REPUBLIC OF SLOVENIA
MINISTRY OF EDUCATION, SCIENCE AND SPORT

Interreg
SLOVENIA – AUSTRIA
European Union | European Regional Development Fund

CROSS-BORDER BENCHMARKING POLICY ANALYSIS

H2GreenTECH

NATIONAL INSTITUTE OF CHEMISTRY

ŠTAJERSKA GOSPODARSKA ZBORNICA

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1. Foreword

This Cross-Border Benchmarking policy analysis was prepared as part of the project H_2GREENTECH – Strengthening R&I capacities in the field of breakthrough hydrogen technologies with the cross-border cooperation of enterprises, R&D centres and higher education financed within the Interreg V-A Slovenia-Austria 2014–2020 cross-border programme.

The project addresses the cross-border (CB) challenge of fragmented R&R and the great potential held by the R&R of hydrogen technology in transport in the programme area with three specific aims in mind:

1. to increase access to and use of research infrastructure on hydrogen technologies in Slovenia and Austria by establishing a one-stop-shop Hydrogen Center for enterprises, researchers and students, with a clear strategy and action plan up until 2025;
2. to build up the competencies of enterprises, R&D centres, and higher education by implementing joint CB projects on hydrogen technologies to develop with three demonstration models developed to show the developed prototypes and educational module in practice; and
3. to facilitate the CB cooperation of research institutions, enterprises and public administration by developing a cross-border Action Plan concerning low-carbon technologies along with a commitment to implementing and disseminating them.

With the innovative approach of the quadruple helix, the partnership is establishing the urgently required one-stop-shop Hydrogen Center as a platform. The thereby improved innovation capacity of all stakeholders adds to the competitiveness of the programme area that is important for hydrogen technology.

To prepare the foundations for improving cross-border cooperation between research institutions, companies and public institutions in the area of low-carbon technologies in Slovenia and Austria, MIZŠ, as a project partner, commissioned a cross-border benchmarking policy analysis.

The analysis consists of:

- a review of existing policies in Slovenia and Austria in the field of low-carbon technologies (with an emphasis on hydrogen technologies);
- with the help of SWOT and PEST analysis of the identified gaps, advantages and opportunities of the cross-border area with respect to establishing a critical mass of R&I capacity for the accelerated development of hydrogen technologies in the Slovenia–Austria cross-border area; and
- examples of good policy development practices in both Germany and China.

The analysis may be useful for policymakers and decision-makers on the local, regional and national levels in Slovenia and Austria.

The final version of the analysis is to be presented to participants at the political forum and will be the starting point for preparation of the Action Plan for the Promotion of Hydrogen Technology in the Cross-Border Area of Slovenia and Austria.

2. Introduction

Low and zero carbon technology (LZC) is the term given to technologies that emit low levels of CO_2 emissions or no net CO_2 emissions. It suits the need to adapt to a low-carbon economy, reduce greenhouse gas emissions, and prevent global warming. To successfully develop and use such technologies, the government should formulate a well-developed system of policy support for the development of low-carbon technology and create a favourable policy environment and an institutional guarantee for low-carbon technology.

First, the establishing and improving of economic policies ensure and support the development of low-carbon technologies. Low-carbon technology development requires considerable capital and an improvement in the production equipment for businesses. The initial investment cost of low-carbon technologies is huge and the government should formulate appropriate economic policies to support low-carbon technologies and flexibly use the ways fiscal and financial leverage are regulated.

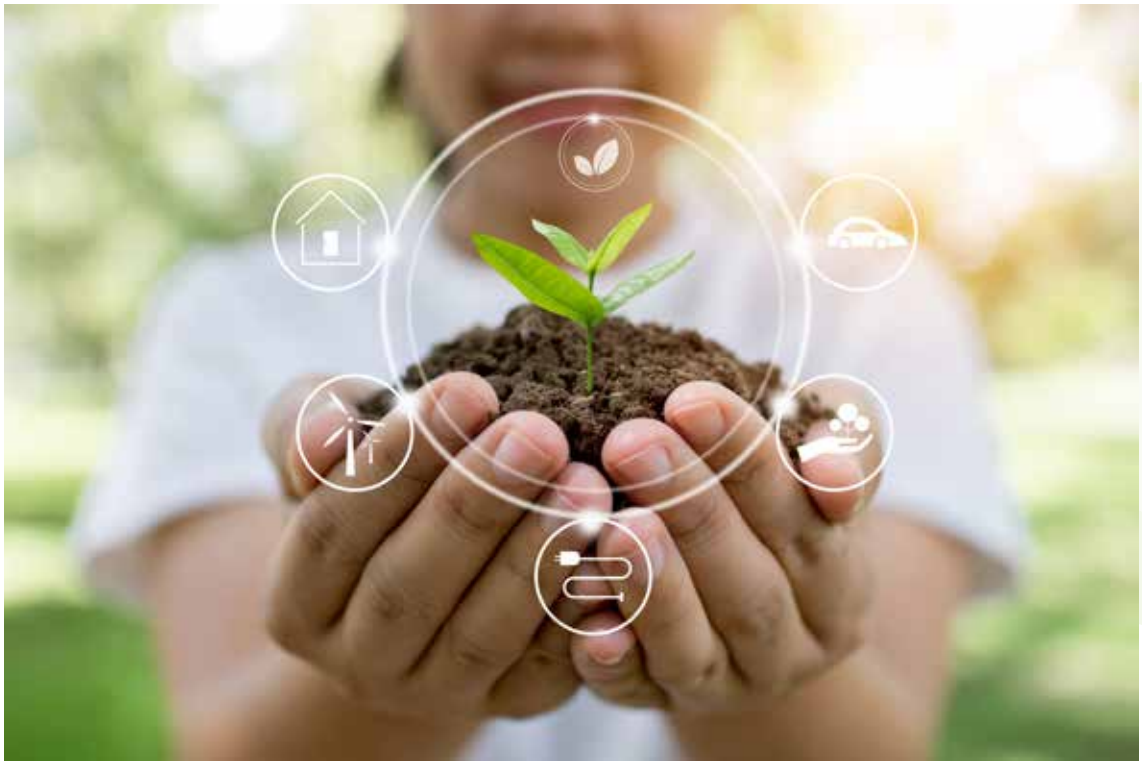
Second, establishing and improving the tax policy can stimulate enterprises to develop low-carbon technologies. Enterprises may be encouraged to develop low-carbon technologies via low-carbon incentives like tax relief, concessional loans, accelerated depreciation, a low-carbon bond issue and so on. However, the government needs to form an external power to encourage enterprises to develop low-carbon technologies by collecting a resources tax and a carbon tax and stimulating enterprises to develop new energy technologies[1].

The use of hydrogen is one of the most promising ways of using low-carbon technologies. The political momentum for hydrogen use continued to gather strength in 2019. As shown by an IEA report[2], a growing number of countries announced hydrogen strategies and roadmaps in 2019, often establishing targets for the deployment of hydrogen technologies:

- In May 2019, a new Hydrogen Initiative was launched at the 10th Clean Energy Ministerial (CEM10) held in Vancouver (Canada) to spotlight the role hydrogen and fuel cell technologies can play in the global clean energy transition. This initiative, co-led by Canada, Japan, the Netherlands, the United States, and the European Commission, aims to boost international collaboration on policies, programmes and projects to accelerate the commercial deployment of hydrogen and fuel cell technologies across all sectors of the economy. The IEA was selected to co-ordinate this initiative.

1 Lv, J.F. and Qin, S.S. (2016) On low carbon Technology. Low Carbon Economy, 7, 107-115

2 Hydrogen analysis by IEA (2019). https://www.iea.org/reports/hydrogen



- In September, 35 countries and international institutions attending the 2nd Hydrogen Energy Ministerial Meeting agreed to the Global Action Agenda as a principle to guide expanded R&D on hydrogen. The document included a target to reach 10 million hydrogen vehicles and 10,000 HRSs within 10 years to encourage the use of hydrogen and fuel cells in mobility.
- Japan, the European Commission, and the United States signed a partnership for future co-operation on hydrogen and fuel cell technologies.
- The European Fuel Cells and Hydrogen Joint Undertaking launched the Hydrogen Roadmap for Europe, highlighting all the opportunities hydrogen creates to decarbonise the gas grid and the transport and industry sectors, and its systematic role in the transition to a sustainable energy system. In turn, the certification scheme developed under the CertifHy project issued the first Guarantees of Origin for projects producing low-carbon hydrogen.

The targets set in various national roadmaps and strategies still largely focus on transport applications, although a clear trend since 2018 has been to include targets for other sectors like industry, domestic buildings and power generation. This shows renewed interest in the cross-sectoral role that hydrogen can play, simultaneously contributing to the decarbonisation of different sectors.

3. Overview of existing policies in Slovenia and Austria regarding low-carbon technologies (with an emphasis on hydrogen technologies)

3.1 The Paris Agreement

The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris on 12 December 2015 and entered into force on 4 November 2016.

Its goal is to limit global warming to well below 2, preferably to 1.5, degrees Celsius compared to pre-industrial levels. To achieve this long-term temperature goal, countries aim to reach a global peaking of greenhouse gas emissions as soon as possible to achieve a climate-neutral world by mid-century.

The Paris Agreement is a landmark in the multilateral climate change process because for the first time a binding agreement brings all nations together for the common cause of undertaking ambitious efforts to combat climate change and adapt to its effects.

Implementation of the Paris Agreement requires economic and social transformation based on the best available science. The Agreement works on a 5-year cycle of ever-more ambitious climate actions performed by countries. By 2020, countries submitted their plans for climate action known as nationally determined contributions (NDCs). In their NDCs, countries communicate the actions they are to take to reduce their greenhouse gas emissions in order to meet the goals of the Paris Agreement. Countries also communicate in their NDCs the steps they will take to build up resilience while adapting to the impacts of rising temperatures.

3.2 The European Union

3.2.1 EU policy on research and technological development

European policy on research and technological development (RTD) has been an important area of European legislation ever since the first Community Treaties were signed, and was extended in the early 1980s with the establishment of a European framework programme for research. Since 2014, most EU research funding has been grouped under Horizon 2020, the 8th EU Framework Programme horizon for Research and Innovation covering the 2014–2020 period, which aimed to ensure the EU's global competitiveness. Its successor Horizon Europe, the next EU research and innovation programme, was launched in 2021[3].

3 Fact Sheets on the European Union (2021): Policy for research and technological development. https://www.europarl.europa.eu/factsheets/en/sheet/66/policy-for-research-and-technological-development

European research on renewables and other low-carbon energy technologies is world-class and delivering potentially cost-effective solutions. The Low-Carbon Energy Observatory (LCEO), created on the initiative of the Directorate-General for Research and Innovation and Horizon 2020, the EU research and innovation programme (2014–2020), analyses in a study[4] the state of play in EU research and innovation trends and the policy measures for 11 low-carbon technologies.

The common findings of studies is that, although European research on renewables and other low-carbon energy technologies is world-class and delivering potentially cost-effective solutions, international competition on these technologies is intense and more must be done to accelerate the roll-out of innovative solutions and to promote European industry ecosystems.

3.2.1.1 The Strategic Energy Technology Plan (SET PLAN)

On 9 October 2009, the European Commission published a Communication on "Investing in the Development of Low Carbon Energy Technologies (SET Plan)". The idea was to better organise research efforts across Europe, select technologies with the greatest potential and together plan how money should be invested. The Commission estimates that an additional investment of €50 billion in energy technology research will be needed over the next 10 years, meaning an annual investment of €8 billion.

In a 2018 report[5], it is stated that the Implementation Plan has three common goals for the field of Bioenergy and Renewable Fuels (hydrogen) at large: to improve the performance (yield and efficiency) of production, reduce GHG emissions along the value chain, and lower the costs.

Some 14 R&I activities have been identified, representing an estimated investment of €3–€4 billion. All activities are new projects, with their duration ranging from 3–5 years to 17 years. The funding sources and instruments will be a mix of public (national) and private funding, plus EU funding where the activity has demonstrable European added value.

3.2.1.2 Smart specialisation

Smart specialisation is an innovative approach that since 2011 has aimed to boost growth and jobs in Europe[6].

This Platform has facilitated mutual learning, data gathering, analysis, and networking opportunities for around 170 EU regions and 18 national governments. Thematic Smart Specialisation platforms

4 Low carbon energy technologies: success and opportunities (2021). https://ec.europa.eu/jrc/en/news/ low carbon-energy-technologies-successes-and-opportunities

5 SEP Plan delivering results: The Implementation Plans. Publication of the EU (2018). https://op.europa.eu/en/publication-detail/-/publication/a3b22c5b-ed41-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-803647918

6 Smart specialisation (2020). https://ec.europa.eu/regional_policy/sources/docgener/guides/smart_spec/strength_innov_regions_en.pdf

have also been created. Regions join forces and pool resources on the basis of matching smart specialisation priorities in high-valued-added sectors. For example, partnerships have been developed in the fields of 3D printing, medical technology, smart grids, solar energy, sustainable buildings, and high-tech farming.

The next generation of Smart Specialisation Strategies is currently being prepared. It is open to the opportunity to incorporate new European industrial policy guiding growth policy within the framework of the European Green Deal in line with the UN's Sustainable Development Goals. The evolution from the bottom-up approach between 2014 and 2020 through to a combination of bottom-up and top-down approaches, using the new concept aimed at the mission of European innovation policy, offers fresh opportunities for the next generation of smart specialisation strategies.

3.2.1.3 Horizon Europe

Horizon Europe[7] is the successor to Horizon 2020 and the EU's key funding programme for research and innovation with a budget of €95.5 billion. It tackles climate change, helps to achieve the UN's Sustainable Development Goals, and boosts the EU's competitiveness and growth.

The programme facilitates collaboration and strengthens the impact of research and innovation on developing, supporting and implementing EU policies while tackling global challenges. It supports the creation and better dispersing of excellent knowledge and technologies.

Horizon Europe is built on three pillars[8]:

1. Excellent Science – rewards excellent researchers in each step of their careers through individual grants to build a team and pursue ground-breaking research with the ERC, finance the mobility of researchers, and support the development of research accessible across Europe.
2. Research Infrastructure – focuses on collaborative projects around six broad topic clusters. For the UEG community, Cluster 1 on Health and Cluster 6 on Food, the Bioeconomy, Natural Resources, Agriculture and the Environment are interesting.
3. Innovative Europe – aims to provide support for emerging and break-through innovations with the new EIC programme and structure innovation ecosystems in Europe, linking education, research and innovation through the European Institute of Innovation and Technology (EIT). The EIT is structured in thematic KICs, among others the Health KIC to foster health innovation.

There are new elements in Horizon Europe, such as:

- The European Innovation Council: support for innovations with a potential break-through and disruptive nature holding scale-up potential that may be too risky for private investors. This makes up 70% of the budget earmarked for SMEs.

7 Horizon Europe Strategic Plan (2021–2024) (2020). https://ec.europa.eu/info/sites/default/files/research_and_innovation/funding/documents/ec_rtd_horizon-europe-strategic-plan-2021-24.pdf

8 What's new in Horizon Europe: The Science|Business summary (2021). https://sciencebusiness.net/news/whats-new-horizon-europe-sciencebusiness-summary

- Missions: Sets of measures to achieve bold, inspirational and measurable goals within a set timeframe. Horizon Europe has 5 main mission areas.
- Open science policy: Mandatory open access to publications and open science principles are applied throughout the programme Factsheet: Open science in Horizon Europe
- New approach to partnerships: objective-driven and more ambitious partnerships with industry in support of EU policy objectives

Global challenges

Just over half of Horizon Europe's funding was earmarked to meet global challenges and increase industrial competitiveness. Actions under the second pillar will be divided into seven thematic strands, including one on climate, energy and mobility, with a proposed €15 billion.

The initiative will also fund projects related to supporting the development of sustainable infrastructure, services and systems for smart and sustainable communities and cities, low-carbon hydrogen and fuel cells, renewable energy technologies, energy storage, decarbonisation of European buildings, road transport without emissions, and smart, safe and accessible mobility systems..

3.2.1.4 The Innovation Fund (IF)

The Innovation Fund (IF)[9] is one of the world's largest funding programmes for the demonstration of innovative low-carbon technologies. It will provide around €10 billion in support between 2020 and 2030 for the commercial demonstration of innovative low-carbon technologies, with a view to bringing industrial solutions to the market for decarbonising Europe and supporting its transition to climate neutrality. The EU Emissions Trading System (EU ETS), the world's largest carbon pricing system, is providing revenues for the Innovation Fund from the auctioning off of 450 million allowances between 2020 and 2030, as well as any unspent funds from the NER300 programme[10].

The Innovation Fund (IF) helps reduce greenhouse gases (GHG) by focusing on:

- innovative low-carbon technologies and processes in energy-intensive industries (steel, cement, glass, chemicals, paper etc.), including products substituting carbon-intensive ones;
- carbon capture and utilisation (CCU);
- the construction and operation of carbon capture and storage (CCS);
- innovative renewable energy generation; and
- energy storage.

The Innovation Fund is a key funding instrument for delivering the EU's economy-wide commitments under the Paris Agreement and its objective to be climate-neutral by 2050, as recognised in the European Green Deal Investment Plan.

9 EU Commission (2020). https://ec.europa.eu/clima/policies/innovation-fund_en

10 NER300 PROGRAMME (2014).https://ec.europa.eu/clima/policies/innovation-fund/ner300_en

3.2.2 EU policy on research and technological development

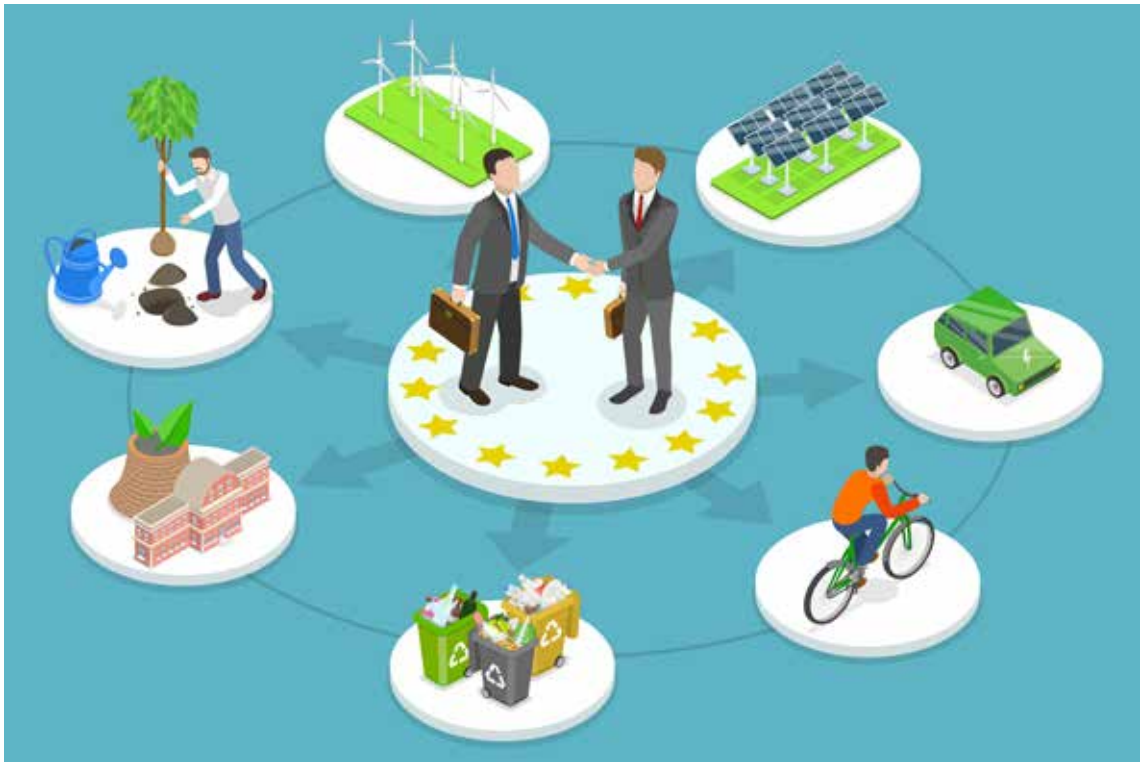
European environment policy rests on the principles of precaution, prevention and rectifying pollution at source, and on the 'polluter pays' principle. The precautionary principle is a risk management tool that may be invoked when scientific uncertainty about a suspected risk to human health or to the environment emerge from a certain action or policy. For instance, should doubts arise about the potentially harmful effects of a product, and should — following an objective scientific evaluation — the uncertainty persist, instructions may be given to stop the product's distribution or withdraw it from the market. Such measures must be non-discriminatory and proportionate and must be reviewed once more scientific information is available.

3.2.2.1 The Environment Action Programme to 2030 (EAP)

Environment Action Programmes have guided the development of EU Environment policy since the 1970s, with each programme having been duly assessed to determine whether their objectives were met.

The 7th Environment Action Programme (EAP)[11] was designed in 2014 to guide European environment policy until 2020. On 14 October 2020, the European Commission published its proposed 8th Environment Action Programme (EAP)[12].

This proposal supports the environment and climate action objectives of the European Green Deal. It gives an opportunity for the EU as a whole to reiterate our commitment to the 7th EAP's vision for 2050: we wish to ensure the well-being of all, while staying within the planetary boundaries.



11 The 7th Environment Action Programme to 2020 (2014). https://op.europa.eu/en/publication-detail/-/publication/1d861dfb-ae0c-4638-83ab-69b234bde376

12 A proposal for an 8th Environment Action Programme (EAP(2020)) https://ec.europa.eu/environment/pdf/8EAP/2020/10/8EAP-draft.pdf

Building on the European Green Deal, it has six priority objectives:

1. achieving the 2030 greenhouse gases emission reduction target and climate neutrality by 2050;
2. enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change;
3. advancing towards a regenerative growth model, decoupling economic growth from resource use and environmental degradation, and accelerating the transition to a circular economy;
4. pursuing a zero-pollution ambition, including for air, water and soil, and protecting the health and well-being of Europeans;
5. protecting, preserving and restoring biodiversity, and enhancing natural capital (notably air, water, soil, and forest, freshwater, wetland and marine ecosystems); and
6. reducing environmental and climate pressures related to the production and consumption (particularly in the areas of energy, industrial development, buildings and infrastructure, mobility, the food system).

In order to measure and communicate whether we are on track to meeting these objectives, the 8th EAP proposal suggests that a new monitoring framework be set up. This would help the EU and its member countries determine to what extent we are living well within the constraints of the planet.

The 8th EAP proposal calls for the active engagement of all stakeholders on all levels of governance to ensure that the EU's climate and environment laws are effectively implemented. It forms the EU's basis for achieving the United Nation's 2030 Agenda and its Sustainable Development Goals[13].

3.2.2.2 The Renewable Energy Directive, Directive (EU) 2018/2021 (RED II)

Directive (EU) 2018/2001 on promotion of the use of energy from renewable sources (RED II)[14] established a common framework for the promotion of energy from renewable sources in the EU and set a binding target of 32% for the overall share of energy from renewable sources in the EU's gross final consumption of energy in 2030. It also established sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels and set out rules on financial support to enhance the use of renewable energy usage. The RED II is a recast of Directive 2009/28/EC (RED I). The recast was made as part of the 'Clean energy for all Europeans package'.

The Directive was adopted in 2020 in line with the European Green Deal, emphasising the need for more ambitious actions to address climate change and meet environmental objectives. The resolution highlighted the essential role of energy in the transition to a net-zero greenhouse gas emissions economy, and particularly the importance of decarbonising the energy system[15].

In November 2020, the Commission published the Renewable Energy Progress Report, showing that in recent years (until 2018) there had been stable growth in the overall share of renewable

13 https://ec.europa.eu/environment/strategy/environment-action-programme-2030_en

14Directive (EU) 2018/2001 (2018) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=fr

15 Briefing - Renewable Energy Directive, Revision of Directive (EU) 2018/2001. (2021). https://www.buildup.eu/en/practices/publications/briefing-renewable-energy-directive-revision-directive-eu-20182001

energy sources (RES) at the EU level. In 2018, the EU had a share of 18% (18.9% for the EU-27) of renewable energy in gross final energy consumption, which was above the indicative trajectory (16%) to reach the 2020 targets. The EU was also above the more ambitious trajectory that the Member States had defined in their national renewable energy action plans (NREAPs).

The deadline for Member States' transposition into national law for most other elements of RED II was set for 30 June 2021 when RED I was to be repealed. This means that the RED II new provisions have yet to fully take effect, even though they had already been altered to better fit the more ambitious climate action priorities[16].

3.2.2.3 The European Green Deal

The European Green Deal[17] is a set of policy initiatives by the European Commission with the overarching aim of making Europe climate-neutral in 2050. An impact assessment plan will also be presented to increase the EU's greenhouse gas emission reductions target for 2030 to at least 50% and towards 55% compared with 1990 levels.

The Policy areas it includes are:

- Clean energy – Climate neutrality by 2050 is the main goal of the European Green Deal.
- Sustainable industry – introduction of the Circular Economy Industrial policy.
- Building and renovation – promoting the use of energy-efficient building methods like climate proofing buildings, increasing digitalisation and enforcing the rules surrounding the energy performance of buildings.
- Farm to Fork – the strategy pursues the issue of food sustainability as well as the support allocated to the producers, i.e. farmers and fishermen.
- Eliminating pollution – the Zero Pollution Action Plan – was aiming to be adopted by the commission in 2021 and intends to achieve no pollution from "all sources", cleaning the air, water and soil by 2050.
- Sustainable mobility – A reduction in emissions from transportation methods is another target area within the European Green Deal. A comprehensive strategy on "Sustainable and Smart mobility" is intended to be implemented.
- Biodiversity – A strategy for protecting the European Union's biodiversity was to be put forward in 2021.

The European Green Deal is a roadmap for making the EU's economy sustainable by turning climate and environmental challenges into opportunities across all policy areas and making the transition just and inclusive for all. The European Green Deal seeks to boost the efficient use of resources by moving to a clean, circular economy, stop climate change, halt biodiversity loss, and cut pollution. It outlines the investments needed and financing tools available and explains how to ensure a just and inclusive transition. The European Green Deal covers all sectors of the economy, notably transport, energy, agriculture, buildings, and industries like steel, cement, ICT, textiles and chemicals.

16 Revision of Directive (EU) 2018/2001(2020). https://www.buildup.eu/sites/default/files/content/eprs_bri2021662619_en.pdf

17 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

Among the measures, the following directly or indirectly affect low-carbon technologies and hydrogen:

The European industrial strategy and action plan for the circular economy

The aim is for EU industry to foster and enable change, innovation and growth. In November 2020, the EU Council adopted conclusions on a new strategy, setting out how recovery from the COVID-19 pandemic crisis could be used as leverage for a more dynamic, resilient and competitive European industry. It also noted the importance of decoupling economic growth from resource use and moving over to a circular system of production. The action plan envisages over 30 measures to create sustainable products, ensure circularity in production processes, and strengthen the role of consumers and public customers. It covers sectors like electronics and ICT, batteries, packaging, plastics, textiles, construction and buildings, and food.

Clean and safe energy at affordable prices

Given that 75% of EU greenhouse gas emissions come from energy use and production, decarbonisation of the energy sector is a key step towards a climate-neutral EU.

Following a presentation of clean energy strategies by the Commission in December 2020, EU energy ministers adopted conclusions about:

- Offshore renewable energy strategies
- Hydrogen strategy

Sustainable and smart mobility

In order to build a society and an economy with zero net emissions, the mobility sector must become more sustainable and smarter. If the EU is to achieve climate neutrality, it is estimated that transport sector emissions will have to be slashed by 90% by 2050.

In line with the objectives of the Green Agreement , the Council recently addressed a number of legislative and non-legislative initiatives, namely:

- the start of the European Railway Year 2021;
- a revision of the rules on tolls for heavy vehicles; and
- new funding under the Connecting Europe Facility in support of the decarbonisation of transport.

The Circular Economy Action Plan – for a cleaner and more competitive Europe

The Circular Economy Action Plan[18] as part of the GREEN DEAL provides a future-oriented agenda for ensuring a cleaner and more competitive Europe created together with economic actors, consumers, citizens and civil society organisations. It seeks to accelerate the transformational change required by the European Green Deal, while building on circular economy actions

18 Circular Economy Acton Plan. (2020)
https://ec.europa.eu/environment/pdf/circular-economy/new_circular_economy_action_plan.pdf

implemented since 2021. This plan will ensure that the regulatory framework is streamlined and made fit for a sustainable future, that the new opportunities from the transition are maximised, while the burdens on people and businesses are minimised.

Circularity is an essential part of the wider transformation of industry towards climate-neutrality and long-term competitiveness. It can deliver substantial material savings throughout value chains and production processes, generate extra value, and unlock economic opportunities. In synergy with the objectives laid out in the Industrial Strategy, the Commission will enable greater circularity in industry by:

- assessing options for further promoting circularity in industrial processes in the context of the review of the Industrial Emissions Directive[19], including the integration of circular economy practices in upcoming Best Available Techniques reference documents;
- facilitating industrial symbiosis by developing an industry-led reporting and certification system, and enabling the implementation of industrial symbiosis;
- supporting the sustainable and circular bio-based sector through implementation of the Bioeconomy Action Plan[20];
- promoting the use of digital technologies for the tracking, tracing and mapping of resources; and
- promoting the uptake of green technologies through a system of solid verification by registering the EU Environmental Technology Verification scheme as an EU certification mark.

On 10 March 2020, the Commission laid the foundations for an industrial strategy to support the twin transition to a green and digital economy, make EU industry more competitive globally, and enhance Europe's open strategic autonomy. The day after the new industrial strategy was presented, the World Health Organisation declared that COVID-19 had become a pandemic.

This update neither replaces the 2020 Industrial Strategy nor completes the processes launched by it – much of that work is in progress, and requires dedicated efforts[21].

A hydrogen strategy for a climate-neutral Europe

To make the EU a pioneer in the use of hydrogen as an energy carrier, in 2020 the European Commission presented its hydrogen strategy as part of the European Green Deal ("A hydrogen strategy for a climate-neutral Europe")[22]. The aim of the EU Hydrogen Strategy is to decarbonise hydrogen production and expand its use in sectors where it can replace fossil fuels.

The EU Hydrogen Strategy focusses on hydrogen produced from renewable energy sources ('green hydrogen'). The EU Hydrogen Strategy provides the following definition of green hydrogen:

19 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), OJ L 334, 17.12.2010, p. 17. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0075

20 Bioeconomy: The European way to use our natural resources Action plan 2018. (2018). file:///C:/Users/grabn/AppData/Local/Temp/KI0318474ENN.en.pdf

21 An official webpage of the European Union. (2021). https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en

22 A hydrogen strategy for a climate-neutral Europe (2020). https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

"hydrogen produced through the electrolysis of water (in an electrolyser, powered by electricity), and with the electricity stemming from renewable sources ". The full life-cycle greenhouse gas emissions of the production of renewable hydrogen are close to zero. Renewable hydrogen may also be produced through the reforming of biogas (instead of natural gas) or the biochemical conversion of biomass, if in compliance with sustainability requirements.

The EU hydrogen strategy provides for three phases:

- by 2024, the production of green hydrogen should increase to 1 million tonnes per year;
- by 2030, the production of green hydrogen should increase to 10 million tonnes per year; and
- between 2030 and 2050, green hydrogen is to be produced on a systemically relevant scale.

(For comparison: at present, almost 10 million tonnes of hydrogen per year are produced in the EU from and with fossil fuels).

Although the biggest focus is on green hydrogen, the EU Hydrogen Strategy recognises the role of other low-carbon hydrogen in the transition phase in the short to medium term.

To support implementation of the Hydrogen Strategy, the Commission also set up the European Alliance for Clean Hydrogen, involving industry leaders, civil society, national and regional ministers and the European Investment Bank. The Alliance will create an investment programme to increase production and support demand for clean hydrogen in the EU.

Many projects are being implemented. Denmark and Germany are building a 3–5 GW offshore wind farm in Bornholm, including an electrolysis plant to supply trucks, buses, ships and aircraft with fuel. Since the submission of the NEPN, Spain has planned to build a 100-MW photovoltaic power plant, a lithium-ion battery system with a storage capacity of 20 MWh, and a hydrogen production system by electrolysis in Puertollan.

Almost all Member States have included clean hydrogen plans in their national energy and climate plans, 26 MSs have joined the Hydrogen Initiative and 14 MSs have included hydrogen in their national alternative fuel infrastructure policy framework. Some have already adopted national strategies or have one in the process of adoption (including Slovenia and Austria).

23 European Clean Hydrogen Alliance (2020) https://www.ech2a.eu/

The European Clean Hydrogen Alliance (ECH_2A)[23] was announced as part of the New Industrial Strategy for Europe and launched on 8 July 2020 in the context of the hydrogen strategy for a climate-neutral Europe.

The European Clean Hydrogen Alliance seeks to ensure the ambitious deployment of hydrogen technologies by 2030, bringing together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, and hydrogen transmission and distribution. With the alliance, the EU wishes to build its global leadership in this domain and support the EU in its commitment to reach carbon neutrality by 2050.

The objectives of the European Green Deal and Europe's clean energy transition require the deep transformation of the production, storage and consumption of energy, with carbon-free power generation, increased energy efficiency, and the deep decarbonisation of transport, buildings and industry. Hydrogen is a key element for accomplishing these goals. It is the missing link in the puzzle to a fully decarbonised economy by 2050.

EU Action Plan: Towards Zero Pollution for Air, Water and Soil

EU Action Plan: "Towards Zero Pollution for Air, Water and Soil"[24] – a key deliverable of the European Green Deal – is a plan that maps activities to achieve an integrated vision for 2050: a world where pollution is reduced to levels that are no longer harmful to human health and natural ecosystems, as well as the steps to get there.

The action plan's main objective is to provide a compass while including pollution prevention in all relevant EU policies, maximising synergies in an effective and proportionate way, stepping up implementation, and identifying possible gaps or trade-offs.

Investments in clean and sustainable design, circular economy business models, cleaner transport and mobility, low-emission technologies, nature-based solutions and sustainable digitalisation offer strong opportunities to consolidate EU leadership in green growth, while reducing inequalities, creating jobs and enhancing collective resilience.

To steer the EU towards the 2050 vision of a Healthy Planet for All, this action plan sets key 2030 targets to speed up pollution reduction.

1. reduce by more than 55% the health impacts (premature deaths) of air pollution;
2. reduce by 30% the share of people chronically disturbed by transport noise;
3. reduce by 25% the EU ecosystems where air pollution threatens biodiversity;
4. reduce by 50% nutrient losses, the use and risk of chemical pesticides, the use of the more hazardous ones, and the sale of antimicrobials for farmed animals and in aquaculture;
5. reduce by 50% plastic waste in the sea and by 30% microplastics released into the environment; and
6. reduce total waste generation significantly and residual municipal waste by 50%.

Following the recent IED evaluation[25], the Commission will revise the EU's rules on industrial emissions in recognition of the fact that new technologies or production processes will often enable emissions of both pollutants and greenhouse gases to be reduced, also in sectors where this is currently not the case.

24 EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil (2021). https://ec.europa.eu/environment/pdf/zero-pollution-action-plan/communication_en.pdf

25 Wood (2021): Wider environmental impacts of industry decarbonisation, final study report. https:// file:///C:/Users/grabn/AppData/Local/Temp/Final_report.pdf

3.2.2.4 EU strategy for the Danube region (EUSDR) – Action plan

The EUSDR is a macro-regional strategy for the Danube Region launched by the European Commission in December 2011[26]. Part of the strategy was an Action Plan that after a decade needed a revision, which started in 2018. The aim of revising the EUSDR Action Plan was threefold. First, after a decade since the first Action Plan had been developed, an update was needed to take account of new developments. The actions have also been streamlined: concentrated by 40% from the 137 actions in the 2010 document to 85 in this new Action Plan, still including new topics (e.g. Artificial Intelligence, Priority Area 8). Second, there is a consensus to make the new Action Plan a document that provides more strategic guidance for the implementation of the EUSDR. Being more than a mere work plan, it seeks to give overall guidance for defining and developing cooperative initiatives and actions on all levels, while providing a solid basis for concrete activities for the next years. The third aim is to make the EUSDR Action Plan more compatible with other programmes and funding instruments.

The revised EUSDR Action Plan was published in 2020 and is an integrated response to this common set of challenges and opportunities. It updates and concentrates the 2010 actions, puts them against the strategic background, and provides links to 'embed' the EUSDR into other programmes. It is based on the consultation of thematic and national coordinators, Steering Groups, and other stakeholder groups.

The action plan has 4 pillars, divided into 10 priority areas, of which the following are linked to low-carbon technologies and R&D:

PILLAR 1: CONNECTING THE REGION

PA2: Sustainable Energy

ACTION 3: To promote decarbonisation and the reduction of air pollutants in the transport sector (both public and freight transportation) by developing the infrastructure for alternative fuels.

ACTION 4: To improve energy-efficient, cost-efficient and innovative low-carbon technologies, including smart solutions while respecting the principle of technological neutrality.

ACTION 7: To explore new and innovative solutions of (subsurface) energy storage.

ACTION 9: To encourage project generation related to the field of energy.

PILLAR 3

PA 7: Knowledge Society

ACTION 1: To promote the coordination of national, regional and EU funds to stimulate excellence in R&I in research areas specific to the Danube Region.

ACTION 2: To promote the participation of Danube countries in EU R&I Programmes, especially in Horizon Europe.

ACTION 3: To strengthen cooperation among universities, research organisations and SMEs in the Danube Region.

ACTION 4: To increase the awareness and visibility of science and innovation in the Danube Region.

ACTION 5: To support the exchange of information and experience sharing for the purpose of preparing future strategic R&I documents applicable to the new programming period.

ACTION 6: To promote horizontal cooperation in science and technology across all PAs and other MRS.

26 EU Strategy for the Danube Region -ACTION PLAN (2020). https://danube-region.eu/wp-content/uploads/2020/04/EUSDR-ACTION-PLAN-SWD202059-final.pdf

3.2.2.5 National long-term strategies

Stable long-term strategies are crucial for achieving the economic transformation needed and the broader sustainable development goals, as well as to move towards the long-term goal set by the Paris Agreement – holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C.

All Parties to the Paris Agreement were invited to communicate by 2020 their mid-century, long-term, low greenhouse gas emission development strategies.

The Regulation on the governance of the energy union and climate action (EU/2018/1999) sets out a process for the Member States to prepare these strategies and new strategies every 10 years thereafter[27].

These long-term strategies should be consistent with Member States' integrated national energy and climate plans between 2021 and 2030.

The national long-term strategies and the EU's strategy must cover, with a perspective of at least 30 years:

- total greenhouse gas emission reductions and enhancements of removals by sinks;
- emissions reductions and enhancements of removals in individual sectors, including electricity, industry, transport, the heating and cooling and buildings sector (residential and tertiary), agriculture, waste and land use, land-use change, and forestry (LULUCF);
- expected progress on the transition to a low greenhouse gas emission economy, including greenhouse gas intensity, CO_2 intensity of gross domestic product, related estimates of long-term investment, and strategies for related research, development and innovation;
- to the extent feasible, the expected socio-economic effect of the decarbonisation measures, including aspects related to macro-economic and social development, health risks and benefits, and environmental protection; and
- links to other national long-term objectives, planning and other policies and measures, and investment.

3.2.2.6 National energy and climate plans (NECPs)

To meet the EU's energy and climate targets for 2030, EU countries needed to establish a 10-year integrated national energy and climate plan (NECP) for the period from 2021 to 2030[28]. Introduced under the Regulation on the governance of the energy union and climate action (EU/2018/1999), the rules required the final NECPs to be submitted to the Commission by the end of 2019.

The national plans outline how the EU countries intend to address:

- energy efficiency
- renewables
- greenhouse gas emissions reductions
- interconnections
- research and innovation

27 https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en

28 National energy and climate plans (NECPs). An official website of the European (2021) Union https://ec.europa.eu/energy/topics/energy-strategy/national-energy-climate-plans_en

This approach requires the coordination of purpose across all government departments. It also provides a level of planning that will ease public and private investment. The fact that all EU countries are using a similar template means that they can work together to make efficiency gains across borders.

In order to better develop and implement the plans, EU countries had to consult citizens, businesses and regional authorities in the process of preparing and finalising them.

In June 2019, the Commission reviewed the draft plans and provided individual feedback to Member States, which followed most of the recommendations. All Member States have now presented their final plans, which include a comprehensive vision for the energy and climate transition in the next decade.

A comparison showed that:

- the NEPNs of France, Germany, Austria and the Netherlands contain concrete plans, while other countries like Portugal are developing rapid and tangible strategies.
- The NEPNs vary in their ambitions. Thus, some Member States have set very ambitious sectoral targets for renewable energy. Austria and Sweden have established a goal of obtaining all electricity from renewable sources by 2030 and 2040, respectively.
- A total of 21 Member States have already abandoned the use of coal (Estonia, Latvia, Lithuania, Belgium, Malta, Luxembourg, Cyprus) or committed themselves to phasing it out (including lignite and peat), setting specific dates in the NEP (see the above graph). Two Member States (Slovenia, Czech Republic) are still considering phasing out coal, while four (Poland, Romania, Bulgaria, Croatia) are not planning to do so. In this context, the use of coal is expected to shrink by 70% by 2030 compared to 2015, and electricity from renewable sources will account for 60% of the electricity produced in the EU.
- Most NECPs acknowledge the role of hydrogen in the energy transition. Half the plans mention concrete hydrogen-related objectives for the domestic generation of renewable or low-carbon hydrogen, for end-use in industry and hard-to-electrify transport sectors (such as Luxembourg, which aims to make steel more sustainable through renewable hydrogen use).

The NECPs provide key information on how Member States intend to achieve their national emissions reduction targets set out in the Effort Sharing Regulation (ESR). Currently, these targets range from 0 to -40% in 2030 compared to 2005 to achieve EU-wide minimum reductions in sectors not covered by the EU Emission Trading System (ETS) of 30% compared to 2005. Compared to their current ESR targets, Luxembourg, Slovakia, Slovenia and Sweden have set more ambitious national targets in the sectors not covered by the EU ETS. Further, many other Member States project that the implementation of their policies and measures planned in the NECPs would reduce emissions beyond their ESR binding targets.

The NECPs provide a vast number of matured projects of renewables that can also contribute to the economic recovery. Examples include building solar farms and hydrogen infrastructure on former lignite mining sites in Greece and Portugal.

3.2.2.7 2030 Climate Target Plan

The Commission's proposal to cut greenhouse gas emissions by at least 55% by 2030 places Europe on a responsible path of becoming climate-neutral by 2050.

Based on a comprehensive impact assessment, the Commission has proposed to increase the EU's ambition for reducing greenhouse gases and set this more ambitious path for the next 10 years[29].

The European Commission will now start preparing detailed legislative proposals concerning how this target can be achieved. By July 2021, the Commission was to review, and where necessary propose to revise, , all relevant policy instruments to accomplish the additional emissions reductions.

3.3 Slovenia

3.3.1 Slovenian policy on research and technological development

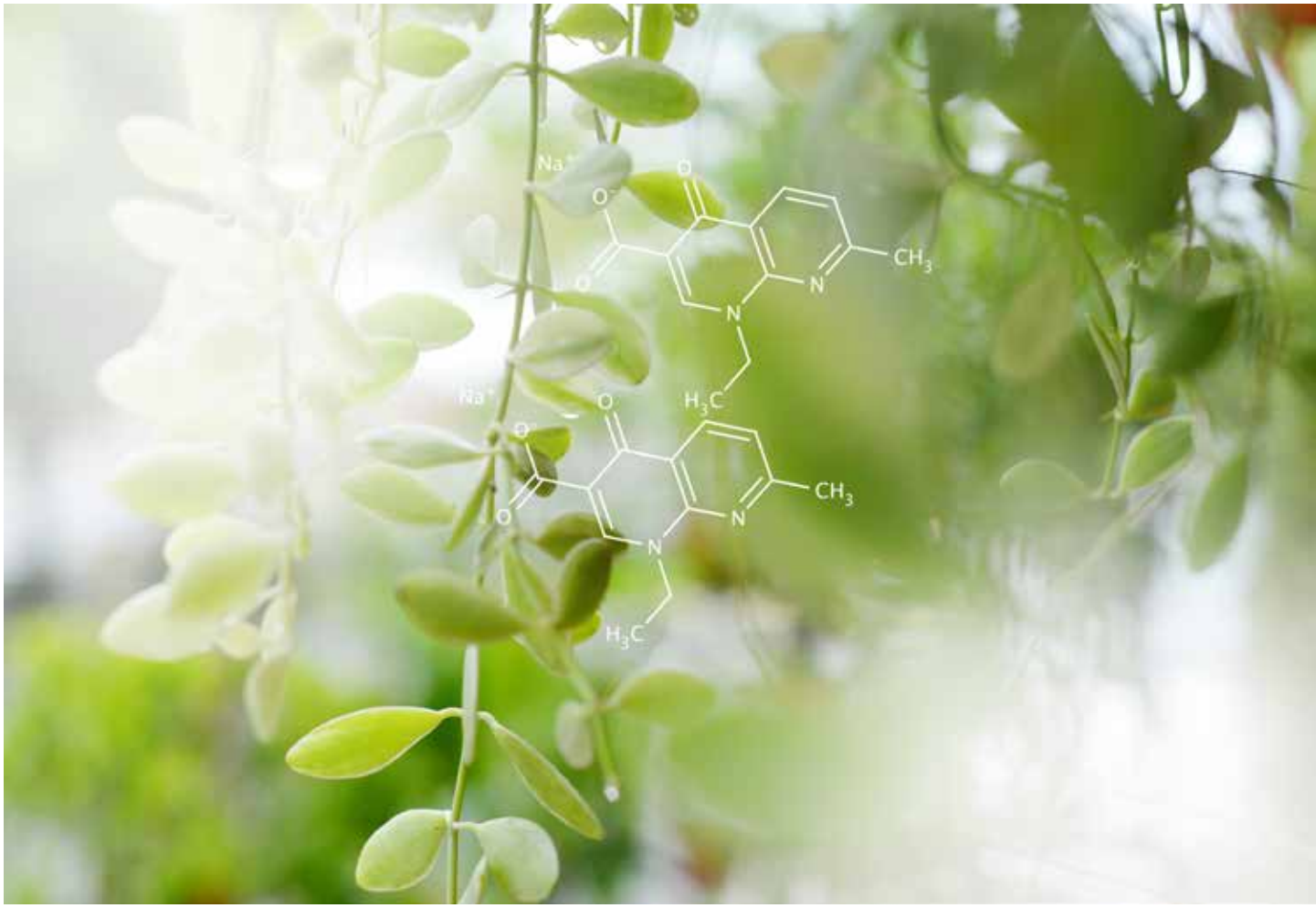
In the field of research and innovation, in 2010 the Government of the Republic of Slovenia adopted a goal for the country to achieve joint public and private sector investments in research and development in the amount of 3% of GDP by 2020 (1% of GDP is the target for public investments). With the Strategy for Sustainable Development 2030, with which Slovenia has also committed itself to implementing the Agenda for Sustainable Development until 2030, Slovenia has given itself two goals concerning research, innovation and competitiveness in Slovenia:

- a competitive and socially responsible business and research sector, where among others there is a focus on environmentally friendly and ecological and technologies innovation which, as an important factor in the companies' competitiveness, also helps to reduce the burden on the environment;
- the transition to a low-carbon circular economy as a priority development direction for the economy as a whole, with the link between economic growth, growth in the use of raw materials and non-renewable energy sources, and the associated increase in the burden on the environment having to be broken.

Center odličnosti nizkoogljične tehnologije/The Centre of Excellence for low-carbon Technologies (CO NOT) was established in 2009 during an intensive search in the area of renewable energy sources and rational energy use. The goal was to unite all vital Slovenian potential in order to enable the harmonious, comprehensive and systematic development of advanced technologies designed to facilitate Slovenia's transformation into a low-carbon society in two fields – hydrogen and lithium technologies. Between 2009 and 2013, a total of 115 partner institutions participated in the CoE, including 66 large and small companies and private research organisations, 44 public research and educational institutions, and 5 partners from non-profit research and development institutions. They registered 101 new patents and developed 311 innovations.

29 https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en

3.3.1.1 Research and Innovation Strategy of Slovenia (RISS 2011–2020) / Raziskovalna in inovacijska strategija Slovenije (RISS 2011-2020)



RISS 2011–2020[30] is a programme document for establishing a modern research and innovation system that will allow a higher quality of life for all through a critical reflection of society, efficiency in addressing social challenges, increased value added per employee, and the assurance of more workplaces of higher quality.

RISS is based on the Development Strategy of Slovenia and is in accordance with the Europe 2020 documents and leading EU initiatives with the aim of achieving synergies in society. It reasonably relates to the National Programme for the Development of Higher Education 2011–2020 (NPVŠ), and together they constitute the "knowledge triangle«, which is at the heart of strategic reflections on the further development of Slovenian and global society.

30 Resolution on Innovation Strategy of Slovenia (RISS 2011-2020). https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Zakonodaja/EN/Resolution-on-Research-and-Innovation-Strategy-of-Slovenia_2011-2020.pdf

3.3.1.2 Research Infrastructure Roadmap 2011–2020/Načrt razvoja raziskovalnih infrastruktur 2011-2021

The basic purpose of the Research Infrastructure Roadmap 2011–2020 ('the Roadmap')[31] accepted by the Government of the Republic of Slovenia on 28 April 2011 was to present and set Slovenia's priorities in the field of research infrastructure. The Roadmap for 2011–2020 identified priority international projects and indicated national priority areas for which it is necessary to develop research infrastructure to further the attainment of scientific excellence in Slovenia in order to ensure a critical mass in medium or large-scale research infrastructure.

Due to the delay of implementation on the international level, mainly due to the necessary harmonisation of national procedures to audit the European Strategy Forum for Research Infrastructures Roadmap (also known as the '"ESFRI Roadmap'), which was concluded in March 2016, a review of the Roadmap was carried out in 2016.

3.3.1.3 Slovenian Smart Specialisation Strategy/Strategija pametne specializacije (S4)

The Slovenian Smart Specialisation Strategy (S4)[32] is the foundation for focused development investments in areas where Slovenia has a critical mass of knowledge, capacities and competencies and innovation potential for placement on global markets, and thereby for strengthening its visibility.

It is an operational plan facilitating the shift to a high-productivity economy:

- through boosting innovation potential;
- by fostering structural transformation and industrial diversification; and
- by supporting the growth of new and fast-growing companies.

The S4's strategic objectives are:

1. to develop and position Slovenia as an attractive ecological country of innovation, focused on the development of medium- and high-tech and comprehensive solutions in clearly and strategically defined niche areas in which Slovenia has capacities and competencies to compete in the global market, and
2. to establish a state-of-the-art, responsive, dynamic, strategically-guided, inclusive and globally connected research, innovative and entrepreneurial eco-system.

S4 contains a description of the stages of strategy preparation in the first phase – the determination of basic priorities within the narrow thematic areas – where three key content areas were first defined. Within the priority area NEW MATERIALS AND TECHNOLOGIES, low-carbon applications are mentioned during a description of industrial and other materials.

31 Research Infrastructure Roadmap 2011-2020 (the Roadmap) (2011). https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Zakonodaja/EN/Research-Infrastructure-Roadmap-2011-2020_2016-ENG.pdf

32 Strategija pametne specializacije (https://www.gzs.si/srip-hrana/vsebina/English/Smart-Specialization-Strategy)

In the 4th quarter of 2016, a call was made for the establishment of strategic development and innovation partnerships (SRIPs) in the context of the smart specialisation strategy. The nine selected SRIPs (one for each priority of RIS3) prepared their Action Plans as the basis for financing. A coordination body composed of three state secretaries assessed and approved them in July 2017.

Strategic Research and Innovation Partnerships, known as SRIPs, are essential pillars of the Slovenian S3 implementation process and based on a stable and participatory governance structure involving quadruple helix stakeholders across different levels of government. The partnerships are flexible institutional structures built around individual S3 priority areas that emerged during the entrepreneurial discovery process.

In total, the SRIPs have 783 members, of which 81% are enterprises, 60% are micro and small enterprises, 18% medium-sized enterprises, and 22% large enterprises, with a balanced structure across both cohesion regions. Knowledge institutions represent 11% of SRIP membership, meaning that practically all key public research organisations, universities etc. are included in the SRIPs.

Certain SRIPs are horizontal in nature and cover several policy domains:

I. Digital:

- I.1 Smart cities and communities;
- I.2 Smart buildings and home with a wooden chain;

II. Circular:

- II.1 Networks for the transition to a circular economy (SRIP Circular Economy);
- II.2 Sustainable food;
- II.3 Sustainable tourism;

III. (S) Industry 4.0:

- III.1 Factories of the future;

SRIP Factories of the future is dedicated to compiling and integrating Slovenian research and innovation know-how, experience from the industrial and academic spheres, and highlighting the priority breakthroughs of new products, technologies and services for Factories of the Future.

By internationalising the results of joint development, adequately protecting industrial property, promoting high-tech entrepreneurship and helping member countries tackle environmental challenges, we will allow the faster and easier transition of companies to the global market.

- III.2 Health/medicine;
- III.3 Mobility;

The main challenges for the transport sector in the EU include improvements for multi-modal mobility and shifting towards low-emissions mobility. The EU is committed to minimising the negative effects generated by transport (e.g. accidents, greenhouse gas emissions, air pollution, noise and environmental effects) and has been promoting low-carbon mobility solutions and their impact on economic growth and jobs in the EU[33].

Therefore, the SRIP ACS+ strategic research and innovation partnership in the field of mobility provides support for its members to become integrated into the global automotive industry and to improve the range of their products and services. It accelerates the efficiency of its members by providing adequate research and development and co-operating with expert development and scientific institutions in both Slovenia and abroad[34].

- III.4. Materials as final products

S4 remains the basis for the implementation of European cohesion policy in the 2021–2027 programming period. European regulations provide for its renewal and treat it as a condition of opportunity.

In the first half of 2020, the Government Office for Development and European Cohesion Policy started the renovation of S4. Activities mainly concentrated focused on renewing the necessary analytical bases and the process of entrepreneurial discovery (EDP). Together with key departments, the Ministry of Economic Development and Technology, the Ministry of Education, Science and Sport, and the Ministry of Public Administration, and all nine SRIPs, they prepared a revised table of focus areas and priorities that was presented in online events to the interested public in March 2021[35].

The Development Centre for Hydrogen Technologies (DCHT) was founded by five companies and two research institutes in a bid to boost research, development and applicable projects in the field of hydrogen and fuel cells in Slovenia. The Centre's main goal is to pool industry and institute-based knowledge capacities. Other goals include providing the conditions for the transfer of expertise, stimulating lasting cooperation between the research and business sectors, influencing state development politics, organising expert meetings on hydrogen technologies and increasing the competitiveness of Slovenian companies and institutes in the long term[36].

33 https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1544118406.pdf

34 https://www.acs-giz.si/en/about-acs

35 I zvajanje in prenova Slovenske strategije pametne specializacije - S4. Portal gov.si. 2021. https://www.gov.si/zbirke/projekti-in-programi/izvajanje-slovenske-strategije-pametne-specializacije/

36 https://rcvt.si/en/rcvt-english/

3.3.2 Slovenian environmental policy

3.3.2.1 National energy efficiency action plan 2020/Akcijski načrt za energetsko učinkovitost za obdobje 2017–2020 (AN URE 2020)

The National Energy Efficiency Action Plan 2014–2020 (AN URE 2020)[37] is the second action plan prepared by Slovenia in line with the requirements of Directive 2012/27/EU on energy efficiency, and the fourth action plan since 2008. The action plan contains essential measures for improving energy efficiency, including expected and achieved energy savings, to accomplishing the national target to increase energy efficiency by 2020 and to contribute to the collective EU target – of increasing energy efficiency by 20%. This target states that primary energy consumption will not exceed 7 125 Mtoe in 2020, meaning that it may not exceed the 2012 figure by more than 2%. Effective implementation of the AN URE 2020 action plan is vital for achieving the objectives of reducing greenhouse gas emissions (GHG) and achieving the 25% target share of renewable energy sources (RES) in the balance of gross final energy consumption by 2020. Energy efficiency is amongst the most cost-effective measures for reaching these objectives, and it also significantly contributes to the objectives in the field of air quality.

3.3.2.2 Operational programme for measures to reduce greenhouse gas emissions by 2020/Operativni program ukrepov zmanjšanja emisij toplogrednih plinov do leta 2020

The operational programme for measures to reduce greenhouse gas emissions by 2020[38] was adopted by the Slovenian government at the end of 2014. The document sets indicative sectoral targets for reducing GHG emissions in sectors not included in the ETS coupons until 2020, as well as until 2030. To increase energy efficiency in the public sector and in households, and for the energy renovation of buildings, it envisages several measures, some of which are already covered by AN URE 2020.

One of these measures was Green Economic growth. The measures to promote it will focus on:

- sustainable consumption and production;
- the conversion of waste into a resource;
- supporting research and innovation; and
- environmentally harmful subsidies and correct pricing.

To bolster research and innovation, the following activities were supported:

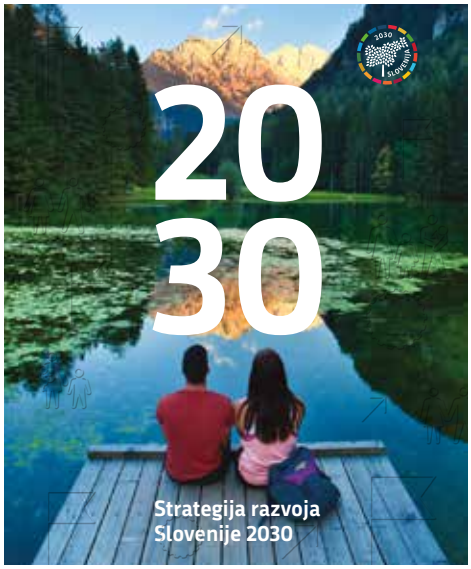
- development activities and technological investments for the production of new or significantly improved products;
- technological and non-technological innovations (e.g. design) with market potential;

37 Akcijski načrt za energetsko učinkovitost do leta 2020 (AN URE 2020) (2017). http://www.energetika-portal.si/fileadmin/dokumenti/publikacije/an_ure/an_ure_2017-2020_final.pdf

38 Operativni program ukrepov zmanjšanja emisij toplogrednih plinov do leta 2020 (2014). https://www.gov.si/assets/ministrstva/MOP/Dokumenti/Podnebne-spremembe/optgp2020.pdf

- the networking of companies with higher education, research, consulting and international institutions for the exchange of knowledge, experience and for the implementation of joint development projects;
- eco-innovation and the development of new green products, services, processes and business models that will enable Slovenia's transition to a low-carbon, resource-efficient society; and
- support for projects for the commercialisation of developed products and the entry of new technologies to the market for obtaining references, e.g. through innovative public procurement (pre-commercial procurement) and demonstration projects.

3.3.2.3 The Slovenian Development strategy 2030/Strategija Slovenije 2030



In 2017, the Slovenian Government developed the Slovenian Development Strategy 2030[39] supported by a long-term national development strategy to achieve several goals towards that vision by 2030 and to meet its commitments regarding the UN Sustainable Development Goals (SDGs). It is a document intended for the policymakers who are responsible for delivering it, while the outcomes are oriented to results that benefit and matter for Slovenian citizens, who are at the centre of the agenda – on both the levels of individuals and society as a whole. The new national development framework is also significant for implementation of the 2030 Agenda due to the clearly defined ways of achieving the national development goals and hence the sustainable development objectives:

- policy coherence with respect to sustainable development will be checked in the policymaking stage;
- the implementation of sustainable development objectives at the national level will be systematically monitored on an annual basis together with national development objectives; and
- the development of capacities in the horizontal understanding of the national and international development context, together with strategic assumptions, will aid in better adapting the implementation of individual development goals.

Strategic guidelines to achieve quality of life and well-being are:

- an inclusive, healthy, safe and responsible society;
- learning for and throughout life;
- a highly productive economy that generates value added for all;
- a well-preserved natural environment; and
- high levels of cooperation, competence, and governance efficiency.

39 he Slovenian Development Strategy 2030. 2017. https://www.gov.si/assets/vladne-sluzbe/SVRK/Strategija-razvoja-Slovenije-2030/Slovenian-Development-Strategy-2030.pdf

Slovenia will implement those strategic orientations for the attainment of the strategy's primary objective by operating in different mutually connected and interdependent (policy) areas covered in the Strategy's 12 development goals. Each goal contains an explanation of the goal's relevance, key guidelines that require further activities in order to attain the high quality of life for all, two to three core outcome indicators that represent the desired outcomes of each development goal, and link to the Sustainable Development Goals.

Slovenia's national development goals share characteristics with the SDGs such as deep interconnections and cross-cutting elements, tackling and addressing the three pillars of sustainable development and inclusiveness. Through the national development goals, the SDGs are linked to the strategic orientations.

The goals include:

Goal 6 – A competitive and socially responsible business and research sector

a. promoting the development of science and research in priority areas and the transfer of research achievements for a highly competitive economy, a higher quality of life, and effectively addressing societal challenges;

b. promoting the internationalisation of foreign direct investment and integration into global value chains and the integration of research organisations into the international environment;

c. providing a supportive and predictable support environment, standardisation, accreditation and metrology systems, and encouraging the development of high-tech enterprises;

d. enabling an environment for the creation of digital trends, supporting new research and technological ideas, sharing economics and developing globally competitive system solutions in the field of smart grids and platforms;

e. promoting creativity and thereby strengthening cooperation between science and the arts;

f. promoting the social and environmental responsibility of companies and research organisations; and

g. by managing state-owned enterprises in the long term and by encouraging the withdrawal of the state from the ownership of non-strategic investments.

Goal 8 – a low-carbon circular economy

a. by delinking economic growth from the growth of resource use and GHG emissions, which will be enabled by educating and connecting various stakeholders for the transition to a circular economy;

b. by promoting innovation, the use of design and information and communication technologies to develop new business models and products for the efficient use of raw materials, energy and by adapting to climate change;

c. by replacing fossil fuels by promoting energy efficiency and the use of RES in all areas of energy use, while coordinating interests in cross-cutting areas: water – food – energy – ecosystems;

d. ensuring that infrastructure and energy use in transport support the transition to a low-carbon circular economy and enable sustainable mobility, including by introducing new mobility concepts and increasing the share of public passenger transport; and

e. using spatial planning to design low-carbon circular economy hubs and development solutions on the regional and local levels.

3.3.2.4 Slovenia's Long-Term Climate Strategy until 2050/Dolgoročna podnebna strategija Slovenije 2050

At its 71st regular session held in April 2021, the Government of the Republic of Slovenia adopted a Resolution on Slovenia's Long-Term Climate Strategy until 2050[40].

The document is, for the period up to 2030, based on already adopted decisions defined in the Development Strategy of Slovenia 2030, the National Energy and Climate Plan (NEPN), the national transport development programme until 2030, the national environmental protection programme for 2020–2030, and other documents. For the period until 2050, it is upgrading these documents and setting new goals.

The society will be based on renewable and low-carbon energy sources, sustainable mobility, and locally produced food.

The document envisages an inclusive transition to a climate-neutral society that will take the principles of climate justness into account. This means the costs and benefits of the transition will be distributed fairly, including to the most vulnerable groups.

When the resolution is endorsed, all ministries will immediately have to start implementing the measures and policies that have been agreed on to reduce greenhouse gas emissions, upgrade them, and abandon any measures that run contrary to the goal of cutting emissions.

The over-100-page-document envisages an 80%–90% cut in greenhouse gas emissions by 2050 compared to 2005. In transport and energy, emissions are to decrease by 90%–99%, in agriculture by 5%–22%, in industry by 80%–87%, in waste management by 75%–83% and in general consumption by 87%–96%.

Being a strategic document, the climate strategy does not include concrete measures. The action plan for implementing the climate strategy by 2030 is the National Energy and Climate Plan (NEPN).

The resolution also puts the share of renewable energy sources in total energy consumption at 60% by 2050. "Slovenia will continue to encourage the sources it has traditionally been using and will set up the conditions for the use of a wide range of renewable energy sources (solar, hydro, geothermal and wind energy and the energy of wood biomass)."

Energy needs will be reduced by boosting energy efficiency, the circular economy, and other sustainable practices. The goal is to make sure that the use of end energy in 2050 will not exceed 40 terawatt-hours.

40 Government adopts resolution on climate neutrality by 2050. 2021. https://sloveniatimes.com/government-adopts-resolution-on-climate-neutrality-by-2050/

3.3.2.5 Integrated national energy and climate plan of the republic of Slovenia (NEPN)/ Celoviti nacionalni energetski in podnebni načrt republike Slovenije (NEPN)

Adopted in 2020, the NEPN[41] is a strategic document laying down objectives, policies and measures for Slovenia regarding the five dimensions of the Energy Union for the period up until 2030 (with a view to 2040): decarbonisation (greenhouse gas emissions (GHG) and renewable energy sources (RES), energy efficiency, energy security, the internal energy market, and research, and innovation and competitiveness.

The key objectives for the 2030 identified in the NEPN are:

- reducing total greenhouse gas emissions by 36%;

To meet the primary objective (reducing total greenhouse gas emissions by 36%), with regard to reducing the use of fossil energy sources and dependence on importing them one proposed action entails support for the implementation of pilot projects for the production of synthetic methane and hydrogen (the indicative target is a 10% share of renewable methane or hydrogen in the transmission and distribution network by 2030).

- an improvement in energy efficiency of at least 35%, namely, higher than the target adopted at the EU level (32.5%);
- renewable energy sources constituting at least a 27% share; relevant domestic circumstances meant Slovenia had to agree to a lower target than for the EU (32%), but will strive to increase this figure in the next NEPN update (2023/2024); and
- and, finally, 3% of GDP to be spent on R&D, of which 1% of GDP will be public funds.

To provide additional financial, human and technical resources to speed up the electricity distribution network's integrated development and management so as to increase its capacity, reinforce its resistance to disruption and its future development potential, boosting connectivity and adaptability.

Slovenia does not have any accurate data on the number of patents in the area of low-carbon technologies. What follows is just some of the information that is publicly available. The "Eco-Innovation Output" component of the EIO Country Profile for Slovenia for 2017[42] reveals that media coverage in the area of eco-innovation (in terms of the number of electronic media) grew considerably in 2017 and 2016 compared to 2015, and exceeded the EU average. Similarly, compared to 2015, the number of publications on eco-innovation (per million inhabitants) rose in 2017 and exceeded the EU average. Still, the number of eco-innovation patents remains small and is below the EU average.

According to the NECP, hydrogen can play a role in integrating the production of renewable electricity, strengthening the security of gas supply, and helping to meet the decarbonisation targets. Renewable hydrogen could be used to store large amounts of electricity produced during periods of low demand. Slovenia expects by 2030 final hydrogen consumption of 10 ktoe (116 GWh) in the transport sector, and by 2040 to consume 63 ktoe (732 GWh), chiefly in the transport, but also gradually in the building and industry sectors.

41 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/

42 The EIO Country Profile for Slovenia for 2017 (2017). https://ec.europa.eu/environment/ecoap/sites/ecoap_stayconnected/files/field/field-country-files/slovenia_eio_country_profile_2016-2017_1.pdf

Implementation of the planned NEPN policies and measures – especially thanks to the necessary additional investment in networks and low-carbon technologies and the increasing of some levies, alongside the expected rise in energy prices in the regional market – will contribute to a gradual increase in energy prices for end customers (no significant price increases are expected by 2030 according to current forecasts121) while also reducing the necessary volume of energy consumption, which will substantially mitigate the increase in final energy costs.

3.3.2.6 A deep demonstration of a circular, regenerative and low-carbon economy in Slovenia/Razogljičenje Slovenije preko prehoda v nizkoogljično krožno gospodarstvo

In 2018, the Slovenian parliament adopted an EIT Climate-KIC-led proposal called "A deep demonstration of a circular, regenerative and low-carbon economy in Slovenia"[43]. The initiative is one of eight Deep Demonstrations launched by the EIT Climate-KIC, which together offer a test-bed environment for the ambitious "1.5°C-consistent systems transitions" called for by the Intergovernmental Panel on Climate Change (IPCC) reports as well as by activists and national and European policy.

Over 18 months, the EIT's Climate-KIC engaged entities with challenges in Slovenia (government ministries and sector leaders) to articulate ambitious intentions for transformational change and build demand for a systemic approach.

In an unprecedented cross-sectoral and cross-disciplinary approach, the working plan seeks to marry different disciplines and work across boundaries, silos and departments. Its overall goal is to position Slovenia as a European leader in harnessing circularity to transform and decarbonise its economy while fostering a green economy and designing and promoting the smart and circular transition of local communities through a coordinated and coherent national approach based on international best practices. As a result, the well-being and prosperity of all Slovenians will be advanced and secured for decades to come and greenhouse gas emissions significantly reduced to help Slovenia reach its targets.

Its overall goal is to position Slovenia as a European leader in harnessing the transformative power of circularity to decarbonise its economy and transform communities while promoting the well-being and prosperity of all Slovenians for decades to come. It is a great example of a country embracing the benefits and opportunities of a radical, structural transformation to a 1.5°C-warmer world.

The programme of work is built on three pillars (see below) and aims to a systems-based approach based on a platform model to enable a process for decarbonising Slovenia's socio-economic system through circular-economy principles.

The three pillars for the National Circular Economy Transition:

- Smart and circular communities
- Circular green development
- Circular policy design and science

43 Slovenia adopts EIT Climate-KIC Circular, Regenerative Economies Deep Demonstration. (2020). https://www.climate-kic.org/news/slovenia-adopts-circular-regenerative-economies-deep-demonstration/

Impacts and results will be felt across the triple bottom line of social, environmental and financial impacts and be seen in all three pillars addressed as well as the value chains mentioned. On top of tangible and quantifiable impacts and results (greenhouse gas emissions avoided, revenue, investment attracted, services and products launched on the market etc.), the different programmes will have a range of additional, indirect effects and benefits via shifts in behaviours, mindsets and practices, thereby creating the framework and conditions needed for systemic change.

The programme will activate and work broadly across national stakeholders, networks and communities, such as:

- local communities
- administration and civil servants
- students and young generations
- teachers and other change agents
- research and academia
- non-governmental and non-profit organisations
- Chambers of Commerce and Industry, associations and other representations of interest
- Strategic Research and Innovation Partnerships (SRIPs)
- start-ups & SMEs (business owners)
- companies
- economic clusters

By implementing this project, Slovenia will better position itself as a role model in the field of decarbonisation and the transition to a circular economy, also including the development of the bioeconomy.

3.3.2.7 Resolution on the National Environmental Protection Programme for the period 2020–2030 (ReNPVO20–30)/Resolucija o nacionalnem programu varstva okolje 2020-2030 (ReNPVO20-30)

The resolution was approved in March 2020 and is a strategic document for environmental protection[44]. It represents a social consensus on future environmental protection or the environmental boundary conditions of Slovenia's development, which has a long tradition and established administrative organisation of environmental protection together with the support of non-governmental organisations and other professional institutions and individuals.

Measures included in the Resolution include a support measure concerning research, development and innovation for environmental protection with two main objectives:

1. better understanding of the environment;
2. to develop and adopt innovative technologies and non-technological innovations that will accelerate the transition to a green, low-carbon and resource-efficient economy and society.

44 Resolucija o nacionalnem programu varstva okolje 2020-2030 (ReNPVO20-30)(2020) http://www.pisrs.si/Pis.web/pregledPredpisa?id=ODLO1985

In the field of research, development and innovation for environmental protection, by 2030 Slovenia will:

- be ranked among the innovation leaders in terms of environmental innovation and technology indicators;
- ensure that targeted investment in research and development contributes to filling the knowledge gap; and
- assure that in the 2021–2030 programming period 60% of research contributes to sustainable development and 35% to management and adaptation to climate change.

3.3.2.8 Comprehensive strategic decarbonisation project/Celoviti strateški project razogličenja

In 2021, Slovenia started preparing the comprehensive strategic decarbonisation of Slovenia's circular economy[45] as a pilot activity on the European level in cooperation with two European public bodies – the European Institute of Innovation and Technology (EIT) and the Joint Research Centre (JRC) of the European Commission. The content of the solutions proposed the comprehensive strategic project be built on three pillars, with each consisting of several programmes that are interconnected and strengthen and upgrade each other:

- the "Smart and Circular Communities" pillar includes programmes of circular schools, circular learning and resources, and circular synergies to establish smart and circular regions;
- the "Circular Development" pillar encompasses programmes in the field of entrepreneurship (circular detection and support for circular innovations in small and medium-sized enterprises and a programme in the field of monitoring implementation; and
- the "Circular Policy-Making and Science" pillar includes programmes in the field of higher education, circular education, policymaking for the transition to a circular economy and in the area of circular public procurement.

Implementation will help with the achievement of several goals of the Development Strategy of Slovenia 2030 and begin to systematically work to improve all three productivities of the economy where Slovenia lags behind the EU-28 average, and thereby contribute to improving competitiveness.

The measures envisaged in the project will make it easier to bridge certain gaps highlighted by key stakeholders involved in the transition to a low-carbon circular economy.

45 Ministrstva pripravljajo strateški projekt razogljičenja Slovenije (2021). https://www.ekodezela.si/eko-okolje/ministrstva-pripravljajo-strateski-projekt-razogljicenja-slovenije/

3.4 Austria

3.4.1 Austrian policy on research and technological development

3.4.1.1 Research and innovation strategies for smart specialisation (RIS3)/ Integrative Strategien für intelligente Spezialisierung (RI3)

Smart specialisation is a policy concept while priority-setting whereby a region can benefit from specialising in a particular area of science and technology. Regional development and growth become knowledge- and innovation-driven and thereby stimulate structural change.

The research, technology and innovation (RTI) strategy of the federal government "Becoming an Innovation Leader" was launched in 2011[46].

Austria employs a longer term perspective in working with the Smart Specialisation concept. The federal government encourages its science and research institutions to realise their role as regional Lead Institutions: universities, science and research centres are indispensable players in the process of knowledge and innovation-driven structural change since they create regional value in both a civic and economic sense. They should be recognised as partners on equal terms as with regional policymakers and the leading companies in discovering and developing a region's smart specialisations.

The strategy addressed measures to strengthen national research structures with a focus on excellence to foster the innovative capacity of companies, allow for thematic priority-setting, raise the efficiency of governance, and link research, technology and innovation to the education system. The strategy also helped to mobilise research, technology and innovation with respect to the grand challenges of society and the economy.

Five states in Austria have their own strategies: Lower Austria, Upper Austria, Salzburg, Styria and Vienna.

46 RTI strategy of the federal government "Becoming an Innovation Leader. 2011. https://www.bundeskanzleramt.gv.at/en/topics/rti-strategy.html

3.4.1.2 Research, Technology and Innovation Strategy of the Austrian Government 2030 (RTI Strategy 2030)/Strategie der Bundesregierung für Forschung, Technologie und Innovation (FTI Strategie 2030)

The new RTI Strategy 2030[47] was adopted by the Council of Ministers in 2021. This paves the way for more investment in research and innovation. Through this strategy, the Austrian federal government aims to bring Austria closer to Europe's innovation leaders. The excellence initiative contained within the strategy provides leading-edge researchers in Austria with extra momentum.

Austria's future Research, Technology and Innovation (RTI) strategy, which the Council of Ministers adopted shortly before Christmas, shows the Austrian federal government's clear commitment to enhancing the country's innovative capacity through science and research. The planned actions identify ways to further increase the efficiency and output of research investments and encompass all areas and stakeholders of Austria's innovation system.

The strategy indicates several fields of action and is designed to bring Austria closer to the forefront of European innovation, enhance effectiveness and excellence, and support the development of knowledge, talents and skills. This also includes actions and activities intended to give Austria's top researchers a further boost.

The Austrian federal government's strategy for basic research thus focuses on expanding support for research excellence, encouraging cooperation, and promoting the competitive allocation of funding as the best decision-making method. The national excellence initiative for basic research is intended to generate a lot of momentum to make Austria more visible internationally as an RTI location and to further develop interinstitutional structures.

The RTI strategy covers a 10-year period, with the actual implementation taking the form of a series of 3-year RTI pacts. The Austrian federal government has made €3.86 billion available for the first RTI pact until 2023, which is a 27% increase over the period from 2018 to 2020, that also includes future funding for the Austrian Science Fund (FWF) and other funding organisations with greater security in terms of planning and financing, the further development of the national foundation – a key component of Austrian RTI funding – into "Fonds Zukunft Österreich" and its future endowment are still unresolved issues..

3.4.1.3 Energy Research and Innovation Strategy (ERIS)/ENERGIE Forschungs- und Innovationsstrategie (ERIS)

Austria issued a new Energy Research and Innovation Strategy (ERIS) in 2017[48], replacing the Energy Research Strategy of 2009. It has shifted towards an integrative and systems-oriented perspective and the role of innovation processes. The ERIS supports the sector coupling of heating, cooling and electricity and has six strategic focus areas:

- energy systems and networks;
- buildings and urban systems;
- industrial energy systems;

47 FTI-Strategie 2030. (2021). https://www.fwf.ac.at/en/news-and-media-relations/news/detail/nid/20210119

48 ENERGY - Research and Innovation Strategy for Austria. (2017) https://nachhaltigwirtschaften.at/resources/e2050_pdf/E-Forschung_Kurzfassung_englisch_v2.pdf

- transportation and mobility systems;
- conversion and storage technologies; and
- transition processes and social innovation.

The ERIS is integrated into #mission2030, which sees a key role for research, development and innovation (RDI) in decarbonisation of the economy and for positioning Austria as an energy innovation country to ensure the future competitiveness of its economy. #mission2030 sets out a range of activities for RDI in two "flagship projects": Flagship Project 9 – Building Blocks of the Energy Systems of the Future and Flagship Project 10 – The Mission Innovation Austria Programme.

3.4.2 Austrian environmental policy

3.4.2.1 Federal Climate Protection Act/Klimaschutzgesetz, KSG

The purpose of this Act[49] (adopted in 2019) is to provide protection from the effects of worldwide climate change by ensuring that both the national climate targets and the European targets are met. The ecological, social and economic impacts shall be taken into consideration. The basis of the Act is the obligation arising from the Paris Agreement, under the United Nations Framework Convention on Climate Change, to limit the increase in the global average temperature to well below 2 degrees Celsius and, if possible, to 1.5 degrees Celsius, above the pre-industrial level so as to minimise the effects of worldwide climate change, as well as the commitment given by the Federal Republic of Germany at the United Nations Climate Action Summit in New York on 23 September 2019 to pursue the long-term goal of greenhouse gas neutrality by 2050.

3.4.2.2 Renewable Expansion Act/Erneuerbaren-Ausbau-Gesetz – EAG

A central energy and climate policy goal of the Austrian government is to convert the country's electricity supply to 100% from renewable energy sources (nationally balanced) by 2030 and to make Austria climate-neutral by 2040. The Renewable Expansion Act (EAG) is intended to create the necessary legal and organisational framework and a long-term stable investment environment[50].

In addition, the investment safety for existing and future plants for the production of renewable gas must be guaranteed while the share of nationally produced renewable gas has to be increased to 5 TWh by 2030. Both operational subsidies in the form of sliding market premiums and investment grants are used as funding instruments for the future renewable electricity and gas supply. The EAG not only addresses the promotion of electricity and gas generation from renewable energy sources, but also the organisation and functioning of renewable energy communities, certificates of origin for renewable energy, and the establishment of green certificates for gas from renewable energy sources.

Investment grants are for new construction, the expansion of photovoltaic systems and electricity storage systems as well as for the new construction of wind turbines up to 1 megawatt (MW). In

49 Klimaschutzgesetz. (2019). https://www.gesetze-im-internet.de/englisch_ksg/englisch_ksg.html

50 Erneuerbaren-Ausbau-Gesetz"; Bundesministerium Klimaschutz, Umwelt, Energie, Mobiliät, Innovation und Technologie (2021). https://www.bmk.gv.at/service/presse/gewessler/20210317_eag.html

order to support the production of renewable gases, a service point will be implemented. Further, the retrofitting of existing biogas plants for the production of renewable gas to natural gas quality, new plants for the production of renewable gas as well as plants for the conversion of electricity to hydrogen or synthetic gas can be subsidised by investment grants.

General Targets (BMK Austria, 2021)

- An increase of 27 TWh in annual electricity generation from renewable sources by 2030 effective in terms of volume
- Integration of the energy system
- Ensuring the security of supply
- Extension of the information content of the loading point directory for publicly accessible charging points
- An increase in the renewable share in district heating

Hydrogen appears in several sections of the draft law and will play an essential role in decarbonisation of the energy system in the future and can make a decisive contribution to the electricity system's flexibility. In the run-up phase, incentives must be created in order to enable the generation of green hydrogen in a competitive market. In addition, electrolysis and pumped storage power plants are to be exempted from network usage and network loss fees in the future. The following paragraph summarises the main topic of hydrogen in the draft version of the EAG[51].

Renewable gas – Investment grants for systems for converting electricity into hydrogen or synthetic gas: (EAG, 2021)

- In future, the construction of electrolysis systems to convert electricity into hydrogen or synthetic gas can be funded with an investment grant.
- The main requirement for the promotion of the production of hydrogen is that H_2 is produced by renewable energy sources.
- The use of renewable hydrogen as a key element for sector coupling and integration aimed at the Paris Agreement targets.

3.4.2.3 Austrian Climate and Energy Strategy #mission2030/Die Österreichische Klima – und Energiestrategie

Taking office in January 2020, the new Austrian government has committed itself to achieving carbon neutrality by 2040, 10 years ahead of the European Union's target. To achieve this ambitious goal, Austria will need to significantly step up its decarbonisation efforts in all energy sectors, continuing and expanding the existing policies and measures.

51 EAG, 2021: Vortrag an den Ministerrat: Erneuerbaren-Ausbau-Gesetz und weitere Gesetzesnovellen; Bundesministerium Klimaschutz, Umwelt, Energie, Mobiliät, Innovation und Technologie; online available at: https://www.bmk.gv.at/service/presse/gewessler/20210317_eag.html

In May 2018, the Austrian Federal Government adopted its Climate and Energy Strategy (#mission2030)[52]. The Strategy aims to meet the Sustainable Development Goals in the areas of greenhouse gas reduction, renewable energy and energy efficiency by 2030, in line with the EU's objectives. The security of energy supply, competitiveness, affordability (including budgetary sustainability considerations) and research and development complete the aims of the Strategy, making it largely consistent with the five dimensions of the Energy Union.

Positioning Austria as an "energy innovation country" in terms of research and development of next-generation technologies is fundamental to Austria's success as a location for business and employment. Decarbonisation will primarily be facilitated through innovative technologies. Many are in the trial stage and their further development depends on target support in the form of pilot projects. Public and private efforts in this direction need to be increased significantly overall.

To this end, research and technological progress and innovation will be key in developing new solutions, proactively helping to shape change processes and positioning Austrian operators in international markets. The task of making the decarbonisation agenda technically feasible, economically viable and socially acceptable depends on a policy of long-term research, technology and innovation (RTI).

Austria also strongly believes that nuclear power is not the answer to climate change. Austria will consistently defend this position on all levels and will lobby for no more funding for nuclear energy. Austria will therefore continue to fight against the use of nuclear energy on the European and international levels and to push for continual improvements to nuclear safety.

In order to launch the integrated Climate and Energy Strategy, the federal government

has identified flagship projects, including both short- and long-term measures, that should be implemented during the current legislative period.

Flagship project 7: RENEWABLE HYDROGEN AND BIOMETHANE

The mission is for Hydrogen to improve network stability via decentral electrolysers and

the long-term storage of renewable energy. At the same time, the cost-effective production of hydrogen should expedite the switching out of fossil fuels in energy-intensive industry.

Flagship project 9: ENERGY RESEARCH INITIATIVE 1 – BUILDING BLOCKS OF THE ENERGY SYSTEMS OF THE FUTURE

Technologically neutral, mission-oriented research and development projects should

enable successful technologies and solutions to be developed that will allow Austria to position itself as an innovation leader in global technology markets. Break-through technologies for industry that enable raw materials and energy consumption to be slashed significantly reduce emissions and increase independence in terms of raw materials and

52 Die Österreichische Klima – und Energiestrategie (2020).
https: C:/Users/grabn/AppData/Local/Temp/20_18_beilagen_nb.pdf

energy with no loss of output. The new products and processes need to focus on highly efficient use of the energy and resources used, where possible on a cascading basis, and to enable the energy demand of industrial plants to be matched with the energy supply from fluctuating renewable energies. The Austrian automotive and aeronautical industries need to remain competitive during the technological switch towards e-mobility, lightweight construction and automated transport by funding R&D. Further, domestic industry must be integrated into international value-added chains in the overall battery/vehicle/energy supply system from production through to recycling.

The Strategy not only forms the basis for Austria's National Energy and Climate Plan (NECP) in accordance with the Regulation of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action1, but also provides the medium- and long-term framework for transforming the energy system in line with the Paris Agreement's goals for climate change.

3.4.2.4 Long-Term Strategy 2050/Langfristige Strategie – Zeithorizont 2050

Pursuant to Regulation 2018/1999 Governance of the Energy Union and Climate Action and decision 1/CP.21 of the Paris Agreement, before 2030 Austria is required to reduce greenhouse gas emissions from sectors not covered by the EU emissions trading system (ETS) by 36% compared with the 2005 levels. The CO_2 emissions from energy-intensive industries and the energy sector are defined and limited across Europe by a linear pathway in the EU Emissions Trading Directive. The emissions covered by the ETS must be reduced by at least 43% over the 2005 levels by 2030. There are no national requirements that apply to Member States for the reduction of greenhouse gas emissions from ETS facilities.

To achieve these goals, Austria has developed its mid-century, long-term low GHG emission development strategy Long-term Strategy 2050 – Austria[53] and is committed to becoming climate-neutral by no later than 2050, without using nuclear energy. The strategy presents a vision for how to achieve climate neutrality and covers all relevant sectors (energy, industry, transport, buildings, agriculture, forestry), highlights the saving potential of human lifestyle and consumption patterns as well as the importance of the contribution of digitalisation. According to the programme for 2020–2024, Austria is committed to become climate-neutral by 2040 and an update of the Long-term Strategy is thus foreseen.

3.4.2.5 Integrated National Energy and Climate Plan for Austria (NECP)/ Integrierter nationaler Energie- und Klimaplan für Österreich

The National Energy and Climate (ENCP) Plan is a 10-year integrated document mandated by the European Union to each Member State in order for the EU to meet its overall greenhouse gas emissions targets.

53 Long_term Strategy 2050- Austria. (2019). https://unfccc.int/sites/default/files/resource/LTS1_Austria.pdf

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

The Austrian Integrated National Energy and Climate Plan for Austria (NECP)[54] contains the following objectives by 2030:

- a 36% reduction of greenhouse gas emissions compared with 2005 levels in sectors not covered by the EU emissions trading system;
- an increase in the share of renewable energy in gross final energy consumption to 46%–50%;
- 100% coverage of domestic electricity consumption by renewable sources (national, net balance, with exceptions for control and balancing energy for grid stabilisation and internal electricity generation from fossil fuels in tangible goods production); and
- an improvement in primary energy intensity, defined as primary energy use per GDP unit, by 25%–30% compared with 2015.

Austria is considered a "strong innovator" in the latest European Innovation scorecard, ranking particularly high in the linkages,1 innovators and intellectual assets dimensions. (EC, 2019). However, Austria could further improve the business and regulatory environment for innovation to fully leverage this achievement to deliver greater employment and economic output. Austria is a very active participant in multilateral efforts for energy innovation, notably under the IEA Technology Collaboration Programme, as well as Mission Innovation. On average, Austria annually spent €140 million on energy-related research, development and demonstration (RD&D) between 2010 and 2018, with moderate fluctuations. Nearly all of these energy RD&D expenditures were allocated to low-carbon technology areas, particularly in energy efficiency.

3.4.2.6 The Hydrogen Initiative

In March 2019, the Austrian government launched its Hydrogen Initiative[55] and presented a roadmap for developing a new hydrogen strategy.

Led by Austria, the initiative was signed in Linz by ministers, state secretaries or other authorised members of the delegations of the 23 EU Member States, Iceland and Switzerland, as well as some companies active in this field.

Several countries, including Slovenia, Ireland, Slovakia, Sweden and the United Kingdom, which did not sign the document in Linz, called on the Austrian presidency to sign the initiative later. Slovenia signed the initiative in Vienna in November 2018.

The government is also preparing a national Hydrogen Strategy, currently subject to public consultation. Its NECP considers renewable hydrogen "as a key technology for sector integration and coupling" and contains the concrete target of renewable electricity-based hydrogen consumption of 1.1 TWh (4 PJ) by 2030. New regulatory and financial measures are announced to pave the way for renewable hydrogen in the industrial, building and transport sectors addressing the entire value chain from generation, storage through to transport and distribution for end use.

Austria holds a favourable position given its current investments in hydrogen research and in pilot and demonstration projects as well as in infrastructure, transport and delivery infrastructure, decarbonising of the steel industry, producing hydrogen from renewable sources etc.

55 The Hydrogen Initative (2019). http://h2est.ee/wp-content/uploads/2018/09/The-Hydrogen-Initiative.pdf

4. SWOT and pest analysis of identified gaps, advantages and opportunities of the cross-border area for establishing a critical mass of R&I capacity to accelerate the development of hydrogen technologies in the cross-border area

4.1 SWOT analysis – introduction

SWOT (strengths, weaknesses, opportunities, threats) analysis is a framework used to identify strengths and weaknesses (S-W) as well as broader opportunities and threats (O-T). Developing more complete awareness of the situation helps with both strategic planning and decision-making.

To prepare the basic SWOT analysis, we used the Cooperation programme Interrreg V-A Slovenia Austria[56]. Given that the programme was prepared in 2014, we updated the data using data available on the Internet.

56 http://84.39.218.252/en2/wp-content/uploads/sites/8/2015/10/SVRK-SI-AT-Cooperation-Program-WEB.pdf

4.1.1 Main characteristics regarding R&I capacity

4.1.1.1 Socioeconomic characteristics

- The programme area covers 38,353 km2, encompassing a population of 3,467,000. Cities account for the majority of the population, representing centres of education, research and knowledge.
- Austria's gross domestic product (GDP) per capita reached USD 47,992.227 in December 2020, while Slovenia's was USD 25,144.
- The policy on research, development and innovation (RDI) in Austria was originally under the responsibility of the central government. Nowadays, each federal state has either its own future-, science- or research-innovation concept or at least a strategy. In Slovenia, the policy framework for RDI is on the national level.
- Levels of gross domestic expenditure on R&D (GERD) in % of GDP also vary.
- In 2019, gross domestic expenditure on R&D (GERD) in Slovenia in all sectors in which R&D is performed amounted to 2%[57]. In Austria, gross domestic expenditure on R&D (GERD) in all sectors in which R&D is performed amounted to 3.19%[58].

4.1.1.2 R&D

- The R&D infrastructure is well developed (i.e. universities/universities of applied sciences and Research and Technology Organisations),
- The cross-border area also has a well-developed ecosystem of support organisations, such as technology and science parks, (technology) business incubators, support organisations (non-governmental organisations (NGOs), government agencies, a chamber etc.).
- The R&D capacities are fragmented and fall short of a critical mass needed to become visible on the EU scale.

4.1.1.3 Levels of competitiveness and SMEs

- In Slovenia's non-financial business economy, SMEs account for 64.5% of value added and 72.0% of employment, thereby exceeding the respective EU averages of 56.4% and 66.6%. Between 2014 and 2018, the value added of Slovenian SMEs rose by 33.5%, slightly more than the 30.8% growth seen by large firms. Between 2018 and 2020, SME value added is projected to have grown by 10.5% and SME employment by 3.6%, creating around 16,600 new jobs[59].
- In Austria, SMEs account for over 60% of turnover, gross value added and investments in the market-oriented economy. In 2017, the turnover generated by SMEs amounted to about €482 billion, the gross value added up to around €128 billion and the volume of investment to €24 billion. SMEs also account for around half of the €66 billion of goods exports[60].

57 https://www.stat.si/StatWeb/en/Field/Index/25/18

58 https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20201127-1

59 file:///C:/Users/grabn/AppData/Local/Temp/Slovenia%20-%20SBA%20Fact%20Sheet%202019.pdf

- SMEs generally invest less for different reasons: difficulty in obtaining financing/funding for innovation projects, shortages in managerial skills for innovation, intellectual property and knowledge processes, limited capabilities and weaknesses in networking and cooperation with innovation stakeholders.
- The Environmental Implementation Report issued by the EU Commission[61] in 2019 showed that both Slovenia and Austria Slovenia exceed the EU average for the European Innovation Scoreboard – Slovenia was ranked 12th in 2018, with a 1.4% increase since 2015, while Austria was ranked 10th and was the seventh-fastest-growing innovator (a 9.0% increase since 2010).
- To evaluate SWOT parameters, we also took account of the current situation and trends in the field of low-carbon technologies (with an emphasis on hydrogen technologies) and the fight against global changes.
- The global climate targets can only be met if a major boost is given to clean-energy innovation since many of the technologies required to bring CO_2 emissions down are currently only in the prototype or demonstration phase. This is the conclusion of a joint report released by the European Patent Office (EPO) and the International Energy Agency (IEA)[62]. In their report "Patents and the energy transition – Global trends in clean energy technology innovation" (April 2021), they showed that on the global level between 2000 and 2019 patenting activities were growing faster in low-carbon energy (LCE) technologies than in fossil-fuel technologies. After seeing a significant drop in 2015, the number of international patent families (IPFs) in LCE areas resumed growth after 2017, while fossil-fuel innovation has started to decline[63].
- Both Slovenia and Austria are committed to achieving carbon neutrality. Slovenia prepared a strategy for reaching carbon neutrality by 2050 and Austria by 2040, 10 years ahead of the European Union's target. To attain these goals, both countries have prepared legislation and policies that directly address the challenges.
- In the field of hydrogen, Austria's NECP emphasises the contribution of hydrogen to increasing the share of renewable energy in final energy consumption to 45%–50% by 2030, and to source 100% of its electricity consumption from renewable energy sources. Slovenia expects by 2030 final hydrogen consumption of 10 ktoe (116 GWh) in the transport sector, and by 2040 the consumption of 63 ktoe (732 GWh) mainly in the transport, but also gradually in the building and industry sectors.
- Slovenia and Austria should support their research centres and industry in carrying out hydrogen-related research. It is appropriate to launch pilot and demonstration projects that can help pave the way for the use of renewable hydrogen as a means to achieve deep decarbonisation.
- A report published jointly by CDP and Oliver Wyman states that in 2019 882 European companies responsible for over 2.3 $GtCO_2e$ of emissions reported €124 billion in new low-carbon investments[64]. Research and development (R&D) investments amounted to €65 billion, of which €43 billion was reported by transport original equipment manufacturers (OEMs), primarily for investments in electrification and autonomous vehicle technologies.

60 https://www.bmdw.gv.at/en/Topics/Business-Location/SME/SME-in-Austria-facts-and-figures.html

61 https://ec.europa.eu/environment/eir/index_en.htm

62 https://www.dw.com/en/tech-needed-to-halt-climate-change-still-underdeveloped/a-57339898 63 https://iea.blob.core.windows.net/assets/b327e6b8-9e5e-451d-b6f4-cbba6b1d90d8/Patents_and_the_energy_transition.pdf

64 https://www.oliverwyman.com/our-expertise/insights/2020/feb/doubling-down.html

- Horizon Europe is the EU's next research and innovation programme, having started in 2021. In synergy with other EU programmes, it will be crucial for leveraging national public and private investment. Together, they will foster new technologies, sustainable solutions and disruptive innovation and spread successful new solutions across Europe and the world. Over 35% of Horizon Europe spending will go towards meeting the climate objectives.

4.1.2 SWOT analysis

STRENGTHS

- Slovenia and Austria are parliamentary representative democracies;
- the cross-border area also has a well-developed ecosystem of support organisations, such as technology and science parks, (technology) business incubators, support organisations (NGOs, government agencies, a chamber etc.);
- the relatively good scientific quality of research and the quality research infrastructure;
- the high share of investment in research, mainly by companies;
- the quality of human resources and increase in the number of researchers, especially in the private sector;
- the strong policy commitment to innovation and research;
- the multiform sector of research institutes and research and technology organisations (RTOs) that engage in different types of technology transfer with businesses;
- the relatively large share of students enrolled in tertiary education and the growing number of students taking technical studies;
- social awareness of the damaging effects of global changes is high;
- Slovenian and Austrian both exceed the average for the European Innovation Scoreboard, showing there are both knowledge and resources to further innovate in technology solutions, including low-carbon technologies.

WEAKNESSES

- the R&D infrastructure is fragmented;
- the area is divided by a border, which reduces the cross-border area's research competitiveness;
- specialisation in medium-tech. industries and expectations are low;
- legislation and new policies are just being introduced;
- the weak interaction of universities and research organisations, non-systematic knowledge transfer and insufficient attention paid to market needs;
- the lack of openness to foreign students, researchers and professors;
- the underexploited potential of knowledge-based capital (patents, brands, models);
- the weak integration of companies (especially SMEs) into global value chains, poor international engagement of SMEs, and relatively modest presence of FDI;
- insufficient capacities of broadband infrastructure and unused ICT potential in education.

OPPORTUNITIES

- current EU and national funding plans offer funding for the research;
- new employment opportunities of researchers connected with increased funding;
- the diversity of companies in the energy sector;
- a reduction of environmental impacts;
- stricter carbon emission standards might be an incentive to accelerate the development of hydrogen technology;
- the development of low-carbon-related projects triggers developments in other areas;
- the development of a clear governance structure in the area of RTDI;
- the efficient and effective use of the research infrastructure and developed knowledge/ competencies through synergies within the knowledge triangle;
- adjustment of the supportive environment and instruments to fields holding clear market potential;
- the acquisition and strengthening of entrepreneurial knowledge and competencies;
- establishment of a supportive environment favourable to the setting up, starting up and growth of companies;
- the promotion of internationalisation, cross-border connections and the inflow of foreign investments;
- the mobility of students, professors and researchers;
- the early introduction and effective implementation of measures focused on the transition to a sustainable society and effective resource management;
- the integration of all social innovations (technological and non-technological) to create comprehensive solutions.

THREATS

- the different development levels due to differences between the two countries;
- a growing imbalance due to different policy development and implementation;
- inexperienced potential users;
- an inadequate plan for commercialisation;
- an inadequate legal framework;
- many barriers, in particular cost and low efficiency, are preventing the introduction of large-scale low-carbon and hydrogen technology;
- the aggressive competition, mainly from China;
- negative public opinion regarding safety, especially for hydrogen technologies;
- delays in structural reforms in fields like the remuneration system in knowledge institutions, reform of the monitoring system of the effects of R&D incentives;
- excessive diversification of RTDI investments from private and public sources;
- the slow strengthening of intangible capital;

- over-dependence of research institutions on public funds, a focus on non-market projects and an insufficiently developed platform for the promotion of technology transfer;
- talent flight (especially of young talents);
- the low level of early entrepreneurial activities and the continuation of the low survival rates of newly established enterprises;
- a further decline in the share of innovation-active enterprises in market services.

4.2 PEST analysis – introduction

PEST analysis (analysis of political, economic, socio-cultural and technological factors), which represents a model of external factors of the macro environment, is used to analyse the business environment in the context of strategic management. It is useful while conducting strategic analysis, market research and preparing business plans. It is a strategic tool that enables understanding of the growth or decline of markets, a company's business position, its potential for growth or the direction in which its operations should develop:

- Political factors explain the ways in which the government is interfering in the economy. It analyses in more detail areas such as tax policy, labour law, environmental legislation, trade restrictions, customs duties and political stability. It can also be an analysis of goods and services that the government wants to provide (goods in the general interest or public goods) and goods and services not provided by the government. The government also has a significant impact on the health, education and infrastructure of the nation.
- Economic factors include economic growth, interest rates, exchange rates and inflation. These factors strongly influence the performance of companies and the way companies make decisions. Interest rates, for example, affect a company's cost of capital and therefore the extent to which a company develops and grows. Exchange rates can affect the price of goods for export and the stock and price of imported goods.

- Social factors address cultural aspects and awareness of healthcare, the population growth rate, the age distribution of the population, attitudes to career advancement and with an emphasis on safety. The high trend growth of social factors affects the demand for the company's products and thus its operations. For instance, an ageing population may mean that the workforce is less extensive and less willing to work (thereby increasing labour costs). Companies could change their management strategy in this regard and thus adapt to social trends (for example, they start to hire older workers).
- Technological factors include technological aspects such as research and development, automation, technology promotion and the degree of technological change. These factors can affect barriers to market entry, the minimum level of efficient production and subcontracting. Moreover, technological changes also affect costs and quality and lead to innovation.

4.2.1 Political factors

SLOVENIA

Slovenia is a parliamentary democratic republic with a head of government – the Prime Minister, elected by Parliament – and a head of state – the President, elected at direct elections. The President can serve for a maximum of two consecutive terms of 5 years.

Slovenia is divided into 212 municipalities (občina). This figure includes 11 urban municipalities (mestna občina). Municipalities are bodies of local self-government. They are headed by a mayor (župan) who is directly elected for a term of 4 years.

Slovenia does not have administrative regions. For the purposes of EU regional policy, it is divided into two NUTS 2 regions: Western Slovenia (Zahodna Slovenija) and Eastern Slovenia (Vzhodna Slovenija). There are also 12 statistical regions at the NUTS 3 level without established self-government structures.

AUSTRIA

Austria is a parliamentary representative democracy where the federal president is elected directly. The president acts as the head of state, whereas the chancellor acts as the head of the federal government. The country comprises nine federal states/ provinces.

Austria is a federal republic made up of nine states (Bundesländer). These states are sub-divided into districts (Bezirke) and statutory cities (Statutarstädte). Districts are further divided into municipalities (Gemeinden). Austria is currently (1 January 2020) is partitioned into 2,095 municipalities. Statutory Cities hold competences otherwise granted to both districts and municipalities. Vienna is unique in that it is both a city and a state.

Austria's constituent states are not mere administrative divisions but possess some legislative authority distinct from the federal government, e.g. in matters of culture, social welfare, youth and nature protection, hunting, building, and zoning ordinances.

4.2.2 Economic factors

SLOVENIA

Slovenia had achieved a high level of economic growth prior to the economic crisis in 2008. However, structural weaknesses had indicated that its development model was not sustainable. During the crisis, GDP fell sharply, which significantly affected economic stability and negatively impacted the well-being of the population[65].

In 2019, GDP per capita reached 89% of the EU-27 average, which was the highest value of this indicator in 10 years. Previously, GDP per capita had dropped to 83%, and had stayed on that level from 2012 until 2015 when it started to rise[66].

Slovenia is among the most prosperous new Member States. It adopted the euro in 2007. Its service sector contributes 69.9% to GDP[67]. The Slovenian economy is very export-oriented. In 2017, exports of goods and services accounted for 82.2% of Slovenian GDP. At the same time, imports of goods and services accounted for 72.6% of Slovenian GDP[68].

According to the OECD, the average household net-adjusted disposable income per capita is USD 20,820 a year, lower than the OECD average of USD 33,604 a year. There is a considerable gap between the richest and poorest – the top 20% of the population earns close to four times as much as the bottom 20%.

AUSTRIA

A variety of economic factors impact how companies operate in Austria. Austria's economy performed well in the last decade. GDP in 2019 amounted to USD 446.31 billion (Trading Economics, 2020)[71]. However, it was estimated to have gone down by 8% in 2020. It is not estimated to rise significantly in the next few years[72].

It is unsurprising that unemployment grew in 2020 given the economic crisis and global lockdown. This resulted in weak tax revenues and the government had to offer economic support to people and companies. The government's support has been useful for saving a huge number of jobs and preventing companies from leaving the market.

Austria is a highly developed country with a free market economy. It was one of the first countries to adopt the euro in 1999. Its service sector contributes 62.5% to GDP[73]. Tourism plays a major role and brings millions of tourists into the country every year. Other notable industries are agriculture, food & drink, construction, electronics, transportation, and mechanical engineering.

According to the OECD, the average household net-adjusted disposable income per capita is USD 33,541 a year, just below the OECD average of USD 33,604. Still, there is a considerable gap between the richest and poorest – the top 20% of the population earns about four times as much as the bottom 20%.

65 OECD, (2020)

66 Eurostat. (2021)

67 Import Export Solutions, (2020). https://www.thinkslovenia.com/info-activities/slovenia-facts-figures

68 Eurostat. (2021)

69 http://www.oecdbetterlifeindex.org/countries/slovenia/

71 Trading Economics, (2020).

72 OECD, (2020)

73 Import Export Solutions, (2020).

In terms of employment, 69% of people aged 15 to 64 in Slovenia have a paid job, slightly above the 68% OECD employment average. Some 73% of men are in paid work, compared with 66% of women. In Slovenia, some 4% of employees work very long hours, less than the OECD average of 11%, with 6% of men working very long hours compared with just 2% of women[70].

In terms of employment, 72% of people aged 15 to 64 in Austria have a paid job, above the OECD employment average of 68%. Some 76% of men are in paid work, compared with 68% of women. In Austria, almost 7% of employees work very long hours, less than the OECD average of 11%, with 10% of men working very long hours compared with just 3% of women[74].

4.2.3 Social factors

SLOVENIA

According to the OECD, Slovenia ranks above the average in job and earnings, housing, health status, social connections, education and skills, work–life balance, environmental quality, and personal security. It is below-average in income and wealth, civic engagement, and subjective well-being.

The population in Slovenia today is just over 2 million[75]. The official language is Slovenian; two minority languages (Hungarian and Italian) are recognised as co-official languages and accordingly protected in their residential municipalities. English is very widely spoken as well. The vast majority of people (83%) are ethnic Slovenians. At least 13% of the population immigrated from other parts of former Yugoslavia, primarily ethnic Bosniaks (Bosnian Muslims), Croats and Serbians. Relatively small but protected by the Constitution of Slovenia are the Hungarian and the Italian national communities.

In Slovenia, 88% of adults aged 25–64 have completed upper secondary education, higher exceeding the OECD average of 78%. This is truer of men than women since 89% of men have successfully completed high school compared with 87% of women. In terms of the quality of the education system, the average student scored 509 in reading literacy, maths and science in the OECD's Programme for International Student Assessment (PISA), higher than the OECD average of 486 points.

AUSTRIA

Austria performs well in many measures of well-being relative to most other countries in the Better Life Index. Austria ranks above the average in income and wealth, jobs and earnings, housing, health status, subjective well-being, personal security, social connections, environmental quality, and education and skills. It is below-average on work–life balance and civic engagement.

The current population in Austria is just over 9 million[76]. The official language is German; however, English is very widely spoken as well. The vast majority of people are ethnic Austrians; however, the country accommodates several ethnic minorities such as Germans, Swiss, Bosniaks, Turks, Hungarians, Croats and Slovenians[77].

In Austria, 85% of adults aged 25–64 have completed upper secondary education, more than the OECD average of 78%. This is truer of men than women since 88% of men have successfully completed high school compared with 82% of women. In terms of educational quality, the average student scored 492 in reading literacy, maths and science in the OECD's Programme for International Student Assessment (PISA). This score is higher than the OECD average of 486.

70 Import Export Solutions, (2020).

74 OECD (2020)

75 Eurostat. (2021)

76 Eurostat.(2021)

77 Eurostat.(2021)

4.2.4 Technological factors

SLOVENIA

In 2019, the R&D sector conduct 2.05% to GDP . IT was 11% higher than in 2010 , but still far from the Barcelona target envisaging an increase in R&D investment to at least 3% of GDP by 2020[78].

The main investor in R&D is the business enterprise sector in terms of both performing and funding.

According to Eurostat, over 10 years (2007–2017), R&D expenditure in Slovenia rose from 1.42% to 1.86% of GDP[79].

In 2019, the share of GDP for Slovenia was 0.42%, below the EU average of 0.63%[80].

A report by the EU Commission – EU Industrial R&D[81] Investment Scoreboard (the Scoreboard, 2020) – that measures the performance of EU innovation-driven industries against major global counterparts, shows that 1 company is in the top 2,500 companies that invested the largest sums into R&D worldwide in 2019[82].

AUSTRIA

In 2019, the R&D sector conduct 3.0% to GDP that is in line with the Barcelona target envisaging an increase in R&D investment to at least 3% of GDP by 2020[83].

The main investor in R&D is the business enterprise sector in terms of both performing and funding.

According to Eurostat, over 10 years (2007–2017), R&D expenditure in Austria rose from 2.42% to 3.16% of GDP[84].

In 2019, the share of GDP for Austria was 0.77%, above the EU average of 0.63%[85].

A report by the EU Commission – EU Industrial R&D Investment Scoreboard (the Scoreboard, 2020) – that measures the performance of EU innovation-driven industries against major global counterparts, shows that 17 companies are in the top 2,500 companies that invested the biggest sums into R&D worldwide in 2019[86].

78 https://howandwhat.net/pestel-analysis-austria/

79 https://www.stat.si/StatWeb/en/News/Index/9400

80 https://rio.jrc.ec.europa.eu/stats/government-budget-appropriations-or-outlays-rd-0

81 https://op.europa.eu/en/publication-detail/-/publication/73e624aa-406c-11eb-b27b-01aa75ed71a1/language-en

82 https://www.stat.si/StatWeb/en/News/Index/9400

83 https://www.stat.si/StatWeb/en/News/Index/9400

84 Eurostat news (2019).https://ec.europa.eu/eurostat/documents/2995521/9483597/9-10012019-AP-EN.pdf/856ce1d3-b8a8-4fa6-bf00-a8ded6dd1cc1

85 https://rio.jrc.ec.europa.eu/stats/government-budget-appropriations-or-outlays-rd-0

86 https://iri.jrc.ec.europa.eu/scoreboard/2020-eu-industrial-rd-investment-scoreboard

5. Examples of good policy development practices

5.1 The Federal Republic of Germany

5.1.1 Overview

Upon introducing its energy concept in 2010, the German government set ambitious targets for the country's energy and climate policy. According to this concept, greenhouse gas (GHG) emissions will have to be reduced by 80% by 2050, as compared to the 1990 levels, and renewables will have to supply 80% of all electricity needs by the same year. In addition, Germany has decided to phase out its nuclear energy by 2022[87].

However, this will come at a high cost. In a study by Hansen et al.[88], the authors tried to take a holistic look and model an energy system as a whole. They concluded that even full decarbonisation is possible by 2050 utilising only domestic energy sources.

The energy transition will require considerable added investment. Estimates of the total amount of annual investment vary from €15 to €40 billion, or 0.5% to 1.2% of Germany's current GDP of around €3,200 billion[89].

Germany is also a world-leading country in research and development[90]. This is not least due to its strong system of research support. It not only finances infrastructure and institutions, but also and especially provides support for university-based, cutting-edge research and research enterprises, for cooperation between industry and science and for innovative business start-ups.

Germany has a federal system with the fundamental principle of subsidiary. Due to the decentralised character of the low-carbon transformation, the federal states have a great opportunity to influence the implementation. In general, all states have adopted their own climate targets, which differ greatly in their ambitions. Geographical circumstances, the structure of the local economy, and the respective state governments are important factors impacting this. While on one side a state-driven approach can lead to better fitting and more localised solutions (the phenomenon of federal governments being tempted to support local interests rather than the 'greater' plan of nationwide goals is also visible in the different resorts of the government. In §1 of the Energy Industry Act (Erneuerbare-Energien-Gesetz EnWG)[91], the objective to provide a safe, low-cost, consumer-friendly, efficient and environmentally compatible energy system was announced.

87 Kumara S; Loosenb M.; Madlenera R. Assessing the potential of low carbon technologies in the German energy system. Journal of Environmental Management Volume 262 2020.

88 Hansen, K.; Mathiesen, B.V.; Skov, I.R. Full energy system transition towards 100% renewable energy in Germany in 2050. Renew. Sustain. Energy Rev. 2019, 102, 1-13.

89 How much does Germany's energy transition cost? (2016). https://www.cleanenergywire.org/factsheets/how-much-does-germanys-energy-transition-cost

90 R&D policy framework. https://www.research-in-germany.org/en/research-landscape/r-and-d-policy-framework.html

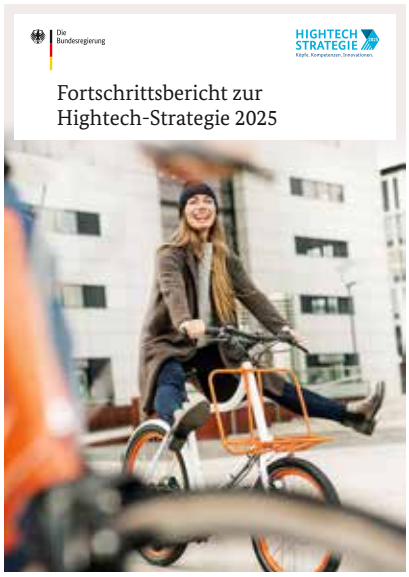
91 MJV. Erneuerbare-Energien-Gesetz-EEG 2017. 2014. Available online: https://www.bmwi.de/Redaktion/DE/Gesetze/Energie/EEG.html

In general, the German government is influenced by a range of different entities and serves as a hub for different interest groups. While there are top-down targets given by international agreements or EU-wide guidelines, there are also influences through established industry and demands by the public that need to be brought in line. Within the political system of Germany, the separation of power and the federal system lead to a discourse between many different departments entangled in multi-level governance. The discrepancy between pro-environment interests and the pro-economic interests of the ministries can be transferred to the economy itself[92].

Influencing policy usually occurs through lobbying by industry associations. Here, it can be clearly observed that associations linked to large and heavy industry such as the Federation of German Industries (BDI) (the so-called Federation of German Industries (BDI) has 100,000 members with a total of 8 million employees) have an influence on draft laws[93]. For instance, the BDI was working on an exemption from the EEG levy for energy-intensive companies in the amount of €5 billion in 2014, designed in a way that does not violate European state aid law. Yet, due to the heterogeneity of its members, the BDI also supports a low-carbon transformation. On the other side, associations supporting the benefitting sectors like the German Renewable Energy Federation (BEE) argue that the transformation would provide numerous jobs and the renewable energies sector itself is already an important factor in public wealth and development.

Finally, public opinion plays a major role in the success of the energy transformation. Unlike the industrial sector, the vast majority of people support the transformation: representative polls reveal levels of positive public agreement of up to 95% (AEE. 2017. "Repräsentative Umfrage: 95 Prozent der Deutschen wollen mehr Erneuerbare Energien")[94].

5.1.1.1 High-Tech Strategy 2025 (HTS 2025)/Hightech-Strategie 2025



The High-Tech Strategy 2025 (HTS 2025)[95] forms the strategic framework of the federal government's research and innovation policy. With this strategy, the German government is helping to meet the societal challenges of "Health and Care", "Sustainability, Climate Protection and Energy", "Mobility", "Urban and Rural Areas", "Safety and Security" and "Economy and work 4.0".

HTS 2025 also includes:

The Decarbonisation in Industry Funding Programme is designed to promote innovative technologies concerning process emissions, particularly in basic industries that hold the potential to make a decisive contribution to climate protection and to secure Germany's position as an industrial location in the long term.

92 Bartholdsen, H.-K.; Eidens, A.; Löffler, K.; Seehaus, F.; Wejda, F.; Burandt, T.; Oei, P.-Y.; Kemfert, C.; Hirschhausen, C.v. Pathways for Germany's low carbon Energy Transformation Towards 2050. Energies 2019, 12, 2988. https://doi.org/10.3390/en12152988

93 The Federation of German Industries. (2021). https://english.bdi.eu/bdi/about-us/#/article/news/the-federation-of-german-industries-bdi/

94 AEE. 2017. "Repräsentative Umfrage: 95 Prozent der Deutschen wollen mehr Erneuerbare Energien. https://www.unendlich-viel-energie.de/akzeptanzumfrage2017.

95 Hightech-Strategie 2025 (2020). www.bmbf.de > The new High-Tech-Strategy

The issues of alternative, pollution-free powertrains and electromobility remain the focus of the research and transfer tasks. Research into new energy storage systems for electric mobility will be stepped up to support the development of fuel cell production and promote the establishment of battery cell production in Germany.

In the H_2ORIZON Project (sector coupling of space, energy and transport on a megawatt scale), technologies for a complete hydrogen cycle will be developed and applied at the German Aerospace Centre (Deutsches Zentrum für Luft- und Raumfahrt; DLR) – from the generation of hydrogen by wind energy, to transport and storage, through to its use in fuel cells for mobility, for electricity and heat supply or for missile tests.

5.1.1.2 Strategy for the Internationalisation of Education, Science and Research

Drafted by the German Federal Ministry of Education and Research (BMBF)[96] and approved by the Federal Cabinet in February 2017, the Internationalisation Strategy[97] builds on and expands its predecessor from 2008. It forms the programmatic framework and the umbrella for the federal government's activities to promote international cooperation in education, science and research. With the guiding principle "International cooperation: networked and innovative", the strategy focuses on five key objectives:

- strengthening excellence through global cooperation,
- developing Germany's strength in innovation on the international stage,
- internationalising vocational training and qualification,
- working with emerging and developing countries to shape the global knowledge-based society, and
- overcoming global challenges together.

BMBF also addresses global challenges like climate change as well as health and food security which do not stop at national borders. They can only be successfully addressed by transnational efforts on the European and international levels. Education and research create the knowledge needed for evidence-based policies. The federal government will increase its efforts to ensure that barriers to effective research into global challenges are overcome and that relevant stakeholders on the European and international levels can interact more closely with each other.

96 Interntionalisation of Education, Science and Research (2017). https://www.bmbf.de/upload_filestore/pub/Internationalisation_Strategy.pdf

97 https://www.bmbf.de/upload_filestore/pub/Internationalisation_Strategy.pdf

5.1.1.3 Integrated National Energy and Climate Plan (NECP)/Integrierter NationalerEnergie- und Klimaplan

Germany's NECP aims for 65% renewable electricity and 30% renewable energy by 2030[98]. To meet these targets, Germany plans to expand its installed wind-energy capacities to 67–71 GW onshore and 20 GW offshore by 2030. For onshore wind where Germany has 53 GW today, this means building new wind farms and repowering existing wind farms, especially the large number of those that are coming off the feed-in tariff in the coming years.

In the area of Research, Innovation and Competitiveness, Germany, as is common with many EU countries, faces major challenges in the field of research and innovation in connection with its move towards greater use of clean and renewable energies within the framework of the energy transition.

According to the NECP, Germany expects to cover about 0.1% of its transport needs with hydrogen by 2030, and around 0.2% by 2040. The NECP does not provide hydrogen production targets nor specific hydrogen-related measures, although they are expected to be included in the upcoming hydrogen strategy.

5.1.1.4 Germany's National Hydrogen Strategy/Die Nationale Wasserstoffstrategie

Germany has set out to become a global leader in the associated hydrogen technologies and the government has drafted a National Hydrogen Strategy to fulfil these ambitions. This factsheet summarises the strategy National Hydrogen Strategy[99] approved by the government in 2020. The strategy 'merely' considers renewable hydrogen produced via electrolysis from renewable electricity as a sustainable long-term solution.

Its "aims and ambitions" are to:

- make hydrogen competitive by pushing cost reductions with a fast international market ramp-up, which would enable technological progress and scaling effects;
- develop a "home market" for hydrogen technologies in Germany and pave the way for imports. A strong domestic market also creates an important signalling effect for the use of hydrogen technologies abroad;
- establish hydrogen as an alternative energy carrier to enable the decarbonisation of hard-to-abate sectors;
- make hydrogen as a raw material for industry sustainable by switching the current production based on fossil energies to renewable energies, and pushing the decarbonisation of emission-intensive industry processes using hydrogen and its derivatives;
- enhance the transport and distribution infrastructure by using Germany's existing gas infrastructure, but also by extending dedicated hydrogen networks or building new ones;

98 Integrierter NationalerEnergie- und Klimaplan. (2020). https://ec.europa.eu/energy/sites/default/files/de_final_necp_main_de.pdf

99 National Hydrogen Strategy (2020). https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.pdf?__blob=publicationFile&v=14

- support research and train qualified personnel in order to systematically get industrial scale solutions to application maturity by 2030;
- design and accompany transformation processes in dialogue with businesses, science and citizens;
- strengthen the German economy and secure global market opportunities for German companies;
- establish international hydrogen markets and cooperation because Germany will have to import sizeable amounts of hydrogen in the medium and long term;
- understand global cooperation as an opportunity;
- further develop and secure quality infrastructure for hydrogen production, transport, storage and use and create confidence given the special physical and chemical properties of hydrogen; and
- constantly improve the framework conditions and take up current developments.

The strategy emphasises research as a strategic element underpinning energy and industrial policy. By developing long-term research and innovation programmes that cover the entire hydrogen value chain – from storage, transport and distribution all the way to its use.

To strengthen the position of German companies and research institutes with regard to hydrogen, they plan to more strongly focus on establishing new research institutes, setting up centres of excellence, and building educational and research capacity aimed at regions particularly affected by structural change.

5.1.1.5 Climate Action Programme 2030/Das Klimaschutzprogramm 2030

The Climate Action Programme 2030 comes as a supplement to the country's Climate Action Law as part of a comprehensive package to set Germany's climate policy on a new footing to include carbon pricing across sectors and a legal control mechanism intended to ensure continuous emissions reductions[100].

The 2030 climate targets stipulate a reduction of greenhouse gas levels by 55% below the 1990 levels, which means carbon emissions must fall from the about 866 tonnes per year in 2018 to 563 million tonnes by the end of the next decade. Meanwhile, Germany is set to miss its non-binding 2020 target, which calls for reducing emissions by 40%.

A major element of the Climate Action Programme 2030 is the proposal for a new national carbon pricing system that covers the transportation and buildings sectors. With the exception of aviation, these sectors are not currently covered by the existing European Emissions Trading System (ETS), which sets limits on carbon emissions from the energy sector and heavy industry.

Carbon storage and carbon utilisation technologies should be researched more, especially with respect to industry emissions that are difficult to avoid. The government says that these procedures are essentially "indispensable" for achieving climate-neutrality by 2050. It says it wishes to initiate a dialogue process with stakeholders to increase the acceptance of carbon storage. A possible storage location could be the "deep subsoil" of the North Sea Federal Climate Protection Act.

100 Climate Action Program (2021). https://www.bundesregierung.de/breg-en/issues/climate-action

5.1.1.6 Germany's Energy Efficiency Strategy 2050/Deutschlands Energieeffizienzstrategie 2050

Germany's Energy Efficiency Strategy 2050[101] is a document that sets out a long-term pathway for strengthening German energy efficiency policy. In this way, it also makes an appropriate contribution to achieving the EU's energy efficiency target (of reducing primary and final energy consumption by least 32.5% by 2030).

The Strategy establishes a new energy efficiency target for 2030, brings together the necessary measures in a new National Energy Efficiency Action Plan (NAPE 2.0) and contains guidelines for how the dialogue process on the Energy Efficiency Roadmap 2050 should be designed.

With the Strategy, Germany has set itself the goal of reducing greenhouse gas emissions by at least 55% by 2030 (compared to 1990 levels). To achieve its overall climate target for 2030, the country will have to both massively

expand renewables and significantly reduce its energy consumption. This two-pronged approach is the only way to ensure that the target is met in the most cost-effective and sustainable way possible.

The climate targets are therefore accompanied by ambitious efficiency targets: by 2050, Germany aims

to halve its primary energy consumption compared to 2008. In the last decade, energy demand has already been noticeably reduced. However, it is already apparent that Germany will have to make much faster progress on saving energy in all of the relevant areas if it wants to meet this efficiency target on time.

Industry, commerce, trade and services account for 45% of German final energy consumption. Although final energy productivity has increased by more than 10% since 2008, absolute energy consumption has remained constant. This makes it crucial to intensify efforts to

significantly increase energy efficiency in this sector. The Climate Action Programme 2030 is preparing the grounds for this.

To achieve the goals, the Strategy suggests that the key leverage for mitigating climate change can be derived from the decarbonisation of processes in primary industries, for example through the use of green hydrogen.

New funding programmes are to promote pioneering projects in this area.

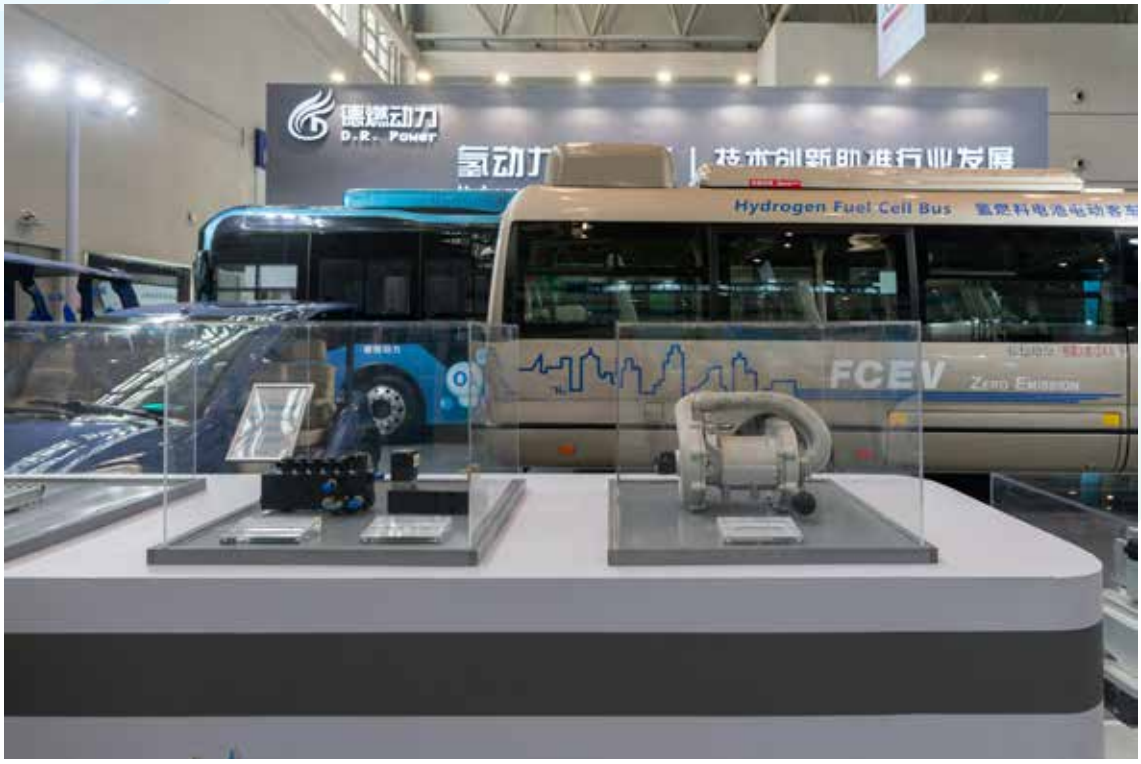
101 Germany's Energy Efficiency Strategy 2050 (2020). https://www.energypartnership.cn/fileadmin/user_upload/china/media_elements/Documents/200407_BMWi_Dossier_Energy_Efficiency_Strategy_2050.pdf

5.2 The People's Republic of China

5.2.1 Overview

China has become one of the largest emitters in the world via the 'high energy consumption, high GHG emissions' pathway since the reform and its opening up in 1978[102]. Especially between 2000 and 2015, the total amount of CO_2 of China was 101,840.9 Mt, roughly 19 times that of France. Moreover, China's CO_2 emissions have risen sharply compared with its own historical emissions. China's CO_2 emissions in 2015 were 10.6 times those in 1971, while China became the biggest carbon emitter in 2006. As a large emitter, China is devoted to solving the environmental problems related to global climate change by developing a low-carbon economy.

To achieve this, since 2005 climate change targets have been included in the China's Five-Year Plans. A number of climate change laws, policies and measures have also been introduced, including: energy conservation targets and associated accountability mechanisms for officials and state-owned enterprise (SOE) managers; frameworks for monitoring, reporting and verifying progress on energy conservation/efficiency; targets and support measures (e.g. feed-in tariffs; subsidised finance etc) for low-carbon energy; and, more recently, air-pollution-related restrictions on coal production and consumption in key regions.



In 2020, China promised to reduce its carbon emission intensity to 60%–65% of its 2005 levels and to achieve peak carbon emissions by approximately 2030. All of these efforts are aimed at the low-carbon economy transition of the whole of China and making China a leader in global

102 Wang S, Zhou D, Zhou P, Wang Q. CO2 emissions, energy consumption and economic growth in China: a panel data analysis. Energy Policy. 2011;39(9):4870–5.

climate governance. These actions and policies were mainly concentrated in the aspects of energy structure adjustment, industrial optimisation, low-carbon cities, the circular economy and low-carbon technology, carbon emissions trading markets, afforestation and carbon sink projects.

Carbon capture, use and storage (CCUS) is acknowledged as one of the key low-carbon technologies[103]. Moreover, in China great efforts have been devoted to CCUS after Chinese leaders attended the Forum of Leader Activity in 2003. In 2005, the Ministry of Science and Technology (MST) of China and the European Commission signed a Memorandum of Understanding on CCUS to achieve Near-Zero Emissions Cooperation on coal use. This cooperation will be carried out in three phases. First, conducting a pre-feasibility study on capacity-building and demonstration projects; second, carrying out a feasibility study on demonstration projects; and third, building and operating CCUS demonstration projects in China.

As a crucial part of the low-carbon economy, the circular economy was introduced to China in 2002 and the Circular Economy Law was issued in 2008. By 2009, there were a total of 178 Circular Economy Pilots in China[104].

5.2.1.1 Hydrogen Strategy

China's ambition to achieve peak emissions by 2030 and carbon neutrality by 2060 will accelerate the development of hydrogen as a fuel for power generation and vehicles. In 2018, hydrogen accounted for 2.7% of China's total energy mix, but that is estimated to rise to 4% per year, on average, between 2020 and 2025, according to the China Hydrogen Alliance (CHA) – a state-sponsored agency tasked to accelerate hydrogen developments in China.

To achieve these aims, China is drafting a plan to develop its hydrogen industry as it seeks to cut emissions. The strategy is being developed by the government's top economic planning agency, the National Development and Reform Commission, according to people familiar with the matter. The plan will focus on the cleanest form of the gas, or green hydrogen, which is produced from water using renewable energy, and will encourage the construction of more hydrogen stations to power vehicles, one official stated, asking not to be identified because the matter is not public. The plan included separate blueprints for energy sub-sectors from solar to geothermal and coal-bed methane, which were all published by the end of 2016, the first year of the period, or in early 2017.

5.2.1.2 China's Circular Economy – overview

China's consumption of the world's resources is reaching crisis levels. To produce 46% of global aluminium, 50% of steel and 60% of the world's cement1 in 2011, it consumed more raw materials than the 34 countries of the Organisation for Economic Co-operation and Development (OECD) combined: 25.2 billion tonnes. The country is taking action. Over the past decade, China has led the world in promoting the recirculation of waste materials by setting targets and adopting policies,

103Zhang Y, Da Y. The decomposition of energy-related carbon emission and its decoupling with economic growth in China. Renew Sust Energ Rev. 2015; 41:1255–66

104 National Development and Reform Commission. China's policies and actions for addressing climate change. 2012. https://qhs.ndrc.gov.cn/zcfg/201211/t20121122_515105.html.

financial measures and legislation. The ultimate goal is a 'circular economy' – closing industrial loops to turn outputs from one manufacturer into inputs for another. This approach reduces the consumption of virgin materials and the generation of waste[105].

To meet these goals, legislation has been implemented in the last decade that has been important for the development of China's circular economy. These are the Law for the Promotion of the Circular Economy, Circular Economy Development Strategies and Action Plan. A further reference to the CE can be found in Chapter 43 of China's Thirteenth Five-Year Plan (2016–2020), which validates the importance of CE as both a national policy and a fundamental pillar of the Chinese economy.

China still must do much more. It needs a national goal and a roadmap to achieve a level of resource intensity similar to that in OECD countries (currently around 0.5 kilograms per dollar of GDP). And it must champion regional and provincial achievements, giving rewards to eco-industrial parks that perform best. Data should be reported regularly. The SND data are 5 years old, for example. Upon seeing the fiscal benefits, companies should have incentives to release accurate data.

5.2.1.3 EU–China cooperation on research and climate change

The EU and China have long-standing cooperation on climate change and agreed to further step up their combined efforts. Since 2005, the EU–China Partnership on Climate Change Search for available translations of the preceding has provided a high-level political framework for cooperation and dialogue[106].

At the EU–China Summit in July 2018, both sides reaffirmed their commitment to advance implementation of the Paris Agreement and intensify their cooperation on climate change and clean energy. The EU and China agreed to strengthen bilateral cooperation for example on:

- long-term low greenhouse gas emissions development strategies;
- emissions trading;
- energy efficiency;
- clean energy;
- low-emissions transport;
- low-carbon cities;
- climate-related technology;
- investment in climate and clean energy projects; and
- cooperation with other developing countries.

105 Mathews, J., Tan, H. Circular economy: Lessons from China. Nature 531, 440–442 (2016). https://doi.org/10.1038/531440a

106 Keyou (Emma) Feng & Chun-Yin (Anson) Lam (2021) An Overview of Circular Economy in China: How the Current Challenges Shape the Plans for the Future, The Chinese Economy, DOI: 10.1080/10971475.2021.1875156

ANNEX 1 – TABLE OF EXISTING POLICIES IN THE EU, SLOVENIA AND AUSTRIA IN THE FIELD OF LOW-CARBON TECHNOLOGIES (WITH AN EMPHASIS ON HYDROGEN TECHNOLOGIES)

EU

EU Policy on research and technological development	
Strategic Energy Technology Plan (SET PLAN)	https://op.europa.eu/en/publication-detail/-/publication/064a025d-0703-11e8-b8f5-01aa75ed71a1
Smart specialisation	https://ec.europa.eu/regional_policy/sources/docgener/guides/smart_spec/strength_innov_regions_en.pdf
Horizon Europe	https://ec.europa.eu/info/sites/default/files/research_and_innovation/funding/documents/ec_rtd_horizon-europe-strategic-plan-2021-24.pdf
Innovation Fund	https://ec.europa.eu/clima/policies/innovation-fund_en

EU environmental policy	
Environment Action Programme to 2030 (EAP)	https://ec.europa.eu/environment/pdf/8EAP/2020/10/8EAP-draft.pdf
The Renewable Energy Directive, Directive (EU) 2018/2001 (RED II)	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=fr
EUROPEAN GREEN DEAL	https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
	Circular Economy Action Plan – for a cleaner and more competitive Europe https://ec.europa.eu/environment/pdf/circular-economy/new_circular_economy_action_plan.pdf
	A hydrogen strategy for a climate-neutral Europe https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf
	An EU Action Plan: Towards Zero Pollution for Air, Water and Soil https://ec.europa.eu/environment/pdf/zero-pollution-action-plan/communication_en.pdf
EU strategy for the Danube region (EUSDR) – Action plan	https://danube-region.eu/wp-content/uploads/2020/04/EUSDR-ACTION-PLAN-SWD202059-final.pdf

EU environmental policy	
National long-term strategies	https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en
National energy and climate plans (NECPs)	https://ec.europa.eu/energy/topics/energy-strategy/national-energy-climate-plans_en
2030 Climate Target Plan	https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en

SLO

Slovenian policy on research and technological development	
Research and Innovation Strategy of Slovenia (RISS 2011–2020)/Raziskovalna in inovacijska strategija Slovenije (RISS 2011-2020)	https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Zakonodaja/EN/Resolution-on-Research-and-Innovation-Strategy-of-Slovenia_2011-2020.pdf
Research Infrastructure Roadmap 2011–2020/ Načrt razvoja raziskovalnih infrastruktur 2011-2021	https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Zakonodaja/EN/Research-Infrastructure-Roadmap-2011-2020_2016-ENG.pdf
Slovenian smart specialisation strategy /Strategija pametne specializacije (S4)	https://www.gzs.si/srip-hrana/vsebina/English/Smart-Specialization Strategy

Slovenian environmental policy	
National energy efficiency action plan 2020/Akcijski načrt za energetsko učinkovitost za obdobje 2017–2020 (AN URE 2020)	http://www.energetika-portal.si/fileadmin/dokumenti/publikacije/an_ure/an_ure_2017-2020_final.pdf
Operational programme for measures to reduce greenhouse gas emissions by 2020/ Operativni program ukrepov zmanjšanja emisij toplogrednih plinov do leta 2020	https://www.gov.si/assets/ministrstva/MOP/Dokumenti/Podnebne-spremembe/optgp2020.pdf

Slovenian environmental policy	
Slovenian Development Strategy 2030/Strategija Slovenije 2030	https://www.gov.si/assets/vladne-sluzbe/SVRK/Strategija-razvoja-Slovenije-2030/Slovenian-Development-Strategy-2030.pdf
Slovenia's Long-Term Climate Strategy until 2050/Dolgoročna podnebna strategija Slovenije 2050	https://sloveniatimes.com/government-adopts-resolution-on-climate-neutrality-by-2050/
Integrated national energy and climate plan of the Republic of Slovenia/ Celoviti nacionalni energetski in podnebni načrt republike Slovenije (NEPN)	https://www.energetika-portal.si/dokumenti/strateski-razvojni-dokumenti/nacionalni-energetski-in-podnebni-nacrt/
A deep demonstration of a circular, regenerative and low-carbon economy in Slovenia/Razogljičenje Slovenije preko prehoda v nizkoogljično krožno gospodarstvo	https://www.climate-kic.org/news/slovenia-adopts-circular-regenerative-economies-deep-demonstration/
Resolution on the National Environmental Protection Programme for the period 2020–2030 (ReNPVO20-30)/Resolucija o nacionalnem programu varstva okolje 2020-2030 (ReNPVO20-30)	http://www.pisrs.si/Pis.web/pregledPredpisa?id=ODLO1985
Comprehensive strategic decarbonisation project/ Celoviti strateški project razogličenja	https://www.ekodezela.si/eko-okolje/ministrstva-pripravljajo-strateski-projekt-razogljicenja-slovenije/

AT

Austrian policy on research and technological development	
Research and innovation strategies for smart specialisation [RIS3]/ Integrative Strategien für intelligente Spezialisierung	https://www.bundeskanzleramt.gv.at/en/topics/rti-strategy.html
Research, Technology and Innovation Strategy of the Austrian Government 2030 (RTI Strategy 2030)/ Strategie der Bundesregierung für Forschung, Technologie und Innovation (FTI Strategie 2030)	https://www.fwf.ac.at/en/news-and-media-relations/news/detail/nid/20210119
Energy Research and Innovation Strategy (ERIS)/ ENERGIE Forschungs- und Innovationsstrategie (ERIS)	https://nachhaltigwirtschaften.at/resources/e2050_pdf/E-Forschung_Kurzfassung_englisch_v2.pdf

Austrian environmental policy	
Federal Climate Protection Act/Klimaschutzgesetz, KSG	https://www.gesetze-im-internet.de/englisch_ksg/englisch_ksg.html
Renewable Expansion Act/ Erneuerbaren-Ausbau-Gesetz – EAG	https://www.bmk.gv.at/service/presse/gewessler/20210317_eag.html
Austrian Climate and Energy Strategy #mission2030/Die Österreichische Klima – und Energiestrategie	https://gruenstattgrau.at/wp-content/uploads/2020/10/mission2030_oe_climatestrategy_ua.pdf
Long-Term Strategy 2050 – Langfristige Strategie – Zeithorizont 2050	https://unfccc.int/sites/default/files/resource/LTS1_Austria.pdf
Integrated National Energy and Climate Plan for Austria (NECP)/ Integrierter nationaler Energie- und Klimaplan für Österreich	lhttps://unfccc.int/sites/default/files/resource/LTS1_Austria.pdf
Hydrogen Initiative	http://h2est.ee/wp-content/uploads/2018/09/The-Hydrogen-Initiative.pdf

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This Cross-border Benchmarking Policy Analysis (the "Policy Analysis") overviews existing documents in the field of low-carbon technologies in Slovenia and Austria, with a focus on hydrogen technologies. Building on SWOT and PEST analysis, it identifies the gaps, advantages and opportunities of the cross-border region for creating a critical mass of research and implementation (R&I) capacities for the accelerated development of hydrogen technologies in the Slovenian and Austrian cross-border area. The Policy Analysis also presents good practices in developing hydrogen technology policies in the cases of Germany and China.

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