

D4.1-Mapping Supply- Competencies in Less Developed Regions

GreenStep

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D4.1: MAPPING SUPPLY-SIDE COMPETENCIES IN LESS DEVELOPED REGIONS

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1. INTRODUCTION

This report corresponds to Deliverable **D4.1** included in **Task T4.1**: Mapping Supply-Side Competencies in less developed regions. Identifying strengths and weaknesses in these areas, it will be enhanced the cooperation among quadruple helix stakeholders (encompassing government, academia, industry, and civil society) in less developed regions, pivotal for sustainable development. Indeed, this is a key component in identifying the **capacities, strengths, and competencies** of local businesses and organizations. Furthermore, it aims to align these assets with **business opportunities geared towards sustainable investments**, thereby promoting more balanced and resilient regional development.

1.1 RELEVANCE OF THE MAPPING SUPPLY

Mapping supply-side competences in a region is crucial for understanding the existing capabilities, resources, and expertise available within local industries, educational institutions, and the workforce. It allows policymakers, businesses, and training providers to:

Identify skill gaps and training needs

Align educational programs with industry demands

Facilitate targeted investments and innovation strategies

Support regional development and competitiveness

Strengthen collaboration between stakeholders

In short, it provides a clear picture of a region's strengths and weaknesses, enabling smarter decision-making and more effective talent and resource management.

The objective of this report is to carry out a **Mapping of Supply-Side Competencies** and analyse the strengths and needs of three regions considered by the European Union as **less developed**:

CENTRAL AND WESTERN LITHUANIA

NORTHERN PORTUGAL

LIBEREC REGION, CZECH REPUBLIC

To this end, a methodology was established for information gathering through relevant stakeholders of the **Quadruple Helix** in each of the regions, ensuring that all key aspects of the regional ecosystem were adequately covered. Enhancing cooperation among quadruple helix stakeholders (encompassing government, academia, industry, and civil society) in less developed regions is crucial for sustainable development. By fostering a dynamic environment for innovation, this task ensures that all voices are heard and integrated into the innovation process. This inclusive approach not only stimulates immediate project outcomes but also lays the groundwork for continued collaboration and innovation post-project.

1.2 WORK METHODOLOGY

The work carried out by FEM followed this sequence:

- 1) **Initial Coordination Meeting:** Several meetings were held with the LDRs' partners to coordinate and define the roadmap for T4.1.
- 2) **Identification of Key Stakeholders:** The LDRs' GREENSTEP partners identified relevant stakeholders from the four sectors of the **Quadruple Helix** (industry, government, civil society, and academia).
- 3) **Stakeholder Contact and Scheduling:** FEMETALINDUSTRY contacted each stakeholder to explain the context and objectives of the initiative and to schedule individual meetings.
- 4) **Supporting Information:** The interview questions were shared with the stakeholders in advance, so they could gather relevant information and prepare their answers beforehand.
- 5) **Online Interviews:** Individual interviews were conducted via **Microsoft Teams**. The sessions were recorded. The order in which the interviews took place was determined by the stakeholders' availability to schedule the meetings. The three study regions overlapped in terms of timing from the 9th of April to the 25th of June.

To gain a comprehensive understanding of the industrial ecosystem—its strengths and areas for improvement—in each region, it is essential to examine the industries present locally and assess how digital transformation and the energy transition are shaping the regional landscape. An initial draft, prepared by the LDR partners of the GREENSTEP project, highlighted a common set of challenges across all analysed regions, notably the shortage of skilled talent and the difficulty in adapting to evolving technological demands and market trends.

This starting point served as the foundation for designing the interview framework used to collect detailed insights from the regions of Norte Portugal, Liberec, and the Central and Western Region of Lithuania. The agents were selected based on their activity in the region, as well as their knowledge of the area's ecological and digital transition processes and their ability to support innovation development within the Energy Intensive Industry ecosystem. Another factor taken into account in the selection of the agents was the impact that all these elements had on their professional and personal activities. Then, a set of questions were designed based on the different topics and the information we needed to gather from the Q-helix stakeholders.

An ultimate objective of this task was to identify the commonalities across the different regions through the perspective of professionals working in strategic sectors—key witnesses to the level of innovation and growth these regions have experienced in recent years, along with the weaknesses and needs. Gaining a deeper understanding of each region could enable us to foster closer connections among the various stakeholders, ultimately weaving a collaborative network between the three regions under study.

Finally, the objective and expert perspective of the professionals would help us to extrapolate a series of improvement proposals that could be applied in each individual case—or across all of them.

1.3 MAPPING OF Q-HELIX ACTORS

During the phases *Work Methodology: Stakeholder Contact and Scheduling and Supporting Information* Provided to LDR Partners, the guidelines for contacting and informing the different actors of the Quadruple Helix in each of the regions were established.

In collaboration with the GreenStep partners from the LDR regions—a search was conducted for regional Quadruple Helix actors, focusing on individuals and entities with significant involvement in the development of the Smart Specialisation Strategy (S3) document or, alternatively, those with a certain proximity to and understanding of its scope. However, this was not always an easy task. Generally speaking, the academic and industrial sectors were the most accessible, in contrast to the civil society and governmental sectors, which proved more challenging to engage for various reasons.

Within Civil Society, contact was mainly established with NGO representatives, some of whom were hesitant to collaborate, citing a lack of familiarity with certain topics addressed by GreenStep—particularly innovation and the S3 Smart Specialisation Strategy. Nevertheless, they were able to provide highly valuable insights into societal perceptions on issues such as youth education and the limited interest among young people in remaining within the regional industrial sector, among others.

On the other hand, governmental participation was more limited across all regions. Despite this, we were able to obtain a general overview of governmental institutions' interest in promoting support measures and improving conditions for both citizens and industry in relation to the energy transition, the new digital era, and workforce training.

The details of each of the process will be described later in the sections related to Liberec, Lithuania, and Northern Portugal, outlining the steps that were followed and, in some cases, the difficulties that certain partners encountered.

In addition to being part of the panel of interviewed experts, the stakeholders were included in the GreenStep project's contact database and showed a willingness to participate in other activities carried out within the project, such as workshops, training sessions, discussions and potential collaborations in innovative projects.

1.4 INTERVIEWS DESIGN

A questionnaire was designed with the aim of gathering relevant information on key topics in the GreenStep project as talent, digital transformation, energy transition, innovation, and Smart Specialisation Strategy, as well as the core competencies required to sustain the Energy Intensive Industry in a given territory. By answering these questions, we not only gain a real and comprehensive picture of the actual scenario but also make it possible to show how it is perceived across different sectors of the **Quadruple Helix**.

The questionnaire consisted of a series of common questions addressed to stakeholders across different sectors, along with other questions that were adapted depending on the specific sector being interviewed, always aiming to gather realistic and meaningful insights from each participant. All interviews took place in a professional and cordial atmosphere, which allowed for a flexible format. Then, in addition to the structured questions and answers, there was room to discuss other relevant topics that emerged during the conversations, such as the stakeholders' roles in current European projects or their interest in participating in collaborative University–Industry initiatives, among others.

The interviews were held in the Teams platform and were recorded to facilitate the preparation of this report, agreed with the attendants. In a limited number of cases, it was not possible to arrange online meetings due to scheduling constraints. Consequently, the questionnaire was sent by email, completed by the recipients,

and returned through the same channel to Ms. Azucena Jiménez, Project Manager at FEMETALiNDUSTRY and the person responsible for the preparation of Deliverable D4.1. This will be duly specified in the sections corresponding to each of the regions.

Besides, these discussions serve as a starting point for potential future collaborations, both within the framework of the GreenStep project and in other potential initiatives and actions that may arise. The list of questions is detailed in **ANNEX 1**. The questionnaire was structured in 4 different sections:

- Human Resources and Workforce Capabilities
- Infrastructure and Productive Resources
- Business and Political Environment
- Innovation and Technology Transfer

2. LIBEREC REGION

The Liberec Region faces several challenges that impact its economic competitiveness and growth potential.

- 1) **Declining industrial competitiveness:** The region's industrial sector is becoming less competitive, primarily due to rising energy costs. Higher energy prices increase production expenses, reducing the ability of local businesses to compete effectively in global markets.
- 2) **Low added value and weak position in global value chains:** Many companies in the region generate limited added value and occupy lower positions in global value chains. This restricts their capacity to capture a greater share of the value generated during production processes and undermines their overall competitiveness.
- 3) **Slow digital transformation:** Small and medium-sized enterprises (SMEs) are slow to adopt digital technologies, which negatively impacts their efficiency, innovation capacity, and competitiveness in an increasingly digital economy.
- 4) **Limited commercialization of R&D outcomes:** Although the region conducts potentially innovative research and development, the commercialization rate of these results remains low. This weakens the conversion of intellectual capital into market-ready products and services, thereby limiting economic growth and innovation.
- 5) **Shortage of students in technical disciplines:** The region struggles to attract students to technical and STEM-related fields (science, technology, engineering, and mathematics). This results in a shortage of qualified graduates, affecting the availability of skilled labour for local industries and innovation-led sectors.
- 6) **Insufficient talent attraction and retention systems:** There is a lack of effective systems to attract and retain talent, both from within the region and externally. These further challenges the development of a competitive, innovation-driven economy.

2.1 Q-HELIX PRESENTATION

The partners from the Liberec region, TUL and ARR, conducted a search for key regional stakeholders with a particular emphasis placed on identifying actors representing the four sectors of the Quadruple Helix model with a certain degree of influence, impact, and involvement in the Smart Specialisation Strategy. It is remarkable that the representatives from academia and industry demonstrated strong willingness to collaborate in the development of deliverable D4.1, offering contacts of individuals holding positions related to innovation, management, and oversight. Below are some of the institutions and entities represented in the Liberec Quadruple Helix, some of which have actively participated in the development of this analysis.

2.1.1 ACADEMY

The **Technical University of Liberec (TUL)** is a dynamic university of medium size that joins forms of technical and university education, the only university in the Liberec Region. TUL has seven faculties and one professional institute. Despite the name, TUL does not only focus on technical fields, but TUL also educates economists, teachers, architects and other experts and works with approximately 200 similarly focused institutions around the world. Top-level results in research and science, excellence in teaching and interdisciplinary collaboration have stood for the Technical University of Liberec since 1953. Around 7000 students study at seven faculties and one specialized institute.

The Technical University of Liberec reaches excellent results in and has achieved a world-wide unique discovery of industrial manufacturing technology of nano-textiles – the Nanospider. The Technical University of Liberec can also be proud of its good social, cultural and sports background.



In the field of technology transfer, the Technical University of Liberec has a tradition of research in close cooperation especially with the textile and automotive industries. This has guaranteed excellent placements to graduates. Furthermore, the University is involved in more than 100 research projects worth almost USD 3 million and in contract research. While connected globally, the University understands its responsibility as an institution uniquely located in Central Europe and engages in cross-border

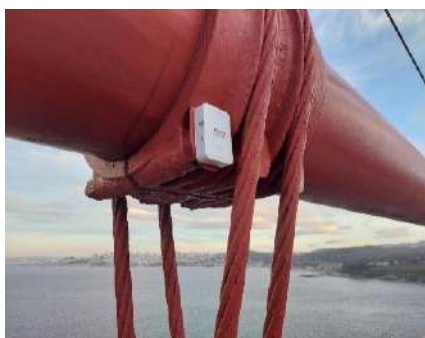
projects. One of the most representative centres of the Technical University of Liberec is CXI, the **Institute for Nanomaterials, Advanced Technologies and Innovation (CXI)**

CXI was established within the OP RaDfI project "Center for Nanomaterials, Advanced Technologies and Innovations" as one of the first centres of this type in the Czech Republic. The CXI building was opened in the year 2012. In the years 2009 - 2013, a highly sophisticated university research centre was built with an emphasis on the applicability of research and development results in practice. The project supported TUL's long-term activities in the field of industrial innovation with qualified personnel and state-of-the-art equipment. CXI



collaborates throughout the university and provides also facilities for students and presently employs 178 employees: a) 20 supervisors and independent researchers, b) 84 senior and junior researchers, 41 technicians / lab assistants and 33 members as administrative support. It is remarkable that almost 50 % of CXI employees are women (87).

2.1.2 INDUSTRY



Statotest s.r.o. is a technology company based in Liberec, Czech Republic, specializing in structural health monitoring systems. Founded in 2020, the company develops advanced IoT-based solutions that continuously monitor the condition of bridges, buildings, and other critical infrastructure. Their systems measure parameters like tilt, vibration, and displacement in real time, enabling early detection of structural issues and improving safety. With a focus on easy installation, low operating costs, and 24/7 data access, Statotest helps clients prevent failures, extend the lifespan of structures, and optimize maintenance planning.

Cermitech is a small but dynamic firm, founded in November 2017, specializing in industrial automation and software-intensive applications. Employing around 10–50 people, the company focuses on the automotive, food, and plastics sectors. Cermitech provides turnkey solutions for production-line automation: assembly, welding systems, end-of-line quality control, robotic manipulation, material handling, and logistics. Their core business is integrating and automating entire manufacturing processes, fully supporting Industry 4.0 transformation. Implements Industry 4.0 solutions to “breathe life into machines,” using sensors, process logic, and data connectivity to create smart, interactive production environments. Recognized for working in an international setting, offering learning opportunities, and maintaining a stable work environment with flexible schedules, operates primarily across Central Europe



Preciosa Group, headquartered in Jablonec nad Nisou, Czech Republic, is a global leader in the production of high-quality crystal products. With a heritage of glassmaking dating back to 1548 in the Crystal Valley of Bohemia, Preciosa combines traditional craftsmanship with modern technology to create a wide range of products, including precision-cut crystals, bespoke lighting installations, glass beads, and jewellery components. The company comprises several divisions—Preciosa Lighting, Preciosa Components, Preciosa Ornela, Preciosa Beauty, and Vinolok—each specializing in different aspects of glass artistry. Preciosa is renowned for its commitment to sustainability and innovation, offering lead-free and cadmium-free crystal options, and actively supports emerging designers through initiatives like the Master of Crystal competition. Their creations have adorned prestigious venues worldwide and have been featured in fashion collections by renowned designers.



2.1.3 CIVIL SOCIETY

Sdružení TULIPAN, based in Liberec, Czech Republic, is a nonprofit organization dedicated to supporting individuals with disabilities. Since its establishment in 2004, it has operated sheltered workshops that provide employment opportunities in areas such as ceramics, textiles, cleaning, and gardening services. Beyond employment, TULIPAN offers social services, counselling, and organizes cultural and educational events aimed at fostering inclusion between people with and without disabilities. Notable initiatives include the annual Tulifest music festival and the Týden s TULIPANem (Week with TULIPAN), both designed to promote community engagement and destigmatization. The organization also runs an online store, TulipáníSHOP, featuring handcrafted products made by its employees.



Ženy ze Severu (Women from the North) is a nonprofit organization founded in 2021 in Liberec by six women from diverse professional backgrounds, including law, marketing, IT, construction, and HR. The group aims to build a supportive community for women's personal and professional growth through educational, networking, and inspirational events. Regular meetups focus on topics such as positive leadership, AI in marketing, and confidence in entrepreneurship. Events

are usually held at the Lipo.ink business incubator in Liberec and are open to women of all ages and professions.

DEX Innovation Centre (DEX IC) is a nonprofit innovation hub based in Liberec, Czech Republic, established in 2012. It focuses on advancing society through impactful digital innovation and research, particularly in smart health, energy, and transportation sectors. DEX IC engages in fundraising for research projects, co-creating new products, building startups and tech teams, and providing educational programs. As the Czech representative for EIT Health and EIT InnoEnergy, it plays a pivotal role in fostering innovation and entrepreneurship across Europe.



2.1.4 GOVERNMENT

Agentura regionálního rozvoje (ARR) is a nonprofit organization based in Liberec, Czech Republic, established in 1993 and fully owned by the Liberec Region. Its mission is to provide expert support for the region's development, benefiting residents, entrepreneurs, and institutions. ARR's activities encompass managing regional development projects, offering consultancy services, and facilitating access to funding opportunities. Notably, it operates the Lipo.ink business incubator, supports the Crystal Valley initiative promoting the glass industry, and coordinates the Smart Accelerator program to foster innovation. Through these efforts, ARR plays a pivotal role in enhancing the economic and social landscape of the Liberec Region.



The Czech Invest Liberec Regional Office is a branch of the national Investment and Business Development Agency, CzechInvest, located at U Jezu 525/4 in Liberec. Its mission is to support business growth and attract investment in the Liberec Region. The office provides information on CzechInvest's services, consults with firms regarding business support from EU structural funds, assists companies interested in investing in the region, and collaborates with local authorities, schools, and institutions to develop the regional business environment. It also organizes seminars to further these goals.



The Krajská hospodářská komora Libereckého kraje (Regional Chamber of Commerce of the Liberec Region) is a nonprofit organization that unites district chambers from Liberec, Jablonec nad Nisou, Česká Lípa, and Semily. Its primary mission is to support and advocate for the interests of businesses and entrepreneurs across the region. The chamber provides services such as business consulting, legislative updates, export assistance, and educational programs. It also organizes networking events and fosters collaboration between the private sector and public institutions. In 2022, the chamber signed a memorandum with the Liberec Region to enhance the business environment and promote cross-border cooperation with regions like Poland's Lower Silesia and Ukraine's Vinnytsia. The chamber's headquarters is located at U Jezu 525/4 in Liberec, with administrative support provided by the district office in Jablonec nad Nisou.



2.2 PARTICIPANT STAKEHOLDERS

Below is a profile of each of the stakeholders who participated in the analysis. All of them took part in online meetings during which A. Jiménez conducted interviews following the guidelines outlined in Sections 1.3 – *Mapping of Q-Helix Actors* and 1.4 – *Design of the Interviews*. These activities were carried out during the months of April and May, with the participation—in some cases—of GreenStep members from ARR and TUL:



Adam Blažek, MBA is the **Head of Industry Relations Department Institute for Nanomaterials, Advanced Technologies and Innovation (CXI) Technical University of Liberec (TUL)**, Czech Republic. He acts as a key liaison between academia and the private sector, facilitating collaboration in applied research, expert consulting, measurement and analysis services, and contract R&D projects. His role is particularly focused on supporting small and medium-sized enterprises (SMEs) that often lack their own internal R&D capacity. Under his leadership, the department helps businesses access cutting-edge research and scientific expertise, driving regional innovation and technology transfer. He is representing CXI and TUL in national and international cooperation frameworks.



Ing. Ondřej Moš, MSc: Director, The University Company TUL, s.r.o. (Univerzitní společnost TUL). His research interests are Human Resource Management (HRM) in SMEs across Europe; employees' visibility, informality, and regional spin: he has significant contributions to the **SHARPEN project** focused on HR processes and practices in SMEs, and Aactively involved in cross-national HRM research within European regions, focusing on HR challenges in SMEs. Besides, through The University Company TUL (a TUL-affiliated enterprise), he supports the commercialization of university research, consultancy, contract services, and collaboration with SMEs and public-sector partners



Kateřina Maršíková, PhD is **Vice-Rector for Foreign Affairs** and Associate Professor at the Department of Business Administration and Management, Faculty of Economics, TUL; Ph.D. in Business Economics & Management from TUL, her research focuses on **HR management**, digitalization and investment in human capital, both in SMEs and higher-ed environments. She led the **ERASMUS+ KA2 strategic partnership** (2016–2019); managed KA9 activity in the **ROLIZ project** and is the principal coordinator and research specialist in the **SHARPEN project** (HRM in SMEs across EU regions) She is Co-authored international papers, Programme guarantor and is Member of TUL Scientific Board. As Vice-Rector, leads the **International Office**, driving global engagement, ERASMUS mobility, and internationalisation of university activities and since 2015, also actively involved in **TUL Career Centre and ethics committee**, bridging students, industry, and university strategy.



Pavel Hübner is a seasoned electronics and embedded systems expert turned entrepreneurial leader. Previously held a **leadership role at JABLOTRON**, overseeing applied electronics development, he **co-founded HARDWARIO**, initially focused on industrial IoT solutions leveraging licensed LPWAN tech (NB-IoT, LTE-M, LoRaWAN) in 2016 to democratize IoT development through modular platforms, with both hardware (**CHESTER, EMBER, etc.**) and cloud platforms and continues to balance technical mentorship with scaling a publicly traded, globally oriented tech firm. Headquartered in **Liberec**, with offices in **London** and **Houston**, and a team of around 28 engineers.



Michal Resl serves as **Chief Strategy Officer (CSO) at Statotest**, a Czech-based technology start-up specializing in continuous online structural health monitoring for buildings, bridges, industrial and energy facilities, using IoT sensors. He is an external face—leading strategy, high-level representation, and project coordination. His background blends technical know-how in **sensor networks** with strategic outreach across European infrastructure and innovation ecosystems. Focused on security and long-term care of structural projects using **IoT** and sensor networks, active in international forums, especially in transport and **smart infrastructure domains**. The company was founded by experts in technical cybernetics from Czech Technical University, aiming to create real-time expert systems to detect and prevent structural failures (e.g., bridges, motorway slopes, rockfalls)



Michal Čermák, CEO & Founder at **Cermitech**, based in **Liberec, Czech Republic**. Holding an **MBA from Duke University** and a **Master's in Economics & Finance**, he has been recognized by his expertise in operational transformation and digital adoption. Michal Čermák is a tech-savvy industrial strategist who combines deep educational credentials and global consulting experience to lead **Cermitech** in its mission to digitize and modernize industrial machinery. His leadership is marked by a structured, data-driven approach and an international mindset rooted in smart automation. As CEO, Michal oversees **Cermitech's mission to “breathe life into machines”**, focusing on integrating automation, IoT, and real-time data into industrial systems. Company specializes in retrofitting legacy equipment with **smart sensors and monitoring**, enabling data-driven process optimization and preventative maintenance.



Nomuun-Erdene Amgalan (Bella), served as **Events Manager** at ESN Liberec, the Erasmus Student Network section in Liberec, for the period of March to July 2023 and now is responsible for coordinating social and cultural activities designed to enhance the Erasmus student experience in the region. **ESN Liberec Highlights:** The team ran a variety of engaging events, including bowling outings, gallery visits, hiking trips to Ještěd, ice-skating, and other health and cultural activities for international students, attracting hundreds of participants, aiming to foster community, wellbeing, and cultural immersion.



Vendula Zedníková is the Co-founder of Ženy ze Severu (Women of the North) in Liberec, she is one of the three core founders—alongside Zuzana Pětníková and Zuzana Heferová—of the association, active for over two years in Liberec. The initiative organizes networking, educational, and motivational events aimed at women from diverse professional backgrounds across the region. Core activities include interactive workshops, storytelling nights, and social gatherings facilitating meaningful exchange among entrepreneurs, creatives, and professionals. Ženy ze Severu provides a **safe, multidisciplinary space** for sharing and empowerment, growing steadily in membership and influence. Plans include expanding to cities like **Jablonec nad Nisou and Turnov**, as well as boosting the association's presence on **Instagram and LinkedIn** to reach broader audiences



Hana Křenková is the Chairwoman, *Women from the North* Association; Partner & Attorney at **Advokátní kancelář Křenková, s.r.o.** As **professional**, she practices Czech law, focusing on general legal practice, civil law, commercial/e-commerce law, labor law, and insurance law. She is a partner in her law firm located in Prague. **Leadership in Civic Association:** As Chairwoman of “Women from the North,” she provides governance and strategic direction to a group focused on promoting women's roles and visibility in Northern regions (Czech Republic or broader “North” context).



Tomáš Drašnar is a project developer and RIS3 Coordinator at **Agentura regionálního rozvoje (ARR)** in the Liberec region. ARR supports entrepreneurship, R&D, innovation, and regional development across Liberec. Tomáš plays a key role in advancing EU-backed Smart Accelerator and RIS3 (Research & Innovation Strategy for Smart Specialisation) programs. His duties include project planning, stakeholder coordination, and boosting regional tech and innovation initiatives. He leads and manages funding applications, planning, and execution for regional innovation and development projects. Regarding **RIS3 Coordination**, he engages with companies, universities, and research institutions to align with EU strategic smart specialisation goals and likely represents ARR in cross-border, regional, and EU-level forums and funding rounds.

2.3 OUTCOMES

During the interviews, detailed information was gathered on topics relevant to the GreenStep project, with particular emphasis on gaining a clear understanding of the current situation in the Liberec region in order to identify its strengths and weaknesses. This aspect is especially important, as one of the main objectives of this analysis is to extract lessons learned and to formulate improvement proposals aimed at fostering technological development, as well as the energy and digital transitions.

While the insights shared by the stakeholders were largely aligned, they were approached from different perspectives within the Quadruple Helix ecosystem and each stakeholder emphasized their specific contributions and needs. The information obtained is presented below, structured according to the four thematic areas of the interview.

2.3.1 HUMAN RESOURCES AND WORKFORCE CAPABILITIES

EDUCATION

The Liberec Region is currently experiencing a significant transformation in education and innovation, with the Technical University of Liberec at the forefront of this change. Traditionally known for its expertise in textiles and glass industries, the university is now shifting its focus towards advanced fields such as artificial intelligence, digitalization, and sustainability. This evolution reflects both the region's industrial heritage and its aspirations to modernize and adapt to emerging technological trends.

The university is actively enhancing education quality by promoting dual education systems and fostering strong partnerships with local industries. These collaborations aim to align academic programs with practical workforce needs, particularly in digital skills and sustainability. Public support is evident in tailored workshops designed to upskill company employees, reinforcing the university's role as a hub for lifelong learning.

Locally, education is regarded as quite solid, particularly given the region's industrial character. Besides the Technical University of Liberec, vocational schools focusing on electrical and mechanical engineering also contribute to a pragmatic, industry-oriented education ecosystem. While continuous improvement is encouraged, the current state of education does not raise significant concern.

Public engagement is a priority for the university, exemplified by successful initiatives like the Night of Scientists, which have notably increased female participation in STEM fields; in some institutes, women now outnumber men. Strategically, the university plays a pivotal role in regional development policies through its involvement in the Smart Specialisation Strategy (S3). Although coordination and ensuring sustained long-term engagement remain challenging, the university's contribution through platforms like "Smart Region" significantly supports the integration of academia, industry, and government sectors.

TALENT RETENTION

The Liberec region faces significant challenges in attracting and retaining talent. Many young professionals, particularly graduates, relocate to larger cities such as Prague or even abroad—especially to Germany—in pursuit of higher salaries and broader career opportunities. This talent drain is exacerbated by lower regional wages and rising housing costs, which contribute to workforce dissatisfaction. Despite low unemployment (around 3–3.5%), companies struggle to find qualified workers, creating a competitive labour market where job candidates often have more leverage than employers.

The university faces challenges in attracting and retaining students. Competition among universities is intense, and technical disciplines often carry the reputation of being particularly demanding, which can affect enrolment numbers. To foster an international environment, the university has embraced English as a second working language, especially at Research institutes, where approximately 20% of the staff are international and courses are offered bilingually in Czech and English.

Another core weakness lies in the education system. Traditional teaching methods fail to engage modern students, and there is a lack of personalization and dynamic communication. Moreover, primary education lacks effective mechanisms to identify and support gifted children, often mislabelling intelligent students as problematic due to boredom. There is also a mismatch between the skills taught in schools and those required in the labour market, particularly in sectors like IT and healthcare. Additionally, smaller companies often lack awareness of university resources, leading to a disconnect between academia and industry that limits collaboration and innovation.

Nevertheless, retaining talented graduates remains a challenge, as many relocate to larger urban centres like Prague. While emerging fields such as AI and 3D printing attract young professionals, regional

salaries tend to lag behind those in Prague and Germany. Additionally, rising housing costs coupled with high salary expectations contribute to workforce dissatisfaction

BUSINESS AND POLITICAL ENVIRONMENT

Public engagement initiatives, such as the Night of Scientists, have been successful in attracting women to STEM fields, with female students now outnumbering males in certain departments. Longer and more immersive internships are supported as a way to provide students with real-world experience and increase motivation.

Company culture is identified as a key factor in retaining employees, with some firms maintaining low turnover by fostering innovative and supportive work environments despite offering lower salaries. Maintaining open communication between educational institutions and industry is important to identify skill gaps—such as in IT and healthcare—and to adjust educational programs accordingly.

Although unemployment rates are low, companies face difficulties finding qualified workers, resulting in a competitive labour market where potential employees have significant leverage. To improve education and training, practical approaches like short workshops and enhanced online outreach are recommended. Understanding the needs and motivations of younger generations is considered crucial to designing effective educational strategies, as traditional teaching methods may not fully engage modern students.

Academic institutions are recognized for offering diverse programs and research opportunities, but there is room for greater personalization of education and improved communication to better inspire and motivate young people. Higher salaries in technical fields like IT and engineering contribute to their popularity compared to other disciplines such as education.

Regarding the energy transition and digital transformation, government incentives and renewable energy adoption are recognized but may not be widely known. Outreach efforts such as workshops exist, but engaging younger generations more effectively—particularly through social media platforms—is necessary to increase participation and awareness.

INNOVATION AND TECHNOLOGY TRANSFER

In the realm of digital and energy transitions, the university collaborates closely with regional authorities to help businesses adopt new technologies, including AI and autonomous systems. Although adoption has been gradual, these topics are increasingly integrated into both academic curricula and industry training programs.

The region's infrastructure for energy transition is evolving, with larger companies adapting more swiftly than smaller enterprises, which often encounter financial limitations. Renewable energy, such as solar power, is present but still limited, driven mainly by high energy costs and governmental incentives.

In research and innovation, the university manages around 80 projects funded by local, national, and European sources, including Horizon Europe. Efficient administrative support minimizes bureaucratic burdens, enabling researchers to focus on advancing technology and innovation. The university's modern facilities and strong corporate partnerships position it as a model of technological progress and operational efficiency within the region.

The university maintains strong connections with local industry by providing students with practical experience through internships and collaborating on curricula and lifelong learning initiatives with companies such as Škoda Auto. Despite these efforts, retaining talent in the region remains a challenge, as many graduates move to larger cities like Prague in search of higher salaries and broader career opportunities. For the interviewees, this point is a weakness of the system that requires greater attention. They emphasize the need for the involvement of local and national authorities, as well as increased financial and human resource investment. Although some professionals balance living in Liberec with commuting to Prague, regional salaries

tend to be lower, and rising housing costs combined with high salary expectations contribute to workforce dissatisfaction.

2.3.2 OVERVIEW OF WEAKNESSES AND STRENGTHS

The Liberec Region demonstrates notable strengths in education and innovation, largely centred around the well-equipped and forward-looking Technical University of Liberec. The university plays a key role in driving regional development through advanced research in nanotechnology, textiles, AI, and sustainability, with the CXI research centre serving as a flagship institution. It actively collaborates with local industry, offers bilingual education, and supports lifelong learning and public engagement initiatives, such as the Night of Scientists, which has successfully increased female participation in STEM. The region also benefits from vocational schools that align well with its industrial character, contributing to a practical education ecosystem. The region struggles to attract and retain students, especially in demanding technical fields, and many graduates leave for higher-paying opportunities in cities like Prague or abroad. Education is still perceived as overly traditional, lacking dynamic communication and personalization. Moreover, while university-industry partnerships exist, they are viewed as underdeveloped and in need of stronger governmental support and investment. The university's potential to drive innovation and workforce development is high, but its impact is limited by financial constraints, talent outmigration, and the slow pace of adaptation among smaller enterprises to digital and energy transitions.

The Liberec Region faces notable digital and technological gaps, particularly among non-technical populations who often lack familiarity with essential digital concepts such as artificial intelligence (AI) and the Internet of Things (IoT). Awareness of digital transformation is growing among young people, especially those involved in innovation hubs and startup environments, where collaboration and joint projects are common. However, familiarity with digital concepts can vary depending on educational background, with those less technically trained being less knowledgeable. Despite this, terms like IoT, AI, and digitization are increasingly recognized, though interpretations differ.

Despite these challenges, Liberec has several strengths to build upon. The region is home to well-equipped institutions, including the Technical University of Liberec and strong research centres specializing in nanotechnology, optics, machinery, and textiles. These centres contribute to advanced sectors like lasers, military, and space technology. The university maintains close ties with local industry, offering students practical experience through internships and collaborative learning initiatives with companies such as Škoda Auto. Public engagement events like the Night of Scientists have successfully promoted STEM careers among women, with female students now outnumbering males in some departments.

Impact of Industry on Society: Heavy, polluting industries have largely disappeared. For example, the textile industry, which once employed tens of thousands, now employs only a few thousand workers. The decline of these industries initially led to unemployment, but new sectors, especially automotive suppliers, have since absorbed much of the workforce thanks to foreign investment. Today, Liberec enjoys relatively low unemployment compared to other regions.

Legislation and regulation in the Czech Republic are developed at the national level. However, if urgent regional needs arise, local actors can appeal to members of parliament or the regional government to advocate for change. Despite this possibility, only the state has the authority to implement legal reforms. ARR Liberec plays an active role in developing and updating the Regional Innovation Strategy, which incorporates input from all sectors of the quadruple helix—academia, business, government, and civil society. While this strategy does not influence national legislation, it helps guide regional priorities and development. Generally speaking, the interviewees express confidence in the Smart Specialisation Strategy (S3), which has been revised multiple times. S3 effectively identifies the region's opportunities and challenges and has been developed

collaboratively with local stakeholders, with no major gaps. Regarding regional support for digital and energy transitions, it is highlighted several funding mechanisms: the European Digital Innovation Hub (EDIH), which provides digitalization support to companies through consulting and system testing, either free or partially subsidized; the Regional Innovation Program, offering small grants of up to approximately €8,000 to support early-stage research, startup ideas, or small projects; and additional funds available to co-finance the preparation of large-scale European project applications, which can be costly.

Cybersecurity remains a weak area, with many companies demonstrating low awareness, insufficient guidance, and operating under unclear regulations. Additionally, technology adoption among small and medium-sized enterprises (SMEs) is slow, largely due to aging leadership, limited digital skills, and the pressure of day-to-day operations, which leaves little capacity for innovation or long-term strategic planning. Funding continues to be a major constraint for innovation, although regional government efforts aim to improve the situation. A key challenge remains in engaging smaller, less-informed companies. Events that bring together business leaders and policymakers have helped enhance communication and awareness.

2.3.3 ENHANCEMENT RECOMMENDATIONS

Special emphasis has been placed on the need to connect academia and industry through information campaigns, as well as making it easier and more agile to establish agreements, contracts, and collaborations. Currently, there is a significant lack of understanding between the two ecosystems and high levels of bureaucracy, which makes collaboration between them unattractive. The knowledge potential is high at the University and Technology Centers in Liberec, which would greatly contribute to innovation and the development of integrated solutions for industry, and consequently, to outsourcing.

Efforts to Connect Academia and Industry: Several initiatives have been introduced to bridge the gap between academia and industry. A Regional Board for Research and Development brings together representatives from academia, companies, and schools to facilitate cooperation. Ongoing education and personal contact are emphasized as key factors in building strong relationships.

Initiatives like longer internships and company collaborations aim to provide students with real-world experience and boost motivation. Some companies manage to retain staff by cultivating a supportive, innovative work culture, even without offering top salaries. Moreover, regional development agencies like ARR Liberec are actively working to bridge the gap between education and industry by promoting cooperation and adapting educational programs to meet market needs. Programs such as workshops, hands-on learning, and online outreach are being encouraged to better align with the expectations and learning styles of the younger generation.

Innovation Barriers and Opportunities: stakeholders remarked that that funding remains a constant constraint, although the regional government is making significant efforts. A major challenge is reaching smaller companies that tend to be less informed or more isolated. Events that bring together top executives and policymakers have helped improve communication and awareness. Technology Adoption in Industry: Large companies in Liberec are adapting well to modern technologies. However, smaller, long-established firms—often 20 to 30 years old—are slower to adopt, frequently due to aging leadership and daily operational pressures. Startups, on the other hand, tend to be more agile and tech-savvy.

The interviews with stakeholders from the Quadruple Helix revealed very similar perceptions regarding the situation in terms of training and the impact of the energy and digital transitions on civil society. However, other aspects—such as talent retention and the industry's adaptation to new markets—are perceived differently depending on the specific sector of the Quadruple Helix to which the stakeholder belongs. It is also common across all regions to observe a general lack of awareness within civil society about topics such as the use of IT technologies or the availability of funding support.

2.4 SUMMARY AND CONCLUSIONS

TOPICS	CONCLUSIONS
EDUCATION	<i>-The Technical University of Liberec is shifting from traditional industries (textiles, glass) to modern fields like AI, digitalization, and sustainability.</i> <i>-Dual education and strong university-industry partnerships are helping align education with labour market needs.</i> <i>-Vocational schools and technical education are well-developed, supporting the region's industrial base.</i>
PUBLIC ENGAGEMENT/ STEM GROWTH	<i>-Events like the Night of Scientists have successfully increased female participation in STEM, with women now outnumbering men in some areas.</i> <i>-The university supports lifelong learning through workshops and public programs.</i>
TALENT RETENTION	<i>-Many graduates leave for Prague or Germany due to higher salaries and better career opportunities.</i> <i>-Low regional wages and rising housing costs discourage young professionals from staying.</i> <i>-Despite low unemployment, companies face a shortage of qualified workers, giving job seekers more leverage.</i>
INNOVATION/ TECHNOLOGY TRANSFER	<i>-The university leads in digital and energy transition efforts, though small companies struggle due to financial limits.</i> <i>-Research is active, with ~80 projects funded by local and European programs.</i> <i>-Strong industry ties, especially with companies like Škoda Auto, support practical training and innovation.</i>
SYSTEM WEAKNESSES	<i>-Traditional teaching methods are outdated and fail to engage modern students.</i> <i>-There is a skills mismatch in key sectors like IT and healthcare.</i> <i>-Gifted children are often misunderstood due to lack of personalized support.</i> <i>-Small companies often lack awareness of university resources, limiting collaboration.</i>
STRATEGIC NEEDS	<i>-Better coordination among university, industry, and government is needed.</i> <i>-Increased financial and human resources from local and national authorities are essential to improve talent retention.</i> <i>-New strategies should focus on raising regional salaries, improving housing conditions, and making education more flexible and engaging.</i>

3. CENTRAL AND WESTERN LITHUANIA

The Central and Western Lithuania Region faces significant economic and social disparities both within the region and as compared to the Capital Region. Capital Vilnius leads in economic growth, while regions like Alytus, Tauragė, Marijampolė and Utena lag behind - evidenced by lower value added per employed person and higher unemployment rates. Poverty and social exclusion are more acute in these underperforming regions, with Lithuania's overall rates surpassing the EU average.

Environmental sustainability issues, such as pollution and insufficient renewable energy use, are identified as negatively impacting regional attractiveness and investment. This is compounded by the socio-economic challenges of transitioning to a climate-neutral economy. Infrastructure disparities between urban centres like Vilnius, Kaunas and Klaipėda and rural / geographically constrained areas exacerbate social exclusion and service accessibility issues.

Regions with disadvantaged geographical features struggle more with poverty and lack basic services like drinking water and wastewater management, highlighting the challenges in remote areas. In terms of the energy sector, an effort to ensure independence of the Lithuanian electricity market and electricity system is concentrated towards increasing domestic energy production, increasing the share of renewable energy sources in total final energy consumption, and introducing pollution reduction measures in the energy sector.

3.1 Q-HELIX PRESENTATION

The partner from Central and Western Lithuania (KUT) carried out a stakeholder mapping process focused on identifying key regional actors across the four sectors of the Quadruple Helix model, prioritizing those with notable influence, impact, and involvement in the Smart Specialisation Strategy. Contrary to the findings in the Liberec region, representatives from the industry sector were not as accessible or willing to participate in this study. However, representatives from the academic sector exhibited a strong willingness to collaborate and demonstrated a proactive attitude toward engaging in other GreenStep initiatives. All stakeholders contacted hold roles related to innovation, management, or strategic oversight. Below are some of the institutions and entities represented in the Lithuanian Quadruple Helix, some of which have actively participated in the development of this analysis.

3.1.1 ACADEMY

The GreenStep project involves the participation of **KAUNO TECHNOLOGIJOS UNIVERSITETAS** (KTU) located in the region of Central and Western Lithuania, Lithuania. This institution is a key innovation and research actor in this less developed region. It is a leading technical Lithuanian university, providing studies of engineering, technologies, physical, social sciences, humanities and arts, and hosts 9 faculties, 8 institutes and 9 research centres.



One of KTU's key priorities is maintaining a synergy with businesses, with 56 new cooperation agreements signed and 33 new start-ups established over 2023. The activities of the

GreenStep are conducted by subsidiaries Faculty of Chemical Technology (CTF) and National Innovation and Entrepreneurship Centre (NIVC). CTF has deep experience in the research and analysis of industrial technologies, both in terms of process engineering as well as sustainability assessment. NIVC has been active for 10 years in technology transfer and entrepreneurship promotion. It is also a coordinator of the technology transfer managers' network in Lithuania, which has recently started cooperation with its counterparts in Latvia and Estonia. Overall, it has the capacity to actively act within local and international ecosystems having a broad network and capacity to ensure maximum impact of the project and contribute to policy making.

LITHUANIAN ENERGY INSTITUTE (LEI) is an internationally established in 1956 recognized energy-related research, development and innovation (R&D&I) competence centre. LEI is a public institution and became known among local and international scientific societies interested in fundamental research in hydrodynamics, thermal physics, material science, simulation and control of power supply systems, hydrology, energy economy. **LEI** is a state technical research centre dealing with energy related research in mathematical modelling of power systems and networks, investigation of their control issues; modelling and optimization research of ICT-based control systems of power systems; renewable energy; analysis of security of energy



supply; development of energy planning methods; fuel cells and hydrogen; thermal physics and fluid mechanics; nuclear safety; structural integrity assessment of components and structures; simulation of complex energy systems. LEI has 235 employees: 110 Ph.D., 30 researchers with B.Sc. and M.Sc., and 40 Ph.D. candidates. The Institute has extensive experience in international projects as coordinators and participants: Horizon Europe & EURATOM, Digital Europe, LIFE, H2020, FP7, FP6, FP5, Intelligent Energy Europe, COST, Eureka, IAEA, INTERREG-type, Nordic Energy Research programme, EuropeAid, ERASMUS+), etc.

3.1.2 INDUSTRY

ORLEN LIETUVA is the Polish PKN ORLEN's subsidiary that operates the Mažeikiai oil refinery – the only crude refinery in the Baltic States (Lithuania, Latvia, Estonia). The refinery's nominal processing capacity is about 10 million tonnes of crude per year. Orlen Lietuva produces the full range of petroleum products – diesel, gasoline, jet fuel, LPG, heavy fuel oil, bitumen, etc. Middle distillates (diesel/jet) form the largest share of output. For the full year 2023, the company reported €6.426 billion in sales revenue and a net profit of €294.3 million. Orlen Lietuva is also investing in low-carbon energy and emission reductions in line with ORLEN Group's climate strategy. Orlen Lietuva's recent initiatives strongly align with Lithuania's national Smart Specialisation Strategy (S3) priorities, particularly in the energy and digital domains. Lithuania's S3 for 2021–2027 identifies priority R&D and innovation areas, including: “strengthening energy efficiency and smart energy solutions,” “use of renewable energy sources,” and development of ICT technologies like artificial intelligence and Internet of Things (IoT).



ACHEMA, AB's annual capacity includes approximately 1.2 million tonnes of ammonia and over 2 million tonnes of fertilizers, positioning it as one of the largest chemical facilities in Northern Europe. Specializing primarily in nitrogen-based fertilizers, including ammonia, urea, ammonium nitrate, and nitric acid, Achema significantly contributes to the Baltic agricultural and chemical sectors. Achema has prioritized energy transformation and emission reductions, initiating several impactful projects. It also integrates digital solutions into its industrial processes to enhance operational efficiency and safety:



Achema's recent developments align closely with Lithuania's national Smart Specialization Strategy (S3), particularly focusing on two priority areas: a) Sustainable energy innovation, which the hydrogen electrolysis project directly supporting Lithuania's objectives in renewable energy and industrial decarbonization, creating a model for advanced energy technology applications in industry and b) Digitalization and advanced manufacturing. Achema's implementation of digital technologies supports S3 priorities on industry competitiveness through innovation, applying artificial intelligence, IoT, and automation technologies to modernize Lithuania's industrial base.

3.1.3 CIVIL SOCIETY

LITHUANIAN INNOVATION CENTER – LICC, is a national innovation support organization established in 1996. Its mission is to enhance the competitiveness of Lithuanian businesses through consulting, training, and innovation policy development. As part of international networks like Enterprise Europe Network, LIC helps Lithuanian startups and SMEs find partners abroad. In the past 1–2 years, LIC has prioritized initiatives at the intersection of energy transition, industrial decarbonization, and digital transformation – often in collaboration with major Lithuanian industrial companies. All LIC's activities tightly correspond with Lithuania's Smart Specialization (RIS3) priorities for 2021–2027.

- 1) Energy and sustainable industry. LIC's projects in energy transition and cleaner production (hydrogen, renewables, energy efficiency in industry) advance the S3 thematic area of strengthening energy efficiency and smart energy solutions, and wider use of renewable energy sources.
- 2) Digital innovation and industry 4.0. The Centre's initiatives in AI, IoT, robotics, and cybersecurity adoption correlate with the S3 priority of ICT and digital technologies (sub-fields like artificial intelligence, IoT, and cyber security are explicitly named in S3).
- 3) Regional and inclusive growth. S3 in Lithuania also stresses spreading innovation across regions and sectors. LIC's regional seminars and its inclusion of industries from agro-food to manufacturing ensure that innovation is not siloed.



INTECHCENTRAS is Lithuania's leading Smart Manufacturing Competence Centre, established in 2007 by the Lithuanian Engineering Industry Association (LINPRA). Based in Vilnius, it serves as a pivotal hub for industrial digitalization, energy efficiency, and innovation, particularly supporting small and medium-sized enterprises (SMEs) in their transition towards Industry 4.0. As a coordinator of the Advanced Manufacturing Digital Innovation Hub, InTechCentras provides services such as digital transformation roadmaps, audits, and consultations, facilitating the adoption of smart technologies in manufacturing processes. InTechCentras's activities are closely aligned with Lithuania's Smart Specialization Strategy, particularly in the following areas:



- 1) New production processes and energy efficiency. By promoting advanced manufacturing technologies and energy-efficient solutions, the centre contributes to the development of high-value-added industries.
- 2) ICT technologies and inclusive society. Through its digital transformation initiatives, InTechCentras supports the integration of ICT in manufacturing, fostering an inclusive and innovative industrial ecosystem.

3.1.4 GOVERNMENT



Ministry of Economy and Innovation (EIMIN). This ministry is responsible for innovation policy and economic development in Lithuania, with a focus on high value-added and sustainable growth. It coordinates investment in green industries and innovation support for businesses. For example, EIMIN has administered the Green Industry Innovation Programme (funded by Norway Grants) – a €9.4 million program supporting innovative environmental technologies and green products. The Ministry also rolled out “Boosting Green Innovation” support measures to help SMEs develop eco-friendly products. In late 2022 it announced a €5 million call for small and mid-sized enterprises to create or adopt environmentally friendly technologies, offering grants up to €50,000 per project. EIMIN's initiatives demonstrate Lithuania's commitment to Green Deal objectives by directly funding business innovation for sustainability.

Ministry of Environment The Environment Ministry leads climate change policy, environmental protection, and circular economy strategy. It has set ambitious goals through the National Climate Change Management Agenda, targeting a 30% reduction in greenhouse emissions by 2030 (from 1990 levels) and



net-zero emissions by 2050. The ministry also steers the transition to a circular economy – the government’s program pledges to reach EU-average recycling rates and fully shift to a circular economy by 2050. In 2023, concrete steps were taken as the government adopted guidelines for transitioning to a circular economy by 2035. The Environment Ministry works closely with other ministries to integrate sustainability across sectors (for instance, collaborating with the Agriculture Ministry to ensure environmental standards in farming and bioeconomy initiatives. Its mission is “to create a sustainable connection between humans and nature”, and recent actions like promoting climate adaptation, peatland restoration, and green public procurement reflect this mission in practice.



THE MINISTRY OF AGRICULTURE
OF THE REPUBLIC OF LITHUANIA

Ministry of Agriculture oversees sustainable farming, rural development, and the bioeconomy. It promotes circular and bio-based production systems in agriculture and forestry. Under Lithuania’s Common Agricultural Policy (CAP) Strategic Plan 2023–2027, the main goal is “to ensure the sustainable development of the agriculture and food sector. The Ministry, together with the Agricultural Rural Development Agency, provides funding and support to farmers for implementing eco-friendly practices.

Through EU and national programs, grants are available for organic farming, precision agriculture, agri-environment schemes, and investments in green farming technology.



Besides, the **Ministry of Energy** drives the shift to renewable energy and energy efficiency. Lithuania was the first EU country to completely stop importing Russian fossil fuels, and it currently generates over one-third of its electricity from renewable sources, aiming for 100% of electricity to be produced from renewables by 2030, the Ministry of Finance supports green innovation through financial policy – for example, it has developed green finance instruments and ensures a significant share of public investment goes to green transition. In 2024 alone, about €1.06 billion was earmarked

for green transition calls for businesses, including funding for renewable energy production, enterprise greening, and sustainable heating solutions. The Finance Ministry also introduced the European Green Bond Standard into national law to attract private investment into sustainable projects. Finally, Central Project Management Agency (CPMA), which helps manage EU-funded environmental projects, and Lithuania’s Innovation Agency, which provides advisory services and matchmaking for companies in the clean-tech and sustainable industry sectors. All these bodies work in collaboration, reflecting a cross-sectoral approach to Lithuania’s green transition.



Kaunas IN is a public institution established by the Kaunas City Municipality to promote the city’s economic development, international visibility, and investment attractiveness. Its mission is to support the growth of the local business ecosystem, facilitate innovation, and enhance Kaunas’

competitiveness in global markets. The organization provides targeted services for businesses, investors, and talent, including investment consulting, business environment analysis, and coordination of tourism and international marketing initiatives. By fostering partnerships between the public and private sectors, Kaunas IN plays a central role in strengthening the city’s position as a dynamic and forward-looking urban centre.

3.2 PARTICIPANT STAKEHOLDERS

Below is a profile of each of the stakeholders who participated in the analysis. Most of them took part in online meetings during which A. Jiménez conducted interviews, following the guidelines outlined in Sections 1.3 – *Mapping of Q-Helix Actors* and 1.4 – *Design of the Interviews*. However, due to scheduling conflicts, it was not possible to organize online meetings with two stakeholders: Laurynas Ragaisis, From **Intercentras**, representing the civil society sector and Paulius Barvainis, from the company **AB Achema**. Instead, both submitted their completed interviews via email in the form of Word documents with detailed inputs. The information provided in these documents was equally incorporated into the report, alongside the feedback obtained from the online-interviewed participants. These activities were carried out throughout the months of April, May, and June.



Mindaugas Bulota is a pivotal figure in Lithuania's innovation landscape. He holds a PhD and is recognized in materials and engineering fields, with an academic H-index around 10 and 516 citations (AD Scientific Index) He is **Head of the National Innovation and Entrepreneurship Centre (NIEC)** at Kaunas University of Technology (KTU) and holds a doctorate and has extensive experience in the innovation ecosystem, supporting student researchers, startups, and manufacturing firms. **Coordinator of the European Digital Innovation Hub (DI4 Lithuanian ID)**, which supports AI, cybersecurity, IoT, VR/AR, and smart manufacturing across Lithuania. Advocates for university-industry collaboration, noting KTU

secures over €33 M in EU research funding—a Lithuanian record—and fostering long-term partnerships with more than 100 businesses. His leadership spans EU-funded projects, academic partnerships, and a strong vision for digital and green transformation.



Nerijus Striūgas, Senior Research Fellow & Principal Investigator, Laboratory of Combustion Processes at the Lithuanian Energy Institute (LEI) in Kaunas is a leading expert in sustainable energy and combustion research in Lithuania and authored/co-authored **118 publications**. **Coordinator** of the Horizon Europe **GIFFT** project (2023–2027), developing sustainable heat solutions for the glass industry and awarded the prestigious **Algirdas Žukauskas Prize**. **He also led WIN-PEAKS** (Horizon 2020) and other EU-funded initiatives on waste gasification and bioenergy networks. Nerijus is active in Interreg and COST actions focused on low-calorific gas, biogas digestion,

cyber-physical systems, and smart energy carriers. He bridges experimental research with applied techno-economic analyses, focusing on transforming waste into energy and chemicals. His EU projects and international collaborations underscore Lithuania's role in the global transition to green energy. Recognised at **Šilumos Energetika 2024** and awarded by the **Lithuanian Academy of Sciences**, highlighting his influence in energy science.



Dr. Irmantas Barauskas is a leading researcher and educator advancing sustainable silicate chemistry and cement technologies. Head of KTU's Silicate Technology Department, his work bridges academia and industry—ranging from textbooks to applied research in low-carbon binders and certification standards—while promoting greener solutions for construction materials. He is recognized as a certified expert in certification of building materials, including cement, concrete, admixtures, and aggregates. Serves actively on Lithuania's National Technical Committee for standardization of inorganic binders. Irmantas advocates for **green cement technologies**, promoting alternative fuels and CO₂ reduction in cement production, collaborating on industry-academic projects aimed at sustainable construction materials, including participation in international lectures on CO₂ adsorption and supplementary binders. He authored **22 research publications**, textbooks and lab manuals and was a visiting lecturer at Brno University of Technology (Czech Republic), speaking on **CO₂ emissions, supplementary cementitious materials, and process intensification in green binder tech**



Paulius Barvainis leverages his position as **Chief Engineer, Process Modeling of the Organic Products Division** at AB Achema, bringing hands-on industry expertise into KTU's Chemical Engineering curriculum. His role exemplifies how **industrial engineering expertise** can enhance higher education programs and help students develop practical skills relevant to large-scale manufacturing. Since 2021, Paulius has been a **practitioner-lecturer** at KTU's Chemical Technology Faculty, teaching "Process Modelling" to upper-level Chemical Engineering students. During lectures, he emphasized real-world issues such as **CO₂ reduction strategies** in industrial production. His teaching bridges academic theory and industrial practice, offering students insights into modelling, simulation, and decarbonisation solutions used at a major chemical enterprise. **Regarding his Industry Contributions & Innovation Focus, Paulius** works on modelling processes related to **ammonia, nitric acid, urea**, and other organic chemical products—central to AB Achema's production lines and engaged in initiatives to improve **energy efficiency**, reduce greenhouse gas emissions, and align with **ISO 14001** environmental standards during teaching and industrial projects.



Laurynas Ragaisis is a seasoned professional blending **technical education and broad distribution experience** with content creation skills. He is an experienced **sales and distribution professional** with a solid technical background, active since 2006 as a Project Sales Manager for **YE International**, managing international distribution, account- and product-management, and commercial correspondence. From 2013 to 2016, he was a partner at **Perfect Ambition Group, LLC**, where he handled supplier negotiations, account setups, product descriptions, and content creation. With roots in KTU's DTech, he is a Multilingual communicator, fluent in **English, Russian, Lithuanian**, with basic knowledge of **Italian and Portuguese**, and well-versed in **politics, psychology, software, and SEO/content writing**. He also maintains visibility in Lithuanian engineering networks.

Terese Skutaitė is the **Head of GreenTech Hub at Innovation Agency Lithuania** (since March 2024), leading efforts to accelerate green tech adoption and circular economy initiatives across Lithuanian industry. She awards a Master's in Politics & Media from Vilnius University, **Bachelor's in Economics & Politics** from ISM University and her past roles include advising a Member of Parliament in the Seimas (Lithuanian Parliament) and procurement management at FL Technics. **Terese is a supporter** of strong policy-business interaction is vital for Lithuania's goal to **reach climate neutrality by 2050**. The Hub offers a "one-stop shop" for consulting, financing advice, and international networking to support businesses transitioning to climate-neutral operations. Significant projects and achievements of the Hub are the oversight of a major report on Lithuania's secondary materials system and promoted the mobilisation of €27M in investments for circular innovation, including grants for experimental green tech solutions involving 9 partner ecosystems across Europe.



Andrius Veršinskas leads efforts at Kaunas IN to bridge academia and industry, improving electronics engineering education and career visibility. He studied **Political Science (Bachelor, 2016)** and **East-Central European & Lithuanian History (Master, 2023)** at Vytautas Magnus University and he is currently the **Business Department Manager at "Kaunas IN"** coordinating initiatives to boost engineering awareness and employment in electronics since at least 2021. Promotes early STEM education in schools to cultivate interest in math, physics, and engineering from grades 8–9 onward and led the **"Ateitis – elektronikams"** ("Future – for electronic engineers") campaign, doubling interest in electronics engineering enrolments by ~40% in Kaunas. He collaborates with KAUNAS IN and universities (KTU, KTK), as well as major electronics companies like Continental, Hella, Kitron, and Littelfuse to address talent shortages and Position electronics engineers as irreplaceable even in an AI-driven future, emphasizing structural thinking and data skills.



3.3 OUTCOMES

During the interviews conducted for the GreenStep project, in-depth insights were collected on topics critical to the initiative for a good understanding of the current landscape in the Central and Western Lithuanian region. This regional analysis is essential to identify strengths and weaknesses, draw lessons from current practices, and develop recommendations that support technological advancement and drive both energy and digital transitions.

In this region, the industrial sector is less represented than in Liberec, but the information provided reflects a very accurate and comprehensive overall perspective, which allowed for conclusions to be drawn without any issues. In contrast, the governmental sector increased its participation in the study compared to the region in the Czech Republic. The remaining sectors showed similar levels of participation in both regions.

Each stakeholder highlighted their unique role, priorities, and challenges within the system. The findings from these discussions are organized below, according to the four thematic areas explored during the interviews.

3.3.1 HUMAN RESOURCES AND WORKFORCE CAPABILITIES

EDUCATION

The general level of education in Lithuania is relatively high, with a significant proportion of the population holding university degrees. However, there is a growing shortage of engineers, particularly in mechanical and industrial fields, which is becoming a concern for the future. In contrast, fields such as software engineering are currently less affected.

Universities in Lithuania are increasingly focusing on reskilling and upskilling employees, especially those with 10 to 20 years of experience, through informal studies like targeted courses rather than full degrees. While young people are generally well-versed in technology, some of the agents remarked a clear gap in soft skills such as communication and teamwork. Universities are trying to address this by conducting surveys and organizing workshops with companies to understand future competence needs, especially in technical fields like energy and AI. However, a general shortage of talent remains a challenge, not due to poor working conditions or salaries—which have been rising—but simply because of demographic limitations. Efforts are underway to attract both local and international talent, though companies are not always prepared for a multilingual workforce. Additionally, while topics like AI, cybersecurity, and energy transition are being integrated into curricula, feedback suggests the coverage is not deep enough, and adapting education to fast-evolving industry needs remains a complex, ongoing process.

Young people are well-adapted to digital tools and transformation processes, since they are generally capable of learning and using digital technologies in both academic and professional contexts. To improve education and training, especially for workers already in the labour market, it is suggested government-supported access to software and digital tools, such as AI learning platforms and business development applications, which are often too costly for individual institutions or companies.

In the region, the level of education is generally adequate to meet current industry needs, as evidenced by high graduate employment rates. Universities maintain close contact with companies, involving them in shaping curricula and providing feedback. However, there is still a gap in emerging areas such as alternative energy sources (e.g., solar, hydrogen) and practical skills with specific systems used in companies. While students are increasingly gaining business and soft skills through interdisciplinary projects and updated curricula, employers still note a need for improved communication and teamwork abilities. The university also conducts foresight workshops with companies to anticipate future competence needs. To support lifelong learning, they are developing non-formal education programs for reskilling and upskilling experienced workers. Public awareness of digital and energy transition topics is relatively high, thanks to national investment and media coverage. Retaining talent remains a challenge, influenced by factors such as salary competitiveness, the mismatch between formal education and vocational needs, and broader cultural shifts in how young people develop soft skills.

Education is managed at the national level, and there are several initiatives aimed at integrating digital transformation into education. For example, a large EU-funded project has been implemented, focused on digital skills for industry workers, which includes training and seminars.

TALENT RETENTION

Taking as an example the case of the Industrial sector in the Chemistry Area, stakeholders highlight both strengths and challenges in the region's approach to workforce development in the chemical industry. While educational institutions provide a strong theoretical foundation in chemistry and related fields, there is a lack of graduates with practical, industry-ready skills. This gap makes it difficult to meet the sector's growing needs, especially as digital transformation becomes more relevant.

Generally speaking, many young people are still unfamiliar with how digital tools like automation and data analytics apply in industrial settings. Effective solutions include integrating more hands-on training and digital skills into academic programs, adopting dual education models, and increasing collaboration between companies and universities. Some companies contribute through internships, internal training, and participation in academic events, although formal education programs are limited, however retaining talent is difficult due to more attractive salaries and working conditions in high-tech sectors. Industrial work's demanding nature—such as shift schedules and physical intensity—can deter highly qualified professionals.

Additionally, while some progress has been made in incorporating topics like the energy transition and cybersecurity into curricula, these remain limited in traditional chemistry programs. Awareness of energy-intensive industries among students is generally low unless they participate in internships or specialized projects. Though outreach efforts exist, they are often occasional rather than systematic, suggesting a need for broader public engagement and stronger industry-academia collaboration.

BUSINESS AND POLITICAL ENVIRONMENT

Renewable energy sources, such as wind and solar power, are present and play a role in the region's economic landscape, contributing to the overall energy production. However, the level of government support and incentives directed toward the development and implementation of renewable energy solutions is relatively limited. Although large companies are active in the region and hold a significant position in its industrial framework, their overall contribution to the region's social and economic development is perceived to be rather modest.

Universities in the region are involved in public policy processes, particularly through their participation in working groups and by serving as consultants for governmental bodies. Nonetheless, the leadership in these areas is typically assumed by consulting companies, which are often commissioned through public tenders to manage strategic initiatives such as those related to the Smart Specialisation Strategy (S3).

Additionally, the region is home to several business incubators, which play a crucial role in fostering innovation and supporting emerging entrepreneurs. These incubators often serve as a bridge between academia, industry, and public institutions, and are instrumental in connecting small teams or startups with larger companies, helping to address industrial challenges and promote regional innovation.

In this context, it has been proposed that establishing more inclusive and active working groups could enhance collaboration among stakeholders and improve the effectiveness of strategic planning. Regarding the S3 document, while it is generally considered a reasonable representation of the region's current situation, some of its thematic areas are seen as somewhat disconnected from on-the-ground realities and may lack practical feasibility.

INNOVATION AND TECHNOLOGY TRANSFER

There is a general consensus that the region possesses a substantial number of technological centres of excellence and universities. In fact, several stakeholders have expressed the view that there may be an excessive number of such institutions relative to the available public budget allocated for research and innovation. This situation has led some actors to suggest that a more effective approach would involve the consolidation of resources, resulting in a more concentrated pool of talent, better equipped and more robustly funded, to enhance the overall impact and efficiency of innovation efforts in the region.

Despite the presence of numerous academic and research institutions, the training currently offered is not considered sufficient or adequately aligned with the needs of today's digitalised industries. Stakeholders have stressed the importance of establishing a stronger connection between universities and businesses to ensure that training encompasses both theoretical foundations and practical skills. The persistent disconnect between academia and industry has once again emerged as a recurring issue, highlighting a structural gap

that continues to hinder the development of a fully functional innovation ecosystem. In this context, stakeholders cited specific examples of underdeveloped areas with significant potential, such as cement production technologies and cybersecurity, which are yet to receive adequate attention in terms of research, education, and innovation.

On environmental matters, Lithuania stands out for its comprehensive and robust legal framework. The environmental regulations in place are among the most stringent in the region, and their effective implementation has contributed to a situation in which pollution is virtually absent. As a result, environmental issues are not considered a pressing societal concern, but rather a challenge that has been successfully addressed—a lesson learned and largely overcome.

With regard to the adaptability of industry to current market demands, stakeholders have observed notable disparities in the level of responsiveness and flexibility among companies. Firms operating in the technology sector, especially those with a strong focus on innovation, tend to demonstrate the greatest agility in adjusting to evolving market conditions. Interestingly, this high degree of adaptability is not necessarily correlated with the size of the enterprise or the financial resources at its disposal. Instead, it appears to be more closely related to the organisational culture, strategic vision, and capacity for innovation inherent in the company.

3.3.2 OVERVIEW OF WEAKNESSES AND STRENGTHS

Lithuania has a generally sufficient presence of universities and research centres. However, there is a clear need for more applied research infrastructure and stronger links between academia and industry to better support innovation, particularly in traditional industrial sectors.

Industry members in Lithuania generally contribute indirectly to the development of regulations and policies through sectoral associations and consultations, but they are not directly involved in decision-making. Companies explore energy efficiency and digitalization opportunities in general, however participation in cooperation networks with public entities is limited to occasional consultations or discussions that remain fragmented. There are some successful partnerships, but sustained cooperation among industry, academia, and government is still underdeveloped.

At the national level, there are several financing programs that support industrial projects related to energy and digital transition. These include subsidies from the Environmental Project Management Agency (APVA), soft loans via INVEGA, and EU-level instruments such as the Recovery and Resilience Facility and the Modernization Fund. Regional funding, however, is more limited.

Most of the companies are exploring opportunities in energy efficiency and digitalization, although no major projects have been publicly disclosed at this stage. Participation in cooperation networks is occasional, typically through consultations or involvement in sectoral discussions, rather than formalized partnerships or public-private projects.

Lithuania is making steady progress toward its energy transition goals, including national targets to achieve 70% renewable energy in final consumption by 2030. However, adapting infrastructure—particularly in energy-intensive industrial regions such as Central Lithuania—remains a significant challenge. While there has been notable development in renewable electricity generation, especially from wind, solar, and biomass, the integration of these sources into industrial processes and the advancement of energy efficiency measures still require further investment and coordination.

Renewable energy sources are increasingly present in the region's economy, contributing around 38% to final energy consumption as of 2023. Nevertheless, energy-intensive industries, which rely on continuous and stable energy supply, have more limited capacity to integrate renewables directly into their operations.

Government support is available to encourage the transition from conventional to renewable energy sources in the industrial sector. These include grants from APVA, soft loans via INVEGA, and financing from the EU's Modernization Fund, aimed at renewable installations and energy efficiency upgrades based on audit results.

Regarding the Industrial scenario, technology adoption is often low to moderate in traditional sectors. This is largely due to high costs, uncertain returns, limited internal expertise, and a general reluctance to implement large-scale changes. While some parts of the industry are modern and aligned with contemporary demands, there is still considerable room for improvement, particularly in digitalization, sustainability, and energy efficiency.

Despite these challenges, the industrial environment is showing positive trends. There is growing emphasis on energy efficiency, sustainable production practices, digitalization, and workplace safety. The industry is increasingly concerned with the energy transition in line with climate targets and is showing a rising interest in automation and data use. Additionally, in light of current geopolitical dynamics, cybersecurity and operational security have become key priorities within the regional industrial landscape.

3.3.3 ENHANCEMENT RECOMMENDATIONS

Several improvements could foster innovation and R&D in Lithuania. These include simplifying funding procedures, increasing investment in applied research, promoting collaboration, reducing administrative barriers, and encouraging a culture more open to risk and experimentation. The innovation needs of the region are not fully met.

-To better adapt education to industry needs, they emphasize the importance of practical tools and closer collaboration between education and industry—for example, through field visits, hands-on training, and student-company interactions. As for students' exposure to energy-intensive industries, most students are not well acquainted with the realities of these sectors. A key reason is the geographic separation: heavy industry is mainly located in regions, while universities are based in major cities. Additionally, there is limited collaboration between these industries and academic institutions.

-The industry-academia connection is a constant battleground: Efforts to Connect Academia and Industry have been addressed, as several initiatives introduced to bridge the gap between academia and industry. A Regional Board for Research and Development brings together representatives from academia, companies, and schools to facilitate cooperation. Organized meetings between government officials and industry leaders have proven effective in encouraging engagement. Ongoing education and personal contact are emphasized as key factors in building strong relationships. Special emphasis has been placed on the need to connect academia and industry through information campaigns, as well as making it easier and more agile to establish agreements, contracts, and collaborations. Currently, there is a significant lack of understanding between the two ecosystems and high levels of bureaucracy, which makes collaboration between them unattractive. The knowledge potential is high at the University and Technology Centres in Central and Western Lithuania which would greatly contribute to innovation and the development of integrated solutions for industry, and consequently, to outsourcing.

-Industrial site visits for students are rare and usually focused on high-tech manufacturing sectors like photonics or lasers. Outreach activities related to heavy industry do exist, but they are typically targeted at local communities near industrial sites, not at students or young professionals, so it is highly encouraged the development of these actions.

In conclusion, while Lithuania is making efforts to support the digital and green transition through education and policy, there is still a gap in integrating energy transition topics into curricula, in building strong university-industry links, and in addressing the economic drivers behind talent migration. The presence of universities and research centres in Lithuania is generally sufficient, but there is a need for more applied research infrastructure and stronger connections between academia and industry. Collaboration with

researchers exists but is not systematic, and the innovation ecosystem remains fragmented, with limited structured partnerships. While high-tech sectors receive support, traditional industries often lack adequate innovation assistance. Barriers to technology adoption include high costs, limited expertise, and cautious attitudes. Although some sectors are modernizing, the pace is slow, especially in energy-intensive and traditional industries. Simplifying funding, encouraging cooperation, and fostering a risk-tolerant culture could enhance R&D. **Energy-intensive industries significantly impact regional society**—economically, socially, and environmentally—bringing both benefits and challenges.

The interviews with stakeholders from the Quadruple Helix revealed very similar perceptions regarding the situation in terms of training and the impact of the energy and digital transitions on civil society. However, other aspects—such as talent retention and the industry's adaptation to new markets—are perceived differently depending on the specific sector of the Quadruple Helix to which the stakeholder belongs. It is also common across all regions to observe a general lack of awareness within civil society about topics such as the use of IT technologies or the availability of funding support.

3.4 SUMMARY AND CONCLUSIONS

TOPICS	CONCLUSIONS
EDUCATION	<i>-Lithuania has a highly educated population, but faces a growing shortage of engineers, especially in mechanical and industrial sectors.</i> <i>-Universities are actively working on reskilling and aligning education with industry needs, yet soft skills and emerging technical areas still show gaps.</i> <i>-Despite strong university-industry collaboration and high graduate employment, talent retention is challenged by demographics and evolving skill demands.</i>
PUBLIC ENGAGEMENT/ STEM GROWTH	<i>-There is an insufficient number of outreach events, scarcely promoted by the University and other public entities.</i>
TALENT RETENTION	<i>-There is a strong theoretical education, but a significant gap remains in practical, industry-ready skills and digital competencies.</i> <i>-Talent retention is hindered by less attractive working conditions in the chemical industry compared to high-tech sectors, and awareness of energy-intensive industries is generally low among students.</i>
INNOVATION/ TECHNOLOGY TRANSFER	<i>-The region hosts many universities and technology centres, but resources may be spread too thin, prompting calls for more focused investment and consolidation.</i> <i>-Lithuania's strong environmental regulations have effectively eliminated pollution, making environmental concerns less pressing for society.</i> <i>-Technological companies with a strong innovation focus show greater adaptability to market changes, regardless of their size or funding.</i>
SYSTEM WEAKNESSES	<i>-Lithuania has a solid base of universities and research centres, but stronger applied research infrastructure and deeper industry-academia collaboration are needed to boost innovation.</i>

	<i>-National-level funding supports the green and digital transition, but regional financing is comparatively scarce.</i> <i>-Renewable energy adoption is progressing, but integration into energy-intensive industries remains challenging due to infrastructure and stability needs.</i>
STRATEGIC NEEDS	<i>-Barriers to innovation—such as complex funding processes, limited expertise, and high costs—slow down technology adoption, particularly in energy-intensive and traditional industries.</i> <i>-Although Lithuania supports the green and digital transitions at the policy level, integration of these topics into education and civil society awareness remains limited, contributing to talent loss and uneven adaptation across sectors.</i>

4. NORTE PORTUGAL REGION

Norte is by far the most industrialized Portuguese region, being the 11th most industrialized region among the 246 NUTS II regions of the EU27. A significant challenge for the region is to promote energy transition in the industrial sector at the same time as competitiveness and growth may be fostered. Furthermore, in the Norte region, transport heavily relies on imported fossil fuels, highlighting the challenge of the introduction of structural changes (public urban transport systems, railway network) and promoting energy alternatives (hydrogen, electric mobility) in order to reduce carbon emissions in this sector. Another relevant challenge is related with reducing intra-regional asymmetries: Most of the economy and population of Norte are located around the cities of Porto and Braga, as large areas of the interior of the region are scarcely populated, creating relevant inequalities in access to infrastructures, services and opportunities. In what concerns to energy, these “low density” territories are relevant producers of renewable energy (wind, hydroelectric, biomass). Overall, the whole region faces a demographic challenge, related with decreasing and ageing population. The strong innovation ecosystem of the Norte region, based on some of the most relevant Portuguese Universities and R&D institutions, may have a strong role in attracting and retaining population and competencies to the region.

4.1 Q-HELIX PRESENTATION

The partner from NORTE PORTUGAL (SPI) conducted a stakeholder mapping process aimed at identifying key regional actors across the four sectors of the Quadruple Helix model, with a focus on those with significant influence, impact, and engagement in the Smart Specialisation Strategy. This process presented challenges not only for SPI but also for Femetealindustry and Nanoprogress, both of which were actively involved in the search for relevant actors in the region.

Although all stakeholders contacted held roles related to innovation, management, or strategic oversight, in most cases it was not possible to schedule interviews due to limited availability. As a result, Portugal’s representation in the study is not as substantial as that of the other two regions.

Nonetheless, a search for relevant institutions within the Quadruple Helix framework was carried out, and the findings are presented below.

4.1.1 ACADEMY

FEUP: The Faculty of Engineering of the University of Porto (FEUP) is the largest of the 14 Faculties that make up the University of Porto, currently one of the most prestigious Higher Education Institutions in Europe. With almost 10,000 students and more than 600 professors and researchers distributed across six departments: Civil Engineering and Georesources, Electrical and Computer Engineering, Mechanical Engineering, Chemical and Biological Engineering, Industrial Engineering and Management and Computer Engineering.

FEUP is located in a true innovation district, where the strong presence of engineering, health sciences and entrepreneurship is highly conducive to the innovation process. The Science and Technology Park of the University of Porto (UPTEC) is also located here, a fundamental structure supporting the transfer of knowledge between the university and the market.



UNIVERSITY OF MINHO – SCHOOL OF ENGINEERING: The University of Minho (UMinho), founded in 1973, is renowned for the quality of its teaching, the quality of its students, the public recognition given to its Alumni, and for its intervention and strong links with the local community and the surrounding region. The School of Engineering is a School devoted to cutting-edge research and capable of addressing real life problems in close cooperation with industry and society.

R&D activities foster the creation of new knowledge, which is in turn applied and taught, constantly renewing the cycle of practice-based learning. As an R&D excellence institution, the school devotes its activities to strategic areas for its development, strengthening its position in the national and international research institutes' network. Research is not only market-driven but addresses also the benefits of long-term approaches to our key partners – Industry and Students.



POLYTECHNIC INSTITUTE OF PORTO – ENGINEERING INSTITUTE (ISEP): Since 1852, ISEP has become a successful trademark in the education and innovation of Engineering, preserving its commitment to the future. Anchored in an applied knowledge-based educational model (hands-on), ISEP follows the international best practices in European quality certification, favouring the development of academic projects in businesses and research groups. More than 6,000 students and 500 employees benefit from an excellent teaching and learning environment, a prestigious and close faculty and quality infrastructures, where a strong international cooperation policy is promoted as well as a global overview of opportunities.

Cooperation with more than one hundred European higher education institutions enables students



exchange through the Erasmus program and international cooperation protocols. The double-diploma agreements with Spanish and Brazilian institutions and the exchange and research partnerships with American, Asian and Portuguese-speaking counterparts should also be emphasized. Tradition and Innovation in the Engineering School with more certified programs in the Iberian Peninsula. As a member of the CDIO consortium, we joined the worldwide leaders in the promotion of a hands-on teaching and learning process which embraces the challenge of training the next generation of engineers. This ability to enforce good practices also supports the leadership of projects such as PRAXIS - European Center for Project/Internship Excellence or the involvement in the Carnegie Mellon University and MIT-Portugal Portugal programs, among others.

4.1.2 INDUSTRY

The **EDP Group**, a leading energy company, is actively involved in the development and implementation of sustainable energy solutions. Their Sustainability Department and Innovation Department are focused on driving the transition towards a cleaner and more sustainable energy system, supporting energy-intensive industries in their efforts to reduce emissions and optimize energy consumption. Throughout our history, they worked to make EDP a leading multinational in the energy transition to renewables, present in four main regions across the globe (Europe, North America, South America and Asia Pacific). But at the heart of it all remains electricity, which moves people, businesses, and the planet. An increasingly greener world, where they anticipate the transformations necessary for sustainability.



Imagem 3D retirada do projecto de arquitectura relativa aos blocos A e B do Edifício Sede da EDP, Baixa-Porto

Galp Energia: The energy sector is heavily influenced by the economic and geopolitical context, which has caused disruptions in the supply chain and price fluctuations. In this scenario, Galp remains committed to sustainable value creation and decarbonisation. The strategy is based on a balance between investing in low-carbon solutions and ensuring affordable and secure energy. These strategic priorities are underpinned by disciplined capital management. Around 65% of the planned gross investments are directed towards growth and transformation projects, while approximately 35% are earmarked for low-carbon initiatives.

Galp will continue to develop its unique and competitive portfolio. Oil and natural gas production is currently concentrated in Brazil's pre-salt layer. Promising exploration projects in Namibia and São Tomé and Príncipe



are also in the pipeline. The results generated by the Upstream business are essential to drive growth and finance the company's transformation.

Sonae Indústria: Sonae is a multinational that manages a diversified portfolio of businesses in the areas of retail, financial services, technology, shopping centres and telecommunications. Sonae Indústria, a major player in the forest-based industry, is committed to sustainable practices in their operations. Their Research and Development Department and Environmental Management Department are actively involved in developing innovative technologies and solutions for energy efficiency and responsible resource management, supporting their contribution to the region's energy transition. As a diversified Group, they leverage their skills and challenges, prioritizing diversity and creating environments where everyone is valued for their uniqueness, recognized for their talent and where they feel they can be themselves



4.1.3 CIVIL SOCIETY

APREN (Portuguese Association of Renewable Energy): The Portuguese Renewable Energy Association (APREN) is a non-profit association, founded in October 1988, with the mission of coordination, representation and defence of the common interests of our members. Their members are either: singular or collective entities that are authorized to produce renewable electricity (producers); or even any entity interested in the technical, legal, financial and economic development of electricity production from renewable energy sources and that can clearly contribute to meet APREN's purposes (non-producers). APREN represents more than 90% of all installed capacity of renewable energy sources in Portugal and works together with official authorities and other similar entities, either national or international, being an important key player in the development of energy policies in Portugal, thereby promoting the deployment of renewable energy resources for electricity production.



Quercus is a Portuguese Environmental Non-Governmental Organization (ONGA) founded on October 31, 1985. It is an independent, non-partisan, national, non-profit association made up of citizens who have come together around the same interest in the Conservation of Nature and Natural Resources and in the Defence of the Environment in general, with a view to sustainable development. Quercus has been occupying a place in Portuguese society that is both irreverent and constructive in defending the many causes of nature and the environment. Its scope of action currently covers several thematic areas of current environmental issues, including, in addition to nature conservation and biodiversity, energy, water, waste, climate change, forests, sustainable consumption, environmental responsibility, among others. This specialized support is largely supported by the work developed by several working groups and permanent projects. This status was progressively achieved through a conduct that is attentive to reality, without losing the fundamental reference point of principles, nor straying from the need to complement critical denunciation with effort to build consensus in Portuguese society, without which no effective sustainable development model will be possible in our country. of the Order of Prince Henry the Navigator, awarded by the President of the Republic, Dr. Mário Soares.



ZERO – Sustainable Earth System Association is a **non-profit, non-governmental environmental organization** with a public interest and nationwide scope. It operates in complete independence from political parties, companies and for-profit entities, religious entities and the government. It was created at the end of 2015, as a result of the common interest of around one hundred people in defending the values of sustainability. The main focus of his work is to change public policies, with the ultimate goal of ensuring structural change in society that allows sustainability to become the norm. It is organized into five thematic areas, within which it seeks to cover a wide range of environmental issues. The thematic areas are Water and

Ocean, Climate Change, Energy and Mobility, Biodiversity, Agriculture and Forests, Sustainable Societies and New Forms of Economy and Soil and Territory Management. They work to make sustainability a structuring element of national and international public policies, through dialogue with decision-makers and companies, through collaboration with similar organizations and through social pressure. We mobilize society through communication, training and awareness-raising.

4.1.4 GOVERNMENT

The **Northern Regional Coordination and Development Commission, IP (CCDR NORTE)** is an indirect State administration service, endowed with administrative and financial autonomy, and subject to the supervision and supervision of the Deputy Minister for Territorial Cohesion. This public institution aims at the



integrated and sustainable development of the Northern Region of Portugal, contributing to the competitiveness and cohesion of the national territory. With the mission of implementing environmental, land use and urban planning policies, as well as regional development in the Northern Region (NUT II), the CCDR NORTE is also responsible for promoting the coordinated action of decentralized services at regional level – in conjunction with the members of the Government responsible for the respective areas – and for providing technical support to local authorities and their associations. CCDR-NORTE, IP is also

responsible for managing community programs originating from European Union funds destined for Portugal and other regional development financing instruments, such as State incentives for local and regional media outlets.

The **Directorate General of Energy and Geology (DGEG)** is the Portuguese Public Administration body which has the mission of contributing to the design, promotion and evaluation of policies related to energy and geological resources, aiming for sustainable development and ensuring security of supply. DGEG's mission includes raising citizens' awareness of the importance of these policies domains in the context of the economic and social development desired for the country, informing them of the instruments available for the implementation of political decisions and disseminating the results of their monitoring and implementation. As general domains: contribute to defining, implementing and evaluating energy policies and identifying and exploiting geological resources, aiming at their valorisation and appropriate use, and monitoring the functioning of their markets, companies and products and support government in decision-making during crisis or emergency situations within the law framework and provide the steering of the Emergency Energy Planning Commission. They also carry out enforcement actions in the fields of energy and geological resources, in accordance with the applicable legislation to their different sectors.



The **Portuguese Environment Agency (APA)** is a public institute, within the scope of the Portuguese Environment and Climate Action Ministry. Their mission is to propose, develop and monitor public policies for the environment and sustainable development, in an integrated and participated manner, and in close cooperation with other sectoral policies and public and private entities. APA counts nowadays with more than



800 highly skilled employees and consultants. **Areas of Intervention:** Air, Water, Waste, Climate change, Chemicals, Noise, Protection of ozone layer, Genetic Modified Organisms, Sustainable development, Citizen participation, Environmental assessments, Environmental economics and green growth and Environmental risks. As **strategic goals:** to increase the level of protection, recovery and enhancement of ecosystem, increase the level of protection of people and goods in risk situation, to improve the knowledge and information about the environment, to reinforce public participation and to ensure the involvement of the institutions and to guarantee the excellence of performing in all assignments.

4.2 PARTICIPANT STAKEHOLDERS

As previously outlined, the process of identifying stakeholders from the Quadruple Helix in the Norte Portugal region presented considerable challenges—not only for the GreenStep regional representative in the region, SPI, but also for other entities that supported the search, as FEMETALiNDUSTRY and Nanoprogress. Although it was possible to establish contact with highly relevant stakeholders from various sectors of the region, such as academic and industrial representatives, stakeholders from the civil society and government sectors proved to be significantly less accessible. Ultimately, direct data collection was carried out with two agents:

a) Alexandre Varela, from the company EDP. This engagement, however, proved particularly valuable, as EDP is one of the leading energy companies at both regional and national levels. As such, the information obtained allowed for a meaningful comparison between the situation in Norte Portugal and that in other parts of the country.

b) Insights gathered from SPI itself, which, due to its extensive regional presence and network of contacts, was able to provide first-hand knowledge and relevant feedback regarding the local innovation and development landscape.



Alexandre Varela, Senior R&D Project Manager and Consultancy Coordinator in EDP Portugal. Alexandre is a mechanical engineer, specialized in Fluids and Heat, responsible for general technical project management and coordination, from energy efficiency in buildings to support to energy strategy planning on the regional level. He also coordinates and supports the development and execution of projects under national and EU funding programs and performs direct support to the Governing Bodies, namely in coordination with the Board of Directors. He manages cross-functional support to general management in institutional, legal and financial matters. He represents EDP at technical level institutional, thanks to his solid communication and interpersonal skills. Specialties: Mechanical Engineering, Energy Sustainability, Energy Efficiency, Renewable Energy, Energy Transition,

Energy Policy, nZEB Buildings, Building Physics, Indoor Environmental Quality, Project Management and Coordination, Business Development.



Manuel Pinheiro is an analyst at SPI Norte Portugal, part of the Sociedade Portuguesa de Inovação group. SPI is a consulting firm established in 1996, with a deep knowledge of the private and public sectors, as well as the processes that allow its clients to foster innovation, be competitive and generate growth. The Group includes SPI, SPI Azores, SPI China, SPI Spain, SPI USA, SPI Ventures, Turivã, Herdade da Torre Vã and an affiliate office in Brussels, through a partnership with the European Business & Innovation Network (EBN). Their positioning as an innovation facilitator, namely the one that results from strong science and technology contributions and a close connection to the dynamics of development, allows us to intervene at a global level, reinforcing the network of contacts and creating organizational value. With worldwide interests, they continue to expand and diversify our international presence. SPI's strong links with companies, business associations, cluster, universities, research centres, municipalities, regional and central administrations and leading international organizations such as the European Commission, allow it to provide high value-added services in the areas of innovation. SPI is a member of GreenStep consortium.

4.3 OUTCOMES

Although it has been possible to contact a considerable number of stakeholders from all sectors of the Quadruple Helix in the region, it has not yet been possible to hold the meetings as originally planned. This work may be feasible at a later stage, and if so, we will update this document with an annex after the deadline for the delivery of D4.1. The information gathered so far has been made possible thanks to the participation of Alexandre Varela from EDP Porto and Manuel Pinheiro from SPI, representing the industry and civil society sectors, respectively. The results and conclusions obtained are presented in the following sections.

4.3.1 HUMAN RESOURCES AND WORKFORCE CAPABILITIES

EDUCATION

The Norte region benefits from a solid network of universities and polytechnic institutes that provide adequate training for the workforce. Nevertheless, a slight disconnect remains between academic offerings and the practical needs of the industry. Although awareness of this gap is increasing within the industrial sector—evidenced by a general trend toward digitalization—some small-scale enterprises remain hesitant to adopt new technologies.

Efforts are being made by academic institutions through partnerships, innovation hubs, and specialized programs. However, further integration with industry is needed to enhance responsiveness to labour market shifts. Strengthening collaboration with the private sector, expanding applied learning opportunities (such as internships and dual education), and implementing targeted reskilling and upskilling programs in digital and green competencies are recommended steps forward.

TALENT RETENTION

Talent retention in the region continues to pose a significant challenge, primarily due to a combination of factors including a limited number of high-skilled job opportunities, comparatively lower salary levels than

those offered in international markets, and restricted prospects for long-term career growth. These conditions collectively reduce the region's appeal to highly qualified professionals, who are further discouraged by suboptimal compensation packages, insufficient work-life balance, and a general perception of stagnation within traditional industries.

On the educational front, although emerging topics such as energy transition, data analysis, artificial intelligence, and cybersecurity are being gradually incorporated into academic curricula, this integration is largely confined to elective or postgraduate courses, with limited penetration into undergraduate programs. Furthermore, while some students are able to gain practical exposure to energy-intensive industries through internships and research projects, such opportunities remain inconsistent and are not yet widely embedded across all fields of study.

BUSINESS AND POLITICAL ENVIRONMENT

In the Norte region of Portugal, social agents and organizations contribute to the development and implementation of regulations and economic development policies, primarily through participation in public consultations and advisory councils. However, their actual influence is often limited in practice. While they are theoretically involved in drafting strategic documents such as the Smart Specialisation Strategy (S3), this engagement tends to be more procedural than impactful, with minimal substantive participation. Familiarity with the S3 document varies, and in some cases, stakeholders do not have a formed opinion on its content. Although the strategy includes important elements relevant to the region's digital and green transitions, major challenges persist in its practical implementation and monitoring.

Financially, the region benefits from several national and EU-supported programs—such as the Recovery and Resilience Plan (PRR), PT2030, and other European funding mechanisms—that aim to facilitate energy and digital transformation initiatives. Organizations like SPI are actively involved in these efforts, supporting companies and public authorities in their digitalization processes. They also participate in collaborative projects that connect public, private, and academic sectors, often focusing on areas like communication and project management rather than technical development. Overall, there is a growing openness among Quadruple Helix actors to engage in joint initiatives promoting the twin transitions, although there remains a need for better coordination and continuity in such collaborative efforts.

Public awareness of industrial activities is modest, with a few existing outreach initiatives such as open days, fairs, and informational campaigns, but these efforts tend to lack scale and visibility, indicating room for more strategic and coordinated communication with the wider community.

INNOVATION AND TECHNOLOGY TRANSFER

The presence of research centres and universities in the Norte region of Portugal is generally considered sufficient, providing a solid foundation for academic and scientific activity. However, there remains significant potential to enhance the impact of these institutions on the regional innovation ecosystem. While some training and innovation needs are being adequately addressed, gaps persist in critical areas such as digital skills development, automation technologies, and climate resilience, which require more focused and targeted efforts. The innovation ecosystem, particularly concentrated around the metropolitan area of Porto, is characterized by a high degree of collaboration among stakeholders. Nevertheless, rural and peripheral areas tend to be less integrated into this network, highlighting geographic disparities that could limit regional cohesion and innovation diffusion.

Several factors have been identified as key to fostering further innovation and research and development (R&D) in the region. These include simplifying access to funding mechanisms, providing stronger incentives for private sector investment in R&D, and improving support for intellectual property (IP) protection and commercialization of innovations. Such measures would help stimulate greater entrepreneurial activity and technological advancement.

When assessing the level of technology adoption across productive sectors, the region exhibits considerable variability. While many companies act as early adopters or even developers of new technologies, a significant portion remains traditional and hesitant to change established processes. This divergence creates a mixed landscape where innovation progresses unevenly. Despite this, the industry as a whole is perceived to possess the capacity to adapt to emerging market trends, although competing effectively with other international markets may pose challenges due to resource constraints and other factors.

The energy-intensive industries present in the region have a notable impact on the local society, influencing working hours, cultural and social life, environmental conditions, and regional wealth. This sector's role is multifaceted, contributing both to economic development and to challenges related to sustainability and social well-being. Overall, while the Norte region demonstrates strong foundations for innovation and technological progress, addressing existing gaps and fostering greater inclusivity across all areas will be essential to maximizing its potential.

4.3.2 OVERVIEW OF WEAKNESSES AND STRENGTHS

Norte exhibits a strong educational infrastructure, a growing higher education enrolment, and robust vocational training efforts. However, challenges remain in closing the gap on tertiary attainment, reducing early school leaving, and increasing graduate employability. The region benefits from excellent research centres and a diverse higher education ecosystem but must continue improving integration and alignment between education and labour market demands.

The region has a sufficient presence of research centres and universities, providing a strong academic and scientific foundation and there is a high degree of collaboration within the innovation ecosystem, especially around the metropolitan area of Porto, however rural and peripheral areas are less integrated into the innovation network, creating geographic disparities.

Many companies are early adopters or even developers of new technologies, although technology adoption is uneven, with many companies reluctant to change traditional processes. This has an impact on competing effectively with international markets poses challenges due to resource constraints. On the other one hand, many companies are early adopters or even developers of new technologies and the industry overall shows capacity to adapt to emerging market trends, the energy-intensive sector significantly contributes to regional economic development and there are established foundations for innovation and technological progress exist in the region.

On the other hand, the impact of research centres and universities on the regional innovation ecosystem can be further enhanced, critical gaps remain in training and innovation, especially in digital skills development, automation, and climate resilience. Also, the access to funding is complex and could be simplified and private sector investment in R&D lacks sufficient incentives.

Support for intellectual property protection and the commercialization of innovations requires significant improvement to better foster entrepreneurial activity and technological advancement. Additionally, the energy-intensive industry in the region presents challenges related to sustainability and social well-being that must be effectively addressed to ensure balanced development. To fully maximize the region's innovation potential, it is also essential to promote greater inclusivity across all geographic and economic areas, ensuring that both urban centres and rural or peripheral zones are equally integrated into the innovation ecosystem.

4.3.3 ENHANCEMENT RECOMMENDATIONS

Based on the analysis of the Norte region, several key recommendations can be made to enhance its innovation capacity and support its digital and green transitions. Strengthening the collaboration between academic institutions and industry is essential to ensure that education and training programs are aligned with market needs. This includes expanding applied learning opportunities, such as internships and dual education, and implementing targeted reskilling and upskilling programs focused on digital and green skills. Greater integration of emerging topics like artificial intelligence, data analysis, energy transition, and cybersecurity into undergraduate curricula is also recommended. To address ongoing talent retention challenges, the region must create more high-skilled job opportunities, offer competitive salaries, and provide better career advancement prospects. Improving work conditions, including compensation and work-life balance, will also help attract and retain qualified professionals.

On the policy and governance side, there is a need for more meaningful involvement of social agents and organizations in policymaking, beyond formal consultations. Better implementation and monitoring of strategic plans, such as the Smart Specialisation Strategy (S3), should be prioritized. At the same time, collaborative efforts across the Quadruple Helix sectors—public, private, academic, and civil society—require stronger coordination and continuity. In terms of funding and institutional support, simplifying access to financial mechanisms, enhancing incentives for private R&D investment, and improving support for intellectual property protection and commercialization are essential steps to stimulate entrepreneurship and innovation.

Additionally, innovation efforts must address existing gaps in digital skills, automation, and climate resilience, while also working to integrate rural and peripheral areas more fully into the regional innovation ecosystem. Bridging these geographic disparities will promote greater regional cohesion. Finally, public awareness and engagement should be increased through more strategic and visible outreach initiatives such as open days, fairs, and informational campaigns. These efforts will help foster a culture of innovation and ensure that industrial and technological developments are understood and supported by the broader community.

4.4 SUMMARY AND CONCLUSIONS

TOPICS	CONCLUSIONS
EDUCATION	<i>-The Norte region has a strong network of universities and vocational institutions. However, there is still a gap between academic programs and the skills industry needs.</i> <i>-Emerging topics like AI and energy transition are mostly limited to postgraduate courses. Expanding applied learning and aligning curricula with market demands is essential.</i>
PUBLIC ENGAGEMENT/ STEM GROWTH	<i>-Public awareness of innovation and industrial activity is limited. Outreach efforts like fairs and open days exist but lack scale and visibility.</i> <i>-There is potential to better engage the public and promote STEM through more strategic communication.</i> <i>-Stronger collaboration among academia, industry, and civil society could support this.</i>

TALENT RETENTION	<i>- Retaining skilled professionals remains a significant challenge in the region. Limited job opportunities, low salaries, and unclear career paths contribute to talent loss. Enhancing work-life balance would also support talent attraction and retention.</i>
INNOVATION/ TECHNOLOGY TRANSFER	<i>-The region has good research capacity and a collaborative ecosystem, especially around Porto. Rural areas are less involved, and many companies are slow to adopt new technologies.</i> <i>-Support for intellectual property and innovation commercialization needs improvement. More private investment in R&D should be encouraged.</i>
SYSTEM WEAKNESSES	<i>-There are gaps in digital skills training, limited access to R&D funding, and insufficient incentives for innovation.</i> <i>-Many policies are developed with limited input from stakeholders.</i> <i>-Regional strategies often lack effective implementation and monitoring.</i> <i>- Geographic inequality in innovation activity is also a concern.</i>
STRATEGIC NEEDS	<i>-Education must better align with industry demands through internships and digital skills training.</i> <i>-Funding access must be simplified and innovation incentives increased.</i> <i>- Reducing the rural-urban gap and enhancing public communication.</i>

5. COMPARATIVE ANALYSIS OF THE THREE REGIONS

The educational landscapes of the Liberec Region, Lithuania, and the Norte Region of Portugal reflect distinct yet converging trajectories shaped by regional priorities and industrial needs. In the Liberec Region, the Technical University plays a central role in transitioning from traditional sectors such as textiles and glass to advanced fields like digitalization, AI, and sustainability, supported by robust collaboration with local industries and dual education models. Lithuania presents a nationally coordinated education system characterized by a relatively high level of academic attainment, with universities increasingly focused on reskilling and upskilling experienced workers through flexible, informal programs. However, a growing shortage of engineers and gaps in soft skills persist. Meanwhile, the Norte Region offers a strong university and polytechnic network, though a partial disconnect remains between academic curricula and industry demands, particularly among smaller enterprises. Across all three regions, the need for deeper integration of digital and green competencies, enhanced soft skills training, and stronger industry-academia collaboration is evident, highlighting a shared strategic direction despite differing structural contexts.

Talent retention presents a significant challenge across all three regions, with distinct contributing factors. In the Liberec Region, a notable outflow of young professionals—especially graduates—to larger urban centres like Prague or abroad, primarily driven by higher salaries and better career prospects, undermines local workforce stability. Similarly, the Norte Region in Portugal faces difficulties retaining highly qualified

professionals due to limited high-skilled job opportunities, comparatively lower wages, and perceptions of stagnation in traditional industries, compounded by suboptimal work-life balance. Lithuania's industrial sector also struggles with talent retention, as demanding working conditions and more attractive compensation packages in high-tech sectors elsewhere draw skilled workers away. Across the regions, a common theme emerges while educational institutions provide foundational knowledge, gaps remain in aligning skills with labour market demands and creating appealing career pathways, underscoring the need for targeted policies to improve compensation, career development, and work environments to better retain talent.

The business and political environments across the three regions exhibit both strengths and challenges in supporting innovation and regional development. In the Liberec Region, active public engagement initiatives, such as the Night of Scientists, and strong collaboration between academia and industry help address skill gaps and foster workforce motivation, although companies still face challenges in attracting qualified talent. Lithuania benefits from the presence of business incubators that bridge academia, industry, and public institutions, fostering innovation and entrepreneurship; however, government support for renewable energy and strategic initiatives like the Smart Specialisation Strategy (S3) is perceived as limited, with leadership often delegated to consulting firms rather than local stakeholders. In Norte Portugal, social agents participate in policy development primarily through advisory roles with limited real influence, and while EU and national funding programs support digital and energy transitions, practical implementation and coordination challenges persist. Overall, while all regions demonstrate growing collaboration between public, private, and academic sectors, enhancing stakeholder engagement and ensuring sustained, effective policy execution remain critical for advancing the twin green and digital transitions.

Finally, the three regions demonstrate unique strategies and face different challenges in innovation and technology transfer. In the Liberec Region, strong collaboration between the university and regional authorities supports gradual adoption of advanced technologies such as AI and autonomous systems, backed by numerous research projects and corporate partnerships; however, talent retention remains a significant issue, compounded by lower regional salaries and housing costs. Lithuania hosts a substantial number of technological centres and universities, yet stakeholders highlight the need for resource consolidation and stronger academia-industry linkages to better align training with the demands of digitalized industries, while also emphasizing a robust environmental regulatory framework that has effectively mitigated pollution. In Norte Portugal, a solid network of research institutions underpins the regional innovation ecosystem, particularly in the Porto metropolitan area, but geographic disparities and gaps in critical areas like digital skills and automation persist; fostering greater private sector investment, improving access to funding, and enhancing IP support are seen as key to advancing R&D and innovation. Overall, while each region demonstrates strengths in research capacity and technological infrastructure, challenges related to talent retention, practical skills alignment, and inclusive innovation diffusion remain central to their ongoing development.

5.1 POTENTIAL COLLABORATIONS AMONG THE THREE LDR

After extracting the revealed information and understanding the situation of each of the studied regions, the comparative analysis of their respective strengths and addressing shared challenges of the Liberec Region, Lithuania, and the Norte Region of Portugal reveals several avenues for fruitful collaboration among the three regions, as described below:

EDUCATIONAL AND WORKFORCE DEVELOPMENT COLLABORATION

Given the Liberec Region's experience with dual education models and strong industry-academia partnerships, it could serve as a valuable knowledge-sharing partner for Lithuania and Norte Portugal, where partial disconnects between academic curricula and industry needs remain. Joint programs focused on integrating digital and green competencies, alongside enhanced soft skills training, could benefit all regions. Collaborative

development of flexible reskilling and upskilling initiatives, inspired by Lithuania's focus on informal learning for experienced workers, may further strengthen workforce adaptability across the regions.

TALENT RETENTION STRATEGIES

All three regions face challenges in retaining highly skilled professionals, mainly due to salary disparities, limited career opportunities, and work-life balance concerns. Sharing best practices and policy frameworks that have been effective in one region—such as Liberec's initiatives in fostering innovative company cultures despite lower salaries—could help formulate tailored strategies to improve talent retention. Collaborative regional networks could be established to promote mobility while encouraging return migration through attractive career pathways.

BUSINESS AND POLITICAL ENVIRONMENT SYNERGIES

Lithuania's model of business incubators bridging academia, industry, and public institutions offers a replicable approach to enhancing innovation ecosystems. The Liberec Region and Norte Portugal could benefit from adopting or adapting such models to improve stakeholder collaboration and entrepreneurial support. Conversely, Portugal's extensive engagement with EU and national funding programs could provide insights and opportunities for the other regions to strengthen their access to financial resources and improve policy implementation mechanisms.

INNOVATION AND TECHNOLOGY TRANSFER COOPERATION

All three regions demonstrate strengths in research capacity and technology infrastructure, but face challenges related to practical skills alignment and innovation diffusion. Collaborative projects focused on emerging technologies such as AI, automation, and renewable energy could be jointly pursued, combining Liberec's advanced research projects, Lithuania's strong environmental regulatory framework, and Norte Portugal's innovation networks concentrated around Porto. Shared platforms for knowledge exchange, joint funding applications, and cross-regional pilot programs could accelerate the adoption of advanced technologies.

In conclusion, targeted collaboration among the Liberec Region, Lithuania, and the Norte Region of Portugal offers significant potential to address common challenges, capitalize on complementary strengths, and foster sustainable regional development through enhanced education, talent retention, innovation, and policy coordination.

ANNEX 1: QUESTIONNAIRE FOR STAKEHOLDERS

Table 1: questions for interviews

Human Resources and Workforce Capabilities
1) WHAT DO YOU THINK ABOUT THE LEVEL OF EDUCATION IN YOUR REGION? DO YOU BELIEVE IT IS ADEQUATE FOR THE CURRENT INDUSTRY? 2) DO YOU THINK THE YOUTH IN THE REGION ARE FAMILIAR WITH THE TERM "DIGITAL TRANSFORMATION" OF THE INDUSTRY? 3) WHAT MEASURES DO YOU THINK WOULD BE EFFECTIVE IN IMPROVING THE LEVEL OF EDUCATION AND TRAINING FOR YOUNG PEOPLE AND WORKERS IN THE REGION'S INDUSTRY? 4) IS THE UNIVERSITY/INDUSTRY/CIVIL SOCIETY/REGIONAL GOVERNMENT INVOLVED IN TAKING IMPROVEMENT MEASURES TO ENHANCE THE LEVEL OF EDUCATION FOR THE NEW GENERATIONS AND INDUSTRY WORKERS? 5) IN YOUR OPINION, WHAT OTHER MEASURES CAN REGIONAL INSTITUTIONS TAKE TO ADAPT EDUCATION TO THE NEEDS OF THE CURRENT INDUSTRY? 6) WHY IS IT SO DIFFICULT TO RETAIN TALENT IN THE REGION? 7) DO YOU THINK ONE OF THE REASONS FOR THE LACK OF TALENT IS THAT WORK CONDITIONS ARE NOT "ATTRACTIVE" FOR HIGHLY TRAINED PROFESSIONALS? 8) TO WHAT EXTENT HAVE TOPICS RELATED TO THE ENERGY TRANSITION BEEN INTEGRATED INTO EDUCATIONAL CURRICULA? ADDITIONALLY, HAVE OTHER KEY COMPETENCIES—SUCH AS DATA ANALYSIS, ARTIFICIAL INTELLIGENCE, OR CYBERSECURITY—BEEN INCORPORATED AS WELL?" 9) DO STUDENTS HAVE DIRECT EXPOSURE TO THE REAL SITUATION OF ENERGY-INTENSIVE INDUSTRIES IN THE REGION? 10) ARE SITE VISITS OR INTERNSHIPS AT THESE INDUSTRIES PART OF THEIR TRAINING? 11) ARE THERE OUTREACH ACTIVITIES AIMED AT INFORMING THE GENERAL PUBLIC ABOUT INDUSTRIAL ACTIVITIES?
Infrastructures and Productive Resources
12) DO YOU THINK THE REGION IS ADAPTING TO THE LEVELS REQUIRED FOR THE ENERGY TRANSITION? 13) ARE RENEWABLE ENERGIES PRESENT IN THE REGION'S ECONOMY? 14) ARE THERE INCENTIVES TO SUPPORT THE TRANSITION FROM CONVENTIONAL ENERGY SOURCES TO RENEWABLE ENERGIES IN THE INDUSTRIAL SECTOR AND FOR CIVIL SOCIETY? 15) IS THERE A PRESENCE OF ENERGY-INTENSIVE INDUSTRY IN THE REGION? IF SO, DOES IT MAKE A SIGNIFICANT CONTRIBUTION TO THE REGIONAL ECONOMY?

16) WHICH IS YOUR OPINION ABOUT THE LEVEL OF TECHNOLOGY ADOPTION IN THE REGION?

Business and Political Environment

- 17) DO GOVERNMENT-RELATED MEMBERS AND INSTITUTIONS IN LIBEREC CONTRIBUTE TO THE DEVELOPMENT AND IMPLEMENTATION OF REGULATIONS AND ECONOMIC DEVELOPMENT POLICIES?
- 18) ARE YOU ACTIVELY ENGAGED WITH OTHER MEMBERS OF THE QUADRUPLE HELIX IN DRAFTING STRATEGIC DOCUMENTS, SUCH AS THE SMART SPECIALISATION STRATEGY?"
- 19) DO YOU BELIEVE THE SMART SPECIALISATION STRATEGY (S3) ADDRESSES THE ESSENTIAL ASPECTS FOR THE DIGITAL AND GREEN TRANSITION OF THE REGION?
- 20) COULD YOU PROVIDE US WITH YOUR OBJECTIVE OPINION ABOUT THE S3?
- 21) ARE THERE REGIONAL AND NATIONAL FINANCING PROGRAMS THAT SUPPORT INITIATIVES AND PROJECTS RELATED TO THE DEVELOPMENT OF THE ENERGY AND DIGITAL TRANSITION IN THE REGION?
- 22) ARE YOU COLLABORATING ON OR DEVELOPING ANY PROJECTS OF THIS NATURE?
- 23) DO YOU PARTICIPATE IN PROJECTS OR ACTIONS INVOLVING COOPERATION NETWORKS BETWEEN THE PUBLIC, PRIVATE, AND ACADEMIC SECTORS?" IF SO, COULD YOU EXPLAIN THE TOPIC?
- 24) ARE THE QUADRUPLE HELIX AGENTS IN YOUR REGION OPEN TO COLLABORATING ON INITIATIVES TO PROMOTE THE DIGITAL AND ENERGY TRANSITION OF THE REGION?

Innovation and Technology Transfer

- 25) IS THE PRESENCE OF RESEARCH CENTRES AND UNIVERSITIES SUFFICIENT?
- 26) ARE THE TRAINING AND INNOVATION NEEDS OF THE REGION ADEQUATELY ADDRESSED?"
- 27) IS THE INNOVATION ECOSYSTEM IN LIBEREC COLLABORATIVE?
- 28) WHAT FACTORS DO YOU THINK COULD BE IMPROVED IN LIBEREC TO FOSTER INNOVATION AND R&D?"
- 29) WHAT IS YOUR OPINION ON THE LEVEL OF TECHNOLOGY ADOPTION IN PRODUCTIVE SECTORS? IF YOU CONSIDER IT TO BE LOW, COULD YOU PROVIDE REASONS FOR THIS?
- 30) DO YOU BELIEVE THE INDUSTRY HAS THE CAPACITY TO ADAPT TO NEW MARKET TRENDS?
- 31) DO YOU BELIEVE THE INDUSTRY IS MODERN AND ADAPTED TO CURRENT TIMES? IS THERE A NOTICEABLE CHANGE IN THE MANAGEMENT OF THE INDUSTRY THAT BRINGS IT CLOSER TO CURRENT CONDITIONS?
- 32) DO YOU CONSIDER THAT ENERGY-INTENSIVE INDUSTRY HAS AN IMPACT ON THE SOCIETY OF THE REGION? FOR EXAMPLE: WORKING HOURS, CULTURAL AND SOCIAL LIFE, ENVIRONMENTAL CONDITIONS, WEALTH?

OPEN DISCUSSION

Stakeholders were invited to provide other appreciations and comments