REPUBLIC OF SLOVENIA
MINISTRY OF EDUCATION, SCIENCE AND SPORT

Interreg
SLOVENIA – AUSTRIA
European Union | European Regional Development Fund

H2GreenTECH

ROADMAP FOR HYDROGEN TECHNOLOGIES IN SLOVENIA AND AUSTRIA

NATIONAL INSTITUTE OF CHEMISTRY

ŠTAJERSKA GOSPODARSKA ZBORNICA

TU Graz
Graz University of Technology

FORSCHUNG Burgenland

KÄRNTEN University of Applied Sciences

REPUBLIC OF SLOVENIA
MINISTRY OF EDUCATION, SCIENCE AND SPORT

Interreg
SLOVENIA – AUSTRIA
European Union | European Regional Development Fund

ROADMAP FOR HYDROGEN TECHNOLOGIES IN SLOVENIA AND AUSTRIA

H_2GreenTECH

NATIONAL INSTITUTE OF CHEMISTRY

ŠTAJERSKA GOSPODARSKA ZBORNICA

TU Graz
Graz University of Technology

FORSCHUNG Burgenland

KÄRNTEN
University of Applied Sciences

The Roadmap for Hydrogen Technologies in Slovenia and Austria (the "Roadmap") presents the perspectives held by a range of stakeholders from the respective governments and industry, as well as non-governmental organisations and academia with respect to cross-border cooperation on developing hydrogen technology until 2025. While the Ministry of Education, Science and Sport in Slovenia led the Roadmap's development, it consulted broadly with the H_2GreenTECH consortium partners, notably the National Institute of Chemistry and the Chamber of Commerce and Industry of Štajerska.
The contents, challenges identified and recommendations found in the Roadmap are a combined view and might not be unanimously endorsed by each participating organisation or its employees.

Project H_2GreenTECH

WEBSITE: www.h2greentech.eu

PROJECT TITLE: Strengthening cross-border R&I capacities in advanced hydrogen technologies by developing synergies between enterprises, R&D centres and higher education.

ACRONYM: H_2GreenTECH

DURATION: 1 March 2020 – 31 August 2022

Project partners

National Institute of Chemistry, Slovenia

Ministry of Education, Science and Sport, Slovenia

Chamber of Commerce and Industry of Štajerska, Slovenia

Graz University of Technology, Austria

Carinthia University of Applied Sciences, Austria

Research Burgenland, Austria

Please cite as

Kumer Peter, Likozar Blaž, Marinič Dragica, Props Petra, Šegedin Urban, Žunič Vojka, Schönfeldinger Marion, Wolf Sigrid (eds) 2022: Roadmap for Hydrogen Technologies in Slovenia and Austria. Ljubljana: Ministry of Education, Science and Sport

Acknowledgment

This publication was issued as part of the H_2GreenTECH project. The project was co-financed by the European Regional Development Fund under the programme Interreg V-A SI-AT.

Published by the Ministry of Education, Science and Sport

Edited by: Kumer Peter, Likozar Blaž, Marinič Dragica, Props Petra, Šegedin Urban, Žunič Vojka, Schönfeldinger Marion, Wolf Sigrid

Design: Minibig, Simon Trampuš s.p.

1st electronic edition

2022 Ljubljana, Slovenia

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani

COBISS.SI-ID 112124419

ISBN 978-961-7065-17-6 (PDF)

Content

ABBREVIATIONS

AT	Austria
B2B	Business to Business
B2F	Business to Finance
B2R	Business to Research
CCS	Carbon capture and storage
CEETT	Central and Eastern European Technology Transfer
CF	Cohesion Fund
DSO	Distribution system operator
EIF	European Investment Fund
ERDF	European Regional Development Fund
ESF+	European Social Fund Plus
EU	European Union
FCH JU	Fuel Cells and Hydrogen Joint Undertaking
GHG	Greenhouse gas
GWh	Gigawatt hours
H_2	Hydrogen
HBOR	Croatian Bank for Reconstruction and Development
IP	Intellectual property
JTF	Just Transition Fund
KET	Key enabling technology
ktoe	kilotonnes of oil equivalent
LEC	Local energy communities
MIZŠ	Ministry of Education, Science and Sport
NECP	National Energy and Climate Plans
NGO	Non-Governmental Organisation
PoC	Proof of concept
R&D	Research and development

RES	Renewable energy sources
RRP	Recovery and Resilience Plan
SI	Slovenia
SID	Slovene Export and Development Bank
SME	Small and medium-sized enterprises
SMR	Steam methane reforming
subDSO	sub-Distribution System Operator
ŠGZ	Chamber of Commerce and Industry of Štajerska
TRL	Technology readiness level

1. FOREWORD TO THE ROADMAP FOR HYDROGEN TECHNOLOGIES IN SLOVENIA AND AUSTRIA

The Roadmap for Hydrogen Technologies in Slovenia and Austria is H_2GreenTECH project deliverable number D.T3.3.1 and **a joint cross-border strategic document that defines the development of hydrogen technology until 2025** with regard to guidelines and priorities in Slovenia and Austria. The aim is to provide a feasible plan for effective cross-border cooperation regarding the development of hydrogen technologies.

The Roadmap was prepared by the Ministry of Education, Science and Sport in collaboration with the National Institute of Chemistry and the Chamber of Commerce and Industry of Štajerska, together with the coordinated participation of key stakeholders (who after stakeholder mapping joined the 'pool of experts') in Slovenia and Austria. End users of this strategic document include policymakers on the national, regional and local levels in each country, small and SMEs, and members of the Hydrogen Center network.

HYDROGEN CENTER

Many state-of-the-art research and development institutions and universities in the cross-border region of Slovenia and Austria are working to develop hydrogen and hydrogen technologies, yet their efforts often disconnected and fragmented.

In order to deepen cooperation and networking and ensure a critical mass of hydrogen and hydrogen technologies capacities, a sustainable cross-border research-industry network in the form of a HYDROGEN CENTER was established in the region.

The HYDROGEN CENTER is both a digital platform for B2B meetings and a One-Stop-Shop that gives companies access to the services, cutting-edge knowledge and research infrastructure of the research institutions.

This will provide the basis for promoting the growth and development of low-carbon technologies, knowledge transfers to young people, and the transition to a carbon-neutral society.

The HYDROGEN CENTER Network aims to bring different stakeholders in the field of hydrogen technologies in Slovenia and Austria together in a long-term cross-border research and industrial network to support the development of hydrogen technology innovations and implement the Roadmap for Hydrogen Technology in Slovenia and Austria, the Hydrogen Center Development Strategy, and the Hydrogen Center Marketing Strategy.

Participation as a member of the HYDROGEN CENTER is cost-free and open to various prospective stakeholders like SMEs and larger companies, R&D organisations with their laboratories, competence centres, educational institutions, start-ups, researchers, students and other individuals from the programme area who, with their professional, development and research work, knowledge, skills and experience, can add significantly to the development of breakthrough hydrogen technologies and their increased use in the cross-border region and beyond.

The Hydrogen Center is coordinated by the Chamber of Commerce and Industry of Štajerska in Maribor. It collaborates with support laboratories at the following locations: Ljubljana: National Institute of Chemistry; Graz: Technical University of Graz, and Villach: Carinthia University of Applied Sciences.

b2b.h2greentech.eu hydrogencenter@stajerskagz.si

Envisioning hydrogen technology in Slovenia and Austria in 2030

According to Slovenia's NECP[1], hydrogen can play a role in integrating the production of renewable electricity, strengthening the security of gas supply and helping to achieve the decarbonisation targets. Renewable hydrogen can be used to store large amounts of electricity produced during periods of low demand. Slovenia expects by 2030 to see final hydrogen consumption of 10 ktoe (116 GWh) in the transport sector and, by 2040, 63 ktoe (732 GWh) being consumed, mainly in the transport, but also progressively in the building and industry sectors[2]. Currently, only Industrial partners are looking for H_2 energy as a medium for decarbonisation. Activities to prepare the Slovenian Hydrogen Strategy are already underway.

According to the NECP[3], Austria holds an ambition of becoming a European leader in the deployment of hydrogen. The government has adopted a national Hydrogen Strategy. Its NECP considers renewable hydrogen "as a key technology for sector integration and coupling" and contains the specific target of renewable electricity-based hydrogen consumption of 1.1 TWh (4 PJ) in 2030. New regulatory and financial measures are to be announced to pave the way for renewable hydrogen in the industrial, building and transport sectors addressing the entire value chain from generation, storage, transport and distribution through to end-use.

The FCH JU (https://www.fch.europa.eu/), in close cooperation with the European Commission – DG Energy, commissioned a study on the "Role of Hydrogen in National Energy and Climate Plans". High and low scenarios regarding Hydrogen use were prepared for both countries. The estimations are presented in the table below.

1 Integrated National Energy and Climate Plan of the Republic of Slovenia. (2020). https://www.energetika-portal.si/dokumenti/strateski-razvojni-dokumenti/nacionalni-energetski-in-podnebni-nacrt/

2 Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans (2020). https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

3 Integrated National Energy and Climate Plan for Austria (2019). https://unfccc.int/sites/default/files/resource/LTS1_Austria.pdf

High and low hydrogen use scenarios in Slovenia and Austria

Estimated renewable/low carbon hydrogen demand by 2030

In the low scenario, renewable hydrogen accounts for 0.1% of final total energy demand (i.e., 0.1 out of 51 TWh/a) or 0.9% of final gas demand (7 TWh/a) according to EUCO3232.5

In the high scenario, renewable hydrogen accounts for 0.3% of final total energy demand (i.e., 0.2 out of 51 TWh/a) or 2.7% of final gas demand (7 TWh/a) according to EUCO3232.5[4]

In the low scenario, renewable hydrogen accounts for 0.6% of final total energy demand (i.e., 1.6 out of 281 TWh/a) or 3.2% of final gas demand (49 TWh/a) according to EUCO3232.5.

In the high scenario, renewable hydrogen accounts for 2.0% of final total energy demand (i.e., 5.6 out of 281 TWh/a) or 11.4% of final gas demand (49 TWh/a) according to EUCO3232.5.

Number of passenger cars

Low scenario: 6,300

High scenario: 12,600

Low scenario: 55,220

High scenario: 110,400

Number of buses

Low scenario: 10

High scenario: 30

Low scenario: 100

High scenario: 200

Number of lorries

Low scenario: 300

High scenario: 700

Low scenario: 2,900

High scenario: 5,900

4 New Commission modelling on 32.5% energy efficiency (2019). https://www.stefanscheuer.eu/energy-savings-on-the-ground/new-commission-modelling-on-32-5-energy-efficiency/1072/

Slovenia's advantages and opportunities

Slovenia holds a unique position to become an exemplary case of a decarbonised society by 2050. Hydrogen can play a role in integrating the production of renewable electricity, making gas supply more secure, and contributing to the accomplishment of the decarbonisation targets. Renewable hydrogen can be used to store large amounts of electricity produced in periods of low demand. Slovenia expects final hydrogen consumption of 10 ktoe (116 GWh) in the transport sector by 2030 and that, by 2040, 63 ktoe (732 GWh) will be consumed mainly in the transport, but also gradually in the building and industry sectors.

Slovenia has a high share of investment in R&D activities, primarily by companies. High-quality human resources are available along with ever more researchers, especially in the private sector. Research and innovation are strongly supported by public authorities. Slovenia exceeds the European Innovation Scoreboard average. A strong supporting environment for knowledge and technology transfer activities already exists. Social awareness of the damaging effects of global climate change is high.

Slovenia has a well-developed ecosystem of support organisations, such as technology and science parks, (technology) business incubators, support organisations (NGOs), government agencies, chambers of commerce, etc.. It also possesses research and infrastructure that are high in scientific standards. Slovenia will be ranked by 2030 among innovation leaders in terms of environmental innovation and technology indicators, its targeted investments in R&D will close the knowledge gap, while 60% of research will contribute to sustainable development and 35% to climate change management and adaptation.

To realise hydrogen's full potential for decarbonising energy systems and to create a true hydrogen economy, industry and public authorities must increase their investments to drive the market forward. Hydrogen is already widely used in industry, and almost all of the hydrogen today is produced from fossil fuels. However, the use of carbon capture and storage (CCS) technology could reduce the emissions from this production, while other methods using renewable energy would produce no CO_2 emissions – green hydrogen.

H_2 opportunity:

2030	H_2 for energy	H_2 demand	reduction of GHG emissions (compared to 2015)
	116 GWh	10 ktoe	4 Mt CO_2
	1,100 GWh	95 ktoe	24 Mt CO_2

Austria's advantages and opportunities

Austria has an ambition to become a European leader in the deployment of hydrogen. Austria's NECP includes the target of renewable electricity-based hydrogen consumption of 1100 GWh in 2030. Austria is in a favourable position given its current investments in hydrogen research, pilot and demonstration projects, as well as in infrastructure, e.g., hydrogen refuelling stations, transport and delivery infrastructure decarbonising the steel industry, along with producing hydrogen from renewable sources. Here, Austria holds a good position by having many renewable sources like water power, photovoltaic and, above all, wind-power plants. At the end of 2021, 1,307 wind turbines with a total output of 3,300 megawatts were generating clean green electricity for some 2.2 million households; namely, about 50% of all households in Austria. With 1,200 MW, Burgenland produces one-third of this amount. This green electricity allows us to produce green hydrogen. By repowering the wind turbines, we are likely to obtain even more green electricity in the next few years.

On 2 June 2022, Austrian federal ministers Gewessler and Kocher published the national hydrogen strategy. The strategy is essentially based on four pillars. Alongside specific expansion targets, guidelines are also set for the use of hydrogen and some declarations of intent for hydrogen imports and cooperation. Eight fields of action are additionally described for achieving the strategy's goals. Specifically, the following expansion goals are mentioned in the strategy:

- By 2030, 1 GW of electrolysis capacity is to be installed in Austria. The strategy here assumes 50% utilisation. This corresponds to around 4.35 TWh.

- By 2030, 80% of the current fossil hydrogen demand (140,000 tonnes) is to be converted to green hydrogen (112,000 tonnes or 3.7 TWh). This goal can be achieved with the capacities mentioned above.
- By 2040, hydrogen demand is expected to range between 67–75 TWh. Of this demand, 16–25 TWh can be covered exclusively with hydrogen. According to the strategy, the rest could also be covered with methane. The expansion path after 2030 remains unclear in the strategy, as to which no concrete goals are set.

However, Green H_2 only makes sense if it can be generated in sufficient quantities. The great advantage of green hydrogen is the ability to seasonally storage energy because the expansion of renewable energy sources entails fluctuating availability depending on the weather and season. The approaches are hence manifold: they range from the direct reduction and use of electric arcs in the steel industry, methanation to green gas or further processing to e-fuels for all types of mobility. Especially in the heavy transport and industrial sectors, green hydrogen as a climate-neutral energy carrier is suitable for quickly bringing about a sharp cut in emissions. This makes fuel cells good solutions for heavy traffic, buses and trains as H_2 can be stored in a gaseous state in tanks that can be refuelled in minutes without compromising their reach.

New regulatory and financial measures are to be announced that will pave the way for renewable hydrogen in the industrial, building and transport sectors while the entire value chain from generation, storage, transport and distribution through to end-use. Legal regulations are being drafted quickly for the fast implementation of H_2 projects. The transition to green energy and a hydrogen economy will then produce sustainable effects for the environment, health and finance in the whole cross-border region.

2. DRAFTING THE ROADMAP: CONTRIBUTORS AND MILESTONES

The Roadmap is a joint cross-border strategic directional document based on consultations with stakeholders.

For the past year, the Ministry of Education, Science and Sport of the Government of Slovenia has been working with key stakeholders: researchers, private sector stakeholders, NGOs, and governments on all levels to inform the preparation of the Roadmap for Hydrogen Technologies in Slovenia and Austria. This Roadmap contains input from tens of universities, research organisations, companies, organisations and individuals sourced through interregional congresses, bilateral consultations, and the Policy Forum.

A subcontractor of the Ministry of Education, Science and Sport (Boštjan Grabner s.p.) led the initial consultations on behalf of the Ministry of Education, Science and Sport. The Roadmap summarises and integrates the stakeholder inputs to create a single cohesive document.

Milestones in the preparing the Roadmap for Hydrogen Technologies in Slovenia and Austria

MILESTONE 1
June-July 2021

First workshop with stakeholders and developing guidelines

MILESTONE 2
August-December 2021

Extension of the pool of experts and defining major challenges and objectives

MILESTONE 3
January-March 2022

Follow-up consultations with stakeholders in the process of organising the Policy Forum

MILESTONE 4
March-June 2022

Final version of the Roadmap

MILESTONE 1 (June–July 2021): First workshop with stakeholders and developing the guidelines

On 17 June 2021, the H_2GreenTECH partners organised the 1st Interregional Congress of H_2GreenTECH (D.C.3.3.) entitled "Strengthening Slovenian–Austrian cross-border cooperation for the development of low-carbon technologies". The congress was coordinated by ŠGZ. The event took place in Maribor in hybrid form (on-site and virtual), with speakers and participants from Slovenia and Austria.

The event was open to everyone. However, the aim was to attract stakeholders from groups identified as project target groups: local public authorities, regional public authorities, national public authorities, sectoral agency, business support organisation, enterprises excluding SMEs, SMEs, higher education and research, education/training centres and schools, the general public, and NGOs. The mapping of relevant stakeholders was prepared within the activity A3.2: cross-border networking of key stakeholders ('pool of experts'") and all stakeholders on this list were invited.

The 1st interregional congress included the workshop "Paving the way for the Roadmap for low-carbon technologies: A shared Slovenian-Austrian agenda", led by Peter Kumer from MIZŠ. Representatives of different stakeholders focused on developing guidelines (objectives, actions, expected outcomes, target groups, timeframes) for more effective interregional cooperation regarding hydrogen technologies. The workshop's main findings were that the professional and scientific sector of the cross-border region is well developed, but lacks a common strategic document to realise the associated potential. A well-developed approach is needed to bring green technologies closer to the market (products and customers). The workshop participants stressed the need to fund cross-border projects and demonstration pilots that would enable better integration.

Based on the workshop results, the first draft of the Roadmap was prepared in July 2022.

MILESTONE 2 (August–December 2021): Expanding the 'pool of experts' and defining the major challenges and objectives

After preparing the draft Roadmap with an emphasis on developing guidelines, the primary aims of the next step were to reach out to more stakeholders and obtain their feedback on the draft and (based thereon) to define the major challenges and objectives.

Representatives of all stakeholder groups were contacted, although more effort was put into reaching out to the regional public authorities and SMEs in Slovenia and to the national public authorities, enterprises, excluding SMEs and NGOs, since representatives of these groups were absent from the 1st interregional congress.

To gather further inputs, stakeholders were reached by e-mail. An invitation to submit comments about the draft version was also sent via the project's media channels.

They were provided with a description of both the project and the Roadmap. Based on that, stakeholders were asked to think of the biggest obstacles to be overcome to improve

interregional cooperation in the field of hydrogen technologies between Slovenian and Austrian companies, research centres, educational institutions, public administration, and NGOs. Moreover, they were asked to define the main activities/objectives that must be taken to overcome those obstacles. The collected responses were meaningfully included in the Challenges and Objectives sections.

MILESTONE 3 (January–March 2022): Follow-up consultations with stakeholders in the process of organising the Policy Forum

A further discussion with stakeholders from the 'pool of experts' with respect to the main challenges and objectives occurred while organising the Policy Forum. This time, all project partners were engaged in obtaining meaningful responses from the stakeholders with the use of specially designed e-forms. The final round of discussion about the Roadmap happened during three interactive workshops held on 16 March 2022 as part of the Policy Forum (D.T3.2.1). The above led to e final version of the Roadmap being prepared.

MILESTONE 4 (March–June 2022): Final version of the Roadmap

The final version was prepared after the editorial board members had carefully examined all of the different stakeholder feedback. Supporting chapters prepared by the editorial board are included in the final version.

3. CHALLENGES

Hydrogen is a fuel for the future, yet its use is already well established. Still, to realise its full potential of decarbonising energy systems and create a true hydrogen economy, industry and governments must increase their investments to propel the market forward. Hydrogen technologies are not without their challenges, while the research and development of hydrogen technologies is an important step towards green energy production. To ensure these technologies become more accepted, it is important to determine the challenges in advance. This chapter provides a broad overview of such challenges, divided into two subchapters: technological and cooperation challenges. Technological challenges are further divided into Hydrogen Production, Distribution, Storage, Infrastructure, and End-uses.

3.1 Technological challenges

3.1.1 Hydrogen Production

Overcoming the Valley of Death

In the industry, concepts too often remain in the prototype stage: they are never implemented and fall into what is popularly known as the Valley of Death. This is because the regulations for upscaling the production sites are strict and quite costly to realise in money and time terms. Local authorities are currently partly overwhelmed by this type of new technologies and the related bureaucracy is thus quite an impediment. Another main issue facing the industry is the missing hydrogen economy and associated infrastructure.

This means that attention needs to paid to the following:

- The adaptation of regulation to better support the development of new hydrogen technology
- Initiation from the industry by supplying hydrogen-based technology products in the hope that they win over costumers. Unfortunately, this is risky for smaller competitors that often then do not invest.

- The commitment of actors that implementation will occur on a comparable scale on both sides of the border.
- The development of projects should last long enough to allow phases from R&D to, say, pilot production. A known and good solution is for a project to be two-part, 100% subsidised in part 1 (R&D) and correspondingly less in part 2. One can also find examples of three-part projects.
- It is important, however, to support the project's continuation after the development project has been completed.

Distinguishing between core technology and application

The usual EU approach is to establish a centre to support the companies and stakeholders. A better approach would be to establish a pilot project/region with direct benefits for the citizens and learning from day one about H_2 by the following:

- starting with an H_2 core technology provider from the region;
- listening to what society needs and create benefits for the citizen in combination with the core technology available in the region – establishing a project to harness this technology and learn, attain volume, decrease costs. Using public administration and educational institutions to achieve volume and a citizen-centred approach; and
- building the ecosystem around this project, thereby providing a basis for know-how and future spinoffs (e.g., projects in Slovenia and Austria: Mebius, ReCatalyst, CONOT, HyCentA[5])

Alternative production of H_2

A focus on considering and finding technologies for sustainable low-carbon hydrogen production other than electrolysis – especially on the research and innovation side of cooperation

Project ideas for the local production and use of H_2

A need for examples and project ideas concerning ways that H_2 can be produced and (ideally) used locally. Only the best-suited projects for relatively quick implementation are e.g., to be selected.

Upgrading H_2 production capacities

An overwhelming majority of hydrogen is currently produced using fossil fuels, including natural gas and coal, with a process called steam methane reforming (SMR).

Yet, the big drawback of the steam-methane reforming technique is that greenhouse gases are then released into the atmosphere. The challenge is to shrink the carbon footprint of the production of Hydrogen by CO_2 capture and Green Hydrogen production based on RES.

5 www.mebius.si; www.recatalyst.si; www.conot.si; www.hycenta.at

Projects concerning efficient and affordable technologies, low-cost hydrogen models for the future, and follow-up carriers (CH_4, NH_3...)

Interesting technologies with thermodynamic aspects are seen on the labour research levels, but there is a need for a single, combining technology which can be offered to the marketplace.

Investment in H_2 technologies and their operation remains expensive and is too great a burden for the companies alone. Research and development still needs public money and co-financing by the both state and the EU.

Harmonising national and regional policy and research with the EU's demands

Slovenia will not only require its own national strategy (Austria has already adopted one), but a well-defined cross-border Hydrogen strategy that outlines the directions of development and economic stimulations for investing and operating in the area of hydrogen technology.

3.1.2 Distribution, Storage and Infrastructure

Decarbonisation of the industry by creating a cross-border electrolysis sector

The establishment of the electrolysis sector, which must evolve towards bigger-capacity projects, needs to be adequately promoted.

Decarbonisation of the industry must be in line with the introduction of hydrogen technologies into production processes. This is also a cornerstone of the multiannual energy programme.

How to integrate H_2 into the Energy System of the future to ensure the most efficient way of production

Electrolysis and steam reforming – the two main hydrogen extraction processes – are extremely expensive. New attempts are being made to use direct electrolysis in solar panel cells by employing new catalyst material (nanomaterials) to lower the energy consumed in catalysis.

A large share of RES on the electricity grid is and will remain inflexible

Managing congestion and balancing each subsystem with a considerable share of inflexible RES, hydrogen prosumers (a prosumer is an individual who both consumes and produces) are of special importance.

The uncompetitive (high) production price of green hydrogen, well above the prices of other energy sources

High prices are a key reason for the lack of demand as prospective consumers prefer other, cheaper energy sources. The lack of demand for green hydrogen reduces the interest of potential green hydrogen producers that would use their resources to develop competitive and more commercially attractive technologies. Subsidising the price of green hydrogen would encourage stakeholders in the production and consumption of green hydrogen to become more involved in various national and cross-border hydrogen projects, with the latter leading to activities to establish cross-border hydrogen transfer infrastructure.

Contributing to solving the problems of the storage, production and integration of H_2 in regional energy systems and solutions for seasonal storage

For transportation, the overarching technical challenge concerning hydrogen storage is how to store the amount of hydrogen required for a typical driving range (>500 kms)[6] within the vehicular

constraints of weight, volume, efficiency, safety and cost. Durability over the performance lifetime of these systems must also be verified and validated, and acceptable refuelling times achieved. Requirements for off-board bulk storage are generally less restrictive than on-board requirements; e.g., there may be no weight requirements or less restrictive ones, but there may be volume or 'footprint' requirements. The biggest challenges include:

- Weight and Volume – the weight and volume of hydrogen storage systems are presently too high, resulting in inadequate vehicle range compared to conventional petroleum-fuelled vehicles;
- Efficiency – energy efficiency is a challenge for all hydrogen storage approaches. The energy required to move hydrogen in and out is an issue for reversible solid-state materials;
- Durability – materials and components are needed that allow hydrogen storage systems with a lifetime of 1,500 cycles;
- Refuelling Time – there is a need to develop hydrogen storage systems with refuelling times of less than 3 minutes over the system's lifetime; and
- Cost – low-cost materials and components for hydrogen storage systems are needed along with low-cost, high-volume manufacturing methods. [6]

No infrastructure for the cross-border transfer of pure hydrogen

No infrastructure currently exists for the cross-border transfer of pure hydrogen, posing an obstacle for many companies interested in green hydrogen. Another limitation in connection with the neighbours' transmission systems is the unclear/indefinite regulatory framework.

6 Hydrogen Storage Challenges (2022). www.energy.gov/eere/fuelcells/hydrogen-storage-challenges

3.1.3 End-uses

Complete the harmonisation (vertical structuring) of the electricity market system

The electricity market system is vertically structured in both the grid segment and market segment into subsystems that essentially have the same characteristics as their parent system (fractal-like subsystems).

This implies:

- in the grid segment of the system that DSO (and subDSO) take responsibility for balancing its own grid
- in the market segment of the system that energy flexibility trading can be performed in local and regional markets, especially in local energy communities.

Development of the transportation and industry sectors using decarbonised hydrogen

The aim is to develop a range of hydrogen technologies in the transportation and industry sectors. The technology allows for greater storage capacity than electric batteries, as well as the need for high motor power or longer autonomy.

Introduction of energy flexibility trading on the level of prosumers and consumers

Prosumers and consumers can offer their flexibilities on the market. The hydrogen prosumer trades flexibility directly with its consumer.

3.2 Cooperation challenges

3.2.1 Most important cooperation challenges in the cross-border region

National border as an obstacle

The area is divided by a border, which hinders the research competitiveness of the cross-border region.

Weak interaction between universities and research organisations –establishment of strong cooperation between the research community and industry

Interaction between universities and research organisations is weak.

Although isolated research cooperation already exists, on the whole the interaction between Slovenian and Austrian researchers is still poor.

Combining demand in the industrial and mobile sectors on the regional level should be encouraged to accelerate the introduction of hydrogen mobility in each national territory. The goal is to establish strong partnerships between the research community and industry.

Uncertain investment climate

The need to:

- adopt a national Hydrogen Strategy (in Slovenia)
- establish a long-term stable regulatory environment both nationally and internationally/EU-wide
- provide investment security for early movers: no retroactive changes to regulation (e.g., the definition of "green hydrogen")
- standardisation (if not meant in a long-term stable regulatory environment)

Support for research, innovation and capability development to facilitate future hydrogen use

There are few research programmes to promote cooperative research projects to better link the region together.

Interregional projects are partly characterised by a very unclear definition of goals/milestones and an unclear distribution of tasks. This prevents effective cooperation.

Identify priority research programmes, which also include education and training for capacity development to support the use of hydrogen in the territory, including technical staff, persons responsible for quality, safety, the environment, firefighters, engineers and researchers.

Unclear regulatory environment

The need for:

- demand-side measures (e.g., a demand quota for industry or mobility) to foster the development of hydrogen
- abolition of the carbon-leakage advantage for grey hydrogen
- establishing effective and cross-sectoral CO_2-price mechanisms
- tax benefits for green hydrogen procedures

Harmonising the strategy on Hydrogen on both sides of the border

Over the last three decades, the INTERREG/ETC programmes have crucially helped stimulate territorial development and reduce all sorts of border barriers in EU border regions[7]. Despite these efforts, the presence of national administrative borders creates inevitable constraints for citizens who cross EU borders. Ensuring that both countries have a 'harmonised' strategy would speed up investments and collaboration.

For technological and economic cooperation, we need roadmaps and strategies on both sides, which must be accepted by both countries.

We also need pilot projects in Austria and Slovenia to strengthen cross-border pilot and demonstration actions. These would be important for demonstrating the technologies to the national authorities to show their techno-economic and environmental benefits.

The Research and Educational field is not sufficiently active

There is a need for more active research and educational work and hence greater visibility and a better approach to projects for applying hydrogen technologies. This would create possibilities for them to breakthrough with test and demonstration projects (i.e., linking research and educational work with the economy).

Without these, it will not be possible to build interregional cooperation. The future lies in greater integration and joint application projects with recognised added value.

Unclear and non-strategically designed guidelines

The challenge is to prepare clear and strategically designed guidelines for the development and introduction of green technologies for hydrogen production.

Concentration and cooperation on R&D capacities to become visible on the EU scale

The need for:

- increased cooperation across border (the area is divided by the border, which hinders the research competitiveness of the cross-border area);
- introduction of better legislation and policies;
- increased cooperation between universities and research organisations by encouraging cooperation and knowledge transfer with regard to market needs; and
- establishing an interregional hydrogen value chain.

7 Medeiros, E. (2018). Should EU cross-border cooperation programs focus mainly on reducing border obstacles? https://ec.europa.eu/futurium/en/system/files/ged/pub_pap_em_should_eu_cross-border_cooperation_programmes_focus_on_reducing_border_obstacles_documents_danalisi_geografica.pdf

The lack of legislative and financial support for implementing green hydrogen technologies

The lack of legislative and financial support is (apart from the obvious technical and cost issues) a crucial obstacle that must be overcome swiftly if we are to accomplish the goals of decarbonisation and to reduce the impact on the global climate. Here, the complicated administrative procedures should also be mentioned as one of the biggest obstacles.

Both Slovenia and Austria are committed to achieving carbon neutrality

Slovenia prepared the NECP for reaching carbon neutrality by 2050[1] and Austria by 2040[2], 10 years ahead of the European Union's target. To achieve these goals, both countries prepared legislation and policies that directly address the challenge. In this context, H_2 plays an important role.

More efforts to integrate other stakeholders into the development of low-carbon technologies (NGOs, universities, research organisations, companies) – Greater flexibility of regional actors regarding solutions and technologies outside the mainstream to give such possibilities a chance

Stakeholder integration provides real opportunities for organisations to achieve more than they could on their own and is a way to improve construction project productivity.

The main challenges for stakeholder integration seem mostly related to the lack of trust and communication among stakeholders, and thus all stakeholders should be involved as soon as possible.

The new reality and changes in the world call for new solutions to be developed and implemented quicker than ever before. This represents a problem, especially for authorities, learning institutions and big organisations, such as research institutes. New, fresh, unconventional ideas, particularly if they come from other fields like NGOs, should be given an opportunity and more chances.

4. RECOMMENDATIONS

In each country, national NECP [1, 2] data were used to prepare the present document. The recommendations are divided into three tables: Transfer of research and innovation to the industry and vice versa; Opportunities for the joint financing of research, development and innovation of hydrogen technologies; and The political framework and priorities.

4.1 Transfer of research and innovation to the industry and vice versa

OBJECTIVE

A broad (thematic) scientific conference on hydrogen-related research

Measures:

The conference could help identify common research approaches and lead to new collaborations. B2R, B2B and B2F (R – research, B – business, F – finance) meetings, workshops and hackathons could also be organised within the proposed conference.

Expected results:

Increased cooperation; greater investments

Target groups:

Researchers from universities, public research organisations, and companies; representatives from the business sector; investors

Time Frame:

1 year

OBJECTIVE
Infrastructure sharing – preparation of concepts

Measures:
Preparation of a concept note, including a list of infrastructure, research capacities and willingness to be part of a sharing system

Expected results:
The prepared concept

Target groups:
Researchers from universities, public research organisations, and companies

Time Frame:
1 year

OBJECTIVE
Finding the right support schemes to enable PoC and pilot projects

Measures:
Support that will help transit from research to industry, enable regulated businesses to invest in early technologies and thereby enable knowledge transfer; raising public awareness through pilot and demo objects

Expected results:
Increased investments; knowledge and technology transfer; raising TRL; raising public awareness

Target groups:
Public authorities, investors and other stakeholders

Time Frame:
1 year

OBJECTIVE
Delta financing for H_2 equipment

Measures:
In the short run, it would be beneficial if the public authorities compensate for the delta financing of traditional applications towards H_2 technology: e.g. Diesel Bus – H_2 Bus, Diesel Generator – H_2 Generator etc. This incentive leads to use cases, providing the basis for applied sciences and technology development

Expected results:
Implementation of technologies – use cases

Target groups:
Public authorities

Time Frame:
1 year

OBJECTIVE

Development of technological showcases on how to invest in H_2 technologies for companies and other stakeholders

Measures:
A national agenda with attractive subsidy possibilities

Expected results:
2–3 investments in each country

Target groups:
SMEs and larger companies, business entities, assisted by research and development institutions

Time Frame:
3 years

OBJECTIVE

Support for evidence-based decision-making about public support schemes

Measures:
Cost–benefit analysis of hydrogen applications

Expected results:
Targeted public investments, targeted achieving of EU and national climate and energy objectives

Target groups:
The research community, state and ministries, players in the energy sector, (top-down approach)

Time Frame:
1 year

OBJECTIVE

Knowledge transfer to the general public

Measures:
Publishing non-scientific articles, press conferences and public roundtables, demonstration objects (pilot scale) or prototypes and more open and less scientific conferences and events including prototype demonstrations, identification of best practices

Expected results:
Boosting collaboration and financing; raising public awareness

Target groups:
Researchers from universities, public research organisations, companies, general public

Time Frame:
2 years

OBJECTIVE

Ensuring strong IP protection for newly developed technologies, technology transfer activities (i.e. licensing) and support for open innovation

Measures:
Conducting through patent searches, evaluation of new technologies, establishing patent protection, technology promotion and licensing; support open innovation where possible.

Expected results:
Protection of newly developed technologies, establishing a competitive advantage in the market, avoiding competition blockages within the designated territory

Target groups:
Researchers from universities, public research organisations and companies, supported by local technology and knowledge transfer offices

Time Frame:
3 years

OBJECTIVE

Build up knowledge databases for hydrogen-related technologies

Measures:
Establishment of a platform where new technologies from research are shared and their potential TRL is discussed

Expected results:
Increased insight for industrial partners to evaluate business cases
Greater investments in newer technologies

Target groups:
Researchers and enterprises

Time Frame:
1–2 years

OBJECTIVE

Introduction of hydrogen prosumers into the electricity market system on all levels of a harmonised (vertically structured) system as the most promising option

Measures:

Consequently, local energy communities (LEC) in Austria and in Slovenia can be formed that trade energy flexibilities to balance their operations. The objective of introducing hydrogen prosumers in LEC on both sides would stimulate cooperation between the two countries on the local and regional levels.
Fuel cells also generate heat that can be used for energy (individual prosumer objects or distance heating models).

Expected results:

A vertically structured system of prosumers included in the energetic grid established

Target groups:

State, authorities, and the business sector

Time Frame:

3 years

4.2 Opportunities for the joint financing of research, development and innovation of hydrogen technologies

OBJECTIVE

Monitoring and drafting proposals to improve financial mechanisms

Measures:

Funding mechanisms:
review existing funding mechanisms on the national, cross-border region SI-AT, transnational, and EU levels and analyse and propose more targeted mechanisms in the field of hydrogen and hydrogen technologies; in Slovenia, there is a Smart Specialisation Strategy giving opportunities for the joint financing of research, development and innovation of hydrogen technologies. The Cohesion Policy EU budget 2021–2027 is delivered through specific funds:

a) the European Regional Development Fund (ERDF), for investing in the social and economic development of all EU regions and cities

b) the Cohesion Fund (CF), for investing in the environment and in transport in less prosperous EU countries

c) the European Social Fund Plus (ESF+), for supporting jobs and creating a fair and socially inclusive society in EU countries

d) the Just Transition Fund (JTF), for supporting the regions most affected by the transition to climate neutrality

e) Calls for a tender starting in Q4 2022 (e.g. Eureka, M-ERA.NET...);

Austrian Ministry (BMK) funded platforms with reference to hydrogen:

a) A3PS – Austrian Association for Advanced Propulsion System – www.a3ps.at;

b The Hydrogen Initiative Flagship Region Austria Power & Gas – www.wiva.at

Expected results:
List of funding mechanisms for projects focused on H_2

Target groups:
All stakeholders

Time Frame:
3 years

OBJECTIVE
Financial support for newly established companies and spin-offs

Measures:
Overview and analysis of existing co-financing opportunities for newly established companies (start-ups) and spin-offs. For example:

1. The cases of Slovenia:

a) spin-offs:
Central Eastern European Technology Transfer (CEETT) platform to which the EIF will contribute €20 million and SID Bank and HBOR €10 million each, aims to establish and invest these funds in a regional venture capital fund. The fund will be designed to finance research projects, technology development and intellectual property with potential commercial value for the economy, at their earliest stage, when they are still in the domain of research teams at universities and research institutes. This will enable their successful development and commercialisation into final products and services of high added and market value for the economy.
For whom the platform is intended:

- Primarily proof-of-concept projects,
- Beneficiaries of the funding must be in the seed, start-up or later stages of development,
- the project must be the result of research at universities or other research institutions.
- The CEETT Platform will invite also private investors to participate[8]

b) start-ups:
Key public funding products for start-ups

- P2 – €54,000 start-up incentive for start-ups.
- SK75 – €75,000 convertible loan for market entry.
- SI-SK – From €100,000 to €600,000 co-investment money for rapid growth.
- Vouchers – Simple small value incentives for SMEs.
- SME Facility – Grants for concept and product development[9].

8 Central Eastern European Technology Transfer – CEETT platform. https://www.sid.si/mala-srednja-podjetja/regionalna-platforma-za-prenos-tehnologij-central-eastern-european-technology

9 Key public funding products for start-ups. https://www.startup.si/sl-si/za-startupe/javni-viri-financiranja

2. The cases of Austria:

a) start-ups and spin-offs:

The most important funding sources in Austria are the Austrian Research Promotion Agency (FFG) and Austria Wirtschaftsservice GmbH (AWS). They offer non-repayable grants, guarantees or subsidised loans. Domestic risk capital firms such as Speedinvest and numerous business angels repeatedly assist start-ups by providing financing, and investing millions of euros in capital[10]

b) spin-offs:

Spin-off initiative: At the same time, in the environment of academic spin-offs, priorities in the area of creating sustainable exploitation strategies and knowledge valorisation were communicated to the interested public, including World IP Day and the Phoenix competition[11]

Expected results:

Projects, focused on H_2,
cooperation between R&D, start-ups and spin-offs.

Target groups:

R&D organisation universities, companies, investors

Time Frame:

3 years

OBJECTIVE

Financial instruments for elevating TRLs to bring technologies closer to the market and to bridge the "valley of death"

Measures:

Funding mechanisms: national, regional, transnational, EU levels
Smart Specialisation Strategy of Slovenia and Smart Specialisation in Austria;
European Commission declares that Key Enabling Technologies (KETs) are crucial for the competitiveness and renewal of European manufacturing. The core of KETs is bridging the "Valley of Death" as a vital aspect of the KETs strategy, which addresses Europe's biggest weakness: the translation of its knowledge base into goods and services. It combines the two issues of deployment and re-industrialisation into an approach that distinguishes three fundamental stages in the innovation chain of KETs and KETs-based products:

a) Technological research, transforming fundamental research into technologies

b) Product development, transforming technologies into product prototypes

c) Competitive manufacturing, creating production systems to commercially produce the products[12]

10 Start-ups and spin-offs: The most important funding sources in Austria: the Austrian Research Promotion Agency (FFG) and Austria Wirtschaftsservice GmbH (aws). https://www.ffg.at/en/Start-up/Foerderungen; https://www.aws.at/

11 Spin-off initiative, Austria. https://www.spin-off-austria.at/sponsors

12 Horizon 2020: Key Enabling Technologies, Booster for European Leadership in the Manufacturing Sector. https://www.europarl.europa.eu/RegData/etudes/STUD/2014/536282/IPOL_STU%282014%29536282_EN.pdf

Expected results:
Research projects – to use the KETs: searching for solutions to 2 types of the valley of death:
a) the technological Valley of Death - it is about the research, development, and innovation of the product,
b) the commercialisation Valley of Death is about the development of a commercial production system.
Product development, transforming technologies into product prototypes of H_2 on the national or cross-border level

Target groups:
R&D organisations, companies, start-ups, spin-offs

Time Frame:
3 years

OBJECTIVE
To define sustainable and profitable business models, especially if we want to establish electric heating prosumers

Measures:
1. Preparation of an interest study to develop proposals of the solutions for decentralised structured small-scale hydrogen production (prosumers) in interregional area

2. Funding mechanisms in Slovenia and Austria such as The Recovery and Resilience Plan (RRP)

a) Slovenia:
greener economy, maximise the benefits of the digital transformation and ensure social-economic cohesion and resilience[13].

b) Austria:
green, sustainable, digital[14]

Expected results:
1. New business models
2. Financial support for the development and implementation the new business models in companies

Target groups:
All stakeholders, particular companies, experts

Time Frame:
3 years

13 The Recovery and Resilience Plan (RRP) in Slovenia. https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility/slovenias-recovery-and-resilience-plan_en

14 The Recovery and Resilience Plan (RRP) in Austria. https://ec.europa.eu/info/sites/default/files/at_rrp_summary.pdf

OBJECTIVE

Ambition for a joint investment project on H_2 close to the national border between Austria and Slovenia

Measures:

1. Joint interregional coordinated planning and implementation of the development and preparation of a project proposal on H_2 in the cross-border region
2. Funding mechanisms on the cross-border level such as Interreg SI-AT; Horizon Europe, European Innovation Funds for large and small projects; private investors
3 Funding mechanisms in

Slovenia and Austria such as The Recovery and Resilience Plan (RRP)

Expected results:

Project proposal for H_2 with investment jointly prepared on the government level of Slovenia and Austria according to needs for H_2 in Slovenia and Austria in the cross-border region

Target groups:

Cross-border cooperation between states, governments SI-AT (strategic solutions), R&D organisations, companies, private investors

Time Frame:

3 years

OBJECTIVE

Further promotion of decentralised, small-scale structured hydrogen production (prosumers) to solve the infrastructure problem while simultaneously expanding photovoltaic areas

Measures:

Seeking opportunities for cross-border cooperation on small-scale hydrogen production, yet also decisions on the government and regional level according to the needs of an application, e.g., for mobility and the economy

Expected results:

Analysis of hydrogen needs in the cross-border region, preparation of a feasibility study for such production and presenting it to decision-makers on the government level

Target groups:

All stakeholders

Time Frame:

3 years

OBJECTIVE

Based on the availability of H_2 core technology in the region, pilot projects to solve citizens' issues and scale by the involved stakeholders are needed

Measures:

Defining a list of pilot projects.
The list should be available to show the extent of the cost and the problems. Due to the higher support available from the EU compared to local authorities, it may be worthwhile defining a package of projects and obtaining support from European institutions.

Expected results:

Pilot projects on H_2

Target groups:

All stakeholders

Time Frame:

3 years

OBJECTIVE

A cross-national or harmonised regional model (hydrogen mobility concept) for the transportation and industry sectors

Measures:

The interregional coordinated planning and implementation of a pilot project such as

refuelling infrastructure for trains, trucks, cars, buses etc. and industry along the main transport routes. This includes the interregional coordination of hydrogen pilot projects in the truck and bus sector.

A scaled sector coupling regional model consisting of green power energy suppliers (possibly fed from a large number of small photovoltaic areas with excess capacities) with more efficient large-scale electrolysis plants (high temperature) and local businesses that also use hydrogen vehicles in the fleet for bus, heavy-duty or long-distance applications is conceivable.

Expected results:

Joint feasibility study for the H_2 pilot project subject to intergovernmental agreement

Target groups:

The state/governments of SI and of Austria (particularly the Interreg region in AT),
R&D organisations, companies, experts, decision-makers

Time Frame:

2-3 years

OBJECTIVE

Business cases to bring technology closer to the market (set up 2–3 pilot projects)

Measures:
Prepare the economic and financial background for demonstrators

Expected results:
Projects used to demonstrate the technical and economic and environmental benefits

Target groups:
State, authorities, business sector

Time Frame:
3 years

OBJECTIVE

Promote the coordinated funding for cross-border research

Measures:
Increasing the attractiveness of calls for tenders between the neighbouring countries through promotional activities

Expected results:
Promotion of activities and cross-border research projects through the Hydrogen Center cross-border network

Target groups:
Research institutions, scientific institutions, industry, educational institutions

Time Frame:
1–2 years

OBJECTIVE

Development of 'Hydrogen Valley'

Measures:
A review of initiatives and opportunities to establish a cross-border Hydrogen Valley

Expected results:
Review prepared

Target groups:
Researchers, the community, state and ministries, players in the energy sector, policymakers, business sector

Time Frame:
2–3 years

OBJECTIVE

Supporting investments at critical points in the value chain (fuel stations, electrolysis)

Measures:
Investments that would enable hydrogen to have a competitive price

Expected results:
National support schemes that would increase the chances of acquiring EU or other external funding and blending

Target groups:
Policymakers, state/ government, business sector, investors

Time Frame:
3 years

** Hydrogen Valleys typically entail a **multi-million-euro investment** in a defined geographic area and cover a substantial part of the hydrogen value chain, from hydrogen production, storage and transport through to its use in sectors like industry, mobility and energy.

4.3 The political framework and priorities

OBJECTIVE

Improved dissemination and communication between Slovenia and Austria

Measures:
Task force

Expected results:
Increased cooperation

Target groups:
All stakeholders

Time Frame:
3 years

OBJECTIVE

Clear commitment to and support for H_2 technology

Measures:
High-level political support

Expected results:
Legal documents showing support for the development of H_2 technology

Target groups:
Policymakers

Time Frame:
1 year

OBJECTIVE

Priorities should be the future energy mix and basic role of hydrogen-related technologies

Measures:
Investments in infrastructure and the promotion of prosumers

Expected results:
A stronger hydrogen economy

Target groups:
All stakeholders

Time Frame:
2 years

OBJECTIVE

Upgrading the regulatory and legislative framework by introducing hydrogen technologies

Measures:
A subsidy and a tax reduction on the price of green hydrogen would encourage interested actors.
A clear or specific regulatory framework would indicate the direction, rules and possibilities of developing the hydrogen economy.
The simplification of administrative procedures.

Expected results:
An upgraded regulatory and legislative framework, including national Hydrogen Strategies

Target groups:
All stakeholders

Time Frame:
2 years

OBJECTIVE

A shift from focusing on traffic and electricity production to currently less considered solutions

Measures:
A new policy focus

Expected results:
A focus on different sectors of end users

Target groups:
Policymakers

Time Frame:
1 year

5. THE ROADMAP TO 2025

The Roadmap for Hydrogen Technologies in Slovenia and Austria has been prepared as part of the Interreg SI-AT H_2GreenTECH project. The Roadmap is a joint cross-border strategic document that refers to the expected development of hydrogen technology until 2025 through guidelines and priorities in the two countries. The absence of national hydrogen strategies in each country means national NECP[1, 2] were used while preparing the present document. Since 2025 is fast approaching, the predictions for **2030** from the NECP and FCH Opportunities for Hydrogen Energy Technologies for Slovenia and Austria documents were considered.

Stakeholder experts identified the main challenges and objectives concerned with the implementation of hydrogen technologies, the Roadmap for hydrogen technologies was reviewed by experts and presented for consideration at the policy forum. The Roadmap you are now holding was then finalised.

A set of technological and cooperation challenges is listed, including the production, distribution, storage of hydrogen and associated infrastructure, end-uses and cooperation issues in the cross-border region of Austria and Slovenia.

Further, a set of recommendations is proposed, including improved knowledge and technology transfer between academia, research organisations, industry and to the general public, the increased financing of R&D for hydrogen technologies, while new incentives and priorities have been established to create an encouraging policy framework.

The **HYDROGEN CENTER** is both a digital platform for B2B meetings and a One-Stop-Shop that gives companies access to the services, and the cutting -edge knowledge and research infrastructure. Its aim is to bring different stakeholders in the field of hydrogen technologies in Slovenia and Austria together in a long-term cross-border Interreg SI-AT region research and industrial network to promote the development of innovations using hydrogen technologies and to implement the Roadmap for Hydrogen Technology in Slovenia and Austria, the Hydrogen Center Development Strategy, and the Hydrogen Center Marketing Strategy.

2022–2023

The organisation of a broad scientific conference on hydrogen-related R&D and technologies, involving all stakeholders and investors, will increase cooperation and investments. The preparation of concepts for infrastructure sharing. Support schemes for PoC and pilot projects will lead to increased investments, knowledge and technology transfer and raise the TRL. Knowledge transfer to the general public, raising overall public awareness. Implementing new technologies (KETs, use cases) through delta financing for H_2 equipment. Build up knowledge databases for H_2 technologies. Identifying sustainable and profitable business models through the development of new business models. Determining new funding opportunities for cross-border research activities. A review of initiatives and opportunities to establish a Hydrogen Valley in the interregional Slovenia-Austria area or beyond. Strengthen the H_2 economy with national support schemes to increase investments at critical points of the value chain (fuel stations, electrolysis) and legislative support for H_2 technology implementation, including national H_2 strategies. Focus should also be given to other areas of application that currently are considered less represented, avoiding a sole focus on transport and electricity production.

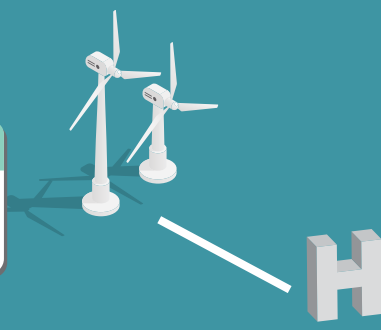
2024–2025

Showcasing H_2 technology investments to companies and other stakeholders. Ensuring strong IP protection for newly developed technologies, licensing activities, and support for open innovation, avoiding competition blockages within the region. The introduction of H_2 prosumers into the electricity market system through a vertically structured system. Preparation of a list of funding mechanisms suitable for projects based on H_2, including financial support for start-ups and spin-offs, and financial instruments for elevating TRLs. Joint investment projects on the government level to support cross-border collaboration. Analysis of hydrogen needs in the cross-border region, preparation of a feasibility study for such production and presenting it to decision-makers on the government level, promoting small-scale prosumers while simultaneously expanding photovoltaic areas. Development of the H_2 mobility concept for the transport and industry sectors through feasibility studies of the pilot projects. Establishing 2–3 pilot projects to be used to demonstrate the technical and economic and environmental benefits of cross-border collaboration in the Interreg SI-AT area. Greater cooperation between Slovenia and Austria in the field of H_2 technologies in the Interreg region.

The vision for 2030

LOWER EMISSIONS

	33–78 $ktCO_2/a$
	1100–3400 $ktCO_2/a$



ONSHORE WIND

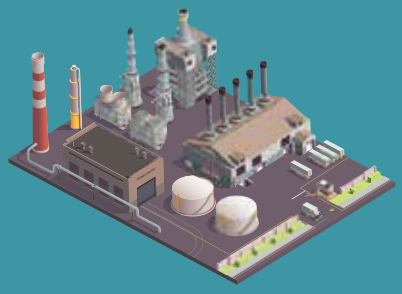
	50–140 GWh/a
	2110–7470 GWh/a

ELECTROLYSERS

	61–180 GWh/a
	1590–5620 GWh/a

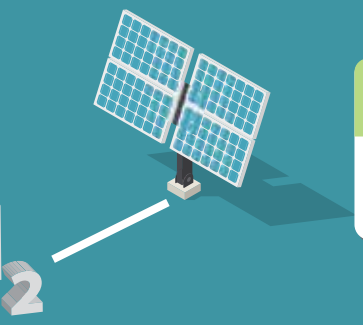
INDUSTRY

	61–180 GWh/a
	1590–5620 GWh/a



BUILDING

	1-10 GWh/a
	81–813 GWh/a



SOLAR PHOTOVOLTAIC

	50–140 GWh/a
	2110–7470 GWh/a

NEW JOBS

	270–690
	3300–10500

ADDED VALUE IN THE LOCAL ECONOMY

	12–31 mEUR/a
	300–1000 mEUR/a

TRANSPORT

	56–128 GWh/a
	474–1207 GWh/a

POWER

	0,1–1 GWh/a
	12–121 GWh/a

6. REFERENCES

1 Integrated National Energy and Climate Plan of the Republic of Slovenia. (2020). https://www.energetika-portal.si/dokumenti/strateski-razvojni-dokumenti/nacionalni-energetski-in-podnebni-nacrt/

2 Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans (2020). https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

3 Integrated National Energy and Climate Plan for Austria (2019). https://unfccc.int/sites/default/files/resource/LTS1_Austria.pdf

4 New Commission modelling on 32.5% energy efficiency (2019). https://www.stefanscheuer.eu/energy-savings-on-the-ground/new-commission-modelling-on-32-5-energy-efficiency/1072/

5 www.mebius.si; https://recatalyst.si; http://www.conot.si; www.hycenta.at

6 Hydrogen Storage Challenges (2022). https://www.energy.gov/eere/fuelcells/hydrogen-storage-challenges

7 Medeiros, E. (2018). Should EU cross-border cooperation programs focus mainly on reducing border obstacles? https://ec.europa.eu/futurium/en/system/files/ged/pub_pap_em_should_eu_cross-border_cooperation_programmes_focus_on_reducing_border_obstacles_documents_danalisi_geografica.pdf

8 Central Eastern European Technology Transfer – CEETT platform. https://www.sid.si/mala-srednja-podjetja/regionalna-platforma-za-prenos-tehnologij-central-eastern-european-technology

9 Key public funding products for start-ups. https://www.startup.si/sl-si/za-startupe/javni-viri-financiranja

10 Start-ups and spin-offs: The most important funding sources in Austria: the Austrian Research Promotion Agency (FFG) and Austria Wirtschaftsservice GmbH (aws). https://www.ffg.at/en/Start-up/Foerderungen; https://www.aws.at/

11 Spin-off initiative, Austria. https://www.spin-off-austria.at/sponsors

12 Horizon 2020: Key Enabling Technologies, Booster for European Leadership in the Manufacturing Sector. https://www.europarl.europa.eu/RegData/etudes/STUD/2014/536282/IPOL_STU%282014%29536282_EN.pdf

13 The Recovery and Resilience Plan (RRP) in Slovenia. https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility/slovenias-recovery-and-resilience-plan_en

14 The Recovery and Resilience Plan (RRP) in Austria. https://ec.europa.eu/info/sites/default/files/at_rrp_summary.pdf

NOTES

REPUBLIC OF SLOVENIA
MINISTRY OF EDUCATION, SCIENCE AND SPORT

Interreg SLOVENIA – AUSTRIA
European Union | European Regional Development Fund

H_2GreenTECH in figures

Duration: 30 Months

Start: 01. 03. 2020

End: 31. 08. 2022

Number of partners: 6

Overall budget: 584.500,00 EUR

Contribution of the ERDF: 496.825,00 EUR

PROJECT COORDINATOR

National Institute of Chemistry,
Department of Catalysis and
Chemical Reaction Engineering

Hajdrihova 19
1000 Ljubljana, Slowenien
dr. Blaž Likozar
+386 1 4760 281
blaz.likozar@ki.si

The project is co-financed by the European Regional Development Fund within the Cooperation program Interreg V-A Slovenia-Austria.

www.h2greentech.eu

@H2GreenTECH

www.linkedin.com/in/h2greentech-project

HYDROGEN CENTER

b2b.h2greentech.eu

H_2GreenTECH

NATIONAL INSTITUTE OF CHEMISTRY

ŠTAJERSKA GOSPODARSKA ZBORNICA

TU Graz
Graz University of Technology

FORSCHUNG Burgenland

KÄRNTEN University of Applied Sciences

www.h2greentech.eu

@H2GreenTECH

www.linkedin.com/in/h2greentech-project