is created for the 2030s to increase their use.	Government of Finland, TEM, Ministry of Transport and Communications	Hydrogen Cluster brings the perspective of companies to the discussion and influences future legislation.
The eSAF Lead Market work must be launched for the entire ecosystem and the progress and scaling of concrete investments must be ensured.	Companies and other actors in the ecosystem	Hydrogen Cluster catalyses and supports the work and the person leading the work.
Launch other Lead market task forces: heavy transport, shipping, green steel, chemical industry and technology exports.	Companies and other ecosystem actors led by an active operator	Hydrogen Cluster is looking for actors to take the lead and supports the start-up.
Finland's next Government Programme must identify the potential of the hydrogen economy and accelerate the scaling of the hydrogen economy.	Government parties	Hydrogen Cluster convinces government parties of the potential of the hydrogen economy and the economic benefits of the hydrogen economy.
HYDROGEN PRODUCTION AND FINLAND'S COMPETITIVENESS		
Create and update a continuous situational picture of and scenario for the hydrogen economy for everyone's use and to strengthen Finland's image.	Hydrogen Cluster	Hydrogen Cluster creates and updates the situational picture and scenarios of the hydrogen economy.
Government to conclude ministerial-level trade and cooperation agreements to promote the hydrogen economy and an ambitious operating environment (e.g. Germany, Sweden, Poland).	Government and Ministers, Business Finland	Hydrogen Cluster seeks international partners and brings together actors. Hydrogen Cluster promotes cooperation with the Baltic Sea region's hydrogen clusters and companies. If necessary, Hydrogen Cluster can act as a signatory party.

Draw up a Finnish hydrogen economy strategy for an international audience, creating a concrete action plan to implement Finland's 10% hydrogen production target and define the competitiveness factors of the operating environment of Finland's hydrogen economy.	Government, TEM, Business Finland	Hydrogen Cluster actively participates in the work and supports the Government and the Ministry in the necessary ways by producing content and commenting.
HYDROGEN SAFETY		
Finland is actively involved in the development of European and global safety standards in order to maintain domestic competitiveness throughout the value chain.	Companies, Finnish Safety and Chemicals Agency (TUKES)	The safety working group of Hydrogen Cluster participates in the development of the selected standards and guidelines.
Finland's guidelines and requirements must be in line with EU and international practices – not stricter than elsewhere, but sufficiently comprehensive to ensure safety.	TUKES, companies	The safety working group of Hydrogen Cluster actively helps and comments on the promotion of TUKES' safety work in Finland.
Communicate and learn openly about safety measures and share experiences – even one serious accident could destroy the acceptability of the industry.	Companies, TUKES	Hydrogen Cluster shares experiences and lessons learned and discusses safety issues openly in working groups.
Determined investments must be made in safety, and it must be ensured that risks are managed throughout the value chain. Share lessons learned openly and get to know the best solutions.	Companies, TUKES	Hydrogen Cluster organises introductory visits and presentations on safety topics for its members.
INNOVATIONS AND TECHNOLOGIES		
Ensure long-term and ambitious research, with the primary aim of achieving impact through intellectual property rights for new technologies and related new business.	TEM, Business Finland, companies	Hydrogen Cluster highlights topics and bottlenecks that are important to companies for the development of the hydrogen economy.
Strengthen ecosystems in which leading companies launch market-driven development paths, research organisations produce technological breakthroughs and new knowledge, and start-ups carry out rapid experiments and develop new business models.	Companies, research organisations and other ecosystem actors and financiers	Hydrogen Cluster brings together the actors, shares information and creates a shared mindset and situational picture.
Make Finland a globally attractive place to develop and scale technology, especially for startups and growth companies.	Private equity investors, Finnish Industry Investment (Tesi), Business Finland, Technical Research Centre of Finland (VTT), TEM	Hydrogen Cluster helps startups and growth companies to network and, where possible, promotes the creation of a favourable operating environment.
Ensure sufficient know-how for the growth of the hydrogen economy. Support the development and integration of education and training into the existing education system.	Actors in the education sector, companies, political decision-makers	Hydrogen Cluster brings together the actors and communicates companies' views and needs to the education sector.
INFRASTRUCTURE EXPANSION		
Ensure an electricity infrastructure that enables investments in and scaling up of the hydrogen economy.	Fingrid	Hydrogen Cluster brings together the actors, shares information and creates a shared mindset and situational picture.
Ensure the construction of a hydrogen transmission network to boost domestic investments and create a liquid and functioning market in Finland and the surrounding areas.	Gasgrid Finland	Hydrogen Cluster brings together the actors, shares information and creates a shared mindset and situational picture.
Assess the need to build a carbon dioxide transmission network.	Gasgrid Finland	Hydrogen Cluster connects actors, shares information and creates a shared mindset and situational picture.

UTILISATION OF BIOGENIC CARBON DIOXIDE		
Enable biogenic carbon capture (BECCS/BECCU) by creating incentives in legislation, e.g. in the context of the reform of the Emissions Trading Directive.	Government of Finland, TEM, Ministry of the Environment (YM)	Hydrogen Cluster emphasises the need for its members to find a legislative incentive for the capture of biogenic carbon dioxide.
Secure the financing of investments in biogenic carbon capture.	Government of Finland, TEM, YM	Hydrogen Cluster emphasises the need for its members to find funding for the capture of biogenic carbon dioxide.
Enable the availability of biogenic carbon dioxide and the emergence of a market for captured carbon dioxide.	Operators in the forest industry, bioenergy and biogas sectors with carbon dioxide side streams	Hydrogen Cluster connects producers and users of biogenic carbon dioxide and helps to solve bottlenecks.
INCREASING CLEAN ENERGY PRODUCTION		
Enable the construction of additional renewable energy and avoid regulations restricting additional construction that would weaken the potential of green transition investments to create new growth in Finland.	Policymakers, Ministries	Hydrogen Cluster and companies are engaged in a dialogue on the effects of the green transition on the national economy.
Facilitate the construction of wind power in industrial areas and near hydrogen production plants to avoid long transmission lines.	Policymakers, Ministries	Hydrogen Cluster and companies engage in a dialogue on the economic impacts and concrete opportunities of the green transition.
ENERGY SYSTEM AND FLEXIBILITY		
There will be a societal debate on the roles of data centres and the hydrogen economy and how these sectors will support Finland's renewable energy-based economic growth and its priorities in the 2030s. The aim is to build a holistically sustainable energy system in which the sectors complement each other, and their roles are coordinated so that they improve the efficiency of the energy system – not only the use of hydrogen as backup power.	Political decision-makers, companies, Finnish Energy, Finnish Data Center Association	Hydrogen Cluster actively participates in the discussion on the synergies of the energy system between data centres and the hydrogen economy.
Ensure the flexibility of the energy system through smart solutions and optimisation.	Companies, political decision-makers	Hydrogen Cluster actively participates in the discussion on energy system optimisation.
SECURITY OF SUPPLY AND RESILIENCE		
Together with the Ministry of Defence, the Finnish Defence Forces and NATO, a plan will be drawn up for the use of, e.g., RFNBOs and green steel as part of public procurement in the defence industry to ensure the overall resilience and fuel self-sufficiency of society, as well as the security of supply of materials.	Ministry of Defence (PM), National Emergency Supply Agency (NESA), NATO, companies	Hydrogen Cluster brings together actors and proposes concrete measures.
Harness the potential of biogenic carbon dioxide to increase self-sufficiency in the production of synthetic raw materials, new products and fuels, and in phasing out fossil raw materials. In addition, the potential of green ammonia will be strengthened to abandon Russian ammonia.	Companies, NESA, political decision-makers	Hydrogen Cluster brings together actors and proposes concrete measures.

FINANCING		
Increase government guarantees and minority holdings in critical hydrogen projects.	Tesi, TEM	Hydrogen Cluster actively informs its members about funding opportunities and informs financiers of the needs of the hydrogen economy.
An annual budget will be reserved for investment support in Finland to promote the hydrogen economy, and long-term funding will be ensured to scale up hydrogen economy innovations.	Ministers, TEM, Business Finland	Hydrogen Cluster actively informs its members about funding opportunities and informs financiers of the needs of the hydrogen economy.
Secure funding for Finland through EU instruments (such as RRF/MFF/STIP, Hydrogen Bank and Innovation Fund) by actively participating in funding calls and development.	Companies, TEM, Business Finland	Hydrogen Cluster actively informs its members about funding opportunities and informs financiers of the needs of the Finnish hydrogen economy.
Use funds from the EU Emissions Trading System (ETS) as an incentive to reduce the price gap between low-emission fuels and fossil fuels, e.g. to accelerate the transition of maritime transport to low-emission fuels.	Political decision-makers, TEM, Ministry of Finance	Hydrogen Cluster actively informs its members about funding opportunities and informs financiers of the needs of the hydrogen economy.
Use EU instruments (e.g. IPCEI, Innovation Fund and Hydrogen Bank) to improve the profitability of projects.	Tesi, TEM, Business Finland	Hydrogen Cluster actively informs its members about funding opportunities and informs financiers of the needs of the hydrogen economy.
Design advanced support systems for Finland and ensure that the EU does the same. In particular, a long-term CfD (Contract for Difference) based on a price gap of about 10 years must be included in the instruments.	EU, TEM, Business Finland, private financiers	Hydrogen Cluster actively informs its members about funding opportunities, informs financiers of the needs of the hydrogen economy and proposes solutions that are practical for companies.
Private financiers must actively participate in risk-sharing, co-financing models and consortia, and support innovation and RDI activities by establishing or joining funds that finance hydrogen economy start-ups and research projects.	Private financiers and investors	Hydrogen Cluster actively informs its members about funding opportunities and informs financiers of the needs of the hydrogen economy.

In addition to the list of measures above, it is good to examine the progress of the hydrogen economy in different sectors and within different time periods (Table 2). The hydrogen economy is developing at different rates in different sectors, depending primarily on the market created by regulation, but also on the development of electrification solutions. When electrification is possible, hydrogen economy solutions will play a more marginal role in the sector in question. The development of the hydrogen economy must focus on the big picture and ensure that solutions are targeted where they produce the best added value and promote the green transition and security of supply. The table below highlights the measures of the hydrogen economy roadmap for different sectors within different time periods, reflecting them on the ambitious goals of the hydrogen strategy. The table reinforces the roadmap's message that bold measures, rapid technological development and investment decisions are needed in the next few years to ensure Finland's competitiveness in the hydrogen economy.

Table 2 Summary of the roadmap for different sectors

	2026–2027	2028–2030	2030–2035
eSAF	Investment decision for the first eSAF plant (~250 MW, 60 kt/year) and projects in pre-planning phase. **What is needed**: - STIP Participation - The Book & Claim system is introduced. - CfD support in place (or CAPEX support)	The first plant under construction. A second wave of investment decisions to meet the 2035 target. **What is needed**: - CfD/OPEX support in use.	4–5 eSAF plants in operation (~250 kt/year). Stabilised exports and domestic consumption. **What is needed**: - Higher mandates in full effect. - Rapid technological development and scaling
Carbon capture	First investment decisions for CCU recovery plants (0.2–0.3 Mt). **What is needed**: - Approved national BioCCU strategy. - Biogenic CO_2 - CAPEX support.	Recovery expanded to more than 1–1.5 Mt/year. The first CO_2 hub has been built. The CO_2 logistics framework is introduced.	Recovery extended to 2–3 Mt/year (CCU + CCS) CO_2 hubs integrated with eSAF, marine fuels and chemicals. **What is needed**: - Rapid technological development and scaling
Hydrogen production	First commercial investment decisions for production of H_2/e fuel projects. **What is needed**: - Fast-track permitting and prioritisation of electricity network connections.	0.2–0.3 Mt/year of clean hydrogen production is under construction. Deployment of warehousing and transportation solutions.	~0.4 Mt/year of clean hydrogen production is in operation. **What is needed**: - Implementation of the RFNBO obligation for industry
Chemical industry	The chemical industry has highlighted the dependence of raw materials on fossil fuels and the replacement of the current grey hydrogen.	Industry is starting to switch from grey to clean hydrogen and hydrogen-based raw materials.	Industry is starting to switch more strongly to raw materials that replace fossil fuels, incl. hydrogen-based.
Hydrogen infrastructure	The first investment decision in the pipeline segment. **What is needed**: - Route selection, permit procedure - CEF funding.	Construction of the pipeline begins. **What is needed**: - Tariff and network operator rules ready.	The commercial use of the hydrogen pipeline will enable industrial demand and exports. **What is needed:** - Integration into the Nordic-Baltic corridor.
Road transport	FID for three hydrogen stations. **What is needed:** - Investment aid for refuelling stations / hydrogen truck investments - Rules for the injection of e-methane into the gas network.	Three filling stations in operation. The first e-methane feed into the gas network. **What is needed:** - RFNBO distribution obligation enters into force, including the use of green hydrogen in transport fuels manufacturing.	Expanded network of hydrogen stations (min. 9 stations according to 2030 AFIR requirements). Mature H_2 and e-methane heavy-duty markets. **What is needed:** - Increase in RFNBO distribution obligation, including the use of green hydrogen in transport fuels manufacturing.

Maritime transport[1]	In 2026, the IMO will decide on a global agreement to reduce emissions from maritime transport. 3–5 long-term off-take contracts have been made. **What is needed:** - Readiness for the parallel use of e-fuels on ships - Bunkering readiness of ports. - Incentives and guidance environment	The Finnish maritime cluster promotes the implementation of legislation and investments. The retrofit of equipment and the acquisition of new equipment are progressing. The bunkering network has been built in 5–7 ports. **What is needed**: - Interoperability standards for measurement, quality assurance and mass balance for RFNBO compliance	The probable RFNBO mandate for maritime transport enters into force. Nationwide bunkering network and integrated supply chains.
Green Steel[2]	In 2026 the EU will define the criteria and targets for green steel. **What is needed**: - An ambitious target for low-emission materials to meet the requirements of the EU Public Procurement Directive. - EU-wide regulatory clarity and funding mechanisms (e.g. CfD) and certification schemes to accelerate hydrogen-enabled steel production and prevent cross-border market fragmentation. - Prioritisation of hydrogen projects in the steel industry at the EU's Industrial Decarbonisation Bank - (IDB).	The use of green steel is obligatory in public procurement in certain sectors, e.g. public construction. The automotive industry also uses green steel for its emission obligations, creating a market. **What is needed**: - IDB funding of at least €100 billion by 2028 to secure funding for large hydrogen projects.	Finland is a leading player in the new green steel industry. **What is needed**: - Financing mechanisms (e.g. IDB) will continue to support investments in the hydrogen economy to meet the needs of the steel industry.

3. Hydrogen Cluster Finland – what is it and what does it do?

Hydrogen Cluster Finland is a national cooperation network that brings together companies, research organisations and public actors to promote the development of the hydrogen economy in Finland. The aim of the cluster is to accelerate the transition towards carbon-neutral society by utilising hydrogen and its derivatives in industry, energy production and transport.

The cluster serves as a platform that:

- **fosters investments and innovation** in the hydrogen economy value chain
- **facilitates cooperation** between companies, research and the public sector
- **influences regulation and market development** at national and EU level.

[1] Final report: An incentive to reduce the price differential and promote the availability of low-emission fuels for maritime transport

[2] Creating the enabling conditions for near-zero emission steelmaking in Europe

A wide range of actors are involved: energy companies, industrial companies, technology developers, as well as research institutes and authorities in close cooperation. The cluster's strength is this diverse ecosystem – it enables rapid development and competitiveness in the international market.

Why is this important for Finland's growth?

The hydrogen economy offers Finland a significant growth opportunity: it creates new investments, jobs and export products, and strengthens Finland's position as a pioneer in clean energy. Through the cluster, Finland can build a competitive hydrogen economy ecosystem that supports economic growth and attracts international partnerships.

4. 2025–2030 Current situation and market development

According to Prime Minister Petteri Orpo's Government Programme, Finland aims for a 10% share of the European Union's hydrogen production and use by 2030. The Government Programme states as follows: "The hydrogen economy is a key tool in the energy transition of industry and in utilising the opportunities of the green transition."

When the EU and Finland stick to their ambitious climate targets, Finland has a lot to gain, unlike if it held onto the fossil economy. At the moment, Finland still imports fossil fuels worth billions of euros, the raw materials for the chemical industry are mainly fossil fuels, and some of the ammonia still comes from Russia. The hydrogen economy offers a solution for meeting climate targets, increasing self-sufficiency and security of supply, and building a vibrant Finland. In addition, we can also offer significant decarbonisation solutions to other European Union member states.

The development of the hydrogen economy is currently at a critical stage. The public debate is characterised by concerns about Europe's competitiveness, energy prices, the viability of climate targets, and doubts about the role of the hydrogen economy and the timetable for its implementation. At the same time, the role of data centres as electricity consumers and investment competitors is a topic of discussion. Therefore, it is necessary to create an atmosphere and a common state of mind that recognises the importance of climate goals for the emergence of new markets and accelerating the green transition – as well as the severity of opportunity costs if the goals are relaxed.

From the perspective of the development of the hydrogen economy, Finland has unique competitive advantages, such as the availability of clean, affordable electricity and the

opportunity to build new renewable electricity production in a cost-effective manner. In addition, our strengths include a good and rapidly developing infrastructure, biogenic carbon dioxide, clean water and a stable society. The EU regulation emphasises the special characteristics of the Finnish operating environment in an exceptional way, enabling the RFNBO additionality requirement to be abandoned due to the low carbon dioxide emissions of grid electricity. Without the additionality requirement, lower production costs, faster commissioning and simpler project planning will be achieved compared to countries where the additionality requirement is in force. However, these competitive advantages can only be exploited by ensuring the realisation of an EU-wide market, which underlines the importance of the objectives agreed at EU level.

Finland is in an excellent position to build a viable hydrogen economy. This roadmap is in line with the Finlandia Declaration[3] published by Finnish Energy, the Chemical Industry Federation of Finland, Technology Industries of Finland and Finnish Forest Industries, which emphasises urgent action and determination. Investments are needed in clean energy production, transmission networks and projects that promote the use of hydrogen. Finland must be an attractive investment destination by providing reliable electricity that is affordable on a European scale, utilising unique sources of biogenic carbon dioxide, making proactive investments in the grid, offering incentives to large electricity users, accelerating reference projects and by streamlining permit procedures. Geopolitical and regulatory challenges require a strong investment environment and an active positioning in the development of the European hydrogen economy.

At the same time, industrial operators are moving forward: around 60 projects are in different phases of planning, corresponding to an annual hydrogen production of 1.5 million tonnes and a total investment of EUR 30 billion. Most of the projects are related to the production and export of synthetic fuels, but they are in the early stages – no investment decisions have been made and no information on off-taker agreements has been published.

[3] Finlandia Declaration: Industry of the Modern Age – Investing in Finland

Regulation and market creation

In the current economic situation, the emergence of voluntary markets is challenging, and consumers' ability/willingness to pay a (voluntary) premium is very limited. In practice, very few new markets have historically emerged entirely on market terms. The creation of the hydrogen economy market is also almost entirely dependent on the regulation created by climate goals and the subsequent distribution obligations and sanctions. At the moment, the laws mandating the use of renewable hydrogen and synthetic fuels are already in force, but the mandates will enter into force later, creating demand for the next few years, and on a larger scale in the 2030s. It is extremely detrimental to the emergence of markets to open up a debate on a large-scale change in targets or a weakening of targets, as this would only increase uncertainty and postpone important investments further.

It is important to ensure that the distribution and use obligations of road, sea and air transport and industry are adhered to both in Finland and in other EU countries, and that an increase in their use is ensured into the 2030s. The competitiveness of Finland or the EU in the global competition of the 2030s cannot be based on the fossil economy. Although part of Europe may benefit from such a scenario, it is obvious that the Finnish economy will be based on the provision of sustainable energy solutions.

As the EU's competitiveness – or lack thereof – and energy prices rise to the centre of the EU debate, it is likely that the EU's hydrogen legislation will also be amended. Changes must be targeted at certain details that regulate operations, not the goals themselves. In the changes, the Finnish government must ensure that Finland's relative competitive position is maintained and that the role of green hydrogen remains an EU goal. At the same time, with these changes, it is justified to promote, for example, the extension of the transition period for the temporal correlation of RFNBO regulation until 2035 and enabling the use of nuclear PPAs in the production of low-carbon hydrogen. Particular attention should be paid to ensuring the status and role of biogenic carbon dioxide in the production of hydrogen derivatives and enabling the availability of biogenic carbon dioxide.

Finland must be proactive in advocating at the EU level in order to maintain its ambition and to keep the investment environment competitive. Especially with regard to biogenic carbon dioxide, Finnish politicians and administration should invest in influencing in advance.

An important factor is to get the end product market going. To this end, Hydrogen Cluster Finland is catalysing the work of the Lead Markets Task Force, in which actors in the value chain of end products are brought together to create new demand and investments. The

eSAF work has been launched first, but there has also been a need to set up a Lead Markets Task Force for maritime transport, heavy transport, industry, steel and technology products, among others.

Influencing at the EU level and the goals and measures agreed upon in the EU are crucial in promoting all end product markets due to Finland's small domestic market.

Aviation

Aviation is one of the most difficult sectors to electrify and is one of the first to be subject to synthetic fuel distribution obligations. The market is expected to be one of the pioneers of the hydrogen economy, which makes investments in the aviation value chain a high priority and offers significant growth opportunities for Finland. Aviation legislation is particularly interesting from Finland's point of view, as it enables, for example, the utilisation of low-carbon hydrogen in eSAF production, bringing cost savings and efficiency. In addition to hydrogen, the production of eSAF requires biogenic carbon dioxide, which underlines Finland's potential as an eSAF manufacturing country.

From 2030, the EU will introduce a 1.2% distribution obligation for synthetic aviation kerosene, the share of which will increase to 5% in 2035 and 35% by 2050. The growth in the distribution obligation for air traffic is illustrated in Figure 2 below.

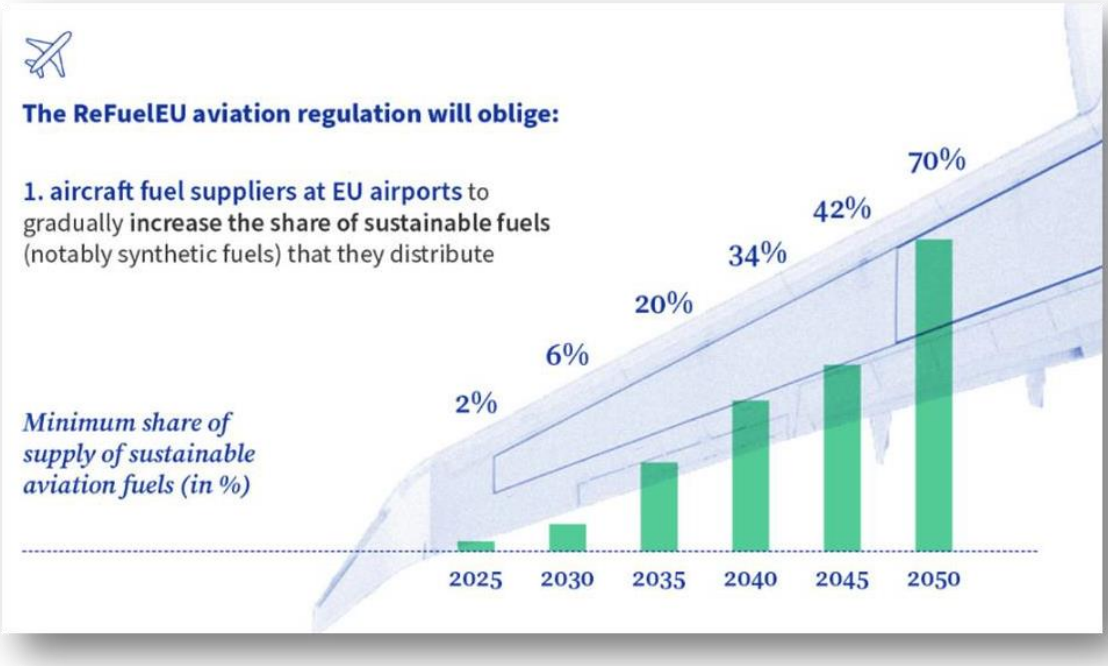

Figure 2 Increase in distribution obligations for air transport in the EU[4]

The eSAF Lead Markets Task Force, launched by Hydrogen Cluster Finland, has set a target that by 2030, Finland will produce 10% of the eSAF jet fuel required by the distribution obligation, i.e. approximately 60,000 tonnes of eSAF per year. This corresponds to approximately one plant with an electrolysis capacity of approximately 250 MW. For comparison, in 2030 the need of Helsinki Airport and Rovaniemi Airport to meet the 1.2% distribution obligation with eSAF fuel is approximately 10,000 tonnes per year, i.e. the targeted capacity makes it possible to sell aviation fuel to the international market through the "Book and Claim" system in addition to self-sufficiency. The key benefit of the Book & Claim system is that eSAF fuel produced in Finland does not have to be physically exported to European airports, but domestic airports can use eSAF fuel above the minimum level of the distribution obligation and sell the excess certificates abroad. This flexibility supports the creation of markets, accelerates the profitability of investments and strengthens Finland's position as a pioneer in sustainable aviation fuel. A prerequisite for the achievement of this production target is that the ReFuel Aviation distribution

[4] European Parliament: 70% of jet fuels at EU airports will have to be green by 2050

obligations and penalties remain at the agreed level and that the "Book and Claim" market has been implemented.

When the eSAF plants are commissioned, other side streams will also be created from the process, which will provide solutions for the value chain of the chemical industry, for example. These include, for example, light hydrocarbons (methane and C_1-C_4 gases), naphtha fractions and diesel products from the Fischer-Tropsch process, and light olefins (ethylene, propylene) and gasoline – the hydrocarbons from the methanol to jet fuel process. In addition, water and waxy fractions are produced, which can be utilised either in further processing or as raw materials for the chemical industry.

Maritime transport

The EU's FuelEU Maritime Regulation has created an emission reduction obligation for shipping in the EU area as of 2025. At the moment, the obligation is not earmarked for synthetic fuels, but the Refuel Maritime Regulation contains a so-called sunrise clause, according to which the EU will introduce a 2% mandate for the use of RFNBO fuels in maritime transport from January 2034 if the share of RFNBO in maritime transport is less than 1% in 2031. In the initial phase, the obligations will mainly be met with LNG and biofuels, but due to the global limitations and availability of biofuels, an attractive market for synthetic fuels will emerge as emission reduction obligations become stricter. Several of the EU's largest shipping companies have already ordered ships that can run on synthetic fuels.

The strategy of the International Maritime Organization (IMO), which operates under the UN, aims for net zero emissions from international shipping by 2050. The intermediate targets are a reduction in emissions of at least 20% by 2030 and 70% by 2040 (base year 2008), as well as a requirement that at least 5% of the energy used by ships be zero- or near-zero emission energy by 2030. The decisions on new binding measures – such as reducing the GHG intensity of marine fuels and introducing global emissions pricing – expected in autumn 2025 were postponed to 2026. It is important that the IMO decision is made because it will strengthen global demand for maritime transport. In the meantime, the EU can play an important role thanks to the FuelEU Maritime Regulation, developing solutions to global needs while the IMO and the US are dragging their feet.

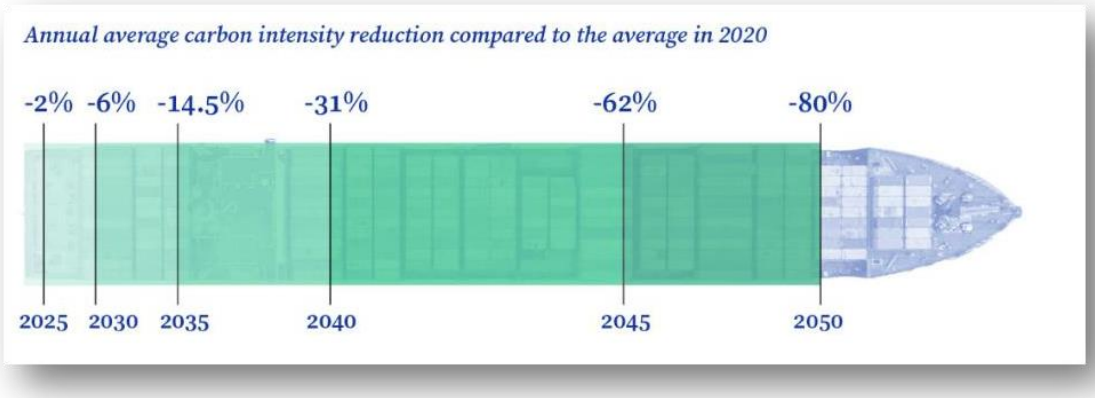

Figure 3 Objectives for shipping[5]

In addition to the production of synthetic marine fuels, Finland has a particularly strong maritime value chain cluster that is able to offer solutions to the shipping companies' need to use alternative fuels. However, according to a report[6] by Finnish shipping companies and Sweco, new, market-based financing solutions are needed alongside traditional subsidies and investment grants in order to accelerate and expand the introduction of synthetic fuels in maritime transport. One key proposal is to improve the price competitiveness of synthetic fuels by using emissions trading revenues (ETS) to offset fuel prices directly to shipping companies. The report also presents the possibility of leveraging long-term purchase agreements (PPAs) and fuel supply contracts, which reduce the risk of investments for both producers and users. As a new solution, the report highlights the possibility of establishing a national fund that would combine public and private capital and EU funding and through which both investments in production facilities and the purchase of fuels could be supported. Such mechanisms would enable the creation of a market for synthetic fuels in maritime transport and scaling up in Finland, as well as support the sector's competitiveness and security of supply in the long term.

[5] FuelEU Maritime: Decarbonising the maritime sector

[6] Final report: An incentive to reduce the price differential and promote the availability of low-emission fuels for maritime transport

Road transport

The EU's Renewable Energy Directive (RED III) creates a market for the use of hydrogen fuels (RFNBO) in road transport. The minimum share obligation that will enter into force in Finland in 2028 as part of the Distribution Obligation Act requires that the share of RFNBO fuels in road transport is 1.5%, and its share will rise to 4% by 2030. In an exemplary manner, Finland has implemented a target level that is significantly higher than the EU's minimum level (1%). The target level of 4% for 2030 is estimated to be 140 ktoe of RFNBO production[7], which will require a production facility of significant size or several investments. Of course, the obligation can also be fulfilled with imported fuels, which is not the goal from the perspective of the national economy, because the progressive target is based on the desire to ensure investments in Finland.

The obligation described above can be fulfilled by distributing synthetic fuels, such as e-methane, for transport, or in the form of clean hydrogen, or with green hydrogen used in the manufacture of transport fuels in Finland. E-methane can be distributed through the existing distribution infrastructure either in a gaseous form or liquefied. No extensive distribution infrastructure, such as hydrogen refuelling stations, has yet been established for the distribution of clean hydrogen, and there is still a limited number of hydrogen vehicles on the road. In Finland, there is one Cefmof hydrogen filling station in Jyväskylä. However, clean hydrogen is seen to play an important role, especially in reducing emissions from heavy-duty vehicles and increasing self-sufficiency, so the government's investments in getting heavy-duty hydrogen transport up and running are important. The alternative fuels infrastructure regulation (AFIR) requires that hydrogen refuelling stations must be located every 200 km across the entire TEN-T core network by 2030. According to a preliminary estimate, in addition to the already planned four hydrogen filling stations, at least five new filling stations would be needed to meet the AFIR requirements in 2030. There is a lot of existing demand potential for green hydrogen used in the production of transport fuels, as it directly replaces hydrogen produced from fossil raw materials.

[7] Emission reduction measures in road transport and their impacts – Finnish Climate Change Panel

Industry

The RFNBO obligations under the EU's Renewable Energy Directive (RED III) guide the use of hydrogen in industry towards climate neutrality.

In accordance with the industrial obligation of the EU's Renewable Energy Directive (RED III), by 2030, the share of RFNBO used in industry must be at least 42% of the hydrogen used, and the share will increase to 60% by 2035. The regulation applies to industries that currently primarily use grey hydrogen in their processes, with the exception of the production of conventional transport fuels and biofuels, which are not covered by this regulation. The industrial obligation aims for a significant transition from fossil raw materials towards renewable hydrogen produced by electrolysis.

The growth of the voluntary market in the use of industrial hydrogen has been non-existent. RFNBO industrial obligations have not been implemented nationally in Finland, and no penalty payments have been imposed on them as in the distribution obligation, so demand is not expected to start until the 2030s. Some EU member states have implemented the RFNBO obligation for industry at a lower level than the 42% required by the Directive. As the shift of industrial hydrogen use from grey to green is the largest single growth sector at the EU level, it would be justified to consider drawing up an EU-level roadmap that potentially has a lower target level but is more binding and creates more incentives.

The utilisation of biogenic carbon dioxide recovered from the side streams of forest industry and energy industry production in synthesis with hydrogen can increase the added value of the hydrogen economy in Finland by several billion euros by 2040. In addition to synthetic fuels, the chemical industry can benefit from high-value-added products such as methanol, ammonia, and polycarbonates. However, this would require, among other things, clear regulatory guidelines for non-fuel-based CCU products.[8]

At the moment, the Finnish chemical industry (including oil refining) produces 90% of domestic hydrogen and uses 80% of it.[9] The main application is in oil refining processes. In the future, clean hydrogen will create growth opportunities for synthetic raw materials in the chemical industry, which will enable clean further processed products and increase Finland's climate handprint through exports. After 2030, it is estimated that approximately 0.5 Mt of CO_2

[8] From emitter to producer – Carbon dioxide economy adds value to the Finnish forest sector
[9] Hydrogen economy - Chemical industry

will be recovered annually from the chemical industry, of which 0.2 Mt is biogenic carbon dioxide. Carbon capture is linked to the production of synthetic raw materials and fuels where CCU solutions enable the replacement of fossil raw materials.[10]

In the steel industry, a 7–9% reduction in CO_2 emissions can be achieved globally by replacing the use of coal with green or pink (using electricity produced by nuclear power in hydrogen production) hydrogen in primary iron production.[11] In Finland, the largest single source of CO_2 emissions is SSAB's Raahe steel mill, whose conversion to green steel production would be a significant boost to the Finnish hydrogen economy.

Finland's competitiveness and hydrogen production

In order to increase competitiveness, Finland must be able to show concrete pioneering in the hydrogen economy in the field of innovations and technologies as well as industrial investments. Finland's pioneering role in hydrogen production would open up the possibility of much more extensive value creation than just end products. It is a question of know-how and many traditional process technologies that can also be utilised in the hydrogen economy. If the domestic market provides suitable references, Finnish companies will be able to participate in international projects and take advantage of the growing demand for both expertise and equipment (valves, pumps, automation technologies, rectifiers, etc.). Clean energy production and flexible final consumption are megatrends that are advancing all over the world.

Hydrogen production in Finland

In Finland, companies are progressing with their investment projects: the roadmap includes about 60 projects in different phases, corresponding to 1.5 Mt/year of hydrogen production and investments of EUR 30 billion (Figure 4). Of course, few projects have yet published a timetable for an investment decision or made an investment decision, but there is plenty of potential.

[10] VTT: Background material for the roadmap to climate neutral chemical industry by 2045
[11] World Steel Association: #steelfacts

At the moment, the following operators produce clean hydrogen in Finland:

- In Harjavalta, P2X Solutions (20 MW electrolyser) with a production capacity of 3,000 t per year. Harjavalta also produces synthetic methane from hydrogen and carbon dioxide.
- STR Tecoil has a 1 MW electrolyser at the waste oil regeneration plant in Hamina.
- Hycamite produces clean hydrogen and solid carbon from natural gas through pyrolysis in Kokkola.
- Fortum's Kalla pilot plant in Loviisa produces green hydrogen.
- Woikoski produces green hydrogen and processes hydrogen side streams.
- Solar Foods Factory 01 produces hydrogen for the bioreactor, where hydrogen and carbon dioxide are used to produce protein.
- Kemira's sodium chlorate plants in Joutseno and Äetsä produce hydrogen by-products.
- Electrolysers used for research and piloting can be found, for example, at VTT Technical Research Centre of Finland and LUT University.

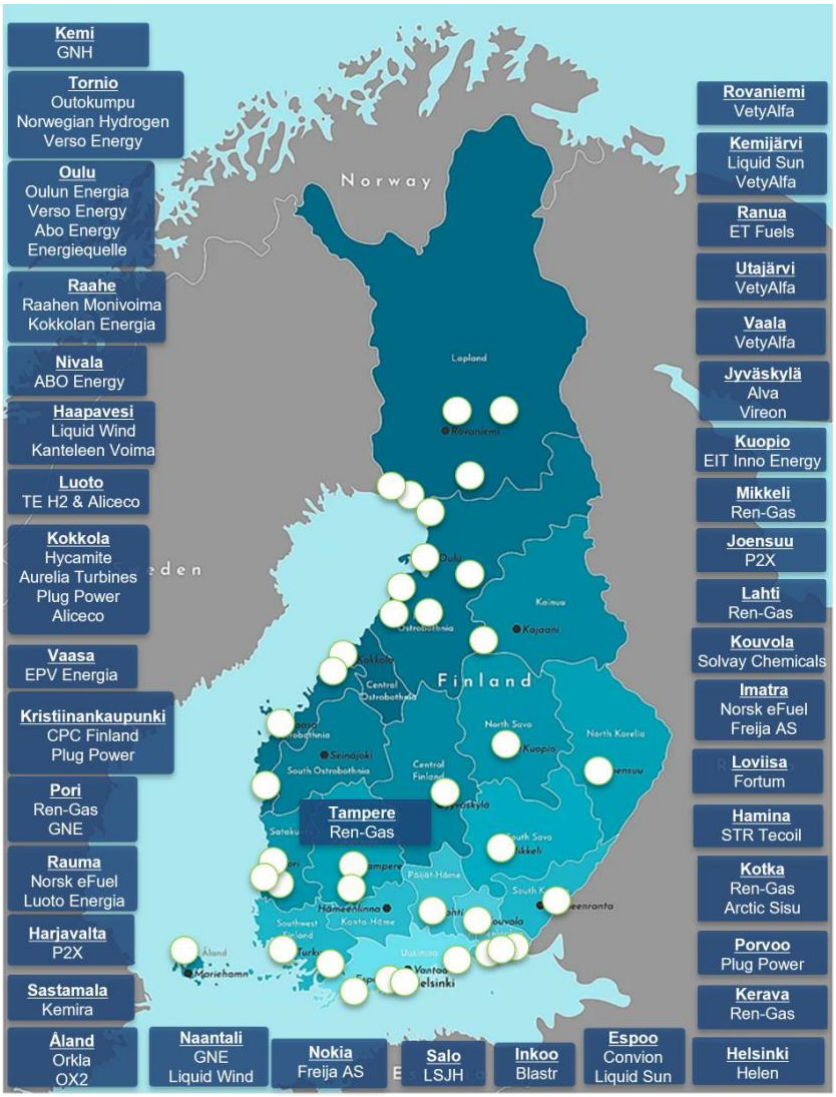

Figure 4 Hydrogen economy projects in November 2025[12]

International cooperation

Finland's hydrogen economy investments also require a wide range of international cooperation in order to be realised. Energy policy and energy investments have increasingly become a tool of national strategic interests of states. Although efforts are being made to promote the integration of energy production and markets within the EU, many countries are approaching the energy sector from a strongly national perspective, which

[12] Hydrogen Cluster Project Map

can be seen, for example, in the state aid policy. National energy policy is competitiveness policy, but at the same time it is part of industrial resilience and security of supply.

Finland needs international cooperation, and especially EU cooperation, to ensure national investments and a successful hydrogen economy ecosystem. Firstly, we need measures to promote awareness of the competitiveness factors of Finland's operating environment. Finland is still not always included in the EU's hydrogen maps. Based on the work of Hydrogen Cluster and other actors, Finland is recognised as a competitive operating environment, but the work still needs to be continued.

Due to Finland's small domestic market, investments in Finland often require taking into account the wider European market. For this reason, cooperation with EU countries is particularly important. The Finnish Government must engage in dialogue and proactively advocate its cause in the European Union so that the EU's regulatory reforms ensure the continuation of the implementation of the mandates now agreed and, on the other hand, ensure that Finland's competitiveness factors are preserved in the reform of legislation. The development of cooperation in the Baltic Sea region as part of Gasgrid's hydrogen infrastructure cooperation projects must play a significant role in international cooperation. Although Finland has a special position and greatest potential in the development of the hydrogen value chain in the Baltic Sea region, the benefits of a broader infrastructure from market expansion to potential hydrogen storage facilities in the Baltics and Poland will create increasing interest in Finland.

The Finnish government must draw up a national hydrogen strategy for Finland that sends a concrete message about Finland as a target for investments. Proposals for measures to achieve the Government's targeted 10% share of the EU's green and low-carbon production and use in Finland should be at the core of the strategy.

The opportunity cost of a progressive climate policy is expensive

Right now, ambitious climate policy is being questioned both globally and within the framework of the EU's legislative work. From Finland's point of view, it is clear that an ambitious climate policy is an important driver and one of the prerequisites for the success of the export industry. Even though climate policy is even taking steps backward right now, it is clear that climate change is progressing at an accelerating pace, which suggests that it will also be necessary to promote climate policy in the future.

The cost of climate change is already $2.3 trillion annually due to the losses arising from natural disaster damages globally, and the figure is rising steeply.[13] As Johan Rockström said at the UN General Assembly, "Failure is not inevitable, it is a choice." Failure to combat climate change is not dictated by fate but is an active choice. We still have the option to stay close to the 1.5 °C level, but it requires rapid and extensive action now. Every avoided tenth of global warming saves lives and livelihoods.[14]

Increasing renewable energy and adhering to the goals of the hydrogen economy is an important part of the EU's climate policy when aiming for the EU's climate neutrality goal by 2050, the achievement of which is not necessarily an energy, environmental, economic policy or other political issue, but a necessity in order to avoid the consequences of climate change in European countries.

Safety and acceptability

Finland must be actively involved in the development of European and global safety standards in order to maintain domestic competitiveness. Finland's guidelines and requirements should be in line with EU and international practices – not stricter than elsewhere, but comprehensive enough to ensure safety.

Security expertise is already an established part of companies' operations, and security is seen as a competitiveness factor that supports investments and strengthens Finland's position as a pioneer in the hydrogen economy. Safety is also related to general acceptability: even a single serious accident could destroy the acceptability of the industry. Therefore, it is necessary to invest in safety with determination and to ensure that risks are appropriately managed throughout the value chain.

Innovations and technologies

In addition to hydrogen production, the added value of the hydrogen economy comes from hydrogen-related technologies and their export potential outside Finland. Expectations for

[13] Global Assessment Report on Disaster Risk Reduction 2025
[14] Potsdam Institute for Climate Impact Research (PIK)

the growth of the technology field play a significant role in the growth of the hydrogen economy, and it is important to ensure rapid growth from research and innovations to an export product.

A hydrogen economy with high added value is based on the utilisation of renewable and low-carbon electricity and bio-based carbon dioxide. Several of the world's leading large technology companies are already operating in these key areas in Finland, developing electrical and automation technology and new process technology solutions in Finland. Several of these companies have launched leading company programmes supported by Business Finland in which leading companies operate alongside an active cooperation ecosystem that includes research institutes, universities and start-ups, and where several pilot projects are underway to develop new innovative solutions. In the ecosystem, leading companies act as openers of market-driven development paths, research organisations are responsible for producing technological breakthroughs and new knowledge, and start-up companies are responsible for rapid experimentation and the development of new business models. In addition to technological innovations, the ecosystem develops new service and business models as well as system solutions that connect the value chains of the entire hydrogen economy.

Finland aims to become a pioneer in RDI activities and technological expertise in the hydrogen economy. The vision is to build a strong ecosystem in Finland in which higher education institutions, research institutes and companies develop electrolyser technologies, automation, digital solutions and bio-CO_2-based processes, among other things, to make them exportable. The pilots and reference projects to be launched must be actively utilised as a platform for the international commercialisation of technologies, and Finland must be active in European innovation networks to ensure competitiveness. The key role of the pilot projects is to enable rapid learning and the systematic sharing of knowledge and experiences between the actors in the ecosystem.

Digital models and simulations can also be used to assess the combined effects of hydrogen economy investments, market development and regulatory paths at the system level. This supports risk management and speeds up decision-making, especially in the early scaling phase. At a later stage, similar digital capabilities will also support the development of a cross-border hydrogen market and market integration at the EU level.

Industrial-scale investments and the scaling up of new innovations are still in their early stages. The challenges are to ensure sufficient funding for the piloting of new solutions, the rapid scaling up of technological solutions, and the development of expertise through

education and training in order for Finland to maintain its competitiveness and progress towards export readiness.

The necessary expertise in the hydrogen economy will be ensured through cooperation between companies and universities, universities of applied sciences and vocational education and training operators, including the expertise needed for the hydrogen economy in existing degree programmes.

Close cooperation between innovators, academia and companies is essential to keep the level of ambition high and achieve the goals of technology exports by 2035. Hydrogen Research Forum Finland has listed the needs of the research world to support the hydrogen economy in the coming years, which will significantly help the development of the hydrogen economy.

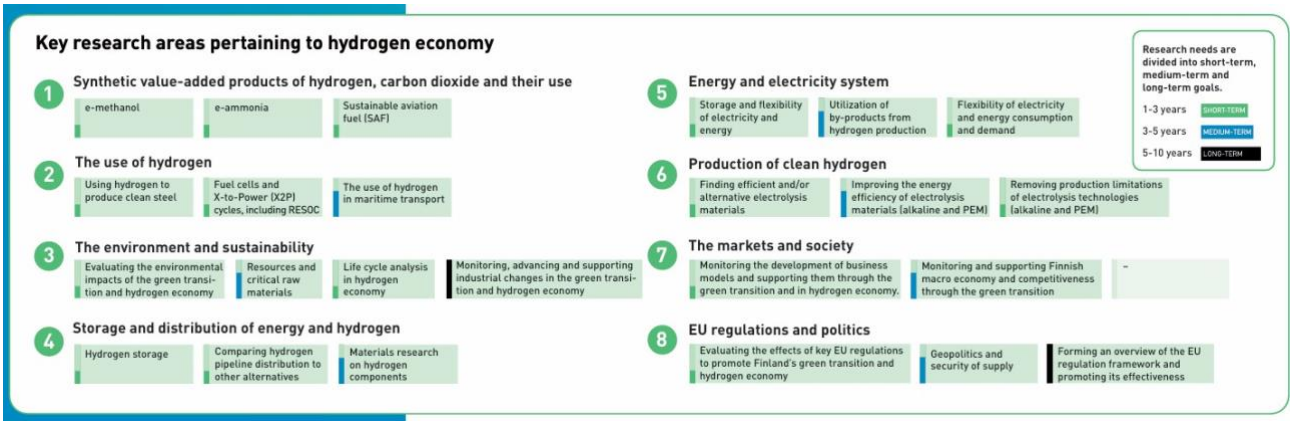

Figure 5 Hydrogen Research Forum Finland: Strategic Research Agenda for Finnish Hydrogen Research[15]

Hydrogen Cluster aims to bring together companies, educational institutions and projects operating around the hydrogen economy and to ensure a seamless flow of information between them. Hydrogen Cluster also conveys a message to decision-makers about the importance of hydrogen technology-related RDI activities and piloting and the need to ensure their long-term funding. Finland actively participates in European co-creation projects and standardisation work to ensure the scalability and market access of domestic innovations.

[15] Hydrogen Research Forum Finland: Strategic Research Agenda for Finnish Hydrogen Research

The success of the hydrogen economy requires expertise and close cooperation with the education sector. The development and integration of hydrogen education into the education system will be actively promoted to ensure that there is enough expertise for the growth and scaling of the hydrogen economy. Special competence needs are seen in the following areas:

- Operation and maintenance
- Hydrogen plant design
- Hydrogen safety expertise
- Business model development
- Financial modelling
- Risk finance and public support mechanisms
- Ecosystem and value chain integration
- Regulation and permit procedures
- Communication and lobbying
- Public relations management
- Business law

Utilisation of biogenic carbon dioxide

Biogenic carbon dioxide is an essential raw material in the production of electrofuels and several hydrogen derivatives. Finland's distinguishing advantage and competitiveness factor is its significant (approx. 30 Mt) point sources of biogenic carbon dioxide, which, in addition to Sweden, do not exist elsewhere in the EU on the same scale and as large point sources. Of the biogenic carbon dioxide capture potential of Finland's large point sources, approximately 8.7 Mt is generated by energy sector plants.[16] However, the utilisation and availability of biogenic carbon dioxide is hampered by the lack of clear legislation or incentives based on legislation. The development of the biogenic carbon dioxide market, clear regulation and thus better availability would have a significant impact on the investment potential of e-fuels. It should also be noted that carbon dioxide capture from biopower plants is still in the testing phase around the world, and none of the pulp mills

[16] Bioenergy Roadmap Report 2024

have an industrial-scale recovery plant, so there is still room for development in technologies.

Carbon capture can be done directly from emission sources or, with Direct Air Capture (DAC) technology, directly from the air. Carbon capture in Finland is progressing in terms of technology, but the biggest bottleneck is the slow development of the market and infrastructure, as well as the complexity of EU regulation, or the lack thereof. According to VTT's estimate, by 2030, CCU applications will have moved from the pilot phase to the industrial scale.[17]

Direct Air Capture is still an evolving technology, and 27 DAC plants have been deployed around the world so far, capturing a total of less than 0.01 Mt of CO_2 per year. Around 130 large-scale plants (>1,000 tonnes of CO_2/year) are under development, and if all of them are realised, the capacity could increase to around 65 Mt of CO_2/year by 2030. The implementation period of the plants is 2–6 years. However, most of the projects are still at a very early stage and investment decisions cannot be expected without strong policy support and market mechanisms that create demand for carbon removal services.[18]

It must be taken into account that the development of DAC plants is rapid and there is great interest in the development of the technology in countries that do not have similar biogenic carbon dioxide point sources as Finland does. Finland's competitiveness in terms of biogenic carbon dioxide will only exist as long as carbon dioxide captured from point sources, including transport and storage costs, is cheaper than carbon dioxide captured locally using the DAC method.

The Finnish Forest Industries Federation and the Bioenergy Association of Finland recognise carbon capture in their climate roadmap and see its potential for the sector as an opportunity to bring added value from current production, among other things. Neither sector has made concrete commitments or set target levels for carbon capture.[19] [20] The biogas industry predicts an increase in biogas production, which will increase the amount of biogenic carbon dioxide on the market. In the biogas sector's 2030 vision, biogas production is projected to rise to a level of 4 TWh, resulting in a carbon dioxide output of

[17] VTT: From emitter to producer – Carbon dioxide economy adds value to the Finnish forest sector
[18] International Energy Agency: Direct Air Capture
[19] Updated Forest Industry Climate Roadmap 2025
[20] Bioenergy Roadmap Report 2024

about 0.5 Mt/a. The potential for biogas production is over 10 TWh, which corresponds to about 1.3 Mt/a of carbon dioxide. Biogas operators have also not defined a public goal for cooperation in the use of carbon dioxide.[21]

Carbon capture and storage (CCS) is one solution for achieving climate goals. The Carbon Removal Readiness Assessment report recommends that policies and guidance be implemented to ensure that a sufficient proportion of carbon dioxide is channelled into permanent storage so that Finland can achieve its carbon neutrality targets.[22] Although permanent stocks are needed to achieve climate goals, it is vital for the end products of the hydrogen economy, the added value that remains in Finland and the replacement of fossil raw materials that CCU remains a competitive way of utilising biogenic carbon dioxide alongside CCS.

Developing a national strategy to promote CCU technologies, ensuring the position of biogenic carbon dioxide in EU regulation, and launching the first fossil-free fuel and chemical pilots are critical to the progress of the hydrogen economy.

Clean energy production

The availability of clean electricity at an affordable price and reliably is a prerequisite for the success of the hydrogen economy. In 2025, slightly more than 1,000 megawatts (MW) of new wind power were built in Finland, and Finland's total capacity grew to almost 9,500 MW. At the end of the year, there were 2,002 wind turbines in Finland, with a total output of 9,433 MW.[23]

In 2025, seven new industrial-scale solar power plants and 224 megawatts of solar power capacity were completed in Finland. At the end of the year, the total capacity of industrial-scale solar power was approximately 349 megawatts. The growth has been rapid, and the growth of the sector now, if not already before, shows that solar power can also be built on an industrial scale in northern conditions.[24]

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21 Biogas 2030
22 Carbon Removal Readiness Assessment Report
23 Finnish Renewables: Press release on wind power 8.1.2026
24 Finnish Renewables: Press release on solar power 8.1.2026

The number of grid connection inquiries received by Fingrid increased to more than 400 GW in terms of electricity production, approximately 70 GW in electricity consumption and approximately 30 GW in electricity storage facilities in the first half of 2025.[25]

According to Fingrid's forecasts, electricity consumption will increase significantly due to the hydrogen economy and other electricity-intensive investments:

- In 2030: Consumption will increase from the current approximately 83 TWh to 103–123 TWh.
- In 2035: Consumption will continue to grow to 104–159 TWh, depending on the scenario.

The biggest drivers of growth are the production of hydrogen and e-fuels, data centres and the electrification of industry. In addition, the electrification of transport and heating will increase demand. Production growth will mainly come from wind and solar power, and grid planning is based on a higher scenario with the fastest growth.[26]

The progress of the hydrogen economy requires enabling the construction of additional renewable energy. Possible regulations restricting additional construction would significantly weaken the potential of clean transition investments to create new growth in Finland. We need a predictable and competitive investment environment and regulation that supports investments in the hydrogen economy and electrification. The construction of wind power could be significantly facilitated, for example, in industrial areas and near hydrogen production plants, which would also avoid long transmission lines.

The hydrogen economy and data centres are both major consumers of electricity, which highlights the need to find synergies in the energy system. As data centre investments progress rapidly, it is appropriate to engage in public debate on the model and priorities of Finland's new economic growth based on the renewable energy potential in the 2030s. The questions of how the potential of new renewable energy is to be distributed across different sectors, how to ensure the added value of the resource in question, and whether there is a need for a political definition of how to promote renewable energy refining investments

[25] Fingrid Group's Half-Year Financial Report H1/2025
[26] Nordic Grid Development Perspective 2025

in the first place are essential. Hydrogen Cluster is also actively participating in this discussion.

From the perspective of all growth sectors, predictable legislation is a prerequisite for growth and investment. Hydrogen Cluster believes that reconciling the roles of the hydrogen industry and data centres – and not just using hydrogen as backup power – can contribute to the efficiency of the overall energy system. In this way, Finland can build a comprehensively sustainable energy system in which the roles of data centres and the hydrogen economy complement each other.

Infrastructure expansion

The Finnish Government is committed to ensuring that the transmission infrastructure for electricity or hydrogen does not become a bottleneck for Finland's clean transition goals and investment conditions.

Gasgrid Finland and Fingrid have engaged in internationally significant cooperation on future scenarios and plans, combining visions and concrete plans for the electricity and hydrogen networks. The ability of Finland's electricity grid to connect new operators to the grid is an excellent competitive advantage compared to other EU countries for promoting Finland's clean transition, also taking into account the regional challenges facing the grid. The hydrogen infrastructure will enable a wider market and positioning production and consumption in different parts of Finland. Gasgrid Finland's and Fingrid's optimisation work to promote the conditions for green growth supports the pioneering nature of Finland's operating environment.[27]

The role of hydrogen infrastructure is important, especially in promoting investments in the early stages of the hydrogen economy and in guaranteeing a wider market at a later stage. The infrastructure significantly supports the competitiveness of the downstream industry and reduces the risk for individual operators. Gasgrid Finland has connected a significant part of the national hydrogen network to European, cross-border EU-funded projects. This will make it possible to use a significant number of EU financial instruments to implement the national hydrogen network and enable export markets based on hydrogen and its various end products. For operators, this enables the development of value chains and further processed products both

[27] Scenarios for the Gasgrid-Fingrid hydrogen economy project

in Finland and in the Baltic Sea region more broadly, which increases the attractiveness of Finland and the region as an investment destination.

Finland's electricity consumption is currently about 83 TWh, but the expected growth of the hydrogen economy and the production of e-fuels will require significant reinforcements. The grid structure is strong in the north-south direction, but the focus of large wind power investments and hydrogen-based industrial projects is mainly on the West Coast, which causes regional transmission capacity bottlenecks. Fingrid estimates that it will invest billions of euros to strengthen the main grid.[28]

The project developers see the current situation in Finland as good. The risk to electricity networks is significantly lower than in many other European countries, where the challenge is delays in electricity network construction projects and lack of development plans. However, the project developers are calling for an even more active approach to the development of electricity networks, as well as local cooperation and foresight in terms of permitting and future plans.

In addition to physical infrastructure, the functioning of the hydrogen economy requires interoperable digital solutions that enable the reliable and up-to-date exchange of information on production, certification, market mechanisms and regulatory supervision. These digital capabilities can be viewed as part of the critical infrastructure of the hydrogen economy. The development of interoperable digital solutions also offers Finland an opportunity to act as a European development platform for the hydrogen economy and as a reliable partner in building cross-border markets.

Finland's industrial areas provide a significant basis for the growth of the hydrogen economy. In many areas, the plans are ready, which speeds up the permit processes and the launch of investments. These regions have strong electricity grid connections and a natural gas network, as well as a planned hydrogen network, which will support hydrogen production and the transmission of e-methane. In addition, the industrial transformation has freed up infrastructure for new uses, which creates cost-effective opportunities for hydrogen economy projects. Utilising these capacities is essential for Finland to ensure its competitiveness and pioneering position in the European hydrogen market.

Together, an efficient electricity, hydrogen, gas and heating system will enable the maximum utilisation of Finland's renewable and clean energy production potential for high-value products

[28] Fingrid: Nordic Grid Development Perspective 2025

and economic growth. Finland's clean production can play a significant role in improving energy security and self-sufficiency, as well as in exporting various end products to the European single market. Clean, domestic production and the energy infrastructure that enables its use are also a prerequisite for long-term competitiveness. The regional implementation of the hydrogen economy also requires the active role of cities and municipalities in zoning, permitting and triggering demand. Digital solutions can support this entity by forming a transparent "digital path" that allows regional capacities, projects and applications to be effectively identified, coordinated and communicated to national and international actors.

Security of supply and resilience

The motto of the Finnish Hydrogen Cluster, **"Hydrogen is freedom,"** emphasises the need to create new independent and resilient economic value chains based on renewable energy, reducing dependence on foreign fossil energy, increasing energy self-sufficiency and building a sustainable European economy in the 2030s. This work requires cooperation between the EU's progressive countries and their industries.

The green transition, especially the development of renewable energy and the hydrogen economy, strengthens society's resilience and security of supply on many levels. The transition towards a decentralised and protected energy infrastructure will reduce dependence on fossil fuels and foreign energy suppliers, which will improve crisis resilience in both normal and exceptional conditions. For example, the ResilEast programme[29] in Eastern Finland emphasises that the production of renewable electricity and hydrogen enables the processing of both energy and raw materials in Finland, which supports economic self-sufficiency and enables rapid reactions in the event of disruptions. In addition, the green transition enables the shared use of defence structures and civilian infrastructure, which means that investments support both national defence and business life in a cost-effective manner.

The production of synthetic fuels has great potential from the point of view of getting rid of oil dependence and fuel self-sufficiency. By utilising domestic biogenic carbon dioxide as a raw material, synthetic fuels could be produced in excess of domestic needs. In addition, the

[29] ResilEast Programme

production of green ammonia would create significant security of supply and enable abandoning Russian fossil-based ammonia.

The National Emergency Supply Agency's extensive Energy 2030 programme develops solutions to secure an uninterrupted supply of energy in a low-carbon society. The studies have highlighted the role of hydrogen, especially in ensuring the security of electricity supply and as a fuel for the necessary reserve production capacity, but also in securing the availability of domestic fuel through synthetic fuels.[30]

The resilience of society and companies is a strongly emerging theme. Over the next decade, we will see Europe's need to create new value chains for the defence industry, the energy industry, and the economy in general, which emphasise the security of supply and resilience of each society. It is important to define these value chains to also serve the needs of the hydrogen economy: steel used by the defence industry or fuel needed for land and air transport creates and increases the resilience of society when it is based on renewable and hydrogen-based feedstocks, such as green steel and RFNBO fuels. This kind of cross-sectoral cooperation enables the achievement of many goals and system-level solutions and the use of appropriations to accelerate the goals of several sectors at the same time.

Public funding

As the economic situation is tight, Finland must prioritise the promotion of the hydrogen economy and reserve an adequate annual budget for CAPEX support in order to repatriate the added value of the hydrogen economy to Finland. The EU provides funding for the hydrogen economy through various instruments such as:

- RRF (Recovery and Resilience Facility), which is a one-time recovery instrument that will expire in 2026.
- MFF (Multiannual Financial Framework), which is the EU's multiannual financial framework for 2028–2034, in which funding for investments in the green transition will increase significantly.

[30] Oil and gas in energy production in the future: Final report to the National Emergency Supply Agency, the Oil Pool and the Natural Gas Division.

- The Innovation Fund, which is an EU funding programme that supports large and innovative low-carbon projects, such as hydrogen technologies, industrial emission reductions and the energy transition.
- Hydrogen Bank, an initiative of the European Commission to boost the production and use of renewable hydrogen in the EU by providing financial incentives and competitive tendering (e.g. hydrogen price support).
- IPCEI (Important Project of Common European Interest) is the EU's special funding and coordination mechanism that supports joint strategic projects of member states, such as clean hydrogen production, infrastructure and innovation, when they are important for the competitiveness of the whole of Europe and the green transition.
- The IDB (Industrial Decarbonisation Bank) is a financial instrument designed by the EU to support the industry's transition to low- and zero-emission production methods. The bank provides strategic financing for large investment projects, such as the use of hydrogen and clean energy, and helps to reduce the risks of investments and accelerate the achievement of the industry's carbon neutrality targets. The IDB will mobilise €100 billion from various sources of funding, including the Innovation Fund.

In addition to these, one of the financial instruments is the so-called Contract for Difference (CfD) model that provides a long-term (approx. 10-year) price gap mechanism that ensures predictable income streams and reduces investment risk. CfDs are already a key tool in EU guidelines, and their introduction in national legislation is also necessary. The modelling carried out by Sweco[31] shows how ETS revenues could be allocated to shipping companies to support the purchase of synthetic fuels, which would narrow the price difference between fossil and low-emission fuels. This incentive would enable shipping companies to make an economically viable transition away from fossil fuels and accelerate the adoption of synthetic fuels in maritime transport. The benefits would include the achievement of emission reduction targets, the strengthening of domestic fuel production and security of supply, as well as billion-euro investments and new jobs in Finland. In addition, the solution would improve Finland's competitiveness and export opportunities as a pioneer in green technology. The costs of the

[31] Final report: An incentive to reduce the price differential and promote the availability of low-emission fuels for maritime transport

incentive would be clearly lower than if the current situation continued without support measures.

International examples show that state aid is crucial in mobilising investments; in Germany, for example, billion-euro support packages from the federal and state governments and IPCEI projects have accelerated the construction of infrastructure and production capacity for the hydrogen economy. In May 2021, the IPCEI project selected 62 projects from the entire hydrogen market value chain for funding, with more than €8 billion in funding from the German government and states to execute the projects. Similar ambition is needed in Finland to ensure that investments are realised and competitiveness is maintained.[32]

Concrete measures of the hydrogen economy roadmap in the Finnish Hydrogen Cluster

Hydrogen Cluster Finland has organised itself into active working groups around the most important issues to be promoted: Finland's competitiveness, regulation, innovations and technologies, safety and communications. The purpose of the working groups is to promote the hydrogen economy roadmap based on their own themes with partners and stakeholders.

Measures to strengthen Finland's competitiveness focus on three main themes: strengthening political influence, clarifying the visibility of the value chain and deepening international cooperation. The parliamentary elections will highlight the vitality benefits offered by the hydrogen economy and its concrete effects on regional policy. In the Baltic Sea region, networks and common messages to be communicated at the EU level will be strengthened, emphasising security of supply and market launch. Under the leadership of the working group, an up-to-date situational picture of the hydrogen economy and scenarios will be built together with the member companies and stakeholders of Hydrogen Cluster.

The focus of the regulation is on the development of an operating environment and legislation that enable investments. The working group analyses the content and impacts of regulation and builds international cooperation and common messages from the

[32] Germany's hydrogen strategy

countries of the Baltic Sea region. The aim is to ensure Finland's competitive position in future EU regulatory changes and to promote a government programme that supports the development of the hydrogen economy.

In safety, the focus is on supporting an accelerated and risk-based licensing process. The aim is to ensure the launch of the new licensing authority and the implementation of the one-stop-shop principle in order to speed up the progress of projects. At the same time, ongoing projects will be supported by organising product demonstrations, safety-related visits and sharing information about hydrogen accidents and their investigations. The working group actively participates in the development of guidelines and standards and influences the creation of global standards.

The Innovations and Technologies group focuses on ensuring the growth and continuity of RDI activities and deepening start-up cooperation. Higher education institutions, research institutes and start-up companies will be brought together to agree on the role of RDI in the ambitious development of the hydrogen economy. The working group highlights the need for financial instruments, especially for piloting, and influences their development. In addition, the development of hydrogen education will be promoted and lessons learned from leading projects and further opportunities will be actively shared.

5. Towards 2035

Objectives of the hydrogen strategy

By 2035, the hydrogen strategy sets an ambitious target for the hydrogen economy to achieve an annual

positive economic impact of €16–34 billion and to create up to 100,000 new jobs. Technology exports are estimated to be worth around €20 billion per year, and they account for a significant part of the overall impact of the hydrogen economy.

The strategy focuses on the entire value chain of the hydrogen economy: clean hydrogen, its derivatives, the transition of domestic industry to clean hydrogen, and technology and service exports.[33]

[33] Hydrogen Strategy for the Finnish Hydrogen Cluster 2023

Lead Market Task Force's goal by 2035

As the distribution obligations increase, the air transport market will also grow and scale. According to the goals set by the eSAF Lead Markets Task Force, by 2035, 10% of the eSAF aviation fuel required by the distribution obligations will be produced in Finland, i.e. approximately 250,000 tonnes of eSAF per year. This corresponds to about 4–5 plants in operation with an electrolysis capacity of about 250 MW per plant.

As eSAF plants have scaled, the number of other side streams generated by the process has also scaled, offering solutions for the value chain of the chemical industry, for example. In order to achieve this goal, it is required that the ReFuelEU Aviation mandates and penalty payments have been increased as agreed and implemented, and that the "Book and claim" market functions seamlessly.

Scenarios until 2035

Hydrogen demand scenario based on mandates

By 2030, EU regulation will create a significant demand for clean hydrogen. The following scenarios examine the market created by RFNBO hydrogen in Europe. It is worth noting that in addition to this market, a market for low-carbon hydrogen is also emerging, which will offer growth opportunities for Finland, as hydrogen produced with nuclear electricity meets the definition of low-carbon hydrogen. Voluntary markets have also not been taken into account here.

In 2030, RED III requires fuel suppliers to replace fossil fuels with renewable alternatives: at least **5.5% of energy** must be RFNBO-based or advanced biofuels, of which **at least 1% are RFNBOs**. This will create a demand for approximately **1.1 million tonnes** of hydrogen in transport at the EU level. In addition, ReFuelEU Aviation will ensure the use of hydrogen in aviation (at least 1.2% of aviation fuels, equivalent to **0.3 Mt** of hydrogen) and FuelEU Maritime in maritime transport (1% of maritime fuels must be RFNBO-based, corresponding to **0.1 Mt** of hydrogen). In industry, RFNBO obligations can generate up to **1.3 Mt** of hydrogen demand if fully implemented by member states. In total, the regulatory demand for RFNBO hydrogen in the EU is estimated to be **2.8 Mt by 2030**, making the fulfilment of distribution obligations critical for investments in the hydrogen economy. It is important to note that, like Finland, other EU member states will also implement EU

legislation more ambitiously than stipulated by the EU minimum, creating a significantly higher demand than the EU obligations.

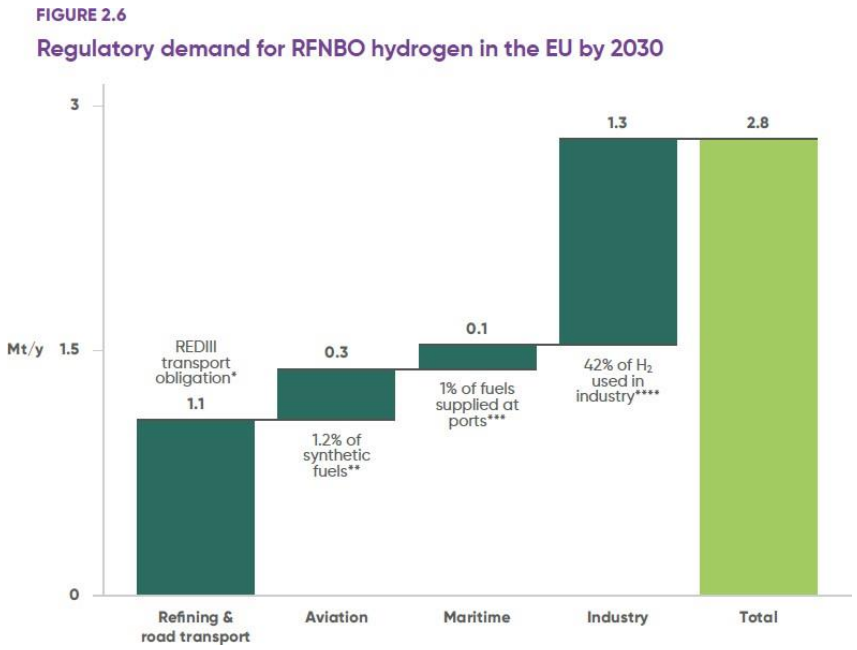

Figure 6 Demand for RFNBO hydrogen in the EU in 2030[34]

Hydrogen Europe does not define the level for 2035 in its scenarios, but some sectors are aware of an increase in distribution obligations by 2035. For example, the need for RFNBO hydrogen in industry will increase from 42% to 60%, meaning 1.9 Mt of hydrogen per year. For maritime transport, the increase is from 1% to 2%, meaning 0.2 Mt/a, and for aviation, the increase is from 2% to 5%, meaning 0.75 Mt/a. For road transport, the increase in the RFNBO mandate has not been confirmed after 2030. In total, the mandates would create a demand of about **4 Mt/a** for RFNBO hydrogen in 2035. Reflecting the hydrogen strategy's target of 10% of European hydrogen production, in terms of the distribution obligation market estimated by Hydrogen Europe, it would mean 0.28 Mt/a and 0.4 Mt/a of hydrogen production in Finland in 2030 and 2035 respectively.

Carbon capture scenario

[34] Hydrogen Europe: Demand for RFNBO hydrogen in the EU in 2030

In 2030, VTT estimates that the technical potential of carbon capture in Finland will be approximately 2–3 Mt of CO_2 per year, and by 2035 it may increase to 3–5 Mt of CO_2 if permanent storage (BECCS) and industrial utilisation (BECCU) solutions progress and the market develops. The actual amount depends on investments, legislation and the generation of demand, but the scenarios show that capture can form a significant part of Finland's hydrogen economy and industrial climate solutions as early as the 2030s.

According to AFRY's factory emissions scenario, recovery will still be moderate in 2030 (0.5–1 Mt of CO_2) but may rise to 2–3 Mt of CO_2 by 2035 if investments and utilisation opportunities proceed as planned. Both estimates emphasise the growing importance of industrial carbon dioxide utilisation after the mid-2030s, when Finland can move from a producer of emissions to a value-added actor.[35] [36]

If we look at the amounts of carbon dioxide needed in Europe, assuming that hydrogen is used as hydrogen in industry and is not further processed with carbon dioxide, the amount of hydrogen needed for further processing in sea, air and road transport is about **1.5→ 2 Mt**. Using VTT's conversion (Figure 7), this would mean about **13→17 Mt of carbon dioxide** capture in Europe and 10% of it for Finland's needs.

Conclusions from the scenarios

Reflecting the hydrogen strategy's target of 10% of European hydrogen production in 2030 and 2035, it would mean **0.28 → 0.4 Mt/a** of hydrogen production in Finland in terms of the distribution obligation market estimated by Hydrogen Europe.

In the project map collected by Hydrogen Cluster, the estimated hydrogen production potential of the projects was 1.5 Mt/a (Figure 4 Hydrogen economy projects in November 2025). This would mean that 19–27% of projects would need to be up and running by 2030 and 2035 in order to reach this minimum target, i.e. several investment decisions would have to be taken in the course of 2026.

If we look at the requirements for renewable electricity production using VTT's conversion (figure below), the production of **0.28 → 0.4 Mt/a** of hydrogen would mean about 11.6→

[35] From emitter to producer – Carbon dioxide economy adds value to the Finnish forest sector

[36] AFRY's background material for the Finnish Forest Industries Federation's roadmap: factory emissions scenario

16.6 TWh of renewable electricity for the years in question. In its plans, Fingrid estimates that consumption will rise from the current 83 TWh to 103–123 TWh in 2030 and further to 104–159 TWh in 2035, depending on the scenario. The consumption generated by the distribution obligation market is very moderate compared to Fingrid's scenarios and provides an opportunity for growth in markets outside the distribution obligation as well. Increasing renewable energy production is also in line with these figures and the required amount of electricity is realistic in relation to the hydrogen economy targets.

If we look at the amounts of carbon dioxide needed, assuming that hydrogen is used as hydrogen in industry and is not further processed with carbon dioxide, the amount of hydrogen needed for further processing in sea, air and road transport is about **0.15→0.2 Mt**. Using VTT's conversion (figure below), this would mean about **1.3→1.7 Mt of carbon dioxide** capture.

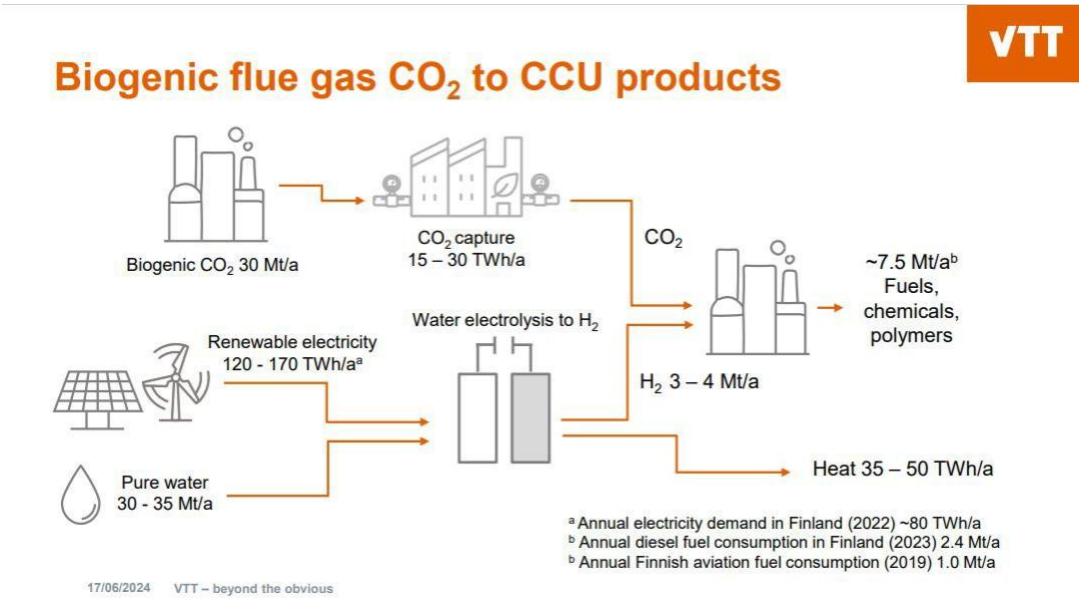

Figure 7 Top-level mass and energy balance of the hydrogen economy[37]

In 2030, 1.3 Mt/a of carbon dioxide would be needed only for the needs of the distribution obligation market. According to AFRY's factory emissions scenario, the recovery in 2030 would be 0.5–1 Mt of CO_2 and, according to VTT's estimates, about 2–3 Mt of CO_2 per year.

[37] VTT: Biogenic flue gas CO_2 to CCU products, presentation material 17.6.2024

In 2035, the need for carbon dioxide will increase to 1.7 Mt. Correspondingly, AFRY estimates the CO_2 recovery level to be 2–3 Mt and VTT 3–5 Mt for the year in question.

In 2030, AFRY's estimate is lower than the amount of carbon capture needed, but other estimates of both 2030 and 2035 needs are possible under both scenarios. However, the realisation of the scenarios requires scaling up the pilots and making investment decisions on a tight schedule in order to achieve the 2030 targets.

With regard to electricity, the electricity grid and carbon dioxide, the roadmaps of different operators until 2035 are well aligned if we only take into account the development of the distribution obligation market and Finland's target of 10% of hydrogen production in Europe. There are a few points of view to consider:

- The roadmaps of different sectors describe what is possible if the operating environment and the mindset are favourable. In other words, the roadmap only shows an opportunity, the implementation of which requires bold decisions and concrete plans from all actors. These plans must be implemented and investment decisions made immediately from 2026 onwards in order for the projects to start during 2030–2035.
- This only takes into account the RFNBO hydrogen market and its growth. Low carbon hydrogen and downstream products bring an additional market on top of these figures, which is still difficult to assess due to the incomplete regulation.
- This includes only the needs of the distribution obligation market, and all other emerging markets and opportunities for e.g. the production of chemicals and proteins will be added this estimate and may offer significant growth opportunities on top of this estimate.
- After 2035, the mandates will increase at a rapid pace, and the components of the hydrogen economy value chain must grow and scale significantly between 2035 and 2040. Therefore, we cannot be lulled into thinking that the demand in 2035 will remain at the same level, but we must constantly prepare for scaling in all these areas: the production, transmission and storage of clean electricity, carbon capture, new investments and the continuous development of technologies.
- The scaling of the market requires seamless cooperation and encouraging regulation in Finland. Although the goals seem reasonable in numbers, they require billions of euros in investments to be achieved as well as a market that will not disappear.

Conclusion

Hydrogen Cluster Finland is committed to this roadmap's goal of making Finland the most competitive hydrogen economy country in Europe. This goal will be achieved through determined actions and bold decisions. We need the courage to invest and a reconstruction mentality – all actors must take an active role, as only proactive and decisive action will take Finland towards the forefront of the hydrogen economy.

Success will not only bring much-needed economic growth, jobs and regional development, but it will also strengthen Finland's security of supply and energy self-sufficiency, increase the resilience of both society as a whole and individual companies in a turbulent world, and take Finland towards our carbon neutrality goal.

Let's build the future of Finland and the hydrogen economy together.

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Hydrogen Cluster Finland is a network of companies and industrial associations that facilitates sharing of information, collaboration and joint ventures, and development of a business perspective to promote hydrogen economy, create business opportunities and support the transformation towards climate neutrality.

Hydrogen Cluster Finland welcomes dialogue and collaboration with companies, clusters, and platforms active in hydrogen economy to create sustainable innovation and business opportunities in Finland, Europe and around the globe.

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