FORGING

INDUSTRY-ACADEMIA FORUM
TO UNCOVER THE POTENTIAL OF
EMERGING ENABLING TECHNOLOGIES

D1.2 Mapping of regional and EU Member States R&I priorities and programmes

GAC Group

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Deliverable abstract

The present document *D1.2* ***Mapping of regional and EU Member States R&I priorities and programmes*** provides a mapping of Research & Innovation (R&I) priorities and policies related to Industry 5.0 and/or emerging enabling technologies, implemented within the European Union (EU) Member States at national and where relevant at regional level.

The report aims at analysing potential alignment between regional and national **R&I strategies related to emerging enabling technologies, programmes and initiatives** and **European ones**. It provides insights of the consultation process that will be set up with regional & national bodies in charge of R&I programming, and initiatives and organisations with interest in emerging technologies for joint awareness raising, co-programming of activities, stakeholders' involvement and co-creation processes, to exploit possible synergies.

An outline of relevant R&I initiatives at EU level is featured to allow for a comparative analysis.

Keywords

R&I strategies and programmes, national and regional initiatives, R&I policymaking, Industry 4.0 and 5.0, emerging enabling technologies

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List of abbreviations

AI	Artificial Intelligence
CRT	Technological Resource Center (Finland)
CIPE	Interministerial Committee for Economic Planning (Italy)
CSO	Civil Society Organisation
DIH	Digital Innovation Hubs
EDP	Entrepreneurial Discovery Process
EC	European Commission
EIC	European Innovation Council
EIT	European Institute of Innovation & Technology
EFFRA	European Factories of the Future Research Association
ERDF	European Regional Development Fund
EU	European Union
FTZ	Free Technological Zones
HE	Horizon Europe
KET	Key Enabling Technologies
I3	Industrial Innovation Initiative
IRT	Technological Research Institutes
ITE	Institute for Energy Transition (Finland, France)
IoT	Internet of Things
MOSTA	Research and Higher Education Monitoring and Analysis Centre (Lithuania)
MS	Member States
NCBR	National Centre for Research and Development's (Poland)
NCES	National Climate and Energy Strategy (Finland)
NPR	National Programme for Research (Italy)
OP	Operational Programme
PPP	Private-Public Partnership
PNCTI	Science, Technology, and Innovation National Plan
PRI	Plan Régional pour l'innovation (Regional Innovation Plan, Belgium)
PPR	Priority Research Programmes
RHU	Hospital-university Research Institutes
RIS3	Research and Innovation Strategy for Smart Specialisation
RIV	Regional Innovation Valleys
RDI	Research, Development& Innovation
R&D	Research and Development
R&I	Research and Innovation
RRP	Recovery and resilience Plan
S3	Smart Specialisation Strategy
SATT	Transfer Acceleration Companies of Technologies
SIX	Sustainable Industry X (Finland)
SMEs	Small and medium-sized enterprises
SSH	Social Sciences and Humanities
S&T	Science and Technology
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
TIP	Territorial Innovation Platforms
TRC	Technological Resource Center

1 Executive Summary

Industry 5.0 “recognises the power of industry to achieve societal goals beyond jobs and growth, to become a resilient provider of prosperity, by making production respect the boundaries of our planet and placing the wellbeing of the industry worker at the centre of the production process. It complements the existing "Industry 4.0" paradigm by having research and innovation drive the transition to a sustainable, human-centric and resilient European industry. It moves focus from solely shareholder value to stakeholder value, for all concerned.”[1]

Alongside all research and innovation efforts developed in science and technology by researchers and entrepreneurs, R&I policies are a barometer to appraise the capacity of Member States to adopt emerging enabling technologies in their industries and accelerate the shift to Industry 5.0. This transformation to a more sustainable industry that is resource-efficient, human-centric and resilient requires pro-innovation policies that will support innovative companies, startups and key industrial players to be competitive while embedding human and environmental factors in their business models.

The present deliverable entitled “Mapping of regional and EU Member States R&I priorities and programmes” is part of the activity in the FORGING project that aims at setting up and developing an exchange with experts from academia and industry across Europe in order to foster the uptake of the Industry 5.0 concept [2]and the evolution of value sensitive innovation within the therein integrated technology frameworks.

Indeed, FORGING acknowledges that technological breakthroughs empowered by enabling technologies hold a transformation potential that can be funneled to address industrial and societal grand challenges, like greening and digitalisation. To exploit this transformative potential, it is considered that the innovation journey that leads new emerging technologies to their market-uptake shall embed value-sensitive considerations, such as environmental and societal implications. FORGING proposes a new methodology that breaks linear innovation trajectories to stimulate new technological visions and pathways attentive to the environment and society, and is human-centred in alignment with Industry 5.0 technological frameworks.

FORGING looks specifically into the technology frameworks of Human-centric solutions & human-machine-interaction; Bio-inspired technologies and smart materials**;** Real time-based digital twins and simulation**;** Cyber safe data transmission, storage & analysis technologies**;** Artificial intelligence**;** and Technologies for energy efficiency and trustworthy autonomy. Each technological area will be approached in co-creation activities involving experts from the FORGING Forum in early-co-creation sessions.

This report provides an overview of the strategies, programmes and initiatives developed in EU Member States to see where these align with the European Commission strategies related to Industry 5.0 and emerging enabling technologies which are underlying the FORGING project. It provides an overview of the R&I landscape in selected Member States looking at the priorities and policies implemented at national and regional level on emerging enabling technologies. The

[1] https://op.europa.eu/en/publication-detail/-/publication/468a892a-5097-11eb-b59f-01aa75ed71a1/

[2] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/industry-50-towards-more-sustainable-resilient-and-human-centric-industry-2021-01-07_en

present mapping provides examples of best practices already put in practice in different European regions and ultimately aims to seize the opportunity of creating links and exploiting synergies where relevant and possible.

The report aims to recognise potential alignment between R&I regional and national priorities and the EU policy framework that support the uptake of emerging technologies.

Consultation with regional & national bodies in charge of R&I programming will be carried out, and other initiatives or organisations with interest in emerging technologies for joint awareness raising, co-programming activities, stakeholders' involvement and co-creation processes, will be undertaken to exploit possible synergies. An outline of the R&I initiatives at EU level is featured to allow for comparative analysis.

2 Introduction

Artificial intelligence, Internet of Things, nanotechnologies, digital twins, bio-inspired materials - emerging enabling technologies are increasing their presence in our societies. These novel technologies are driving significant scientific and technological progress contributing to improvements of our lives while disrupting our current production models. Be it in health, agriculture, industry, environment, and in our daily lives, their field of application is extremely broad and has the potential to tackle the most pressing societal and environmental challenges.

FORGING elaborates on emerging enabling technologies which are a concept of the European Commission that spins from the initial Key Enabling Technologies (KET) concept.

According to the European Commission (EC), KET "drive innovation throughout the economy and cut across industries with a trend towards full convergence and integration. They underpin Europe leadership across industrial value chains such as the automotive and industrial robotics and have the capacity to improve people's health and safety and drastically reverse climate change"[3].

Europe prioritises 6 KETs considered as strategic areas:

- advanced manufacturing
- advanced materials
- life-science technologies
- micro/nano-electronics and photonics
- artificial intelligence
- security and connectivity

"Emerging technologies are technologies whose development, practical applications, or both are still largely unrealized. These technologies are generally new but also include older technologies finding new applications. Emerging technologies are often perceived as capable of changing the status quo"[4]. Despite a lack of consensus around the definition of emerging technologies, according to Daniele Rotolo, Diana Hicks, and Ben R. Martin, co-authors of the publication "What is an Emerging Technology"[5], some attributes help to qualify a technology that is emerging. These

[3]https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/key-enabling-technologies_en

[4] https://en.wikipedia.org/wiki/Emerging_technologies

[5] http://sro.sussex.ac.uk/id/eprint/56071/1/2015RP_Rotolo_Hicks_Martin_Preprint.pdf

are:"(i)radical novelty, (ii)relatively fast growth, (iii)coherence, (iv)prominent impact, and (v)uncertainty and ambiguity"[6].

FORGING looks specifically into 6 technological frameworks, notably Human-centric solutions & human-machine-interaction; Bio-inspired technologies and smart materials**;** Real time-based digital twins and simulation**;** Cyber safe data transmission, storage & analysis technologies**;** Artificial intelligence**;** and Technologies for energy efficiency and trustworthy autonomy. Each technological area will be approached in co-creation activities involving experts from the FORGING Forum in early-co-creation sessions.

While the benefits of these technologies seem evident, a deeper reflection of the risks of their use in society and the environment is required, especially if we consider the impact they may have on the most vulnerable layers of society, ethical questions or the risk of social isolation that some of these technologies may trigger. In this context, FORGING fuels the necessary discussion that underpins the shift to Industry 5.0 as it aims to embed the human and environmental considerations of these technologies ensuring their application will benefit the society at large, leaving no one behind, and will represent no harm to our planet and the environment.

3 Concept and methodology

The scope of the present activity is to conduct research of the regional and national priorities and programmes of 14 European Member States[7] previously identified for our analysis.
The underlying methodology consists in mapping EU countries representing the European geographical and economic diversity. Our selection reflects the 4 groups that fall into the categories of the European Innovation Scoreboard[8]: innovation leaders (Finland, Sweden, Belgium), strong innovators (France, Germany, Greece, Italy), moderate innovators (Lithuania, Portugal, Slovenia, Spain) and emerging innovators (Croatia, Hungary)[9].

In order to analyse the uptake of the concept of emerging technologies across European Member States, desktop research was conducted to identify key elements such as: national priorities and strategies, regional or national programmes implemented at Member State level. As the outcome, an overview of the agendas set up by the selected Member States to support the uptake of emerging technologies in their countries and their preparedness to shift to Industry 5.0.is provided

Next steps of this activity entail a consultation process consisting of exchange with representatives of regional & national bodies in charge of R&I programming to get their feedback on the programmes and priorities set up in their country. Initiatives and organisations related to emerging technologies that have been established on the basis of the national strategies and programmes may be consulted as well for joint awareness raising, co-programming activities, and to exploit possible synergies with these. Particular emphasis will be put on promoting the FORGING Forum to the programme holders and initiatives in the different EU countries.

[6] http://sro.sussex.ac.uk/id/eprint/56071/1/2015RP_Rotolo_Hicks_Martin_Preprint.pdf

[7] Belgium, Croatia, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Poland, Portugal, Slovenia, Spain, Sweden

[8] https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en

[9] "The European Innovation Scoreboard provides a comparative analysis of innovation performance in EU countries, other European countries, and regional neighbours. It helps countries assess the relative strengths and weaknesses of their national innovation systems and identify challenges that they need to address". Source: https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en

4 The EU R&I landscape for emerging enabling technologies in the EU landscape

European Research and Innovation priorities are driven by the twin transition[10] towards climate neutrality with the implementation of the European Green Deal[11] and digital leadership[12].Framework programmes from Horizon Europe, Digital Europe, EIC and EIT digital largely sustain the goals set by the European Commission to build a competitive and innovative industry which is at the same time sustainable and fair respecting planet boundaries.

The Digital Europe Programme provides strategic funding to projects in five key capacity areas: in supercomputing, artificial intelligence, cybersecurity, advanced digital skills, and ensuring a wide use of digital technologies across the economy and society, including through Digital Innovation Hubs.

EU strategies related to emerging technologies clearly aim to advance the shift from Industry 4.0 to Industry 5.0 fostering the advent of new disruptive technologies as a means to improve wellbeing and tackle the pressing challenges of our society.

Through the new European Innovation Agenda[13], launched in 2022 by the European Commission, the EU aims at positioning Europe as a global innovation leader. For Europe to thrive in this new deep tech wave and become "a world-leading innovation powerhouse", 5 flagships were set: help companies scale up; enable experimentation and public procurement; strengthen innovation ecosystems; attract new talent; and improve policymaking tools[14]. This will allow research, innovation and deep tech to embrace the vision of Industry 5.0, which clearly aims at serving the benefits of society and tackling pressing and complex challenges in different sectors such as health, agrifood, environment, and causing no harm to the environment.

With the purpose of pushing less advanced regions in Europe, and strengthening innovation in strategic priority areas, the EC has launched the Regional Innovation Valleys[15], a bid to designate 100 locations across Europe and encourage collaboration between more and less advanced regions. The idea is to combine EU research funding (HE) with regional development (I3) spending on innovation and maximise the impact of both funding streams through the synergies between the two.

[10] https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/twin-green-digital-transition-how-sustainable-digital-technologies-could-enable-carbon-neutral-eu-2022-06-29_en

[11] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

[12] https://digital-strategy.ec.europa.eu/en/activities/digital-programme

[13] https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-innovation-policy/new-european-innovation-agenda_en

[14] https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-innovation-policy/new-european-innovation-agenda_en

[15] https://eismea.ec.europa.eu/news/regional-innovation-valleys-calls-proposals-are-now-open-2023-05-17_en

4.1 Regional strategies at EU level

While the scope of this report is not to identify the regional R&I strategies at EU level, a couple of examples of regional strategies implemented across different regions of Europe are proposed to showcase their relevance in supporting the uptake of innovation and novel technologies.

What is "Smart Specialisation Strategy"?

Smart Specialisation Strategy[16] (S3) is the EU's principal methodology for reinforcing national and regional innovation eco-systems. It aims at strengthening regional innovation ecosystems so that they are better equipped to stimulate and sustain economic growth. They provide a framework for European Regional Development Fund (ERDF) support for research and innovation to the tune of an estimated EUR 56 billion for the 2021-2027 period. Thematic Smart Specialisation Platforms [17]and partnerships have also become key tools for connecting innovators with similar or complementary strengths and priorities in all Member States and regions, including in technology areas that are key for the twin green and digital transition.The European Union has requested the Regions, since the 2014-2020 programming of European funds, to develop a "Smart Specialisation Strategy" (known as S3) to guide its investments in research and innovation.
The principle of smart specialisation is based on the definition of strategic priorities in terms of innovation. These strategic innovation areas are defined according to the strengths of the territory and must meet the needs of companies to take advantage of market developments. European Regional Development Fund (ERDF) is dedicated to research and innovation focusing on targeted areas of innovation, to create a competitive advantage and improve the impact and visibility of European funding.

Country examples of Smart Specialisation Strategy and Strategic innovation areas are provided in the dedicated section of each of the selected countries.

Other initiatives at EU level

European Digital Innovation Hubs: These are initiatives that support digital innovation in SMEs and public administrations across all regions of the EU, by complementing national and regional digitalisation strategies, in order to help companies innovate and become more competitive using digital technologies.

In Belgium, new approaches were explored with the deployment of **sandbox** environments created by opening up data from knowledge institutes and companies, so that entrepreneurial citizens and small companies can develop and test new solutions. In 2021, Sci Mingo, one of the science policy actors launched with support of the Flemish Government a science communication academy where young PhD students and scientists can acquire the necessary science communication skills.

In Portugal, spaces aimed at helping small and medium-sized enterprises (SMEs) and the Portuguese public administration in the adoption of digital solutions were created, providing five core services: testing before investing - experiment with digital solutions and validate if they are applicable to the business. SMEs and Public Administration are only able to invest after evidencing that the solutions

[16] https://s3platform.jrc.ec.europa.eu/what-we-do
[17] https://s3platform.jrc.ec.europa.eu/home

enable them to be more competitive. These structures aim to break barriers, share knowledge, develop skills, and demonstrate solutions. Additionally, assistance is provided in obtaining financing, facilitating relationships and partnerships, and supporting entrepreneurship. Main services offered by this initiative are digital training, collaboration network with other peers, access to funding and support to incubation. Favourable conditions for entrepreneurship acceleration, hosting startups and support their incubation and growth are provided.

4.2 EU partnerships advancing the vision of Industry 5.0

Industry 5.0 presents an innovative, resilient, socio/human-centered, and competitive vision for European industry. To prioritise relevant R&I programmes at the EU level, several EU partnerships have been identified that closely align with FORGING's technological frameworks and embrace the vision of Industry 5.0.

In the table below, crucial information and links to the specific strategic research agendas of each partnership are provided. It is recognised that technology road mapping is an ongoing process subject to constant change therefore a snapshot is provided here with links to each research and innovation agenda and the partnership itself.

Partnership	**Key Digital Technologies Joint Undertaking - https://www.kdt-ju.europa.eu/**
Technology layers	- Process technology, equipment, materials and manufacturing - Components , modules and systems integrations - Embedded software and beyond - System of systems - Edge computing and embedded artificial intelligence (cross-sectorial) - Connectivity (cross-sectorial) - Architecture and design: methods and tools (cross-sectorial) - Quality, Reliability, safety and cybersecurity (cross-sectorial)
Strategic Research and Innovation agenda	https://www.kdt-ju.europa.eu/sites/default/files/2023-02/ECS-SRIA%202023.pdf
Type of partnership	Institutionalised. Public-Private Partnership for research, development and innovation – funds projects for assuring world-class expertise in these key enabling technologies, essential for Europe's competitive leadership in the era of the digital economy. KDT JU is the successor to the ECSEL JU programme, supporting its ongoing projects.
Funding opportunities available	Yes. The KDT JU Programme is open to any organisation that can make a contribution to the RD&I objectives of the programme. https://www.kdt-ju.europa.eu/current-call

Members or Partners	the EU, represented by the Commission; the following participating states: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden; the following industrial associations: EPoSS (https://www.smart-systems-integration.org/), AENEAS (https://aeneas-office.org/) and INSIDE (https://www.inside-association.eu/)

Partnership	**ADR Association - https://adr-association.eu/**
Technology layers	Cross-sectorial AI, Data and Robotics technology enablers: - sensing and perception, - knowledge and learning, - reasoning and decision making, - action and interaction, - systems, methodologies, hardware and tools
Strategic Research and Innovation agenda	https://adr-association.eu/wp-content/uploads/2020/09/AI-Data-Robotics-Partnership-SRIDA-V3.0-1.pdf
Type of partnership	Public Private Partnerships
Funding opportunities available	No
Members or Partners	Industrial and research members, founding associations: Big data value association (www.bdva.eu), Confederation of laboratories for artificial intelligence research in Europe (claire-ai.org), European laboratory for learning and intelligent systems (ellis.eu), European association for artificial intelligence (www.eurai.org), European robotics association (www.eu-robotics.net)

Partnership	**European Smart Networks and Services Joint Undertaking - https://smart-networks.europa.eu/**
Technology layers	A- Human-centric and vertical services, - system architecture, - edge-computing and meta-data, - radio technology and signal processing, - optical networks, - network and service security, - satellite communications technologies, - opportunities for devices and components
Strategic Research and Innovation agenda	https://smart-networks.europa.eu/wp-content/uploads/2022/11/networld2020-sria-2020-final-version-2.2-_compressed.pdf
Type of partnership	Institutionalised. Public Private Partnership

Funding opportunities available	Yes. The European Smart Networks and Services Joint Undertaking (SNS JU) is a Public-Private Partnership that aims to facilitate and develop industrial leadership in Europe in 5G and 6G networks and services.
Members or Partners	The EU, and the The 6G Smart Networks and Services Industry Association (6G-IA) https://6g-ia.eu/

Partnership	**European Partnership Made in Europe - https://www.effra.eu/made-in-europe-state-play**
Technology layers	• Advanced smart material and product processing technologies, and process chains (additive manufacturing, joining, shaping, structuring, surface tailoring, etc.) • Smart mechatronic systems, devices and components • Intelligent and autonomous handling, robotics, assembly and logistic technologies • De-manufacturing, recycling technologies, and life-cycle analysis approaches • Simulation and modelling (digital twins) covering the material processing level up to manufacturing system, and factory and value network level from design until recycling. • Robust and secure industrial real-time communication technologies, and distributed control architectures and standardized equipment protocols as OPC-UA • Data analytics, artificial intelligence, machine learning and deployment of digital platforms for data management and sharing • New business and new organisational approaches, including links with regulatory aspects such as safety, data ownership, and liability • A skilled workforce • Standards
Strategic Research and Innovation agenda	https://www.effra.eu/sites/default/files/made_in_europe-sria.pdf
Type of partnership	PPP between European Commission, Member States and EFFRA. The European Factories of the Future Research Association (EFFRA) is a non-for-profit, industry-driven association promoting the development of new and innovative production technologies.
Funding opportunities available	Yes.
Members or Partners	European Commission, Member States and EFFRA

Partnership	**New European BAUHAUS - https://new-european-bauhaus.europa.eu/index_en**
Technology layers	No targeted technology layers. The New European Bauhaus (NEB) was launched to translate the European Green Deal into tangible change on the ground that improves our daily life, in buildings, in public spaces, but also in fashion or furniture.

Strategic Research and Innovation agenda	The New European Bauhaus opened its activities by proposing a series of conversations on the places we inhabit and on our relationship with natural environments, beyond the built space. It was an attempt to discover beautiful, sustainable and inclusive ways of living and to use them to inspire our way forward.
Type of partnership	The New European Bauhaus is a creative and interdisciplinary initiative that connects the European Green Deal to our living spaces and experiences.
Funding opportunities available	Yes. - New European Bauhaus Prizes (https://prizes.new-european-bauhaus.eu/) Although NEB has no specific EU programme at its disposal, over 100 million Euros were already invested into NEB projects supported by different MFF programmes such as Horizon Europe, the European Regional Development Fund (ERDF), LIFE, the Single Market Programme and Digital Europe (https://new-european-bauhaus.europa
Members or Partners	EU Comprehensive list of partners available here: https://new-european-bauhaus.europa.eu/about/official-partners_en

5 Emerging enabling technologies reflected in EU Member States' national and regional policies

In this section, an overview at different Member States (MS) is outlined with a lens on research & innovation priorities in the context of emerging technologies.

What is the strategy implemented at national level to push the uptake of emerging technologies? Is there a common harmonized approach in the different Member States when we talk about Industry 5.0.? Are these programmes aligned with the EU policy goals?

Fourteen European countries have been selected as examples of the EU geographical diversity, reflecting the 4 groups that fall into the categories of the European Innovation Scoreboard[18]: innovation leaders (Belgium, Finland, Sweden), strong innovators (France, Germany, Italy), moderate innovators (Greece, Lithuania, Portugal, Slovenia, Spain) and emerging innovators (Croatia, Hungary, Poland).

The present analysis aims to identify how the uptake of emerging technologies is reflected in Member States' national and regional policies. Key priorities and most relevant programmes related to emerging technologies at national and regional levels are mapped in those selected countries to provide an overview of the level of adoption of these technologies and their industry-specific use cases in Member States.

[18] https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en

The outcomes of the comparative analysis are further summarized in chapter 6.

5.1 Belgium

In Belgium, most of the research and innovation competences actually belong to the Regional and Community level. Science, Technology and Innovation (STI) is managed at different levels: in terms of legislation and budget, scientific research is mainly a community competence, whereas innovation is almost completely a regional competence. In Belgium, almost 80% of the total public R&D&I support is managed by the Communities and Regions[19].

Flanders R&I policy
In its **Innovation Pact of 2003** and on subsequent occasions (Pact 2020, Flanders in Action, Vision 2050) the Flemish Government has stated its ambition to reach a 3% R&D-intensity, thus subscribing to the Europe 2020 3%-target. The R&D effort for Flanders represented almost two-thirds of the GERD for the whole of Belgium in 2019. Flanders ranks higher than Austria, Germany, the USA and the EU-27 average. A total of 76% of the funding come from private funding and 24% from the public sector. Since 2018 **calls for Citizen Science** project proposals are launched regularly in collaboration with Scivil, the knowledge centre for Citizen Science.

'Industry 4.0' boosts the transition to data-driven local industry that is internationally competitive. Flanders Make is focusing on industry-driven technological research and is an essential lever for underpinning the transition to Industry 4.0. As a strategic research centre, **Flanders Make** works on **production monitoring, artificial intelligence and robots**. The research results are applicable for SMEs and large companies in Flanders, as well as in the social economy. This promotes product and production innovation in key sectors in Flanders, such as the automotive and engineering industries. These innovations will lead to greater quality, more sustainability and higher productivity. In order to strengthen the research power of Flanders Make, an additional €6.5 million are allocated.
Scientific projects rely on the active participation of citizens for data gathering and data processing. Researchers from universities, university colleges and research centres initiate the projects. They collaborate with trained science communicators to reach and to engage the general public. In 2018 the FWO and the Royal Academy of sciences launched a comprehensive project "Science Agenda: people's questions to scientists"[20]. They collected 10,559 questions which were categorized in 5 clusters: society, science and technology, biology, health and medicine and culture. From 2019 onwards these themes were further elaborated both in science policy (**artificial intelligence, cybersecurity, personalised medicine**) as in new science communication initiatives: science podcasts, video's "Science figured out", blogs etc.

Research organisations (Antwerp, Brussels, Ghent, Leuven, Hasselt) are also **funding sources**. Information relating to on-going research conducted at the Flemish universities can be consulted via the Flanders Research Information Space research portal (FRIS)[21]. A second group of key research actors are the strategic research centres (4 in Flanders). Imec (Interuniversity Microelectronics Centre) is a world-leading research and innovation hub in nanoelectronics and digital technologies, employing around 4,000 researchers. It creates disruptive innovation in application domains such as healthcare,

[19] https://dermine.belgium.be/sites/default/files/articles/FR%20-%20Plan%20national%20pour%20la%20reprise%20et%20la%20résilience.pdf
[20] https://www.fwo.be/media/1023943/vwa_booklet_eng.pdf
[21] www.researchportal.be

smart cities and mobility, logistics and manufacturing, energy and education. The Flemish Institute for Biotechnology (VIB) is an independent research institute where 1,700 top scientists from Belgium and abroad conduct pioneering basic research in domains such as **brain & disease research, cancer biology, microbiology, molecular neurology** or inflammation research. The Flemish Institute for Technological Research is an independent research centre in the area of clean tech and sustainable development. **Flanders Make** is the Flemish strategic research centre fostering production innovation in the manufacturing industry, thus supporting the further **digital transition towards Industry 4.0** and strengthening its international competitiveness.

Several initiatives aim at better diffusing technology and deepening links between innovative companies and researchers. Support is available to companies, institutions, networks and researchers. Promotional campaigns, such as "**Ik innoveer!" - "I innovate**!" have been set up to enhance innovation among smaller and less-technological firms. Other examples to stimulate innovation are:

- Baekeland mandates allowing researchers to research with a specific business-oriented purpose in close relation with the business,
- TETRA Fund aimed at applied-research projects,
- support for the universities to professionalise knowledge diffusion towards SME's "Blikopener" ("Mind opener"),
- 'Collective Research & Development and Collective Knowledge Dissemination/Transfer (COOCK)' is a policy instrument that focuses on groups of companies, for the valorisation of research results by accelerating the introduction of technology and/or knowledge,
- **Living Laboratories, or test beds (**"Proeftuinen"): These are structured test environments in which organisations can test innovative technologies, products, services and concepts, using samples of individuals, who are used as testers in their normal living and working environments. Current Living Labs operate in the fields of **Industry 4.0 and Smart cities**.

Cluster policy is an important instrument. Flanders has 7 large-scale spearhead clusters: **Catalisti (sustainable chemistry), Flanders' Food (agro-food), Strategic Initiative Materials (advanced materials), Flanders Logistics Cluster, Flux50 (energy), the Blue Cluster (sea-related activities) and HealthTech Flanders (personalised medicine)**. The objective of the cluster policy, approved on 4 March 2016 by the Flemish government, was to unlock untapped economic potential and to increase the competitiveness of Flemish companies through cooperation between actors and focus on partnerships between Flemish companies.

R&I policy in the region of Brussels

The Brussels Capital Region is a small knowledge-intensive city-region, with a vibrant R&I ecosystem that warrants substantial leverage for economic and social development[22]: it hosts 51 higher education institutions, three of the seven Belgian university hospitals, a large number of researchers, a highly educated population, the region is a forerunner in the digital and health sector, a tech-start-up hub and contains the highest number of start-ups per capita in Europe.

The regional R&I funding agency **Innoviris** aims to maximise the leverage potential of the investment in research and innovation. To this end, a **Smart Specialisation Strategy** was adopted in 2006, which

[22] https://innoviris.brussels/

was developed via an *Entrepreneurial Discovery Process* (EDP) in the elaboration of the Regional Innovation Plan (RIP).

The most recent **Regional Innovation Plan**[23] encompasses three strategic domains that reflect the strengths of the region and refine the initial domains defined in 2006: **personalised medicine and well-being** (bioinformatics, clinical studies, medical devices, etc.), **green economy** (ecological building, sustainable chemistry, circular economy, etc.) and **digital economy** (big data, SaaS, IoT, information security, etc.). All were identified through discussions with more than 200 actors: entrepreneurial agents on the one hand (entrepreneurs, university colleges, universities, public research institutions, professional associations) and policy and society representatives on the other hand. The **Smart Specialisation Strategy** has also been adopted by the regional operational plan for ERDF 2014-2020, to ensure consistent regional policies and increase the local growth and development potential of the aforementioned areas.

Priorities in Brussels regarding the digital technologies are:

- **Cybersecurity**: the issue of IT security (technical and user) is becoming central in federal organisations.
- **Quantum computing**: although the "quantum computing" technology is still in its development phase, it can revolutionise the way computing resources are used by 2030/2035.
- **Cloud computing** and new tools: the evolution of IT technologies forces departments to question technological choices that have been made for many years in order to turn to new, more agile and flexible solutions;
- **Digital divide**: part of the population, which is shrinking from year to year, has still not entered the all-digital era and the region should continue to deliver services to the population in the traditional way, even if it becomes an exceptional procedure to help this part of the population to enter the all-digital era.

In recent years, the policy-oriented **programme Anticipate** allowed to define topics such as *making invisible populations visible*, *governance of the future* and *tourism and quality of life in the city.* Eleven academic research projects, with 21 partners (and in collaboration with government administrations), are currently running these topics. Several projects are related to the three strategic domains, including ***green chemistry, artificial intelligence, personalised medicine*, and *circular economy***, each of which was the subject of a specific call.

Wallonia R&I policy

In Wallonia, R&I policy is managed by the regional administration for research (Service Public de Wallonie – Economie, Emploi & Recherche, SPW-EER) under the responsibility of the Minister of Economy. The SPW EER supports, values and evaluates applied research projects of companies, universities, universities and research centers, through direct aids or calls for projects. The Walloon government has defined a policy in the frame of the digital strategy of Wallonia, in synergy with the initiative AI4BELGIUM[24] - a coalition that brings together the public and private sector, academia and civil society - and the European approach on Artificial Intelligence.[25]

Since 2006, the Walloon Government has set up a **cluster policy** composed of 6 competitive clusters in key sectors for the Walloon Economy: agrifood industry, life-science and pharma, mechanical

[23] https://innoviris.brussels/fr/plan-regional-innovation
[24] https://ai4belgium.be/
[25] https://www.digitalwallonia.be/fr/publications/kickoff-digitalwallonia4ai/

engineering, space and aeronautics, sustainable building and chemistry and transport, logistics and mobility.

5.2 Croatia

Croatia is still in its infancy in terms of defining a coherent research and innovation agenda in general as they are at the stage of shaping an enabling legal framework for research and innovation activities. There is also a mapping exercise on Croatian scientific activities in execution. Foresight methodologies are being used to map scientific and technological developments and are expected to identify areas of science and technology with the highest potential for growth based on current comparative advantages and prerequisites for their smooth development over the next 5-15 years. This will enable the adoption and/or revision of strategic documents and the directing of investments that will contribute to the development of products, services and processes of high added value and to the increase of the competitiveness of Croatian science and economy. Scientific and technological forecasting will provide an overview of possible areas of investment and development and will enable a more efficient alignment of development priorities and investment, recognition and technology in the Republic of Croatia. The country has not yet established emerging enabling technology strategies but is working towards them.

The Croatian government has set up a national development strategy for 2030 that addresses the following research directives[26]:

- Sustainable economy and society
- Crisis response resilience
- Green and digital transition
- Coherent regional development

The strategy aims to focus on research development, specially in the following areas:

- stimulate R&D in companies
- modernize academic research legislation to enable knowledge creation and sharing, innovation and successful commercialization.
- research capacity development in STEM
- research infrastructure investment
- digital transformation of science
- innovation ecosystem support, especially in the areas of ICT, AI and robotics, biotechnology and green technologies.

The financial institutions in charge of funding is the Croatian Bank for Reconstruction and Development[27] is the development and export bank and export credit agency of the Republic of Croatia whose main task is to promote the development of the Croatian economy. In order to financially fund and support innovation businesses, a Venture Capital fund has been created, named FRC2 Croatia Partners SCSp VC fund.[28]

[26] https://hrvatska2030.hr
[27] https://www.hbor.hr/en/about-us/
[28] https://www.hbor.hr/en/frc2-croatia-partners/

5.3 Finland

In Finland, the National Roadmap for Research, Development, and Innovation, which was adopted by the Government in 2020[29], consists of a set of measures aimed at developing the operating environment for RDI. The roadmap provides guidelines for sustainable growth[30], increased R&D activities, and improved wellbeing[31]. The ultimate goal is to raise R&D expenditure to 4% of GDP by 2030.

The roadmap not only focuses on increasing the quantity and quality of RDI activities but also aims to strengthen competence centres and ecosystems, enhance cooperation among R&D actors, and expand the role of the public sector in driving and utilising innovation. These measures aim at elevating competence levels, enhance the international appeal of Finland's RDI environment, and encourage companies to invest more in RDI activities within the country. The strategic priorities of the RDI roadmap include competence, partnerships, and public sector innovativeness.

The Finnish government has set up a parliamentary RDI working group, appointed by the Prime Minister's Office, to examine the increase in public R&D funding. The group's report explores ways to strengthen long-term commitment to increased public research and development funding. They have also established key principles for the development of the RDI system, including predictability and long-term vision, leverage, comprehensiveness, scientific freedom, high-quality research and education, effectiveness, competitiveness, cooperation, internationalisation, recognition of global challenges, and technology neutrality.

The Parliamentary Working Group on Research, Development, and Innovation (RDI) sets objectives for the allocation of research and development funding in Finland. In addition to funding proposals, the working group makes recommendations to strengthen the management of the RDI system, enhance the availability of R&D skills and labour force, promote cooperation, make strategic decisions at the national level, evaluate the effectiveness of R&D funding, and create a favourable environment for research and innovation. The working group's efforts are based on the Act on Research and Development Funding, which came into effect on January 1, 2023, and will lead to a significant increase in state funding for R&D from 2024 to 2030.

The Multi-annual plan for the use of research and development funding[32] emphasises the need to develop the RDI system and R&D funding in a balanced manner over the long term. The shortage of skilled labour and the availability of an R&D workforce pose significant challenges to the Finnish RDI system. To support the targeted growth in RDI activities, investments are called for in higher education, increasing the number of R&D personnel, particularly those with PhD-level expertise. The working group recommends the initiation of a process to determine Finland's national R&D priorities and make strategic choices regarding RDI activities. Enabled by this high-level operational framework, several domain specific national strategies provide more concrete pathways for operationalisation.

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[29] National Roadmap for Research, Development and Innovation, https://tem.fi/documents/1410877/2095051/Updated+RDI+Roadmap+2021.pdf/550bffa3-331b-b94c-ebff-8b442fe7b184/Updated+RDI+Roadmap+2021.pdf?t=1643278753288

[30] Sustainable Growth Programme for Finland, https://vm.fi/en/sustainable-growth-programme-for-finland

[31] The Finnish Sustainable Growth Programme focuses on 6 key elements: Green transition supporting structural adjustment of the economy and underpinning a carbon-neutral welfare society; Digitalisation and a digital economy strengthening productivity and making services available to all; Raising the employment rate and skill levels will accelerate sustainable growth; Access to health and social services will be improved and their cost-effectiveness enhanced.

[32] Multi-annual plan for the use of research and development funding, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/165008/VN_2023_56.pdf?sequence=4&isAllowed=y

Bio-inspired technologies and smart materials

The Finnish Bioeconomy Strategy[33] aims to double the value added of the bioeconomy in a sustainable manner and achieve climate neutrality by 2035. The bioeconomy sector is of significant importance to Finland, as it contributed 13% of the national economy's value added, amounting to EUR 26 billion in 2019. The strategy emphasises the implementation of bioeconomy in a resource-wise manner through the operationalisation of circular economy. It aligns with the green transition goals of Finland and the European Union. The strategy focuses on increasing the value added, particularly by highlighting the use of new bio-based products in industries such as textiles, pharmaceuticals, and even battery materials. All these efforts are based on sustainable utilisation of renewable raw materials. According to the strategy document, bioeconomy involves the sustainable use of renewable natural materials, as well as the development and deployment of related innovations and technologies. In Finland, bioeconomy also encompasses services that utilise nature, such as nature tourism.

The Finnish Bioeconomy Strategy was drawn up by the Ministry of Agriculture and Forestry, the Ministry of Employment and the Economy, and the Ministry of the Environment in 2014, and updated in 2022. Increasing the value added of bioeconomy is recognised as a crucial priority that other strategies did not adequately address. The strategy's measures align with the objectives of various other strategies, including the Forest Strategy, the Industrial Strategy, and the EU Clean Planet for All strategy. The strategy's measures are categorized into four main areas: 1) higher value added from bioeconomy, 2) a strong knowledge and technology base, 3) a competitive operating environment, and 4) usability and sustainability of bioresources and other ecosystem services[34].

The Bioeconomy Strategy sets objectives to be achieved by 2035, including doubling the value added of bioeconomy, generating competitive and innovative solutions to global challenges, promoting business growth domestically and internationally, increasing resource-wise use and recycling of materials, reducing dependence on fossil fuels and non-renewable resources, ensuring ecological sustainability, social justice, and the renewal capacity of renewable resources, and enhancing competence in the bioeconomy.

To increase the value added of the bioeconomy, the strategy includes measures such as implementing an RDI (research, development, and innovation) program for the green transition of the bioeconomy. It also aims to facilitate the establishment of innovative pilot and demonstration facilities, as well as the construction of the first industrial-scale plants in Finland. Funding for these measures will be provided through the Sustainable Growth Programme for Finland. The implementation of the strategy will involve collaboration among several ministries and stakeholders. The regions of Finland play a crucial role in achieving the strategy's objectives and are encouraged to develop their own bioeconomy action plans.

Cyber safe data transmission, storage and analysis technologies

A national coalition called 6G Finland[35] has been established by several Finnish research institutes and companies involved in 6G research and development. The primary objective of this initiative is to

[33] The Finnish Bioeconomy Strategy. Sustainably towards higher value added - http://urn.fi/URN:ISBN:978-952-383-579-5

[34] The strategy also includes specific measures tailored to different sectors. To increase value added, the strategy aims to develop new raw materials, manufacturing methods, products, and services. It also seeks to improve resource efficiency, utilize side streams and circular economy models, and explore promising developments in sectors such as forestry, food and energy production, pharmaceuticals, chemicals, textiles, water supply, fisheries, aquaculture, tourism services, and the natural products sector.

[35] 6G Bridge Program, https://www.businessfinland.fi/en/for-finnish-customers/services/programs/6g-bridge

enhance Finland's competitiveness in the emerging field of 6G, which is still in the process of being standardised.

The coalition aims to achieve its goals by forging new international partnerships, intensifying national cooperation on 6G through more coordinated actions, and amplifying the global impact of Finnish expertise in 6G. The founding members of 6G Finland include renowned educational institutions such as Aalto University, University of Helsinki, Lappeenranta-Lahti University of Technology, University of Oulu, University of Tampere, and Oulu University of Applied Sciences. Leading companies and research centers, namely Nokia Bell Labs, VTT Technical Research Centre of Finland, Finnish Defense Research Agency, and Business Oulu, are also part of the coalition.

One of the initial steps for 6G Finland is to develop a research and development roadmap focused on the most important shared priorities. The coalition also aims to serve as a national contact point for Finnish 6G knowledge and actively participate in 6G discussions both domestically and internationally. Finland has been at the forefront of 6G research, with the launch of the **6G Flagship initiative in 2018**[36]. Additionally, Finland leads the European 6G flagship initiative called Hexa-X, which is funded by the European Union. The Finnish government has prioritised the establishment of a national 6G test network as part of the Rapid Recovery Funds (RRF) program. Furthermore, Finland has launched the 6G Finland initiative[37] to bring together all relevant stakeholders in 6G research, development, and innovation (RDI) efforts.

Business Finland launched the 6G national research program to support these goals through funding collaboration. The program goals are increasing ecosystem-driven collaboration in research and innovation for 5GA/6G; building future business ecosystems in 5GA/6G and attracting international investments; strengthening the key capabilities in 5GA/6G; and fostering testing and experimentation facilities in 6G. The programme is focused in the context of industry verticals including smart cities, smart energy, smart ports and smart factories with different ecosystem players.

Human-centric solutions and human-machine interaction

Finland has developed a national strategic roadmap called the Digital Compass[38] , which extends until 2030 and provides guidance for Finland's digital transformation and development. The digital compass establishes national objectives for human-centric effective utilisation of digital systems to ensure Finland's success in the ongoing transformation. It aims to enhance the understanding of the benefits, concepts, and direction of digitalisation and the data economy. The digital compass sets ambitious targets and a vision to strengthen Finland's position among the leading countries in digital development. Reliable communication networks and seamless data flow provide the foundation for services and innovations in the current technological transformation. However, challenges include low investment in ICT for productivity, a shortage of skilled professionals, marginalisation, and the necessary changes in operating culture and paradigms brought about by digitalisation. To address these challenges, the plan outlines areas of focus encompassing the development of diverse skills among citizens and enhancing the digital capacity of small and medium-sized enterprises. Additional investments in skills, research, development, innovation, and attracting investment are identified as crucial for achieving this transformation.

Finland's Digital Compass builds upon the EU's Digital Compass introduced in 2021 and incorporates national targets and themes that complement the EU's compass. Finland aims to be the first Member State to develop a national strategic roadmap. The compass revolves around four key areas: skills,

[36] Oulu 6G-Enabled Wireless Smart Society & Ecosystem, https://www.6gflagship.com/about-us/

[37] https://www.businessfinland.fi/en/for-finnish-customers/services/programs/6g-bridge

[38] Digital Compass, https://julkaisut.valtioneuvosto.fi/handle/10024/164472

secure and sustainable digital infrastructures, the digital transformation of businesses, and the digitalisation of public services. Finland's targets in the digital compass are more ambitious than those set by the EU. The implementation of the digital compass aligns with the EU's objectives while addressing Finland's specific national goals and priorities. It recognises the importance of skills development, reliable digital infrastructure, digital transformation in businesses, and improving public services through digitalisation.

Artificial Intelligence

Finland's Artificial Intelligence 4.0 programme[39], based on a national AI strategy formulated in 2017, aims to position Finnish industry as a leader in sustainability, renewal capacity, technological leadership, and solutions that promote carbon reduction by 2030[40]. The program's interim report presents concrete objectives and proposed measures to achieve the AI vision for 2030. The goal is for Finnish small and medium-sized enterprises (SMEs) to lead digitalisation on an international scale. The programme emphasises that the green and digital transitions are crucial for sustainable development and economic competitiveness. It specifically focuses on digitalising manufacturing companies and revitalising value creation. Key assets of Finnish industry include sustainability, renewal capacity, and technological leadership. However, maintaining Finland's position as a leading country in technology and AI requires concrete and comprehensive actions. The programme's thematic sub-groups, in collaboration with stakeholders, have identified objectives, key results, measures, and indicators necessary for achieving the vision.

The interim report presents a set of proposals for Finland to become a winner in the twin transition by 2030. To maintain leadership in AI, Finland must increase investments in new competencies and key technologies, such as those related to the data economy, value creation through data, high-performance computing, and the integration of network technology and AI. Additionally, attracting international talent is crucial.

Combining nature smartness (using products and solutions to create economic, social, and environmental benefits) with digital technology is vital for achieving a triple victory in sustainable development. This triple victory entails economic growth, higher employment and well-being, and climate and environmental benefits. Finally, the programme recognises that small and medium-sized industrial companies play a significant role in Finland's economy. Their sustainable development relies on leveraging new technologies to enhance productivity, competitiveness, and environmental sustainability.

Real time-based digital twins and simulation

Sustainable Industry X (SIX)[41] is a Finnish, industry-driven initiative shaping and implementing next-gen green and digital industry agenda in practice. SIX provides essential tools for forming a joint agenda from national level strategies and implementing that agenda in an industry- driven way. In practice it forms a continuous industry driven implementation chain from strategic level to factory floors and products. Sustainable Industry X Research Ecosystem (SIRE)[42]: Strategic Research and Innovation Agenda describes the major challenges, intended impacts and medium to long-term R&D&I themes to tackle them, in the domains of the Green, Circular Economy, and Sustainable Digital Transformation.

[39] Finnish Artificial Intelligence Program, https://julkaisut.valtioneuvosto.fi/handle/10024/163693
[40] Finnish AI Region, https://www.fairedih.fi/en/frontpage/
[41] https://www.six.fi/smart-manufacturing
[42] Sustainable Industry X Research Ecosystem (SIRE): Strategic Research and Innovation Agenda, https://cris.vtt.fi/ws/portalfiles/portal/78548913/SIE_SRIA_21_Dec_2022_Final.pdf

The horizon is that Finnish manufacturing industry in 2030 and beyond will be a globally competitive, interconnected and adaptive sociotechnical value creation system that ensures sustainable growth and social welfare, in a resource-constrained world.

Digital twins are featured as a key technology that fosters innovation by providing a testbed for the development and validation of new products, services, and technologies. They are prioritised for enabling companies to model and evaluate different scenarios, simulate the impact of potential changes, and accelerate the development cycle. This agility facilitates the adoption of emerging technologies, such as AI and the Internet of Things (IoT), enabling Finnish industries to stay at the forefront of technological advancements. Digital twins also identified as key in supporting Finland's industrial policy objectives of sustainability and environmental responsibility. By analysing and optimising energy consumption, waste management, and production processes, companies can reduce their environmental footprint. This aligns with Finland's commitment to transitioning towards a more sustainable economy and contributes to achieving the country's climate targets.

Technologies for energy efficiency and trustworthy autonomy

Finland is a prominent player in energy technology innovation, ranking fourth among International Energy Agency (IEA) member countries in terms of government budget allocations for energy research and development (R&D). Innovation is seen as crucial for the commercialisation and cost reduction of emerging energy technologies necessary to achieve Finland's climate goals. There is a particular emphasis on addressing challenges in hard-to-abate sectors and developing energy technologies and services with global deployment potential to maximise climate benefits and promote economic competitiveness.

"Zoom" on the Finnish energy efficiency policy

Energy efficiency as a crucial component of Finland's strategy to achieve carbon neutrality by 2035.

Finland's energy and climate policies focus on achieving carbon neutrality by 2035, ensuring energy security, reducing energy import dependency, promoting a sustainable economy, and protecting biodiversity. The updated Climate Change Act of Finland, introduced in July 2022, legally obligates the country to reach carbon neutrality by 2035. To support this goal, the Act sets binding targets for reducing greenhouse gas emissions (excluding land use, land-use change, and forestry) by 60% by 2030, 80% by 2040, and 90-95% by 2050. The Act also mandates the development of specific measures to achieve these targets. Finland has a low reliance on fossil fuels compared to other countries in the International Energy Agency (IEA) due to its nuclear reactors and significant domestic production of renewable energy, mainly from forestry solid biomass, hydro, and wind. In 2021, fossil fuels accounted for 36% of Finland's total energy supply, the second-lowest share among IEA countries and much lower than the IEA average of 70%. Finland imports all of its crude oil, natural gas, and coal, as it has no domestic fossil fuel production. The country's energy intensity and per capita energy consumption are high due to the presence of a sizable heavy industry sector and the demand for heating in the cold climate.

The National Climate and Energy Strategy[43] (NCES) outlines Finland's measures to achieve the European Union's (EU) 2030 energy and climate targets and attain carbon neutrality by 2035. Finland plans to maintain a significant share of nuclear energy, increase electricity and heat production from renewables, enhance energy efficiency, and electrify most energy demand across various sectors. The country also aims to develop and commercialise new energy technologies while reducing their costs

[43] National Climate and Energy Strategy, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164323/TEM_2022_55.pdf

to drive the energy transition in hard-to-abate sectors like industry and heavy transport. Bioenergy, particularly forestry biomass for electricity and heat, and biofuels for the transport sector, play essential roles in Finland's climate and energy policy. The plan to achieve carbon neutrality relies on increasing carbon removals from land use, land-use change, and forestry to offset remaining emissions.

The focus on energy efficiency aims to lower energy costs, protect vulnerable consumers, and enhance energy security. The industrial sector, accounting for over half of the country's energy demand, is expected to yield the highest savings through energy efficiency agreements with targeted action plans. In the buildings sector, the transition from oil to more efficient heating solutions, such as heat pumps, has contributed to improvements in heating efficiency. Finland is a global leader in heat pump sales, and district heating systems are shifting from fossil fuels to bioenergy and waste heat. The country is also renowned for its development of thermal storage solutions, providing flexibility to both district heating networks and the electricity sector through sector integration.
Finland has made significant progress towards carbon neutrality by deploying the first new nuclear reactor in Europe in over 15 years and experiencing substantial growth in onshore wind generation.
In transportation, Finland has made progress in improving the performance of passenger cars and has experienced a significant increase in the number of electric vehicles (EVs) on the road. The goal is to electrify the transport fleet further, and ambitious targets for 2030 have been set. Looking ahead, Finland aims to increase the value added by the industry sector without increasing its energy demand, significantly raise the share of non-combustion sources for space heating and promote the electrification of transportation.
To achieve its climate neutrality goal by 2035, Finland recognizes the need for a substantial increase in renewable energy sources. Onshore wind generation is expected to play a significant role, along with the development of large-scale offshore wind farms. Solar photovoltaic (PV) is also projected to see rapid deployment. Wood fuels will contribute to reducing fossil fuel demand in the short term, but the government's long-term vision involves transitioning to non-combustion technologies such as heat pumps, waste heat recovery, and geothermal systems for heating and cooling.

Finland seeks to increase its "carbon handprint" by exporting clean technology, thereby making a positive global impact on climate change. Overall, Finland's strategy includes promoting energy efficiency, increasing the share of renewable energy sources, fostering innovation, and expanding the export of clean technology to achieve its climate goals and strengthen its economic position.

Best Practice: Sustainable Industry X Research Ecosystems (SIRE)[44]: strategic research and Innovation Agenda 2022

- Autonomous part of the Sustainable Industry X (SIX), a national bottom-up initiative for the green and digital renewal of Finnish industry;
- Promotes dialogue between industry and research on strategic research needs of Finnish industry and, under this theme, to enhance collaboration between the member organisations;
- Puts together and updates a Strategic Research and Innovation Agenda (SRIA) for Finnish industry;

[44] Sustainable Industry X Research Ecosystem (SIRE): Strategic Research and Innovation Agenda, https://cris.vtt.fi/ws/portalfiles/portal/78548913/SIE_SRIA_21_Dec_2022_Final.pdf

- Operates as an open ecosystem where all Finnish research organisations (universities, universities of applied sciences, public research institutes, private research organizations) can become members

5.4 France

The main strategies at national level in France are the **Plan for Investment of the Future**[45] **(PIA4)** and **France2030** that provides a roadmap of the strategy for growth and development for the present decade.Launched 10 years ago, the **Plan for Investment of the future (PIA4)** finances promising and innovative investments throughout the country and in strategic sectors for France. The PIA4 plan is endowed with €20 billion over five years, including €11 billion mobilised under the recovery plan.

The PIA4i plan is geared towards the Ecological and energy transition, with at least one third of investments in favor of the ecological transition, and no expenditure that will be unfavorable to the environment. Strategic and priority investments are part of the new so-called “directed” investment logic aiming to finance investments that meet the transition challenges of our society. These include **technologies of the future** relating to strategic markets and sectors such as **green and digital technologies,** medical research and health industries, the cities of tomorrow, adaptation to climate change or even the digital education. These priority investment strategies for French economic independence concern, for example, **digital (artificial intelligence, cloud, cybersecurity, quantum technologies), health (bioproduction of innovative therapies, fight against infectious diseases and emerging, digital health),** cultural and creative industries or education in the digital age.

Support programmes and initiatives[46]:
With the aim of supporting researchers and entrepreneurs, the PIA 4 relies on existing structures and proven procedures of support programmes or initiatives: **excellence initiatives (IdEx, ISite), priority research programmes (PPR), hospital-university research institutes and projects (IHU and RHU), technological research institutes (IRT) and for the energy transition (ITE) or technology transfer acceleration companies (SATT**). Funds are available to support innovative companies at each stage of their development: they are mobilised for innovative companies which need access to funding sources to cover the risk inherent of their projects in research and development (R&D). The PIA4 intends to support innovative companies through innovation funds operated by BPI France, innovation competitions for start-ups and SMEs, and through the financing of their most risky R&D projects.

The PIA 4 plan puts the Investments at the heart of the territories just like the previous actions "City of Tomorrow" or "Territories of Innovation", accelerating territorialisation, by seeking stronger partnerships with local players and by anchoring territorial demonstration in real conditions.

The 20 acceleration strategies targeted by the State reflect a clear push on **emerging technologies**, as featured in the table that mirrors areas of priorisation such as **Cybersecurity, Quantum technologies, AI, Cloud, 5G** and telecommunications network technologies and choices in terms of innovation, and sectors to benefit from public funding opportunities.

The 20 French national strategies

[45] https://www.gouvernement.fr/strategies-d-acceleration-pour-l-innovation

[46] https://www.gouvernement.fr/technologies-numeriques-0

Digital technologies	o Cybersecurity; o Quantum technologies; o Artificial Intelligence; o Cloud, o 5G and future telecommunications network technologies
Ecological transition and carbon-free energies	o Carbon-free hydrogen, o Recycling and reincorporation of recycled materials o Biobased products – Sustainable fuels
Medical research and health industries	o Biotherapies and bioproduction of innovative therapies; o Digital health; o Emerging infectious diseases - nuclear radiological biological and chemical threats
Sustainable transport and mobility	Digitalisation and decarbonization of the mobility
Responsible agriculture, food sovereignty	o Sustainable and healthy food; o Sustainable agricultural systems and agricultural equipment contributing to the ecological transition
Sustainable cities and territories	Sustainable cities and innovative buildings
Education, training, youth and culture	o French cultural and creative industries; o Digital education
3 national strategies are under preparation*:	
Ecological transition and carbon-free energies	o Decarbonisation of industry* o Digital greening* o Advanced technologies for energy systems*

These acceleration strategies aim to identify the main challenges of tomorrow's socio-economic transition and to invest massively through a global approach (financing, standards, taxation, etc.). Exceptional investments will be made in a few emerging and priority sectors and technologies. Structural funding for innovation ecosystems and higher education organisations (research universities, laboratories of excellence, etc.), research and innovation (university hospital institutes, technological research institutes …), is available to make France attractive for students, teachers, researchers and entrepreneurs.

The France 2030 Plan

The **France 2030** plan is one the major economic plans for France, endowed with 30 billion euros deployed over 5 years, aiming to develop **industrial competitiveness and future technologies.** The objective of the France 2030 Plan is to accelerate the transformation of the key sectors of the French economy through innovation and to position France as a leader in the world of tomorrow. The aim is to invest in the energy sector, in order to build a carbon-free and resilient France, develop small, innovative nuclear reactors in France with better waste management. Become the leader in green hydrogen and decarbonize the French industry.

Announced in November 2021, the second phase of the **national artificial intelligence strategy** targets the dissemination of artificial intelligence technologies while aiming to support innovation in priority areas such as on-boarded AI, AI in the territories and AI at the service of ecological transition.

As part of the **France 2030** strategy, which contributes to master digital technologies in a secure manner, the Minister in charge of the Digital Transition launched early April 2023 a call for projects "Trusted artificial intelligence demonstrators (DIAC)" operated by Bpifrance: this scheme will support the development of hardware, software and system innovations to ensure the maturation and demonstration of systems' critical functions integrating trusted artificial intelligence (safety and security, robustness, explainability, ethics, etc.). Projects must demonstrate a clear functional need that will aid to strengthen the position of players in an existing market or in a new market (in particular medical devices, transport and new mobility, Industry 4.0, energy and energy networks, critical infrastructures, etc.). The project must demonstrate its ability to bring added value in terms of structuring the industrial sector and the value chain.

The launch end of April 2023 of a second wave of the call for projects "Artificial intelligence demonstrators in the territories" (Démonstrateurs d'Intelligence Artificielle dans les territoires (DIAT), operated by the Banque des Territoires: aimed at supporting technology demonstrator projects based on data science and artificial intelligence that meet the challenges of the territories. These demonstrators will aim to make use of a low-energy consumption AI to serve the environmental challenges and objectives of communities and collective interests, while validating in a real environment technologies of emerging and innovative players.
The relaunch of the call for projects "Technological maturity and demonstration of on-boarded artificial intelligence technologies", operated by Bpifrance, has two main goals:
1) disseminate through demonstrators in real conditions solutions implementing an AI functionality in an embedded system, as close as possible to the sensor (in particular mobility, consumer IoT, medical devices, energy networks, urban infrastructure or telecommunications infrastructure, agricultural equipment);
2) to support the development of advanced hardware architectures for the needs of the algorithms deployment in specific targets. This component more specifically targets projects in the field of hardware dedicated to AI, in particular semiconductors.

Law on multi-annual research programming - LPRR 2021-2030

The **law of research programming** for the period from 2021 to 2030**,** dated 24 December 2020, contains various provisions relating to research and higher education. The three main ambitions are: to better finance and evaluate public research, to improve the attractiveness of research professions and to place science in an open relationship with society.
University innovation hubs bring together the strengths of all the players in the innovation ecosystem: higher education institutions, research organisations, local authorities, entities in charge of transfer (the Transfer Acceleration Companies de Technologies, SATT) and development subsidiaries, incubators, Technological Research Institutes (IRT), Institutes for Energy Transition (ITE), Technological Resource Center (CRT), and structures in charge of economic development for innovation (competitiveness clusters, regional innovation agencies, etc.).
The objective is to enable universities to adopt a consolidated and common strategy, while exchanging with the economic world, and provide skills and technologies by streamlining relations between players in all dimensions: expertise, access to technological platforms, research partnerships, intellectual property, creation of start-ups; strengthening student training in entrepreneurship; ensuring the support of all innovative projects at the highest level, whether carried out by students, or researchers.

Regional strategies of research and innovation for a smart specialisation (RIS3 ou S3)

At regional level, there are 2 main strategies, the **S3** and the **SRDEII**, leader of financial aid from the region. Please see chapter 4.2

Several projects have been implemented within the Smart Specialisation Strategy which puts forward specialised assets of a region.
The Strategic Innovation Areas (SIA) of the 2021-2027 programming of European funds, defined in axis 4 of the SRDEII, are: Digital, data industry and creative industry; Eco-construction, sustainable and smart city, green and low-carbon energies; Aeronautics, space, defense, sustainable and smart mobility; Healthcare; Luxury and cosmetics; Agriculture, agrifood and nutrition. The strategic technologies selected for this programme are: **artificial intelligence, high performance computing, quantum, materials and cleantech, hydrogen, bioproduction, biotechnology and health technologies, deeptech**.

There are several examples of European Regional Development Fund (ERDF) funds mobilised in the field of technology in a specific region:

SMART-SPACE: Smart Manufacturing in the Alpine region[47]

The Alpine Space is characterized by a strong industrial concentration which covers varied sectors of activity such as mechanics, textiles, chemistry, agri-food, etc.
One of the challenges of the Alpine Space is, with the contributions of digital technology, to maintain a highly competitive and job-creating industry. The main objective of the SMART-SPACE project, **Smart manufacturing** for Alpine Space SMEs, (Industry 4.0) is the development of the Alpine Space innovation ecosystem to foster the competitiveness and sustainable growth of companies, with the advancement of smart manufacturing technologies can help companies to become more competitive, productive and safe. Smart Space aims in particular to promote **digital technologies** among industrial SMEs in the Alpine region, to develop digitalization and to strengthen cooperation between European regions.

The SRDEII, leader of economic aid from the region

Important programme at regional level, the **SRDEII** isthe regional plan for economic development, innovation and internationalization. In a nutshell the SRDEII defines the orientations of the Region concerning business support, support for internationalization, real estate investment and business innovation; attractiveness of the regional territory; solidarity development of the social and solidarity economy, and the development of the circular economy, particularly in terms of industrial and territorial ecology. This regional scheme may include a cross-border component with local authorities of neighbour States; guidelines for support in the development of agricultural, craft, industrial, pastoral and forestry activities.

47 https://www.europe-en-france.gouv.fr/fr/projets/smart-space-linnovation-numerique-pour-repondre-aux-defis-sociaux-et-economiques-alpins

The **SRDEII** is adopted by the Region, before approval by the regional authorities and after consultation with the government.

5.5 Germany

Germany is a strong economic power in Europe and implements an innovation strategy that aims above all to support its research and industry players. In February 2023, the German federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung) has published its "**Strategy for the future of Research and Innovation**" (Zukunftsstrategie Forschung und Innovation)[48]. The strategy for the future replaces the previous "High-Tech Strategy 2025"[49]. In its new strategy the Federal Government defines the goals, milestones and priorities of its research and innovation policy for the coming years with the proclaimed aim to strengthen Germany's innovative power and secure Europe's technological sovereignty.

In a chapter entitled "Secure Germany's and Europe's Digital and technological sovereignty: Exploit the potential of digitisation", the ideas of "catching up in the central key technologies, taking leading international positions, and opening up new areas and fields of innovation" are put forward. Without mentioning the concept of industry 5.0, the German strategy nevertheless strongly aligns with the fact that new technologies and innovations are important means to show leadership on international level, co-construct norms and standards, but also to build a prosper and sustainable future, bringing value to society. It emphasises: "New technologies and innovations must also always have the ambition to have a broad impact on economy and society and make a contribution to the necessary economic and social transformation toward sustainability, including contributions to digitisation."[50]

The strategy further indicates "We promote key technologies from basic research to their applications in products, services and new business models.". Even though the term *key technologies* is not defined, some examples point to **Microelectronics** (Security chips, Embedded Security, Sensors and Power Electronics) and associated software technologies (including cloud solutions); robotics and specifically human-machine interaction are mentioned as well. Material research including the use of **digital twins** for the simulation of material properties, notably to investigate on innovative industrial processes, as well as the use of **artificial intelligence** in production processes are other technology frameworks put forward. In addition, the strategy indicates that by promoting biotechnology in combination with other cutting-edge technologies, such as digitalisation, miniaturisation and artificial intelligence, new impetus for bio-based value creation will be provided in Germany. It further indicates the promotion of biologisation of materials research, as the use of biological knowledge and the integration of biological principles and mechanisms into materials research (**bio-inspired materials**). The resilience of information and communication systems, including cybersecurity, are another key aspect of the envisaged digital and technological sovereignty, mentioned together with 6G, block chains, quantum technologies and photonics.

[48] https://www.bmbf.de/bmbf/de/forschung/zukunftsstrategie/zukunftsstrategie_node.html

[49] See intermediary results published in https://www.bmbf.de/SharedDocs/Publikationen/de/bmbf/1/31522_Fortschrittsbericht_zur_Hightech_Strategie_2025.pdf?__blob=publicationFile&v=6

[50] Bundesministerium für Bildung und Forschung (02/2023): Zukunftsstrategie Forschung und Innovation, https://www.bmbf.de/SharedDocs/Publikationen/de/bmbf/1/730650_Zukunftsstrategie_Forschung_und_Innovation.pdf?__blob=publicationFile&v=4, p.60-69

The German government aims to implement this strategy through the funding programme "**Development of digital technologies**", implemented through the Federal Ministry for Economic affairs and climate action (Bundesministerium für Wirtschaft und Klimaschutz)[51]; it is "supporting application-oriented (pre-commercial) research and development projects that are concerned with current technological developments and market requirements. In the funded projects, technical feasibility and economic viability are demonstrated on a pilot basis with model users. The results are expected to be a starting point for the creation of new marketable products, solutions and business models - especially for small and medium-sized enterprises". The programme aims to foster "strong alliances of partners from business and science".

The starting point for the present funding programme is the previous funding programme "**Funding Framework - Development of Digital Technologies**" for the period 2019 to 2022 which has been considered highly successful. The previous funding programme had already started aligned with the preceding innovation strategy "High-Tech Strategy 2025" which shows that the programme allows for continuity even when the underlying strategy has been modified.

Based on the funding programme, specific funding calls are published[52] and the procedure for submitting project proposals is explained. An example for a funding call is "SmartLivingNEXT -Artificial intelligence for sustainable living and home environments" (call closed 03/2023). Some calls are oriented towards European and/or international cooperation, requiring however a secured co-funding of the international partners by their funding agencies. The grants for the German organisations are awarded by way of project funding in the form of a non-repayable subsidy, a co-funding from the involved institutions being required (different % according to the type of organization).

Germany supports organisations from research, academics and industry, above all SMEs, through various funding programmes. Several databases are available that allow for the search by funding level (federal, regional, EU) or thematic fields: the central database, the "Förderdatenbank", publishes all calls related to the "**Development of Digital Technologies**" programme, as well as other regional, national and EU-wide programmes: https://www.foerderdatenbank.de/FDB/Content/DE/Foerderprogramm/Bund/BMWi/entwicklung-digitaler-technologien.html. Another example is the "Förderinfo" website which contains a specific page on key technologies: https://www.foerderinfo.bund.de/foerderinfo/de/foerderung/bund/schluesseltechnologien/schluesseltechnologien.html
A multitude of collaborative projects has been funded under the programme; they have been summarised in a brochure.[53]

The federal innovation strategy is most relevant to "emerging enabling technologies", but many regions (Länder) also implement innovation strategies that aim to foster what they call "key

[51] Bundesministerium für Wirtschaft und Klimaschutz (1. Juli 2022): Bekanntmachung Förderprogramm „Entwicklung digitaler Technologien" (2022 bis 2026), https://www.digitale-technologien.de/DT/Redaktion/DE/Downloads/Publikation/edt_bekanntmachung_foerderprogramm.pdf?__blob=publicationFile&v=1. The predecessor ministry in charge was the Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic affairs and Energy).

[52] All calls are published on https://www.digitale-technologien.de/DT/Navigation/DE/Foerderaufrufe/foerderaufrufe.html.

[53] Bundesministerium für Wirtschaft und Klimaschutz (01/2023): Entwicklung digitaler Technologien, https://www.bmwk.de/Redaktion/DE/Publikationen/Digitale-Welt/entwicklung-digitaler-technologien-broschure.pdf?__blob=publicationFile&v=4

technologies"; these are not always defined the same but can be seen as in line with the technology frameworks FORGING is looking at.[54]

What is specifically visible is that the federal strategy and funding programme related to key technologies explicitly foresees European and international cooperation in some fields; alignment with European funding mechanisms is put forward both in the federal documentation, as well as some of the regional innovation strategies. All strategies seem very strongly application-focused; innovation for production processes, translated through different digital technologies and technology frameworks, being often at their heart.

5.6 Greece

Greece has suffered a major economic crisis in recent years and is just recovering from it. It had to face many challenges, at economic and societal, demographic and environmental levels. Despite the heavy repercussions, the research and innovation ecosystem in Greece has many assets with its network of high-quality universities and its cluster of enterprises[55]. In the aftermath of the Covid-19 pandemic, which led to a large-scale health and socio-economic crisis, several measures were set up to accelerate the digitalization of the country[56].

In 2020, the Digital Transformation Strategy 2020-2025 or the so-called Digital 'Bible' was presented with the aim to define a series of objectives to accelerate the digital transformation of the country. This strategy had been defined before the pandemic but its presentation was accelerated due to the urgent situation of the country[57] as further developed in the «Digital Transformation Bible 2020-2025»[58].In line with this strategy, Greece published a white paper which objective was to define a national strategy for **Artificial Intelligence** to enhance the economic and social growth of the country as outlined in the White Paper: Democratising AI, A National Strategy for Greece[59].

[54] Examples of innovation strategies of some regions (non-exhaustive list): Bavaria: https://www.bayern.de/wp-content/uploads/2023/03/Digitalplan-Bayern.pdf (focus on digital key technologies, e.g. Artificial Intelligence); Baden Württemberg: https://wm.baden-wuerttemberg.de/de/innovation/schluesseltechnologien (focus on Biotechnology, information technology, telecommunications, microsystems technology and nanotechnology, new materials, surface technology, photonics and environmental technologies) and https://wm.baden-wuerttemberg.de/de/innovation/innovationsstrategie-des-landes; Nordrhine Westfalia: https://www.wirtschaft.nrw/sites/default/files/documents/21-0924_mwide_broschuere_regionale_innovationsstrategie_des_landes_nrw-web2.pdf (focus on Technological innovations from robotics, analytics, artificial intelligence, quantum computing, software technology and telecommunications)

[55] Smart Specialisation Platform, European Commission, « Greece », https://s3platform.jrc.ec.europa.eu/greece

[56] https://www.greeknewsagenda.gr/topics/business-r-d/7379-the-digital-transformation-%E2%80%9Cbible%E2%80%9D-of-greece-2020-2025). The Greek News Agenda. "The Digital Transformation "bible" of Greece »

[57] https://www.greeknewsagenda.gr/topics/business-r-d/7379-the-digital-transformation-%E2%80%9Cbible%E2%80%9D-of-greece-2020-2025)

[58] https://www.greeknewsagenda.gr/topics/business-r-d/7379-the-digital-transformation-%E2%80%9Cbible%E2%80%9D-of-greece-2020-2025).

[59] http://democratisingai.gr/assets/DEMOCRATISING_AI_final.pdf

A year later and to cope with Covid-19, in 2021, the National Recovery and Resilience Plan - NRRP "Greece 2.0"[60] was published, aiming to promote the recovery of the national economy and divided into 4 pillars: Green; Digital; Employment, skills and social cohesion; Private investment and transformation of the economy. Under this last pillar, the "Promoting research and innovation" aims on the one hand to strengthen the link between science and business; and on the other hand, to promote public and private investment in R&D, as indicated in the Greece 2.0 – National Recovery and Resilience Plan[61].

A National Research and Innovation Strategy for Smart Specialisation (RIS3) has also been established by the Greek government for the period 2014-2020. For the present programming period (2021-2027), the National Smart Specialisation Strategy further aims to be in line with the European Structural Funds Policy objective 1 (PO1): "A smarter Europe - innovative & smart economic transformation". In addition, Greece has a hybrid RIS3 with a centrally managed national strategy by the General Secretariat for Research and Technology and 13 regional strategies (by regional authorities and coordinated by the Ministry of Economy and Development) [62].

In 2022, the new Greek law "**Emerging IT and communications technologies, strengthening digital governance and other provisions**" creates one of the first unified frameworks on emerging technologies in the European Union, entitled "A Unified framework for emerging technologies Greece"[63]). This law strives to address the potential impact of emerging technologies, such as artificial intelligence, Internet of Things, Blockchain, and Smart Contracts, in our daily lives. The legislation "Greece - Newly Introduced legal provisions concerning emerging technologies- Artificial Intelligence/Blockchain/Internet of Things (Law 4961/2022)"[64] introduces a legal framework to the application of novel technologies. Several national strategies have emerged since then to strengthen and encourage technological innovation in Greece, placing the country in a real "technological" turning point.

5.7 Hungary

In the European Union, Hungary currently ranks among the emerging innovators according to the European Innovation Scoreboard[65] (EIS), which is produced annually by the European Commission. The Government's goal is to become one of Europe's major innovators by 2030, through boosting the value creation capacity of the innovation ecosystem and the productivity of the business sector.Achieving this ambitious goal requires a complex approach to economic development: in addition to a continuous increase in resources, success will also require a more results-oriented and efficient planning and use of EU and national funding.

The National Research, Development and Innovation Fund **(NRDI) Fund**, managed by the NRDI Office, is a separate public fund under the Public Finance Act that provides public support for research, development and innovation from domestic sources and is used exclusively for this purpose. The NRDI Fund, established in 2015, was enlarged and provides predictable funding for RDI. The NRDI Fund's

[60] https://greece20.gov.gr/wp-content/uploads/2021/07/NRRP_Greece_2_0_English.pdf
[61] https://greece20.gov.gr/wp-content/uploads/2021/07/NRRP_Greece_2_0_English.pdf
[62] https://s3platform.jrc.ec.europa.eu/greece)
[63] https://www.efdpo.eu/a-unified-framework-for-emerging-technologies-in-greece/
[64] https://www.szlaw.gr/en/our-news)
[65] https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en

2021 programme strategy already included calls for proposals and was split into two parts.

- The Research Sub-fund finances socially useful research projects, programmes to support excellence in higher education and research institutions and individual researchers.
- The Innovation Sub-fund supports business innovation and market-oriented R&D activities, partly carried out in business-academia cooperation, through programmes with an investor approach.

A portfolio of competitive calls was implemented by the NRDI Office for the period 2021-2027 to facilitate the purpose-oriented use of RDI funds coming from EU and the National Research, Development and Innovation Fund (NRDI Fund). The calls promote research excellence, corporate development and innovation, researcher-industry cooperation as well as the implementation of innovative ideas.In charge of RDI policy until June 2018, the NRDI Office is responsible for developing the funding schemes financed from different sources. This ensured the coordinated and holistic management of objectives and instruments.

At national level, specialisation priorities cover the following fields: Systems science; Smart production; Sustainable society.Under the sectoral priorities are the sectors: Health and well-being; Vehicle and other machine industries; Renewable energies; Food industry; Agricultural innovation. The Horizontal priorities are: ICT; Sustainable society and Sustainable environment.

The vision of Hungary's RDI strategy for 2021-2030 is a knowledge-based, balanced, sustainable economy and society capable of creating high added value in all areas of the country, through the instruments of RDI policy.The RDI policy aims to put Hungary among the strong innovator countries in the EU by the end of the decade, through the value-creating capacity of the RDI ecosystem, intensive improvement of the innovation performance of the business sector and consistent implementation of smart specialisation. To this end, the Government has committed in its RDI strategy to increase R&D expenditure as a share of GDP to 3% by 2030.The RDI strategy sets out three main overarching objectives for its innovation policy: making more use than at present of the research results of public research institutions (research institutes and higher education institutions); improving the innovation performance of domestic enterprises, especially small and medium-sized enterprises and strengthening cooperation between actors in the R&D and innovation system.

The RDI strategy revolves around three main objectives, notably to strengthen knowledge production by expanding and modernising the capacity of the RDI institutional system and ensuring the supply of researchers; enhance knowledge flows by encouraging cooperation between actors in the RDI ecosystem, increase cross-sectoral interoperability between sectors and expand opportunities for knowledge transfer; make more effective use of knowledge by boosting innovation in enterprises. Increase the efficiency of knowledge production, knowledge flows is the basis of the strategy, but to achieve its vision, government intervention is essential as RDI actors have only limited influence.
The RDI strategy propose the following objectives:

- Openess to innovation, creative thinking and value creation
- Creation of an RDI-supporting regulatory framework and business environment
- Strengthening of regional, social and economic cohesion through RDI
- Creation of a funding system that promotes both stability and incentivisation
- Stimulate a demand-driven RDI
- Ensure gender equality in the RDI system

Complementary to the RDI strategy, Hungary designed the 2021-2027 National Strategy for Smart Specialisation (S3). S3 strategy for Hungary is described under chapter 4.2.In Hungary, the research

and innovation policy devised a priority to promote the objectives of the **National Smart Specialisation Strategy (S3)** adopted by the Government in 2014. Based on the results of broad social consultation, the S3 defines the specialisation directions and sectoral and horizontal priorities according to regional characteristics. The components of the National S3 cover a classification by regional characteristics: Knowledge regions; Industrial production zones; Low S&T driven regions. S3 can be seen as an umbrella strategy for the strategic planning of three areas: the RDI Strategy, the Strategy for Strengthening Hungarian Micro, Small and Medium Enterprises, and the National Digitalisation Strategy.

According to the Hungarian government website, "the integration and alignment of the S3 and the RDI strategy are essential to boost Hungary's RDI performance in this decade". While the former defines the horizontal objectives and RDI-specific areas of intervention necessary for the development of the innovation ecosystem, S3 builds on the pillars of the strategic objectives of the three areas and sets priorities with high development potential, where the concentration of resources can contribute to increasing the competitiveness of the economy.

In the seven-year period starting in 2021, S3 will contribute to this government goal by identifying the national strengths and setting out the so-called smart specialisation priorities.The selection of the S3 priorities started with the application of the so-called "Entrepreneurial Discovery Process" (EDP), in line with EU methodological recommendations, and with the involvement of a wide range of stakeholders.Another important step in the entrepreneurial discovery process is the Territorial Innovation Platforms (TIP) network building on university centres and initiated by the Ministry for Innovation and Technology. The platforms play a major role in monitoring and evaluating the implementation of the strategy.

5.8 Italy

On December 15, 2020, the **National Programme for Research 2021-2027[66] (NRP)** was approved by the Interministerial Committee for Economic Planning (CIPE), resulting from extensive and in-depth discussions initiated by the Ministry of University and Research with the scientific community, state administrations and regional entities, and civil society.One of the key objectives of the programme is to leverage research and innovation to achieve the United Nations' Sustainable Development Goals, the priorities of the European Commission, the Cohesion Policy Objectives 2021-2027, as well as the Next Generation EU initiative. The programme is aimed to answer the question of what research can do for the country, and how it can contribute to improving the quality of life of citizens as well as cope with emergency situations, such as the Covid-19 pandemic.To achieve these objectives, the **NRP 2021-2027** takes a participatory and dynamic approach that enables citizen involvement, innovation directionality, and dedicated knowledge and technology transfer actions in favor of territories, companies, and public administration. It also seeks to promote positive changes by leveraging basic and applied research and policies.

The programme is structured into system priorities, large research and innovation areas and related intervention areas, national plans, and missions. The system priorities are designed to consolidate the strengths and overcome the weaknesses of Italy's research system. The large research and innovation areas and related intervention areas are based on the clusters of Horizon Europe and the National

[66] https://www.italiadomani.gov.it/en/Interventi/investimenti/fondo-per-il-programma-nazionale-ricerca-pnr-e-progetti-di-ricerca-di-significativo-interesse-nazionale-prin.html

Strategy for Smart Specialisation. They are also aligned with the national context's specificities highlighted by the consultation and contributions of the involved administrations.The **NRP 2021-2027** also includes national plans for research infrastructure and open science. These plans are integral to the programme's objectives and are expected to be updated periodically. Finally, the programme includes missions, which are multisectoral initiatives aimed at achieving ambitious and concrete objectives through research-driven intervention policies guided by scientific data and evidence.

In addition to NRP, the following strategic documents entail the Italian R&I programmes landscape in the field of technology and innovation:

- National Recovery and Resilience Plan (Piano nazionale di ripresa e resilienza, PNRR)[67]
- Strategic Programme on Artificial Intelligence[68]
- National Digital Competence Strategy[69]
- Strategy for technological innovation and digitalisation of the country[70]
- 5G Emerging Technologies Support[71]
- Fund for Investments in Scientific and Technological Research
- Sustainable Growth Fund.

The Italian programmes mentioned above have a time window projected towards 2030, which today also represents a turning point and a moment of global transformation.
Italy has structured its strategy through both a national and regional management/financing line. This stems both from the need to have a high-level coordination (basically pertaining to the Prime Minister's Office, such as the National Recovery and Resilience Plan and a regional specificity (FCS, ERDF, etc.).

The current national innovation strategy is based on three main aspects: digitisation of society; innovation in the country and the sustainable and ethical development of society.The overall objective is to foster the design and application of new technologies, adapting it to the needs of communities and territories. The planned activities require national/regional coordination, with ministries, local authorities, territorial agencies and private actors. Funding from Axis II of the "Emerging technologies support programme in the area of 5G" aims at allocating funds for the implementation of research and development projects in the national territory[72].

The digitisation process is intended to enable widespread application throughout the country by revitalising specific areas, taking into account local excellences and peculiarities. The digital tool, thanks to dedicated platforms, guarantees the circulation and easy access to information. Hence, the immediate availability of Italian innovative assets, facilitating their sharing. Citizens (intended both as users and operators in the sector) are supposed to be trained to access new technologies through a

[67] https://www.mur.gov.it/sites/default/files/2021-01/Pnr2021-27.pdf
[68] Strategic Programme on Artificial Intelligence 2022 - 2024 https://docs.italia.it/italia/mid/programma-strategico-nazionale-per-intelligenza-artificiale-en-docs/en/bozza/index.html
[69] National Digital Competence Strategy https://docs.italia.it/italia/mid/strategia-nazionale-competenze-digitali-docs/it/1.0/index.html
[70] Strategy for technological innovation and digitisation of the country 2025 https://docs.italia.it/italia/mid/piano-nazionale-innovazione-2025-docs/it/stabile/la-strategia.html; https://docs.italia.it/italia/mid/; https://assets.innovazione.gov.it/1610546390-midbook2025.pdf
[71] 5G Emerging Technologies Support Programme https://www.mise.gov.it/it/comunicazioni/servizi-alle-imprese/tecnologia-5g/tecnologie-emergenti-5g

[72] https://www.gazzettaufficiale.it/eli/id/2023/01/20/23A00247/sg

process of continuous training and updating.Overall, the technological development is considered to be ethical, responsible and non-discriminatory. The State is committed to ensure its promotion, maximising its benefits and collective access.

The main objectives that the Italian programmes aim to achieve are:

- strengthening of digital skills and telematic communication systems
- retraining the workforce in accordance with new technologies
- increase productivity and automation processes
- create an approach linked to experimentation, applied research, technology transfer (creation of so-called 'emerging technology houses') while ensuring sustainability and replicability throughout the country
- implementing an eco-green approach that is compatible both from the point of view of financial sustainability and the actual implementation of new technologies
- create an infrastructure, both telematic (e.g. 5G networks) and physical (e.g. major works in the transport sector), capable of guaranteeing/facilitating the dissemination of technologies and the exchange of information and human resources
- compensate for the gaps in the national health apparatus in response to future health emergencies.

The focus is on funding research and development projects of a national nature, with a vision towards collaboration with other forms of international funding (e.g. Horizon Europe) capable of supporting Italy's economic commitment and creating a dialogue with other Member States working on the same issues in a collaborative approach. This tends to support social innovation actions, the creation of new business realities (from spin-offs to SMEs) for research/development/production activities, as well as tackling the major challenges related to strategic sectors for Italy and with significant socio-economic impacts for the State.

5.9 Lithuania

The Lithuanian government designed a national programme composed of twenty action plans for the implementation of R&D innovation priorities. It provided measures necessary for the implementation of the priorities, in particular technologies and products to be developed and supported, as showcased in the following box. Advanced technologies are mentioned in several action plans that set innovation priorities for example the priority areas: new production processes, materials and technologies, Health technologies and biotechnologies Agro-innovation and food technologies:

Action plans for the priority area "Transport, logistics and information and communication technologies":

- Smart transport systems and information and communication technologies;
- Technologies/models for the management of international transport corridors and integration of modes of transport;
- Advanced electronic contents, content development technologies and information interoperability;
- Information and communication technology infrastructure, cloud computing solutions and services.

Action plans for the priority area "New production processes, materials and technologies":

- Photonic and laser technologies;
- Functional materials and coatings;
- Structural and composite materials;
- Flexible technological systems for product creation and production.

Action plans for priorities of the priority area "Energy and sustainable environment":

- Smart systems for energy efficiency, diagnostic, monitoring, metering and management of generators, grids and customers;
- Energy and fuel production using biomass/waste and waste treatment, storage and disposal;
- Technology for the development and use of smart low-energy buildings – digital construction;
- Solar energy equipment and technologies for its use for the production of electricity, heat and cooling.

Action plans for priorities of the priority area "Health technologies and biotechnologies":

- Molecular technologies for medicine and biopharmaceutics;
- Advanced applied technologies for individual and public health; Advanced medical engineering for early diagnostics and treatment.

Action plans for the priority area "Agro-innovation and food technologies":

- Sustainable agro-biological resources and safer food;
- Functional food;
- Innovative development, improvement and processing of biological raw materials (biorefinery).

Action plans for priorities of the priority area "Inclusive and creative society":

- Modern self-development technologies and processes;
- Technologies and processes for the development and implementation of breakthrough innovations.

The Lithuanian Innovation Development Programme 2014-2020[73] defined the main priorities and strategy for innovation around four objectives:

- To develop innovative society by developing new knowledge and its application.
- To enhance innovation potential of business.
- To promote the cooperation creation of value networking, development and internationalisation.
- To increase efficiency of innovation policymaking and implementation and promote innovation in the public sector.

This programme was linked to Smart specialisation[74] as measures covered by the action plan will facilitate the promotion of the established specific priorities of the smart specialisation area stimulate the competitiveness of the economy of Lithuania.In order to boost Lithuanian innovation capacity and following the recommendations from OECD, and EC, the **Innovation reform**[75] was implemented to identify and strengthen the importance of experimental development in the innovation process. It is strategically important to cover full innovation cycle to shift **the focus towards efficiency of the innovation activities.** The effort is made on strengthening impact of R&D performed by STI to the state economy and to consolidate the innovation system.The approval and initial implementation of the new R&I policy support measures under the Operational Programme (OP) 2014-2020 aimed at implementing the Lithuanian Smart Specialisation Strategy.Ministerial strategic actions (projects) are related to the horizontal objectives of the Plan for the

[73] https://eimin.lrv.lt/uploads/eimin/documents/files/Inovaciijos/Strategijos/Lietuvos%20inovacij%C5%B3%20pl%C4%97tros%20programa_patvirtinta%202013%2012%2018_EN.pdf

[74] https://smsm.lrv.lt/en/sector-activities/science-1/smart-specialisation

[75] https://eimin.lrv.lt/uploads/eimin/documents/files/Inovaciijos/tyrimai_analizes/The%20road%20to%20convergence%20updated%20web.pdf

Implementation of the Provisions of the Programme of the Government which are **digital transformation, Green Deal**, and reduction of exclusion, including regional development.
A clear priority is attributed to **Digital Transformation** with digitisation of public services such as e-Government 360° (heath, culture, social services) and implementation of a policy in alignment with the Green Deal and the implementation of environmental economic measures and building sustainability of investment.

General priority areas in terms of R&D and innovation development and their specific priorities were identified; proposed measures required for their implementation, specific technologies and products to be developed in implementing individual priorities; proposed mechanisms for implementation, monitoring and impact assessment of the smart specialisation process.
As a result of the Research and Higher Education Monitoring and Analysis Centre's (MOSTA)s analysis, expert discussions and surveys, the following legislation was prepared as part of the **smart specialisation strategy.** Priority development areas for R&D&I included: Energy and sustainable environment; Inclusive and creative society; Agro-innovation and food technologies; **New production processes, materials and technologies; Health technologies and biotechnologies;** Transport, logistics and information and communication technologies (ICT).

The programme for Lithuania Smart Specialisation Lithuania began in 2012. With regard to smart specialisation, measures contributing to the implementation of the relevant R&D&I priority are set up and indicated in the action plans (see above the Action plans).Main goal in Lithuania was to develop innovative technologies, products, processes and/or methods and, through the use of these results of activity, responding to global trends and long-term national challenges. Improving competitiveness and opportunities of Lithuanian entities to position themselves on global markets was a goal to achieve.
The targeted outcome in implementing R&D and innovation priorities is new adjusted technology, processes and products developed on the basis of R&D and innovation. The underlying rationale was that priorities had to define specific targeted outcomes (development or application of technology and processes), the implementation of which would lead to pooling of science and business centres with a high level of expertise. Lithuania's smart specialisation strategy evolved through joint efforts of a number of institution; main actors being the Ministry of Education and Science, the Ministry of Economy and MOSTA authorised thereby.

5.10 Poland

Poland is an Emerging Innovator laced 30th in the EU innovation ranking. Although the total innovation indicator for Poland increased by 7.8%, this is still less than the EU average of 8.8%. In the Global Innovation Index 2021 Poland was ranked 40th. Research and development intensity - expenditure on R&D as a percentage of Gross Domestic Product - in Poland rose from 1.21% in 2018 to 1,32% in 2019, according to the latest data published by OECD. The R&D intensity in the EU27 area experienced a more modest increase to 2.1%. [76]Poland's performance has improved with a strong increase in the years 2018-2020 due to broadband penetration and opportunity-driven entrepreneurship. According to the estimations of the Polish agency in charge of implementing R&I policy, the National Centre for Research and Development (NCBR), over 10.000 innovative businesses operate in Poland. About 60-80% of businesses are planning to secure grants to co-fund their research work. National Centre for Research and Development is currently the most effective institution in Poland supporting innovations

[76] https://www.gov.pl/web/ncbr-en/polish-research--innovation-policy

in business and science. 2020 was a very successful year for NCBR as it announced 73 calls for proposals (total allocation amount of PLN 6.9 billion).
The main objectives of Poland's innovation policy cover the areas of **digitisation and transformation towards industry 4.0** (implementation of the Artificial Intelligence Policy and creation of AI School); enhancing citizens' skills (e.g. trainings for entrepreneurial or digital skills); green economy (e.g. Green Innovation Hub, supporting activities aiming at achieving zero-emission economy, environmental clauses in trade agreements and public procurement); innovations, start-ups, new technologies (e.g. industrial property law, help local government units with stimulating the start-up market).

After the outbreak of the coronavirus pandemic, the role of innovation was considered key to overcome the crisis and new technologies, AI, IoT or technology transfer prove to be extremely important in this context.The National Center for Research and Development (NCBR), has implemented programmes following a model based on the idea of problem-driven research inspired from the American research agency Defense Advanced Research Projects Agency (DARPA). Programmes implemented in Poland at the national level during 2014-2020 can be found on the Polish government website[77].

The Initiative for Polish Industry 4.0 - The future Industry Platform was implemented a key strategy to uptake innovation and technology. As a successful initiative to push technology across the country, the **Future Industry Platform**[78] launched in 2016 was part of the Responsible Development Plan ('Morawiecki Plan') by the Ministry of Finance and Development. Main goal of the Morawiecki Plan was to provide industrial financing over a 25-year period, while pursuing an agenda of re-industrialisation through the setting of new partnerships, export oriented support measures and comprehensive regional development.

The main mission of the Platform[79] is to act as an integrator of all stakeholders interested in **Industry 4.0** as well as an **accelerator of the digital transformation** of Polish industry. The Platform seeks to achieve these goals through a mix of activities comprising knowledge transfer and awareness raising, as well as the development and application of digital transformation support measures.

5.11 Portugal

In 2022 Portugal ranked 15th out of the 27 MS in the European Commission Digital Economy & Society Index[80]. Portugal has the infrastructures and innovation capacity needed to take a lead in the fourth industrial revolution. Nevertheless, digital skills have been identified as one of its weaknesses. More

[77] https://www.funduszeeuropejskie.gov.pl/en/site/programme-websites
[78] https://ati.ec.europa.eu/reports/policy-briefs/poland-initiative-polish-industry-40-future-industry-platform
[79] https://eimin.lrv.lt/uploads/eimin/documents/files/Inovaciijos/Strategijos/Lietuvos%20inovacij%C5%B3%20pl%C4%97tros%20programa_patvirtinta%202013%2012%2018_EN.pdf
[80] https://digital-strategy.ec.europa.eu/en/policies/desi-portugal

graduates in ICT fields are required to revert the trend of the digital divide. Despite the efforts undertaken, there is room for the country to accelerate its digitalisation efforts"[81]. Specifically, Portugal is challenged by the need of effectively applying its skills. In 2016 the Ministry of Economy started a process to get a reliable and realistic overview and diagnosis for digital transformation in order to develop a National Digital Strategy.

The **PATD – Action Plan for the Digital Transition**[82] is the national plan to accelerate the digital transition, and it is considered of high priority aiming at placing Portugal among the digital leaders of the European Union. The digital transition is one of the 4 strategic pillars outlined by the Portuguese government for the period 2019-2023, along with climate action, demographic challenge and inequalities reduction.

Portugal targets on several initiatives to accelerate the digital transition and implements several initiatives set up to support the uptake of new technologies in the industry.**Free Technological Zones (FTZs)** are physical environments for testing, geographically located, in a real or near-real environment for new technologies that need specific and adapted regulatory regimes. They are a "safe space" in which companies can test innovative products, services, business models, and delivery mechanisms without immediately incurring all the normal regulatory consequences related to the activity in question. They allow Testing and experimentation in a real or near real way, with direct and permanent control by the competent regulatory authorities, particularly in terms of testing, provision of information, guidelines and recommendations, corresponding to the concept of regulatory sandboxes. Portugal joins a small group of countries that have created similar schemes: Australia, Canada, India, Singapore and the United Kingdom.

Development of Test Beds: Infrastructure and equipment for the provision of testing and experimentation services for products and services for SMEs and Startups, in physical or virtual space. The Test Beds concept aims at providing infrastructure and equipment by entities that have installed capacity, to provide services to SMEs and Startups. These services consist of testing and experimenting with innovative products and services, from these SMEs and Startups, in physical or virtual space.

The strategic programme Industry 4.0 - **"Industria 4.0"**[83] - is the pivotal Portuguese strategic framework implemented at national level to boost innovation and digitalisation. Launched in 2017 for a programming period of 4 years, it aims at "Shifting gears to become a key player of the 4th Industrial Revolution" and "(to) develop industry in the digital era"[84], as can be read in the brochure. A total of 60 public and private funded measures were set up, encompassing 6 strategic pillars: human capital qualification; technological cooperation; startup 4.0; financing and investment incentive; internationalization; standards and regulation. With a bottom-up approach, Industria 4.0 will be implemented through a platform launched by the Ministry of Economy and managed by COTEC, a private company.

With the strong support of the private sector, especially private groups, Industria 4.0 had an impact in over 50.000 companies and trained over 200. 000 workers. Over 10 months of preparation, the government worked with over 200 companies in different working groups, which represented different strategic sectors (agroindustry, retail, tourism and automotive). This process involved for the first time multinational companies such as Altice-PT, Bosch, Deloitte, Google, Huawei, Microsoft, Siemens or Volkswagen. The consultation process and cross-sectoral dialogue between companies,

[81] https://digital-strategy.ec.europa.eu/en/policies/desi-portugal
[82] https://portugaldigital.gov.pt/wp-content/uploads/2022/01/Portugal_Action_Plan_for_Digital_Transition.pdf
[83] https://ati.ec.europa.eu/sites/default/files/2020-06/DTM_Ind%C3%BAstria%204_PT.pdf
[84] https://ati.ec.europa.eu/sites/default/files/2020-06/DTM_Ind%C3%BAstria%204_PT.pdf

employees, associations, science and political actors allowed all economic operators to gain a uniform understanding of the potential of Industry 4.0.
The strategy aims to create favourable conditions for the **development of i4.0 start-ups** as well as leverage national technological solutions in an international context. Finally, the initiative plans to position Portugal as an international HUB by attracting resources and creating fiscal and legal conditions to attract foreign investors. A considerable effort was put on this strategy: "It is not a State strategy, nor it is from Government. It is strategy of the country. This concerns the digitalization of industry" said the Secretary of State for Industry[85] .

The "**Indústria 4.0**"[86] plan was presented as a strategy to overcome competitiveness challenges and prepare the Portuguese Industry "at the forefront of the of the 4th industrial revolution"[87]. The government underpinned the urgency to raise awareness about digital transformation and the necessity for requalifying human capital. The initiative aims to provide the Portuguese industrial sector with the knowledge, information and tools needed to transform, adapt and empower its national workforce.

Six strategic pillars and 10 flagship initiatives underpin "**Indústria 4.0**": Finance, Digital Skills lme, i4.0 technical courses, Learning Factories, International Missions, Adira Industry 4.0, Future 2020, BoschDigital, 4AC Indústria 4.0 and PSA Mangualde Consortium.

The plan 4.0 is structured around 6 strategic pillars: human qualification, technological cooperation, start-up i4.0, financing and investment incentives, internationalization and standards and regulation.
The initiative's bottom-up approach applied during the design and the implementation n can be transferable to other sectors or countries. Stakeholders' engagement has proven to be of crucial importance to the development and final outcome of the initiative. Another sector currently in study to scaleup the method used for this initiative is fintech (finance service and technologies), as **blockchain** and new payment platforms open a wide range of possibilities for the development of digital platforms. Other relevant sectors for the Portuguese economy, will follow a similar approach in order to ensure their readiness for the 4th industrial revolution.

In the framework of the **Recovery and resilience Plan (PPR)**, funding instruments have been mobilised. The funding model combines public and private funding. Overall, an investment of €4.5 billion has been budgeted for the next 4 years. Public funding of the measures will be made available through Portugal 2020 ERDF funds. A total of €2.26 billion are allocated for the adoption of technology and infrastructures linked to the concept Indústria 4.0. Different financial tools will be used (loans, tax deductions, call for proposals or vouchers). For instance, through the financial instrument of a voucher "vale Indústria 4.0" the government will distribute vouchers of 7.500€ each to support SMEs' digital transformation. In addition, a credit line supports export activities.

The **Programme Compete 2020**[88] is the operational programme which aims to improve the competitiveness and internationalization of the Portuguese economy. Oriented mainly to the less developed regions of Portugal - North, Center and Alentejo region (it has a national scope in Cohesion Fund projects), it forms with the Regional Operational Programs of the Continent a diversified network of public policy instruments with common rules and objectives covering the entire national territory.

[85] https://ati.ec.europa.eu/sites/default/files/2020-06/DTM_Ind%C3%BAstria%204_PT.pdf
[86] https://www.iapmei.pt/Paginas/Industria-4-0.aspx
[87] https://ati.ec.europa.eu/sites/default/files/2020-06/DTM_Ind%C3%BAstria%204_PT.pdf
[88] https://portugal2020.pt/wp-content/uploads/4_brochuracompete2020.pdf

One of its pillars contributes to strengthening research and innovation capacities and promotes all stages of the R&I chain (from R&D to the enhancement of knowledge). It favors a logic of interaction between all actors in this system, with special focus on research and knowledge dissemination entities (composed of universities, public laboratories, public R&D centers and interface entities, such as Technological Centers and companies (as central entities of the innovation component). It focuses on the following assets: Scientific Research & Technological Development / Technology Transfer / Scientific and Technological Research Infrastructures / Economic Valuation of R&D Results / Collective Efficiency Strategies of Networks and Clusters.
As part of the overarching **Portugal 2030**[89], which embodies the agreement established between Portugal and the European Commission for the application of cohesion policy funds (ERDF and ESF+) for the 2021-2027 programming period, the **Innovation and Digital Transition Programme (COMPETE 2030**) aims to pursue the following strategic objectives, out of which comes the Strategic Objective 1, dedicated to **Research &Innovation, Digitalization, productive investment**.It is aimed to support investment in research and innovation, digitalisation, competitiveness and internationalization of companies, skills for smart specialisation and industrial transition.

5.12 Slovenia

In terms of R&I strategy and priorities, the Slovenian Ministry of the Economy, Tourism and Sport is responsible for setting the industrial strategy[90] as well as the Slovenian sustainable smart specialisation strategy with the focus on the following verticals:

- Smart cities and communities
- Smart buildings and wood supply chain
- Smart networks for circular economy transition
- Sustainable food
- Sustainable tourism
- Factories of the future (robotics and components, photonics, plasma processes, smart sensors, smart materials, smart factory management)
- Health
- Mobility
- Materials as end products (steel, aluminium, rapid prototyping technologies, recycling technologies, molds, material process development, smart composite materials, functional coatings)

The strategy in technology development includes the following horizontals[91]:

- Digital transformation (new business models)
- IoT
- IoS (internet of services, platforms)
- Cybersecurity
- HPC and big data
- GIS-T (integrated systems for data capture, data products, location services)

[89] https://www.compete2020.gov.pt/Estrutura_Objetivos_C2030

[90] https://www.gov.si/en/policies/business-and-economy/innovation-and-technological-development/

[91] https://www.gov.si/assets/ministrstva/MKRR/Slovenska-strategija-trajnostne-pametne-specializacije-S5-marec2022.pdf

A **Research and innovation strategy**[92] has been set up for 2030 covering the following priorities:

- research in the field of environment, sustainability, biodiversity, farming, forestry and food
- digital transformation of the economy and society
- life quality of all generations
- sustainable resource management
- energy

Major findings from the Slovenian innovation ecosystem report ([93]) are: «The structure of the innovation ecosystem in Slovenia was built on the experience gained in twinning programmes with partners from Austria, Ireland and Germany and elsewhere. Slovenia does not have a central innovation, research, and development coordination, but has two key coordination verticals in place, one for the research and development under the domain of the Ministry of Education, Science and Sport and its agencies and the other for the growth, smart specialisation and start-up under the domain of the Ministry of Economic Development and Technology and its implementing institutions and networks. A third vertical may be noticed within the scope of the Government Office for Development and European Cohesion Policy with the Smart Specialisation Strategy".

Several strategies and programmes were adopted and implemented in the last decades to support research, development and innovation. "Their priorities and measures changed through the years, thus affecting the strategic set up and financing, for example from support for clusters, competence centres and centres of excellence earlier on to SRIPs lately. The key current programming documents are well developed in terms of context, however the implementation of some of these programmes, for example Research and Innovation Strategy, is lagging behind"[94].

«The Smart Specialisation Strategy of Slovenia has the possibility to strengthen the collaborative approach to innovation and may be seen as a governance framework to organise interactions among the elements of the Quadruple Helix Model as their strong involvement ensures diverse knowledge, innovation and mutual cross-learning, while their coordination is crucial for efficiency. Clusters, centres of excellence and competence centres are seen as a thread of development that was diluted with yet another change, the introduction of structures necessary for the implementation of the smart specialisation strategy, such as Strategic Research and Innovation Partnerships (SRIPs) which bring together representatives of the businesses, knowledge institutions and the state in the target areas of the Smart Specialisation Strategy.»

«Mapping of the support instruments in Slovenia listed over 70 different support mechanisms available from the Slovene Enterprise Fund, Slovene Research Agency, SPIRIT, Ministry of Economic Development and Technology, Ministry of Education, Science and Sport as well as several private institutions.»[95]

The financial institution that primarily manages funds intended for the use of European cohesion funds is the SID Bank (SID – Slovenska izvozna in razvojna banka, d.d., Ljubljana), a promotional development and export bank[96] 100% owned by the Republic of Slovenia. SID bank develops, provides and promotes

[92] http://www.pisrs.si/Pis.web/pregledPredpisa?id=RESO133

[93] https://www.podjetniski-portal.si/uploads/gradiva/krepitev_inovacijskega_ekosistema/srss161_slovenia_ecosystem_d2_state_of_play_report.pdf

[94] https://www.podjetniski-portal.si/uploads/gradiva/krepitev_inovacijskega_ekosistema/srss161_slovenia_ecosystem_d2_state_of_play_report.pdf

[95] https://www.podjetniski-portal.si/uploads/gradiva/krepitev_inovacijskega_ekosistema/srss161_slovenia_ecosystem_d2_state_of_play_report.pdf

[96] https://www.skladskladov.si/en/about/about-fund-od-funds

long-term financial services designed to supplement financial markets for the higher competitiveness of economy, creating new jobs and sustainable development of Slovenia.

10 priority areas have been designed for national research infrastructure[97]:

- smart materials and nanotechnologies
- sustainable energy sources and environmental technologies
- energy efficiency, sustainable building and geoinformation sources,
- biotechnology, biomedicine and biological sources
- analytic capabilities
- digital national sources
- social science and humanities research infrastructure
- space applications research infrastructure
- safe and healthy food.

5.13 Spain

In Spain, the overarching Strategy for Science, Technology, and Innovation has been set up for the programming period of 2021-2027[98]. This national strategy sets the guidelines and priorities for fostering science, technology, industry 4.0 and innovation in Spain, promoting collaboration between the public and private sectors, strengthening knowledge transfer, and encouraging participation in international R&D programs. It follows the main lines of the industrial national plan implemented in 2019[99].

The main plan related to emerging technologies is the **National Plan for Digital Enabling Technologies**[100] has been launched by the Ministry of Industry, Trade and Tourism of Spain, with the aim to promote the digital transformation of industries through the advancement of enabling technologies such as artificial intelligence, cybersecurity, cloud computing, among others at country level. Spain as a decentralised state has autonomous regions with separate governments and ruled by specific policies in terms of R&I. In the present report we focus on two of those regions, the Basque Country and Catalonia, as they both historically represent an advantage of competitiveness and innovation since 19th century. Nowadays these regions maintain this competitive advantage and are an example for the other territories in Spain.

Basque Country (Euskadi):

[97] https://www.gov.si/assets/ministrstva/MKRR/Kljucni-dokumenti-S5/Priloga_Mapiranje-raziskovalne-infrastrukture_MIZS_februar-2021.pdf

[98] https://www.ciencia.gob.es/Estrategias-y-Planes/Planes-y-programas/PEICTI.html

[99] https://www.mincotur.gob.es/es-es/gabineteprensa/notasprensa/2019/documents/docu%20directrices%20generales%20de%20la%20política%20industrial%20española.pdf

[100] https://www.ciencia.gob.es/Estrategias-y-Planes/Sistema-de-Informacion-sobre-Ciencia--Tecnologia-e-Innovacion--SICTI-.html

In the Basque Country, a Science, Technology, and Innovation (PCTI) Plan 2030[101] was implemented as a regional framework aiming to drive science, technology industry 4.0, and innovation in the Basque Country until 2030. It focuses on strategic areas such as sustainability, digitalisation, and talent development, promoting collaboration between companies, universities, and research centers. Complementary to the PCTI plan, the Basque Country has adopted a Circular Economy Strategy 2030[102]. This document establishes the strategy for transitioning to a circular economy in the Basque Country, promoting resource efficiency and fostering innovation in sustainable business models.

Catalonia (Catalunya):

In Catalonia, a draft Law on Science is currently being presented. This draft law aims to establish the regulatory framework for promoting science, technology and industry 4.0, and innovation in the Catalonia region. Barcelona, the capital of Catalonia has its own strategic plan entitled "Barcelona Science Plan 2020-2023[103]". This strategic plan seeks to position Barcelona as an international reference in science and innovation, fostering research, entrepreneurship, and technology transfer. Furthermore, the Catalan Strategy[104] (ECAT2020) was launched by the Catalan government as a strategic paper that set the priorities and objectives to drive a knowledge-based and technology-driven economy in Catalonia, promoting innovation, digitalization, and internationalization.

5.14 Sweden

The **Research and Innovation Bill**[105] sets out the direction of policy for the next four years. The focus is on societal challenges such as climate and environment, health and welfare, digitalisation, skills supply and democracy. The document lays out the framework for investments and priorities for the coming years. In addition, it formulates and codifies the analysis of the state of the Swedish research and innovation system.The Swedish government runs national research programmes and commissions

[101] https://www.euskadi.eus/contenidos/informacion/despliegue_pcti_euskadi/es_def/adjuntos/Bases_PCTI_Euskadi_2030_documento.pdf

[102] https://www.euskadi.eus/contenidos/informacion/economia_circular/es_def/adjuntos/EstrategiaEconomiaCircular2030.pdf

[103] https://www.barcelona.cat/barcelonaciencia/ca/qui-som/una-ciutat-de-ciencia-i-coneixement/pla-barcelona-ciencia-2020-2023

[104] //efaidnbmnnnibpcajpcglclefindmkaj/https://fonseuropeus.gencat.cat/web/.content/ris3cat/documents/2014-2020/ecat-2020.pdf

[105] Swedish Research Council, https://www.vr.se/english/just-now/news/news-archive/2021-01-15-new-initiatives-in-the-governments-research-bill-that-relate-to-the-swedish-research-council.html

the operationalisation of some of these to research councils such as Formas[106] and Forte[107]. Formas is responsible for four of these – Climate, Sustainable Spatial Planning, Food and Oceans and Water. Forte is responsible for the programmes on applied welfare, working life, mental health, antibiotic resistance, and migration and Integration. All of the programmes are broad, ten-year initiatives that aim to contribute to solving prioritised societal challenges and strengthening collaborations between those performing the research, those funding the research and stakeholders in society.

Strategic Innovation Programmes[108] are an initiative in which three national agencies provide funding for activities in strategic areas for Sweden. These areas have been identified collaboratively by stakeholders from businesses, academia, and the public sector, who recognise the need for collaboration and joint efforts.The organisations Vinnova, Energimyndigheten (Swedish Energy Agency), and Formas (Swedish Research Council for Sustainable Development) collectively finance collaborative work among diverse stakeholders to strengthen selected areas and develop sustainable solutions to global social challenges. The stakeholders collectively formulate challenges, establish long-term objectives, and prioritise investments in research, development, and innovation.
In total, there are **17 Strategic Innovation Programmes** funded by Vinnova, Energimyndigheten, and Formas. The management of the RE:Source and Viable Cities programmes falls under the responsibility of the Swedish Energy Agency.

The Research and Innovation bill, prepared every four years, reflects the strategic dimensions of Sweden's national research base, operationalised in terms of research policies and priorities and technology foresight exercised conducted by innovation agencies such as Vinnova. These initiatives play a significant role in shaping the funding strategies of Research Councils, foundations, and funding agencies. The involvement of the private sector is integral to these processes.The innovation agency Vinnova, for instance, engages in regular consultations, workshops, and hearings with representatives from academia and the private sector to assess research strengths, weaknesses, and needs within the Swedish science and innovation system. Foresight studies are another important input in research policy formulation. These studies help identify and prioritise key research and technology areas, with active contributions from private sector actors. Industry associations, as well as companies and individuals, participate in workshops and foresight studies to express their opinions and highlight their specific needs.

"Zoom" on the research policy: a bottom-up and multi-stakeholder approach

The research policy formulation process incorporates a bottom-up approach. Funding agencies issue broad calls for tenders that reflect key research and technology areas, allowing applying institutions to define their research project themes accordingly. Research policies are developed based on the outcomes of these activities. Funding agencies work closely with the Swedish Research Council and sectoral Research Councils to seek advice on defining key research and technology areas. When formulating research policy measures and funding programs, funding agencies often assess their potential impact using indicators such as economic potential and Sweden's current position. Expert opinions, including those of academic experts and private sector representatives, are frequently sought through formal processes to gauge the potential impact of funding programs. Overall, Sweden's research and innovation policy formulation involves **multiple stakeholders and inputs.** Agencies like Vinnova, technology foresight studies, consultations with academia and the private sector, and assessments of economic potential and current position all contribute to shaping research policies and

[106] Research council Formas, https://formas.se/en/start-page/about-formas/what-we-do/national-research-programmes.html

[107] Research council Forte, https://forte.se/en/about-forte/special-initiatives/

[108] Strategic Innovation Programmes, https://www.vinnova.se/en/m/strategic-innovation-programmes/

funding strategies. The objective of the policy is for Sweden to become one of the leading countries globally in research and innovation, establishing itself as a prominent knowledge-driven nation.

National research programmes that target major societal challenges represent a relatively recent development in Sweden. These programmes exhibit certain distinctions compared to "traditional" programmes. They are funded for a duration of ten years and have broader scopes, demonstrating greater ambition. In addition, they strive for active and strategic coordination of research funding and other related activities in Sweden, while fostering synergies among various stakeholders. In contrast to "traditional" research programmes that primarily focus on building a project portfolio aligned with programme objectives, these national research programmes serve as platforms for both new and ongoing research. Additionally, they aim to establish connections with international programmes and EU Joint Programming Initiatives. They seek to make significant contributions to society by promoting development, knowledge creation, evidence-based policies and management, ultimately aligning with national policy objectives.

A specific characteristic of the Swedish Science and Innovation System are research funding foundations – independent in the selection of research areas - which are partly equipped with public funding capital. The most important of these foundations are the Knowledge Foundation (with a focus on information and communication technology), the Swedish Foundation for Strategic Research (with a focus on natural sciences, engineering and medicine), and the Foundation for Strategic Environmental Research (with a long-term focus on environmental research).

In addition, the private sector is actively involved in all national agencies through formal or informal consultations and participation in the assessment of project funding applications.

Best Practice: the Swedish Strategic Innovation Programmes

An exemplary best practice is Sweden's **Strategic Innovation Programmes (SIP)**, which goal is to enhance Sweden's international economic competitiveness and address global challenges through improved collaboration among universities, companies, civil society organisations, and government agencies, utilising an innovation system approach. Rather than funding individual projects or programmes, the focus initially was on providing funding to large consortia of partners and stakeholders involved in emerging ecosystems. The Strategic Innovation Program (SIP) initiative was preceded by the establishment of Strategic Innovation Agendas (SIAs) using a bottom-up approach. From 2013 to 2017, a total of 17 strategic innovation programmes received funding for up to 12 years. Within these programmes, companies, higher education institutions (HEIs), and other organisations collaborate to define challenges, set long-term goals, and prioritise investment in research and innovation. The SIPs then allocate funds to projects, primarily through open calls but also strategic initiatives. Some early SIPs heavily drew upon previous Sectoral Programmes, while later SIPs like IoT Sweden, SIO Grafen, Smart Built, and Medtech4Health introduced a mix of continuity and more radical change.

The SIPs have undergone regular evaluations, which concluded that the SIPs made a significant contribution in making Sweden attractive for investment, but their impact on sustainable growth was more modest. To achieve more radical, transformative goals and address societal challenges, it was recommended to prioritise the needs of societal stakeholders, establish clearer and more specific visions, and focus on fewer but larger changes. These recommendations were also reflected in the joint input from various organisations to the Research and Innovation Bill 2020, which led to the

development of the **next-generation SIPs**, known as **SIP 2.0**. Formas, Vinnova, and STEM were tasked by the government to further develop the SIPs and accelerate the sustainable transformation for **increased societal benefits and the competitiveness of Swedish industry**.

In 2022, the agencies Stem, Formas, and Vinnova initiated the launch of the new generation programmes under the label **"Impact Innovation".** A mobilisation and preparation process commenced, allowing stakeholders to collaborate and outline the system changes they aim to achieve within the programmes. This process will culminate in a full programme launch in 2024. Overall, the evolution of the SIPs exemplifies successful continuous innovation policy development, characterised by iterative adjustments in measures, content, and priorities. It builds upon previous programmes, incorporates insights from evaluations, aligns with global trends, leverages innovation policy research, and adapts to changing policy emphases.

At regional level, ALMI Business Partners (ALMI)[109] includes 21 regional offices spread over Sweden providing consulting services for regional and business development. ALMI is owned by the Swedish government and regional authorities. It operates across Sweden through 40 locations around the country. It performs a complementary role on the Swedish market. Its operation helps develop and finance small and medium-sized businesses, promoting sustainable growth. It has customers in all commercial phases, from ideas to successful companies. The Agency for Business Development (NUTEK) focuses on business development and regional development activities.

In Sweden, innovation policies give considerable attention to regional aspects, with regional growth agreements serving as key tools for coordinating policies and fostering regional industrial development. **Regional Growth Agreements**[110] are formed in the Swedish counties through collaborations between various stakeholders, establishing Public-Private Partnerships. These partnerships are defined by their business-oriented approach, with a focus on aspects such as the availability of skilled workforce, business activities, the industrial environment, and the regional innovation system. These partnerships, aligned with the VINN Excellence Centre[111] concept, represent long-term research collaborations between universities, public sector entities, private sector actors, and Vinnova. By involving industrial enterprises, research projects are targeted towards areas that are both relevant to the industry and scientifically demanding.

Enabled by the innovation system architecture outlined in this analysis, a number of domain specific national strategies provide more concrete pathways for operationalisation.

Cyber safe data transmission, storage and analysis technologies

Sweden introduced its national cybersecurity strategy, "A National Cybersecurity Strategy"[112] in 2017, which marked the second national strategy following the initial release in 2010. The 2017 strategy encompasses various strategic objectives, as assessed by ENISA. These objectives include combating cybercrime, achieving a balance between security and privacy, raising citizen awareness, protecting critical information infrastructure, developing national cyber contingency plans, fostering international cooperation, promoting public-private partnerships, establishing institutionalized cooperation among public agencies, supporting research and development efforts, and conducting cybersecurity exercises.

[109] ALMI, https://www.almi.se/en/in-english/

[110] Swedish Agency for Economic and Regional Growth, https://www.government.se/government-agencies/swedish-agency-for-economic-and-regional-growth/

[111] VINN Excellence Center, https://www.vinnova.se/en/publikationer/vinn-excellence-center/

[112] A national cyber security strategy, https://www.cyberwiser.eu/sites/default/files/SE_NCSS_en.pdf

In March 2020, significant updates were made through the publication of the Comprehensive Cyber Security Action Plan 2019-2022[113]. This action plan serves as an effective means to translate and implement the national strategy into concrete and measurable actions.During the same period, the Swedish Defence Research Agency collaborated on a report titled "Critical Nordic Flows - Collaboration between Finland, Norway, and Sweden on Security of Supply and Critical Infrastructure Protection"[114]. This report explores avenues for enhanced trilateral cooperation among the three countries to prepare for potential disruptions to the cross-border flow of vital goods and services. The report focuses on six societal sectors, namely communications and digital networks, energy, food, financial infrastructure, pharmaceuticals, and transport.

Human-centric solutions and human-machine interaction & Real time-based digital twins and simulation

Produktion2030[115] is a Strategic Research and Innovation Platform. The aim is to increase competitiveness in Swedish manufacturing industry across a set of inter-related domains:

- Resource-efficient production: The goal is to minimise resource consumption and environmental impact throughout the entire lifecycle of products and production systems. This is crucial in a country like Sweden with high wages, quality standards, and material costs. Efficiency in using materials, people, energy, capital, and time is essential for maintaining competitiveness.
- Flexible production: With increasing consumer demands for customised and personalised products, manufacturing processes need to be adaptable and flexible. This involves handling volume changes, different product variants, new materials, and combinations of materials. New knowledge, innovative manufacturing methods, automation solutions, and digitalization contribute to achieving flexibility.
- Virtual production development: Converting information and data into knowledge for decision-making in virtual and physical production systems is important. This requires leveraging digital tools and technologies to simulate and integrate systems, enabling decentralized management and monitoring of the production process.
- Humans in the production system: While digitalisation plays a significant role in manufacturing, humans still have a crucial role to play. Collaboration between humans and advanced automated production systems is essential. Technological advances demand new competencies in personal safety, communication, interfaces, and task allocation between humans and machines. Additionally, improved workstations, methods, and ergonomics are necessary.
- Circular production systems and maintenance: Transitioning to a circular economy and implementing circular production strategies, such as re-manufacturing, is vital for smart and resource-efficient production. Extending the service life of products and production systems through smart maintenance, material combinations, and data analysis is important. Developing competence in this area and creating service-based products are key to achieving circularity.
- Integrated product and production development: Strengthening the integration of product and production development processes and tools is crucial. Rapid, parallel, and integrated development is necessary to meet market demands for speed and flexibility. This integration ensures that products create value for all stakeholders in the supply chain.

[113] Comprehensive cyber security action plan 2019-2022, https://www.cyberwiser.eu/sites/default/files/Sweden_CyberPlan_March2019.pdf

[114] Critical Nordic Flows, https://www.cyberwiser.eu/sites/default/files/critical-nordic-flows.pdf

[115] Made in Sweden 2030, https://www.vinnova.se/globalassets/mikrosajter/strategiska-innovationsprogram/agendor/made-in-sweden-2030-eng.pdf

Artificial Intelligence

Sweden's National Approach for Artificial Intelligence[116] serves as a reference for the government to outline forthcoming policy initiatives with the aim to strengthen Sweden's welfare and competitiveness by means of artificial intelligence (AI). Sweden has identified several key areas for accelerating the use of AI in the country. These areas include:

- Re-usable models: Sweden aims to leverage existing knowledge bases, components, and pre-trained models for specialised tasks with less data. The focus is on making general models and components, particularly for Swedish language models and speech-to-text components, widely available for both the public and private sectors.
- Privacy-preserving AI: Addressing privacy concerns while working with sensitive data is crucial for maximising the value of AI and data-driven methods. Sweden aims to develop methods for privacy-preserving data and model sharing, along with legal aspects and best practices for implementing AI solutions.
- Decentralised AI: Given data privacy restrictions and limited bandwidth, decentralized AI systems, such as edge computing and federated learning, are becoming increasingly important. Sweden recognises the potential of collaboration in this area, as decentralised AI is critical for applications in IoT, government agencies, and healthcare.
- AI systems, platforms, and operations: Core AI algorithms are only a small part of an AI application. To deploy AI applications efficiently, Sweden emphasises the need for mature systems and platforms that support development and operations. Collaboration around AI platforms, system operations, and building data-driven systems is encouraged.
- Complex systems management: Combining machine learning and operations research can enhance the efficiency of operations and processes in various industries and organizations. Sweden aims to build competence, knowledge, and platforms in this area, benefiting medium-sized companies and the public sector.
- Verifiable robustness: AI systems must exhibit robustness against unknown situations, noise, anomalies, and malicious manipulation, particularly in industrial and medical settings. Sweden seeks verifiable robustness in complex AI systems and recognises it as a shared challenge across sectors, promoting collaboration.
- Decision making under uncertainty: Quantifying uncertainty in AI models is a challenge but essential for making accurate decisions. Sweden recognises the importance of addressing uncertainty in real-world industrial scenarios, healthcare, and public decision making. Collaboration in this area is seen as valuable, as approaches and solutions may be similar across different sectors.

Technologies for energy efficiency and trustworthy autonomy

The Swedish government has set a goal of achieving net-zero emissions by 2045 and recognises the need for accelerated actions from the industry. As a result, a new institutional innovation called the Fossil Free Sweden initiative[117] was established to serve as a mediator between government ministries and the industry. The Fossil Free Sweden organisation receives funding from the government but maintains a neutral status, enabling constructive dialogues between industries and policymakers regarding policies and industry commitments. The organisation took the lead in initiating and facilitating a road mapping process - Roadmap for fossil free competitiveness[i] - guiding industry sectors

[116] National Approach for Artificial Intelligence, https://wp.oecd.ai/app/uploads/2021/12/Sweden_National_Approach_to_Artificial_Intelligence_2018.pdf

[117] Roadmap for fossil free competitiveness, https://mb.cision.com/Public/4172/2616255/8b26ab6e818884d6.pdf

to propose politically viable policies that could be effectively implemented and verified by the government.

6 Comparative analysis

The desk research conducted across 14 European countries provides a helicopter view on the R&I agendas focusing on emerging technologies implemented in different Member States. Innovation is considered a competitive advantage in most countries for driving competitiveness, retaining talents and ensuring prosperity, and the main national strategies are aligned with those of the EU and geared towards policies and programmes supporting researchers, entrepreneurs, and innovative technologies.
With the Covid-19 pandemic having drastically changed our world and production systems, the adoption of digital technologies has been widely accelerated to ensure the functioning of supply chains during lockdowns but also as a means of granting EU technological sovereignty. However, a closer look at the programmes related to emerging technologies shows that countries are positioned at different levels when it comes to the deployment of these novel technologies. Most countries have set a strategy for Artificial Intelligence but it does not always consider the long-term societal impact and ethical issues. In Greece for instance, a law on Artificial Intelligence has been adopted, while this topic is still on discussion at EU level.

In most plans, the term “emerging technologies” or “enabling technologies” is not referred as such. In most countries, strategies navigate the Industry 4.0 rather than the Industry 5.0. concept. Some national strategies implemented for Industry 4.0 seem to be more focused on efforts to digitalise the public Administration and SMEs as well as to upskill population with digital skills, rather than drawing a clear pathway for the transition to the 5th industrial revolution. Plus, the merging of societal and environmental factors into the business models as a strategy do not seem to be a clear priority in such cases. In Member States that prioritise the adoption of novel technologies, there is alignment with the 6 technology frameworks considered as strategic EU priority areas.Several initiatives implemented at local level as innovation facilitators such as the Digital Innovation Hubs[118], regulatory sandboxes (Belgium, France, Portugal, etc.) seem to have good adherence across Member States while offering conditions to open access to tech and ease collaboration between researchers, tech entrepreneurs and allow them to test their experiments in real-like environments (such as living labs). Such initiatives are largely endorsed by the EC through the new European Innovation Agenda[119] while preparing the ground for encouraging tech innovators to take risks and be able to test their inventions before bringing it to the market.

Recent Initiative launched by the EC aimed at designating Regional Innovation Valleys[120] can help create good synergies between regions and countries while being a push for less advanced regions to accelerate their adherence to novel technologies hosting talents, entrepreneurs and researchers and creating favourable conditions for joint collaborations and partnerships with universities and private companies. Enhanced cross-border collaboration would benefit regions that are moderate innovators to exchange and learn from other countries where emerging tech is deployed at large scale. An EU initiative going in the same direction are the I3 strategies.

[118] https://digital-strategy.ec.europa.eu/en/activities/edihs

[120] https://eismea.ec.europa.eu/news/regional-innovation-valleys-calls-proposals-are-now-open-2023-05-17_en

The present analysis has shown that countries are embracing the vision of Industry 5.0 at a different pace, and mostly not using this term in their strategies and programmes. Some countries demonstrate readiness to overtake the transition to the Industry 5.0 supporting a clear roadmap for emerging technologies, while in other MS national strategies lack a comprehensive plan to prepare the shift to the Industry 5.0 and the uptake of novel technologies in a value-sensitive approach.

To see countries fully embark on the Industry 5.0 concept and reap its benefits, besides strong innovation supportive policies, stakeholder engagement is needed in the whole ecosystem - industry, policy-makers, academia, including its users and the population in general. A clear understanding of the opportunities and challenges posed by this tech wave needs to be recognised and endorsed by society at large. Like for a new product ready to be introduced in the market, large consensus is needed to grant adherence and avoid the risk of being only accepted by a minority of early adopters.
Therefore, continuous awareness raising campaigns would help further unleash the potential of these technologies among society which acceptance is commonly confronted by ethical, societal and environmental purposes. Enhanced cross-collaboration between Member States to share experiences and adopt a common strategy would be advantageous.

Finally, to help diffuse the positive impact of the new innovation wave, although innovation policies are Member States' competences, a EU roadmap on Industry 5.0 could serve as a guideline to set a harmonised approach (although not a binding document) for all Member States willing to navigate the Industry 5.0 with a common understanding.

7 Conclusion

The research conducted as part of the FORGING project illustrates different levels of policy and programme development regarding emerging technologies across Member States. While some countries have designed strategies to adopt emerging technologies in alignment with EU strategic priority areas, in others an agenda for Industry 5.0 is not available.

As part of the methodology set for this activity, further steps of this analysis will be a consultation of representatives of regional and national authorities working in R&I to collect insights on the programmes implemented in their region or countries. These exchanges would potentially lead to joint awareness raising, co-programming of activities, stakeholders' involvement and co-creation processes. The FORGING team will also continue its efforts in promoting the FORGING Forum, a community of experts from academia and research, spanning from technology experts to individuals with SSH background, towards the national authorities and in particular the programme holders and relevant initiatives that have been developed in the different EU Member States.