Project: 101081833 – BIOTRANSFORM – HORIZON - CSA

BIOTRANSFORM
TRANSITION PATHWAYS TO CIRCULAR BIO-ECONOMY

Circular BIOeconomy TRANSFORMation for regions by enabling resource and governance networks

D1.1: Report on limits of the linear fossil economies

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List of Terms and Definitions

Abbreviation	Definition
EMAF	Ellen MacArthur Foundation
EC	European Commission
FoEE	Friends of the Earth Europe
UN	United Nations
SDGs	Sustainable Development Goals
EEB	European Environmental Bureau
SERI	Sustainable Europe Research Institute
OECD	Organisation foe Economic Co-operation and Development

Table 1: Terms and Definitions

Executive summary

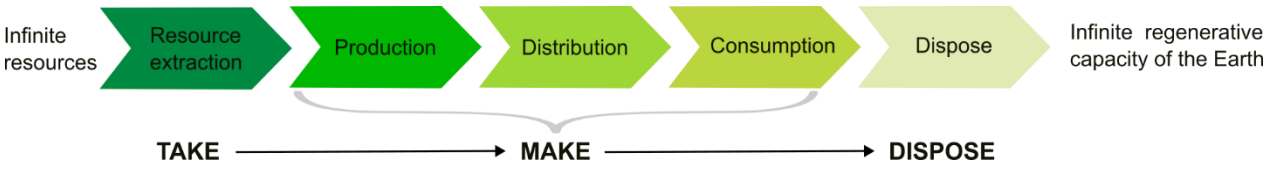
BIOTRANSFORM provides European policymakers with an adequate assessment and policy development framework, knowledge base and expert support ecosystem to accelerate the transition from linear fossil-based systems to circular biobased systems. This deliverable sets the scene to support such transitions by obtaining a better understanding of the current environmental, economic and social limits of linear and fossil-based economies in Europe by analysing the existing status and challenges faced in our six case-study regions and their economies. We first present the general status, trends and expected evolution of linear economic systems in the European Union as a whole and then we delve into the specifics of the case studies. The analysis and the findings presented in this deliverable were obtained via desk research and complemented with semi-structured interviews with policymakers and other stakeholders that are involved in the efforts to support the transition from linear and fossil-based systems to circular and bio-based ones. Our findings demonstrate the main limits of the current system, faced in the case study regions, and the barriers to achieving relevant sustainability goals. We conclude that transitioning to circular bio-based system is the way forwards to alleviate the impacts (environmental, economic and social) and instability caused by the linear systems.

1. Introduction

1.1 Linear fossil-based economies

Over the last 150 years, the industrial evolution has been dominated by a linear model of production and consumption in which goods are manufactured from raw materials, sold, used and then discarded through landfilling or incinerated as waste. Through breakthrough technological advances, the industrial revolution has increased the productivity of the global economy and has brought unprecedented prosperity to society. In order to grow, the established economic system has provided incentives to increase sales and to develop economies of larger scale, leading to an ever-increasing consumption of goods and services. This predominant economic model is characterized by the 'take, make, dispose" pattern (Figure 1) and it is built on two strong assumptions: boundlessness and easy availability of resources (energy and raw materials) as well as a limitless regenerative capacity of the Earth (Wautelet 2018).

Figure 1: The linear economy - The 'take, make and dispose' approach of production. Adapted from Wautelet 2018

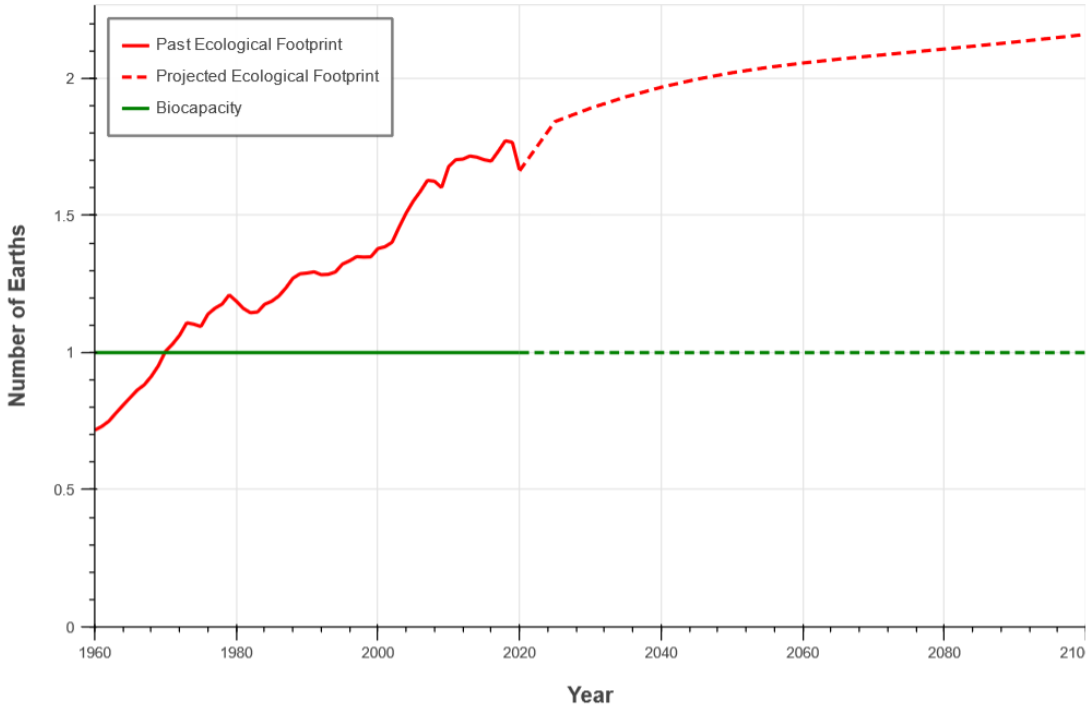


Linear fossil-based economies, a category of linear systems, are based on the use of fossil carbon and other raw material. These non-renewable carbon resources, which include coal, oil, and natural gas, supply approximately 80 percent of the world's energy production, being a fundamental driver of the technological, social, economic and development progress. Fossil carbons provide fuel for electricity, heating, and transportation, while also feeding the processes that make a huge range of products, from steel to plastics[1].

According to the Global Footprint Network, by 2010, the global economy (both other linear and fossil-based systems) used the equivalent of 1.5 Earths to provide the resources needed and to absorb or reintegrate the waste generated as a result of human activities. In other words, already a decade ago the Earth needed one year and a half to produce and absorb what is consumed (as raw materials) and eliminated (as waste) in one year (Bonciu 2014). More recently and following this pattern, July 29th 2022, marked the day that humanity's demand for ecological resources exceeded the resources Earth could regenerate within the year[2], highlighting the increase in humanity's ecological and carbon footprint. If consumption trends continue with the same pace, it is estimated that by 2030, humankind would require two Earths to function (Figure 2).

[1] https://www.nationalgeographic.com/environment/article/fossil-fuels
[2] https://www.weforum.org/agenda/2022/08/earth-overshoot-day-climate-crisis/

Figure 2: Humanity's Ecological Footprint and future projections



Source: https://www.footprintnetwork.org/resources/footprint-scenario-tool/

1.2 Circular economy and bioeconomy

While the linear and fossil-based economies have been very successful in generating material wealth in the industrial nations up to the 20th century, they have demonstrated weaknesses in the new millennium and the' ultimate breakdown in the near future of such systems is forecasted (Sariatli 2017).

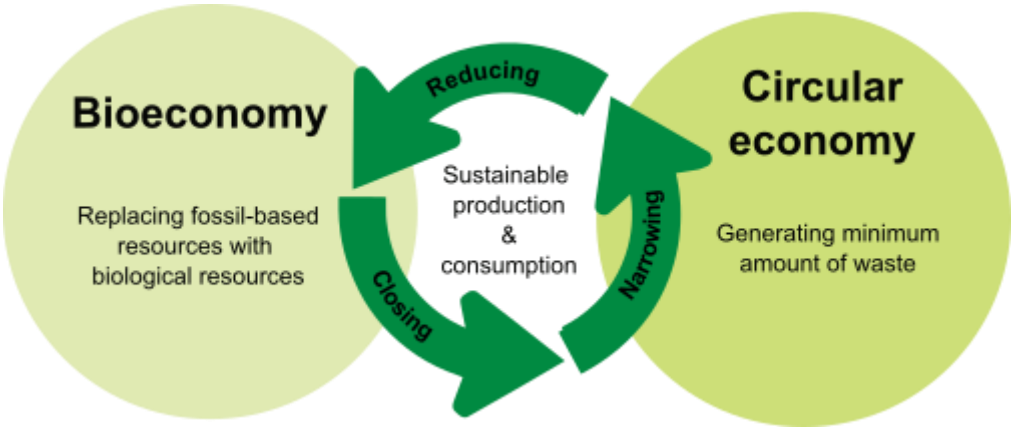
Finite supplies of fossil fuels and raw materials, climate change impacts of their use and peak oil prices require a shift towards the use of renewable bio-based resources such as plant materials or agricultural waste for the production of chemicals, materials, products and fuels among others. In order to move into a more sustainable economic system, the more frequently discussed and applied approach for overcoming the current linearity of product lifecycles is the concept of circular economy.

The Ellen MacArthur Foundation (EMAF) has defined circular economy as a framework for an economy that is restorative and regenerative by design. Specifically, EMAF's circular economic model aims to create economic, natural, and social capital based on three core principles: (1) design out of waste and pollution, (2) keep products and materials in use, and (3) regenerate natural systems an industrial system that is restorative or regenerative. In contrast to the current linear model, a circular economy model emphasizes economic growth and activities that are dissociated from the consumption of finite resources and minimize system wastes, ultimately achieving positive society wide benefits (Tan and Lamers 2021). According to the European Commission (EC), circular economy is an economic system in which *"…the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised"* (EC 2015). Circular economy aims to retain the value of different kinds of resources (not only biological) in the economic

cycle as long as possible, including but not limited to, renewable biological resources, while also focusing on the way products and materials are designed, produced, used and disposed.

Bioeconomy encompasses additional activities other than the above by adding value to biological waste and residue streams, such as the transformation of non-residual biological resources into higher value products and the efficient production of renewable biological resources (Figure 3). The EC's bioeconomy strategy interprets circular bioeconomy as a framework to reduce the dependence on natural resources; transform manufacturing; promote sustainable production of renewable resources from land, fisheries, and aquaculture; and promote their conversion into various biobased products and bioenergy, while creating new jobs and industries (EC 2018).

Figure 3: Schematic representation of a circular bioeconomy resulting from the intersection between circular economy and bioeconomy concepts



Source: Tan and Lamers 2021

1.3 EU sustainability goals and targets

The Goals of the EC's bioeconomy strategy are: 1) to limit and adapt to climate change; 2) to reduce dependence on non-renewable unsustainable resources (including replacing fossil fuels); 3) to manage natural resources sustainably; 4) to ensure food and nutrition security and 5) to strengthen European competitiveness and create jobs[3]. The strategy aims to integrate bioeconomy with circular economy (See also EC's circular economy action plan[4]) as circular bioeconomy is very promising pave the way for a sustainable EU future aiming to replace the traditional linear economic model with circular ones where resources are used efficiently and waste is minimised.

Towards a circular bioeconomy transition, and taking into account existential threats of climate change and environmental degradation, the EC formed a new growth strategy in 2020, the European Green Deal. This new strategy includes a set of policy initiatives with the overarching aim of making the European Union (EU) climate neutral in 2050 by reaching emissions reductions of at least 55% by 2030 compared to 1990 levels[5]. The Green Deal aims to achieve three main goals: First, it focuses

[3] https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b690-01aa75ed71a1/language-en
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN
[5] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

on achieving net-zero emissions by proposing specific strategies that can help curb emissions across all sectors, with a strong focus on energy; energy production makes up more than 75% of total EU-27's greenhouses gases. The objective is to increase the share of renewable energy in the EU's energy mix. Second, it plans to decouple growth from resource exploitation. While reduction in emissions have been achieved in the last decade, Europe remains one of the major contributors of resource consumption in the world. The EU material footprint (i.e. total consumption of fossil fuels, biomass, metals and non-metallic minerals, including embodied in imports) in 2022 was estimated at 16 tonnes per capita[6], being more than double what is considered a sustainable and just limit (EEB & FoEE 2021). Third is the need to foster an inclusive green transition and to leave none behind[7].

The EU bioeconomy strategy goals are all linked and crucial for the implementation and achievement of the Green Deal objectives with a clear overlapping among them. We can thus, have synergistic effects towards their objectives by transitioning to circular bioeconomy. Moreover, through EU's dedicated strategies and action plans the EU is demonstrating its commitment into mainstreaming the United Nation's (UN) Agenda.

More specifically, the UN's 2030 Agenda for Sustainable Development sets a number of Sustainable Development Goals (SDGs) to solve global challenges, promote growth, and create a sustainable future. The SDGs that correspond to the sustainable development goals of the EU, the targets of the EU Green Deal and the circular bioeconomy transition are:

- Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- Goal 12. Ensure sustainable consumption and production patterns
- Goal 13. Take urgent action to combat climate change and its impacts
- Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

In order to achieve these Goals, well designed policies and strategies are required to make transitions and use resources efficiently. In that sense, Europe is facing a dual challenge – first, to stimulate the growth needed to provide jobs and well-being to all citizens and – second, to ensure that the quality of this growth leads to a sustainable future.

1.4 The BIOTRANSFORM project

The BIOTRANSFORM project comes to fill the current gap in policy guidelines for successful transition from other linear and fossil-based systems to circular bio-based ones. The project aims at analyzing and evaluating circular bio-based transition pathways, across 6 regions in Europe, and use

[6] https://ec.europa.eu/eurostat/cache/sankey/circular_economy/sankey.html?geos=EU27&year=2022&unit=THAB&materials=TOTAL&highlight=&nodeDisagg=0101100100&flowDisagg=true&language=EN&material=TOTAL

[7] https://www.weforum.org/agenda/2021/07/what-you-need-to-know-about-the-european-green-deal-and-what-comes-next/

the results to provide a comprehensive methodology towards an EU-wide transition tailored to policymakers. BIOTRANSFORM equips policymakers with the tools to set informed priorities that serve environmental, economic, and social goals, being actionable, futureproof, and aligned with supply-and-demand trends in related industries and value chains. The project will provide guidelines and recommendations for policymakers in the transition towards circular bio-based systems and provide suitable financing guidance to go along the overall guidelines.

The current report focuses on mapping the environmental, economic & social limits of other linear and fossil-based economies in two levels: initially by giving the general framework in EU level and subsequently, emphasising the issues in the 6 case-study regions and the main bioeconomy topics explored in the project (Table 2). This report presents the findings of the above analysis in the following chapters:

- **Chapter 2** presents the methodology that was followed for the deliverable.
- **Chapter 3** provides an EU level analysis regarding the current status and limits of other linear and fossil-based economic systems.
- **Chapter 4** includes the regional analysis of the relevant other linear and fossil-based economies in each of the 6 regions including the barriers of those economies to achieve relevant sustainability goals.
- **Chapter 5** provides an overview of the regional limits according to the findings of chapter 4 and interviews carried out in the case study regions as well as an EU level overview of the main limits based on the regional findings.
- **Chapter 6** concludes the report.

Table 2: Representatives of each case-study region leading the transition initiatives

Country	Region	Main bioeconomy topics	Leader
Austria	Northern Burgenland	vineyards, vegetation & sludge from lake, agribusinesses	ALCN
Czech Republic	Charles Spa Region	hot springs & associated spa tourism, beverages & food production	HUB
Finland	Country level	forestry	VTT
Germany	North Rhine-Westphalia	chemical industry, biogenic side & residue streams	CLIB
Greece	Western Macedonia	decarbonisation of energy production, agriculture, mining, fur & leather	CluBE
Spain	Andalusia	tourism, retail, transportation, underdeveloped industry, agriculture	CTA

1.5 Relation of the deliverable to other tasks

This deliverable represents research into the limits of the current linear and/or fossil-based economy at EU and regional level (case-study regions) when trying to achieve policy targets on EU and regional level. It is based on data available as of April/May 2023 and serves as a source of data for other tasks in WP1 and also subsequent work in WP2 and WP3. In the latter work packages, transition pathways for the different regions will be chosen, and the relevant quantitative and qualitative data for these activities are updated as necessary, including data on trend development of linear and circular industry development in the case study regions and countries.

2. Methodology

The current analysis consists of desk research that was complemented by semi-structured interviews as described in the BIOTRANSFORM's task-specific description of action (DoA). A desk research study has been carried out to identify the limits of the current linear fossil-based economy at EU and regional level (case-study regions) to achieve the UN 2030 Agenda and EU policy targets. Q-PLAN was responsible for the EU level desk research presented in chapter 3. Chapter 4 presents the desk research conducted by each case study region partner (see Table 2) presenting the limits and challenges of the current economic system there. Q-PLAN developed a desk research template for the case study partners, available in annex I, to use is as a guide for the desk research in order to address the main issues covered in this report in a comparative and similar manner. Relevant literature both in English and local languages was searched and used as the basis for the analysis. The sources used included but were not limited to public reports, project deliverables and peer-reviewed publications.

Additionally, for each of the 6 case-study regions, responsible partners conducted semi-structured interviews with relevant key policymakers and other stakeholders like experts, regional authorities, etc. Q-PLAN prepared the interview questionnaire that included questions that would be used to compliment this deliverable but also D1.2 and is available in annex II. In total 31 interviews were conducted in person and via zoom or equivalent digital platform. Interviews notes were taken or they were audio recorded and contributions to this report were provided as summarizing text translated into English, available in annex III. The questions developed for the questionnaire were formatted as such to identify the perceptions of policymakers/stakeholders on the current linear and/or fossil-based economies and the potential transition pathways to a circular bioeconomy for their region. The questions touched on the limits of fossil-based economies, the future of circular bioeconomy and the information needs to design effective transition policies. The interviews' reporting summary was used in chapter 5 to provide a summarising overview of the main limits of each case study region according to the available literature and expert opinion. EU level analysis

2.1 The current status of linear fossil-based systems, trends and expected futures – a general overview within the EU

By 2050, it is estimated that the human population will reach approximately 9 billion people enjoying increasing wealth (Godfray et al. (2010, p. 812)). To respond to this increased global demand, the economy will require about three times the resources it currently uses. In the EU, each person consumes 16 tonnes of materials a year, of which 6 tonnes become waste and half of that is landfilled (EC 2016). The global material use has seen a 10-fold increase since 1900 and according to the Sustainable Europe Research Institute (SERI) it is expected to double between 2010 and 2030.

From 2000 to 2019, the total domestic material consumption (DMC) rose by more than 65 per cent globally, amounting to 95.1 billion metric tons in 2019. The two regions accounting for about 70 per cent of the global DMC are 1) Eastern and South-Eastern Asia and 2) Europe and Northern America[8]. The consumption of raw material in the EU has declined to a degree and stabilised since 2010 (Figure 4) but with the amounts still remaining at high levels and above the global DCB of 12.3 tons per capita. The main drivers of this growth in material consumption is related to the increased population density, industrialisation and the outsourcing of material-intensive production from developed to developing countries.

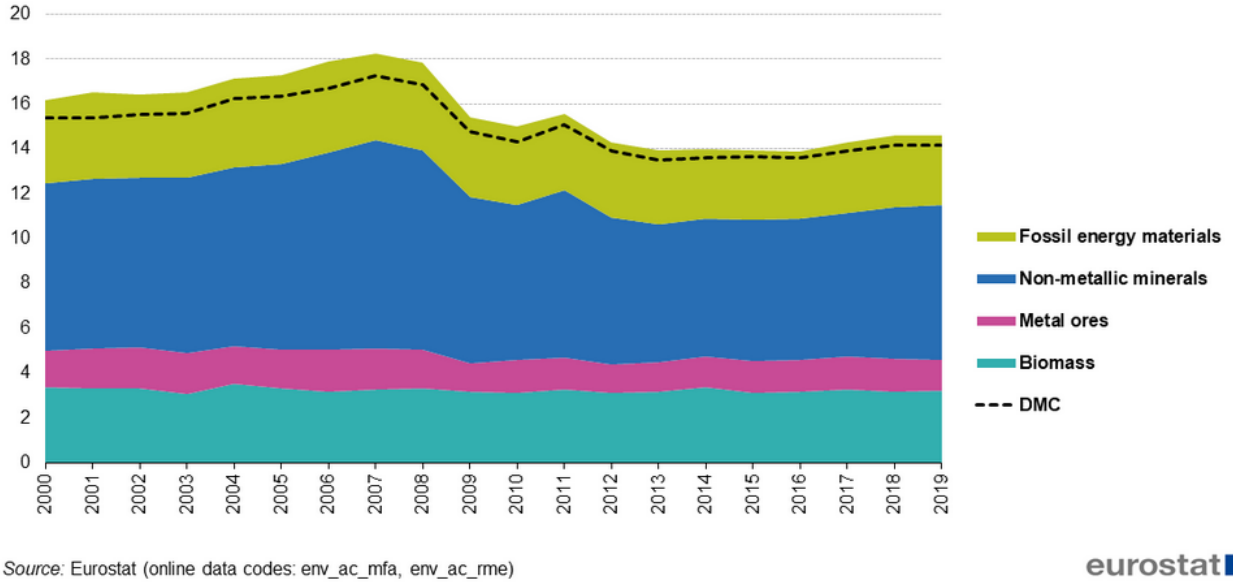


Figure 4: Raw material consumption (RMC) by main material categories, EU, 2000-2020 (tonnes per capita), (DCM=Domestic Material Consumption)

In 2020, 2.1 billion tonnes of waste (or about 4.8 tonnes per capita) was generated in the EU. While the greater parts originate from the construction (37.1 %), mining (23.4 %), and manufacturing (10.9 %) sectors, household waste represented 9.5 % of the total (Figure 5).

More than a half (60.2 %) of the waste was treated in recovery operations: recycling (39.2 % of the total treated waste), backfilling (14.6 %) or energy recovery (6.4 %). The remaining 39.8 % was either landfilled (31.3 %), incinerated without energy recovery (0.5 %) or disposed of otherwise (8.1 %)[9].

A snapchat at the EU CO_2 emissions, from the mid-18th century through today, shows that after the Industrial Revolution, growth in emissions was still relatively slow until the mid-20th century. However, from the 1950s onwards and within 50

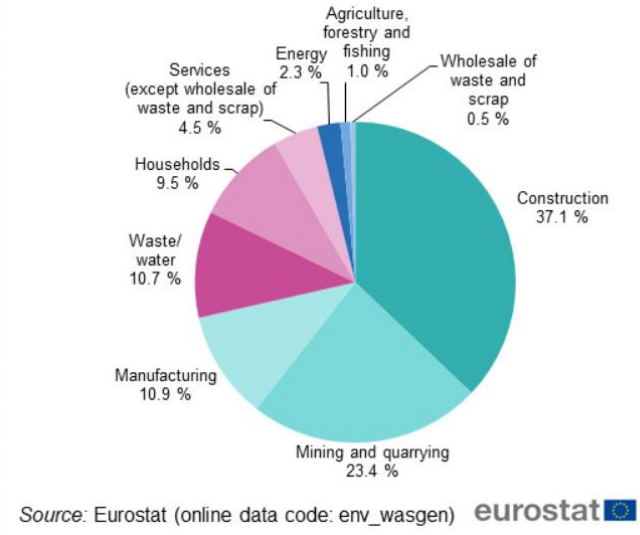
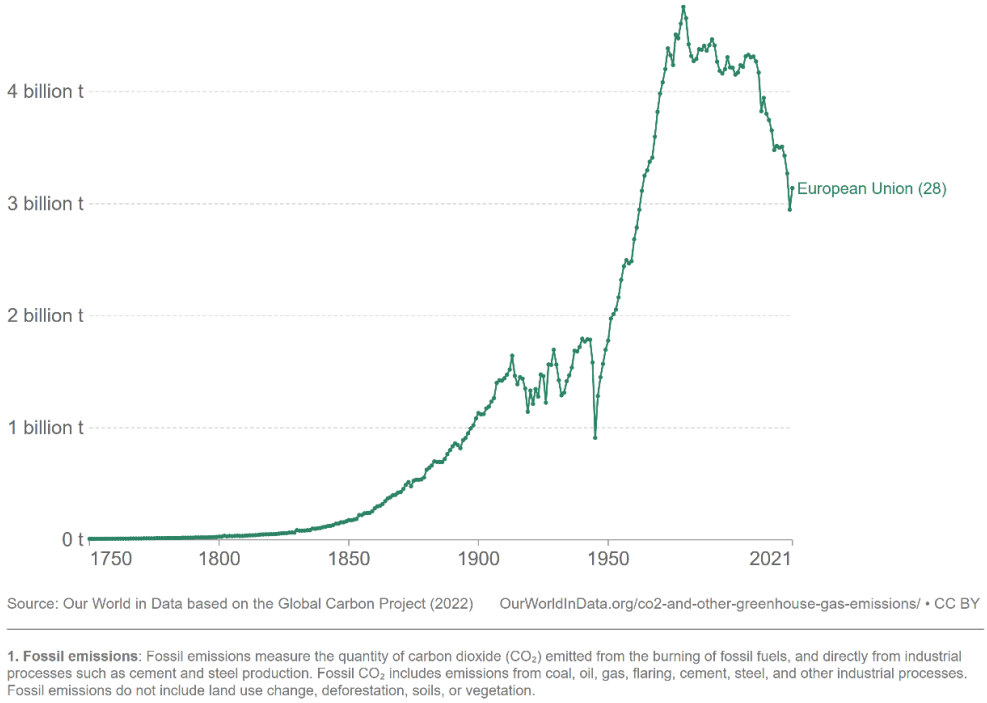


Figure 5 Waste generation by economic activities and households, EU, 2020 (% share of total waste)

[8] https://mdgs.un.org/sdgs/report/2022/goal-12/
[9] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics

years until the 2000s, a 4-fold increase in CO_2 emissions is observed reaching 4 billion tonnes. The last 20 years of efforts to mitigate climate change have led to significant decrease in emissions but still remaining in much higher levels compared to the pre-industrial era (Figure 6).

Figure 6: Annual CO_2 emissions. CO_2 emissions from fossil fuels and industry. Land use change is not included.



Source: CO_2 emissions - Our World in Data

2.2 Limits of the current linear (fossil-based) economies

2.2.1 *Environmental*

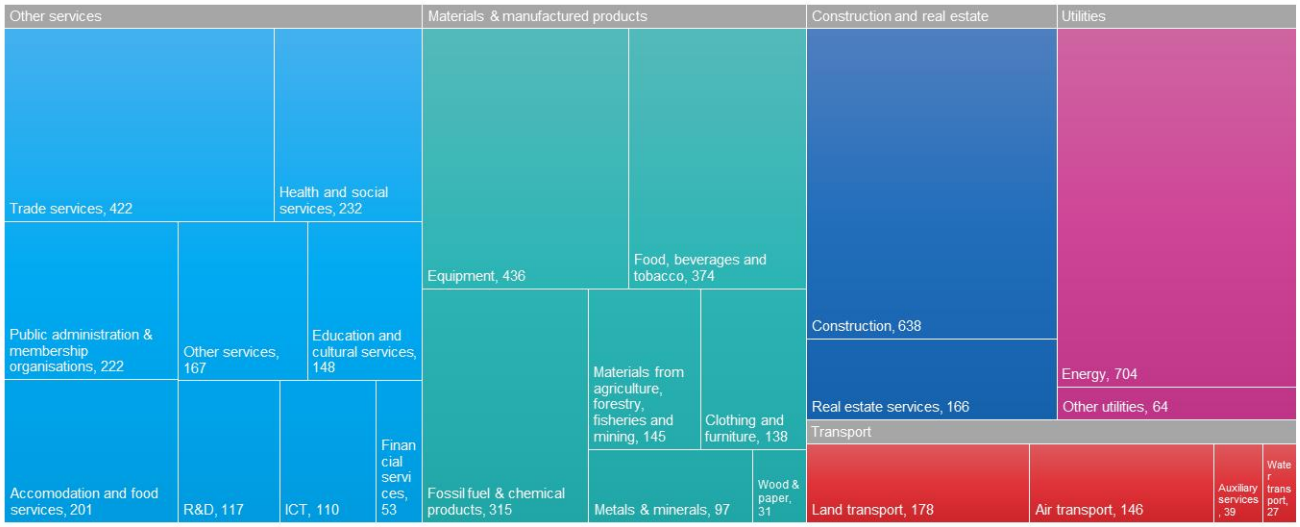
Despite the prevalence of linear fossil-based models, they tend to ignore the environmental burdens generated from the production and consumption processes and ignore the natural boundaries of such economic growth. This is the result of depleting non-renewable resources (such as fossil fuels or minerals) leading to inefficient use of resources and a constant demand for them (Mazur-Wierzbicka 2021). The ecological disadvantage of the linear fossil-based economy is that the production of goods is at the expense of the productivity of the ecosystems. The excessive pressure on the ecosystems jeopardizes the provision of essential ecosystem services, such as water, air and soil cleaning (Michelini et al., 2017).

All three steps of the “take-make-dispose” mentality (Figure 1) affect ecosystem services in different ways. The collection of raw materials requires high energy and water consumption, leads to can lead to emissions of harmful substances and disruption of natural capital such as forests and lakes. Production of goods and products is also often accompanied by high energy and water consumption and potentially also by harmful emissions. Eventually, when these products are discarded, space is

taken up from natural areas and toxic substances are often also emitted (PBL, 2018b)[10]. Currently, the production of materials used daily for human needs is responsible for 45% of the CO_2 emissions[11]. At the same time, more than 90% of global biodiversity loss and water stress impacts, and approximately 50% of global climate change emissions come from resource extraction and processing (European Green Deal, 2019). Planetary boundaries (i.e. climate change, biodiversity loss etc), the nine bio-physical limits that should be respected to maintain conditions favourable to human life, shouldn't be exceeded and exploiting non-renewable natural resources (and exceeding some such limits) would lead to a drastic change in human societies by disrupting some of the ecological bases (ecosystem services) underlying the current socioeconomic system.

Figure 7 shows the carbon footprint by broad product group. The size of each box represents the relative size of the CO_2 footprint for that product group. The 'Materials & manufactured products' category represents 23 % of the total CO_2 emissions due to domestic final demand for products. The groups 'Utilities' and 'Construction and real estate' represent 11 and 12 % of the CO_2 emissions, respectively. Transport accounts for 6 %. The group 'Other services' represents 25 %, a slightly larger share compared to the group 'Materials & manufactured products'. Whereas services generally emit relatively little CO_2 directly (7 %, source: air emission accounts), the CO_2 footprints of the services product groups clearly show that the demand for some of these services is also an important driver of CO_2 emissions, due to the indirect CO_2 emitted to supply these services[12].

Figure 7: CO_2 footprints, by product group, EU-27, 2019 (kg per capita)



Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:CO2_footprints,_by_product_group,_EU-27,_2019.png

2.2.2 *Economic*

In addition to the damage caused by linear economies to the provision of ecosystem services, such models also jeopardise the supply of materials. This uncertainty is caused by fluctuating raw material

[10] https://kenniskaarten.hetgroenebrein.nl/en/knowledge-map-circular-economy/ce-disadvantages-linear-economy/

[11] Circular economy: definition, importance and benefits | News | European Parliament (europa.eu)

[12] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_statistics_-_carbon_footprints#Products_with_largest_contribution_to_the_carbon_footprint

prices, scarce materials, and geopolitical dependencies on different materials. With linear models, the economy grows exposed and vulnerable to price fluctuations of the materials while the increased material consumption increases the exposure to externalities (Sariatli 2017).

Since 2006, fluctuations of raw material prices have significantly increased. Such instability not only creates problems with the availability of raw materials, it also creates greater risks in the market. This, in turn, discourages future investments in the extraction and processing of materials, which in return leads to raw material prices continuously rising over time. In addition, price fluctuations prevent companies from being able to make price forecasts, giving them a weaker competitive position compared to companies that are less material-dependent (Circle Economy, 2018a).

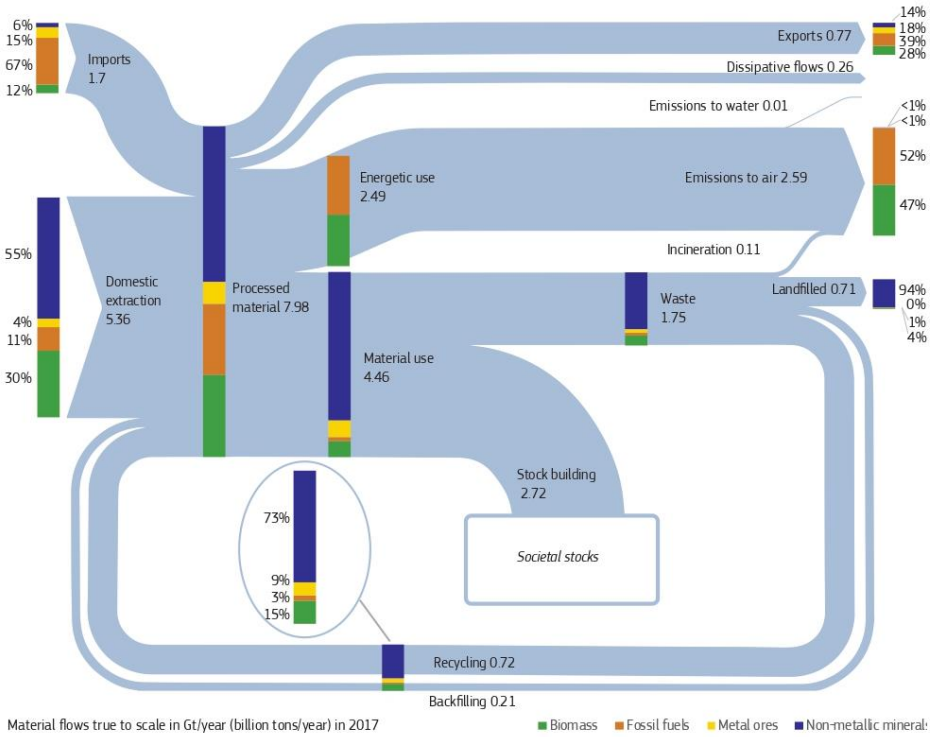
European availability of raw materials needed in many industries is limited; fuel and mining materials are mainly imported. Purchasing materials is the largest input cost of the EU manufacturing sector, representing 30-40% of the sectors' cost structure. Prices of raw materials have increased in real terms approximately 300% between 1998-2011 and they continue to increase contributing to the unstable supply and volatile prices of resource. (EC 2016). The EU currently imports, in raw material equivalents, about half of the resources it consumes and is particularly exposed to risks related to the supply of the 27 non-energy and non-agricultural 'critical raw materials' identified by the EC; Many of these raw materials are essential in high-tech products[13].

As a result of the increase in trade and the fragmentation of value chains, the geopolitical interconnectedness of products has become increasingly strong. This interdependence, inevitably leads to complications as scarcity of one raw material will have a widespread effect on the prices and availability of many other goods (EC 2020). Such effects are amplified in cases of global health crises, like the recent COVID-19 pandemic, and geopolitical threats, like the war in Ukraine, having an immediate and strong impact on trade of materials and prices.

The impact and the dependency from raw materials is depicted in figure 8 that shows the overall material flows through the EU economy in 2017. At that point, more than 67% (5.36 billion tonnes - Gt) of the mass of raw materials processed in the EU originated from domestic extraction, 21% (1.7 Gt) was imported and 12% arose from recycling and backfilling (0.72 Gt and 0.21 Gt, respectively). The domestic extraction of non-metallic minerals, which contain construction materials and industrial minerals, is much larger than imports of these materials. While they are the biggest contributor by mass to societal stocks and recycling (Figure 8), they are also the largest part of landfilled waste, highlighting that needs for increasing circularity of these materials exist. However, fossil energy materials, while being a large part of EU imports, contribute little to stock-building and most of them are use for energetic used and result in emissions to air. A comprehensive look at all of the EU materials flows highlights bottlenecks (EC 2021).

[13] https://www.europarl.europa.eu/thinktank/infographics/circulareconomy/public/index.html

Figure 8: Material flows in the economy (EU, 2017)



Source. Raw Materials Scoreboard, European Innovation Partnership on Raw Materials, 2021

2.2.3 *Social*

In addition to the issue of limited supply of raw materials available, a significant increase in demand for materials is also predicted for the future. The expected growth of the global economy, the global population and the middle class will put further pressure on increased demands on food, animal feed and other resources. The UN International Resources Panel has projected that resource use per person will be 71% higher in 2050 compared to 2017[14]. However, it is estimated that 60% of the world's major ecosystems that produce those resources have already been degraded or used unsustainably. If the economy continues to exploit natural resources at the current rate, by 2050 we will need more than two Earths to sustain mankind (EC 2016).

The demographic evolution of the growing human population further shifts the concentration of the population from the traditionally densely populated industrialised nations towards the emerging markets. According to the Ellen MacArthur Foundation (2013), the economy is unavoidably growing to be supply constrained – particularly in the western economies that already operate at their near maximum capacity, for example in terms of food. Addressing these questions is fundamentally challenging, even if one discounts the local and global political tensions, the growing interconnectedness of the markets through financialisation and the deterioration of the environment (Sariatli 2017). Thus, shifting to more circular and bio-based economic systems seems in certain parts of the world to be the only way to sustain the human population.

[14] https://populationmatters.org/the-facts-resources-consumption/

Moreover, gender and age are critical factors that intersect with the limitations of linear economic systems. Such systems have been build without considering gender aspects and thus, gender inequality has been shown to be a barrier to development (Silva and Klasen 2021). Established linear economic systems reinforce traditional gender roles, leading to occupational segregation as well as an increased pay gap among the two genders that is apparent even in the EU countries. However, due to the efforts for structural changes, the paying gap has been decreasing, young women are more highly educated than young men[15] and transitioning to circular bioeconomy, a new economic system, can lead to an era that such gender inequalities are decreased. This transition, opens up new sectors and opportunities that do not carry the same historical gender biases as traditional industries and can be built under a completely different framework thus, leading to more balanced gender representation and reduced inequality.

Such transition to circular bioeconomy could also address the challenges young people face to find employment in traditional linear industries. The EC has been openly promoting bioeconomy education in Europe[16] and more and more young adults obtain education and skills to support such transition. Moreover, and in relation to the increase of individuals with higher education over time[12], the last years it is observed a shift of consumers demands towards more sustainable products and services. Young and highly educated people are more concerned about the environment (Poortinga et al. 2019) and this shift in perceptions puts a huge pressure on the current linear systems, necessitating the shift towards more sustainable economic systems. This shift was intensified during the COVID-19 pandemic as it heightened people's concerns around the climate crisis and this has brought the environmental footprint of the products and services into focus. This behavioural change, driven by increased environmental awareness and the influence of young, educated consumers, are crucial in supporting the transition to a circular bioeconomy and could function as an added limit for the current fossil-based model of the economy.[17]

The transition to circular bioeconomy can be seen as a way to create a more equitable economic system that addresses and reduces gender inequalities by fostering an inclusive environment, promoting higher education and employment opportunities for women, and aligning with the values of a younger, more environmentally conscious generation.

3. Regional analyses

The BIOTRANSFORM case-study regions represent diverse industries and regions with differing financial background and bioeconomy topics that the project aims to support as presented in Table 2. This chapter presents the desk research findings for each case-study regions and the limits identified of the linear and fossil-based economies of each region as a whole, while also providing information on the main bioeconomy topics addressed during the project implementation.

[15]https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Educational_attainment_statistics#Educational_attainment_levels_vary_between_age_groups
[16]https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/promoting-bioeconomy-education-europe-2022-09-21_en
[17] Sustainable shift: consumers demand greener products in wake of pandemic (eonenergy.com)

3.1 Burgenland and Northern Burgenland Region, Austria

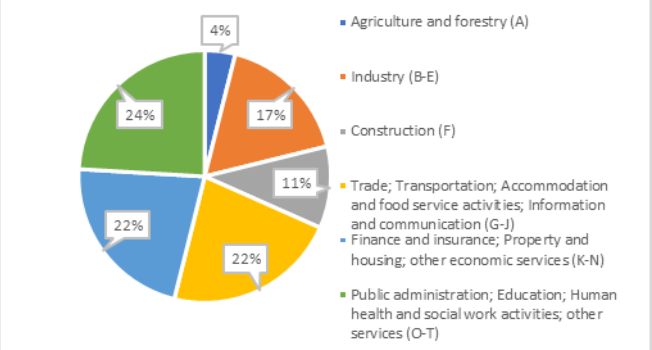
3.1.1 Current status, trends and future of regional of linear (fossil-based) economy

Burgenland is the easternmost and least densely populated federal state in Austria (297.000 inhabitants). It consists of two statutory cities and seven districts with a total of 171 municipalities. It is 166 km in a North-South direction. The Region of Northern Burgenland is classified in five political districts, namely Mattersburg, Eisenstadt - Umgebung, Eisenstadt (the federal capital), Rust, and Neusiedl. The political regions align with the EU classification tailored to the Austrian provinces and are summarized under NUTS:AT 112[18]. Burgenland is the province with the lowest GDP per capita in Austria and an employment rate of 135.400 jobs. The country's gross regional product (GRP) totaled approx. €9.5 bn in 2021, representing 2.3% of Austria's GDP. In the same year, the GDP per capita adjusted for purchasing power amounted to €32.000. The northern part of Burgenland (NUTS:AT 112) has a healthy economic activity with a GDP of €33.100 (Statistik Austria 2021).

Table 3 shows that the economic structure is strongly dependent on the public sector and together with the finance and property sector the turnover amounts to almost 50%. In this respective economy sectors with a high yield of fossil-based input would be (B-H). Quantitatively interesting material flows for a circular bioeconomy can be expected under the sectors (A - I).

Table 3: Gross value-added Burgenland by Industry in € and share of the whole value, modified after (Statistic Austria 2021)

Burgenland classification after ÖNACE	Million €	Share %
Agriculture and forestry (A)	333	4
Industry (B-E)	1464	17
Construction (F)	891	10
Trade; Transportation; Accommodation and food service activities; Information and communication (G-J)	1890	22
Finance and insurance; Property and housing; other economic services (K-N)	1875	22
Public administration; Education; Human health and social work activities; other services (O-T)	2044	24



Economic development since 2000

Historical development shows that the contribution of Burgenland companies to total value added has always been minor, amounting only to 2.3%. Particularly since Austria's accession to the EU, Burgenland has undergone a remarkable catching-up process in terms of infrastructure, economy, and education. The region has managed to generate average annual growth of around 3.5 % since the year 2000. In the years 2000 - 2013, the secondary economic sector grew the most, especially the service sector (+60.8%), and here primarily the branches "accommodation and catering" and "provision of professional, scientific, technical and other economic services". The economically

[18] https://ec.europa.eu/eurostat/web/nuts

strongest sector around the industry is the "manufacturing of goods". This sector accounts to almost 90% of the employees and contributes mainly to the value creation in the region. A more detailed analysis of the industrial sector (i.e. (B) Mining, (C) Production of goods, (D) Energy supply and (E) Water supply and waste disposable) is summarized in Table 4. A detailed analysis shows that above all the secondary and tertiary sectors (+39.7% and +60.8%, respectively) grew particularly dynamically (Fachhochschule Burgenland 2015). The share of the agricultural sector in total value added is minimal at 3.7% and is hardly subject to change (3.9% in 2021).

Table 4: Workplace results of the performance and structural statistics 2020 by sections of ÖNACE 2008 and NUTS 3 Industry B-E

ÖNACE 2008	Short name	NUTS 3	Work-sites	Employees in the annual average	Gross wages and salaries in 1 000 EUR
B	Mining	Nordburgenland	6	-	-
C	Production of goods	Nordburgenland	551	7,736	279,685
D	Energy supply	Nordburgenland	51	663	42,339
E	Water supply and waste disposal	Nordburgenland	35	463	18,189

However, due to its proximity to the former Iron Curtain, Burgenland initially lagged behind the earlier stages of development seen in Western Austria, but subsequently managed to achieve higher average GDP growth rates compared to the rest of Austria (Sybille 2007). Especially economic sectors that require a linear and fossil-based economy were able to grow strongly in the region, whereas traditionally bioeconomic sectors have stagnated for the last 20 years.

Commuters and public transport:

Despite, even with the region's GDP growth, the majority of the population still relies on commuting to Vienna and its surrounding areas on a daily basis for employment. This is illustrated by the following figures, with 633.4 passenger cars per 1,000 inhabitants, the Burgenlanders own the most vehicles in a nationwide comparison. The domestic labour market cannot absorb all the employable inhabitants, as there are not enough available jobs in the region. About 49,100 people, or 36.8% of the employed, are required to commute to another province. About 25,500 Burgenlanders travel daily to Vienna, 15,700 to Lower Austria, and 6,300 to Styria. The so-called commuter balance in Burgenland is approximately 72% and thus affecting 98,600 residents. This circumstance has resulted in Burgenland having the highest density of road kilometers in the region, totalling 49.8 km per 100,000 inhabitants (Fachhochschule Burgenland 2015). However, in accordance with the guiding principles, sustainable, optimised, shared, innovative, and safe, improvement measures have already been implemented in the overall transport strategy of Burgenland (Burgenländische Landesregierung 2022).

Public transportation in Burgenland is still underdeveloped as can be seen in Figure 9 (2021), which illustrates the public transport quality in the North of Burgenland and shows that only around the provincial capital Eisenstadt and close to the border to the metropolitan region of Vienna the quality of public transport is good to very good. However, only quality class C could be achieved in the other areas.

These two facts show that commuters mostly use individual transportation and mostly burn fossil fuels to commute. The same dependency is true for the transport sector. So far, this is a structural limit of the region showing the still high dependency on fossil fuels.

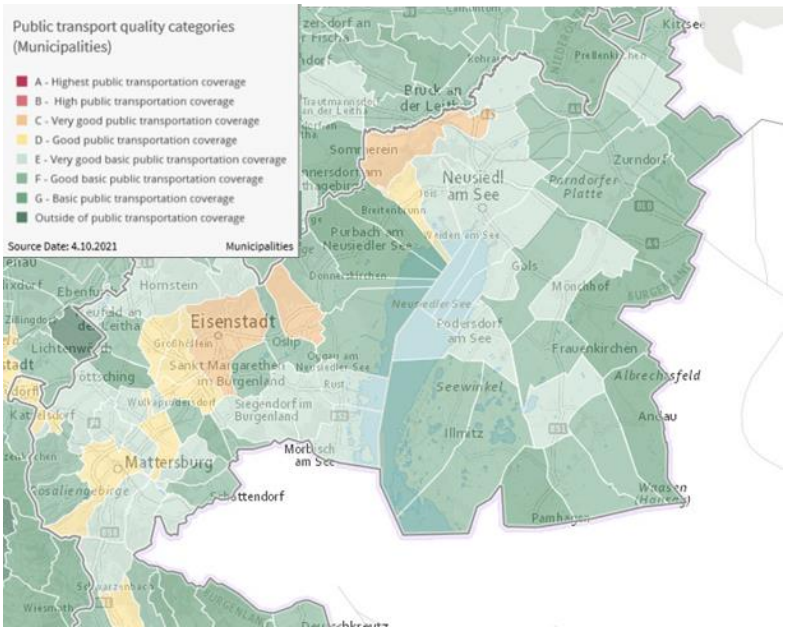


Figure 9: Public transport quality of northern Burgenland, Source (Statistik Austria 2021)

Future development Burgenland:

Figure 10 shows the spatial location of priority topics that the state government has imposed on itself according to the future image 2025. In this context, 2 topics in particular fall into the North Burgenland region, namely wind energy and storage and sustainable quality of life.

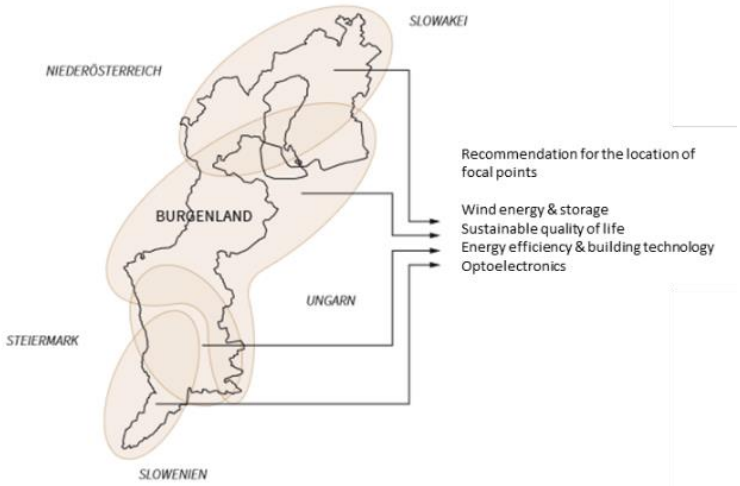


Figure 10: topics of particular interest

Already in 2020, the share of renewable energy represented to more than 50% of the total regional energy consumption. This was achieved by increasing both the energy efficiency and output of renewable energy (Huber, Reiter, and Sedlak 2014). This is particularly interesting in light of recent reports, which indicate that current political forces appear to be working against their self-imposed goals. Only recently, the federal government objected to the attempt by the provincial government of

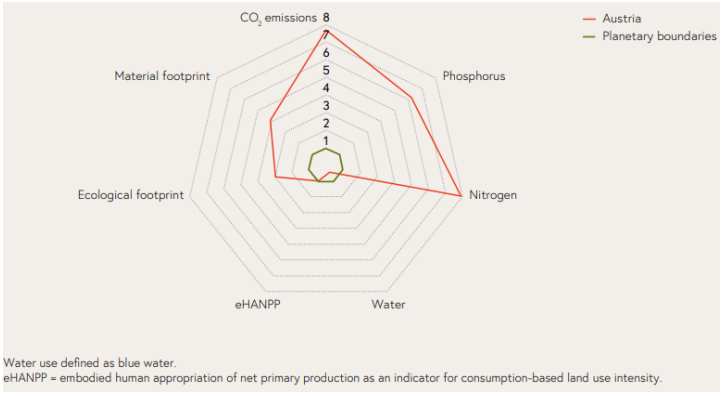
Burgenland to increase fees for wind power and photovoltaic systems in its spatial planning law, as this jeopardizes the federal government's expansion targets (APA 2023).

This is also connected with the fact that tourism and the industry that is formed around the sector is an important pillar for the region. The importance of this sector has been specifically emphasized in the new regional development program (Burgenländische Landesregierung 2022). Lake Neusiedl is a tourism hotspot and has the highest density of vacation accommodations in Burgenland and very intensive agricultural land use. In addition, agricultural priority zones are designated in the new spatial planning to minimise the consumption of agricultural land by construction activities. Remarkably, 55 percent of the area is under a nature conservation title (Burgenländische Landesregierung 2022). The focus on the tourism sector indicates a growing aversion to the expansion of renewable energies.

3.1.2 *Limits of linear (fossil-based) economies*

Environmental

Figure 11 illustrates the boundaries of linear economic activity at the national level. Austria's high consumption levels (also referred to as economic boundaries) exceed planetary boundaries in almost every category, particularly in terms of high CO_2 footprint, as well as phosphorus and nitrogen consumption in agriculture. Additionally, the Domestic Process Output is depicted, representing everything consumed by society and released into the environment. Among these societal outputs, CO_2 emissions constitute the largest portion (95%) and occur across all sectors of the economy. These emissions primarily consist of fossil carbon and can only be circularised if the carbon material input streams are of natural origin. Increasing the input of biobased streams can be achieved through the identification of secondary biomass streams and improving efficiency in both agriculture and the manufacturing sector.



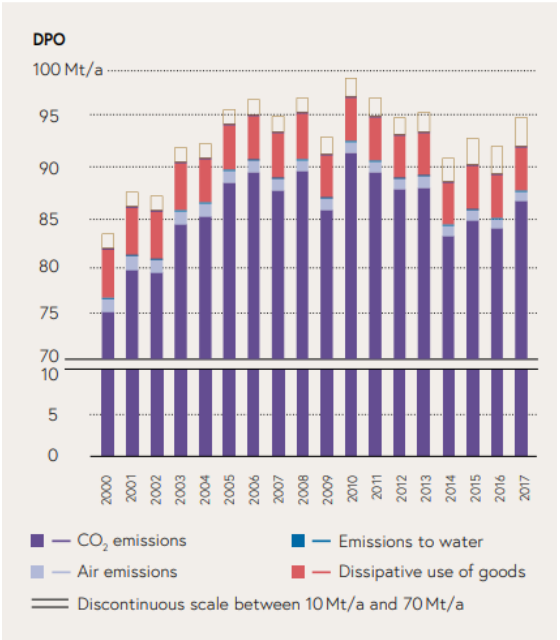


Figure 11 CO_2 emissions of Austria in relation to planetary boundaries, after (Nina Eisenmenger et al. 2020)

For Burgenland specifically, the CO_2 equivalent emissions were 1.8 million tonnes in 2021 with an increase of 4.7% from 2020 mainly due to traffic. This represents 2.3% of all Austrian's CO_2 emissions (Umweltbundesamt 2023). NO_x-emissions account to 4,430 tonnes in 2021, which is following a clear

downward trend from 1990 onwards. $PM_{2.5}$ emissions amount to 535 tonnes in 2021 and SO_2 to 197 tonnes.

According to the water information system Austria (WISA) the exposure to nitrogen (dominantly nitrate) inflow to water and groundwater bodies is high in Northern Burgenland, being between 10 and 40 kg N/ha (Federal Ministry Republic of Austria - Agriculture, Forestry, Regions and Water Management 2021). Above 45 mg/l nitrate were found in groundwater resources in the agricultural zones of Northern Burgenland (Federal Ministry Republic of Austria - Agriculture, Forestry, Regions and Water Management 2020). Because of the high agricultural activity, almost all 42 measured pesticides and/or their metabolites could be detected (above measuring limits) in µg/l concentrations at least at one of the 4 sampling points in Burgenland with for example around 0.2 µg/l glyphosate at all points or between 0.1 and 0.9 µg/l dimethenamide at almost all points (Federal Ministry Republic of Austria - Agriculture, Forestry, Regions and Water Management 2023).

The land consumption in the political region Neusiedl am See, which represents around half of northern Burgenland is one of the highest in Austria in comparison to the population density, summing up to 1303.3 m^2 per head in 2022 (ÖROK – Österreichische Raumordnungskonferenz 2022). The other part around the capital Eisenstadt is calculated with 1005.8 m^2 per head, which is also high. This is partially due to the intensive use of land for traffic with 522.2 m^2 (Neusiedl am See) and 325.5 m^2 (Eisenstadt Umgebung) per head and settlements with 608.5 m^2 and 509.3 m^2 respectively.

The soil properties are partially characterised by the big Lake Neusiedl including rewetted lowland fens, peat layers, brown earth, crude soil, gley soils, salty soils, and tschernosems (Naturschutzbund Burgenland 2022). Further, we can identify different heavy metals in the topsoil layer of farmland in Northern Burgenland, for example up to 17 As, 18 Pb, 0.42 Cd, 55 Cr, 17.2 Co, in a few areas 81 Cu and 2.3 Mo, up to 40 Ni, less than 0.12 Hg, around 0.48 Se, 0.86 Th, 92 V, and 74 Zn (all values in mg/kg) (Umweltbundesamt 2007).

To avoid repeating the limitations of a fossil-driven linear economic model, Burgenland has numerous opportunities to enhance its primary production in a sustainable and more efficient manner. For instance, there are 5,800 Burgenland-based enterprises managing an extensive area of 184,086.9 hectares (ha), including 878 organic farms. (Burgenländischen Landesregierung 2023). Whereas currently, 34.4% or around 136,000 ha of the total area of Burgenland are protected areas (Fachhochschule Burgenland 2015).

Thus, the environment provides ecosystem services, such as the provisioning of natural resources (including grain, vegetable, fruit, and wine production) through agricultural ecosystems. Additionally, local regulation of air, climate, and water, particularly through the ecosystem of lakes, notably by the Neusiedlersee, is conducted. The tourism industry in the region benefits significantly from the recreational and cultural values offered by the natural ecosystem areas (Jonathan Wentworth 2011) (Katharina Opitz, Christian Wutschitz, and Alexander Lang 2021).

The Burgenland state government has been promoting responsible production and consumption patterns since 2019 with the program "Bioland Burgenland – 12 Points for Smart Growth with Organic Products." This program includes targeted support for converting to organic farming, aiming to increase the organic share in Burgenland to 50% by 2027 from the current 31%. To create new income opportunities for farmers, the organic share is to be significantly increased in state and near-state kitchens as well as in kindergartens and state schools. The broad and systemic approach of the

program is also evident in its pursuit of goals such as health and well-being of the population, clean water, and climate protection measures (Amt der Burgenländischen Landesregierung 2020a).

However, without the transition from linear fossil-based farming systems, tensions arise that can jeopardize the transformation. The agroecosystems of the Neusiedler See, Parndorfer Platte, and Seewinkel areas (Doris Damyanovic 2017) pose a threat to the provision of recreational and cultural values due to the loss of habitat for biodiversity conservation, nutrient runoff, waterway sedimentation, and pesticide poisoning of humans and non-target species. (Power 2010). While a high proportion of organic farms can be observed in Burgenland (37 %) (Amt der Burgenländischen Landesregierung 2020b), the number of such farms has stagnated in recent years.(Doris Damyanovic 2017).

This is evident in the Seewinkel district of North Burgenland. The Seewinkel area is home to around 30 small salt lakes that are surrounded by steppe grasslands and situated within intensively farmed land. These complexes of shallow lakes and dry grasslands are remnants of the Puszta, a former vast pasture landscape, which greatly contributes to the region's high biodiversity. These remnants not only provide habitats for breeding and migratory birds, including several species of geese, but also for rare or endangered species such as the hoopoe, and European ground squirrel, and a variety of plants, including the Pasque flower, dwarf iris, and multiple orchid species. The intensification of agriculture has led to several impacts on biodiversity. The land-use-change due to draining in the 1960s turned the heavily pastured, well-structured landscape with marshy bogs and high species diversity partly into a monotonous area (see Figure 12). Hence, the significant impact of economic and industrial activities on the area can primarily be attributed to land use changes in the past, particularly the draining of wetlands, which strongly encouraged CO_2 and CH_4 releases (Krauss, Zhu, and Stagg 2021).

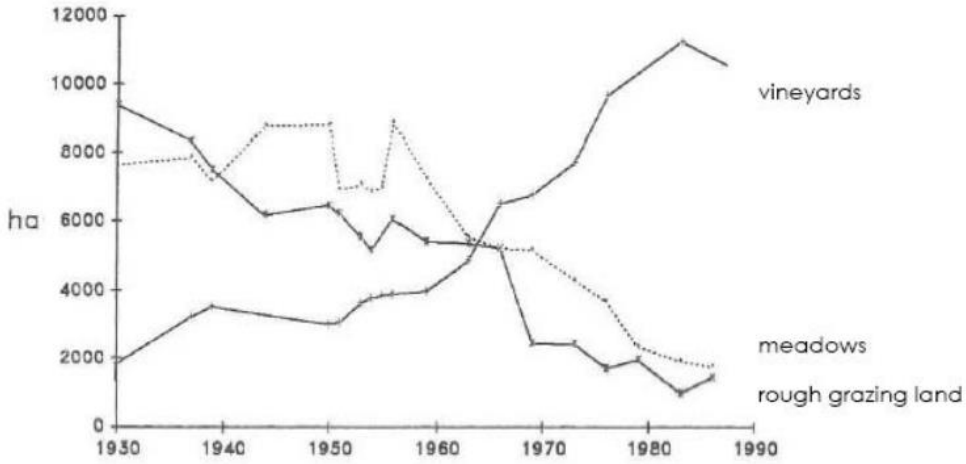


Figure 12: Development of vineyards, meadows, and rough grazing in the district of Neusiedl am See between 1930 and 1990 (Thomas Wrbka et al. 2012).

The cessation of cultivation of low-yield locations led to a reduction of wet meadows, nutrient-poor grassland, and dry grassland, whose use is necessary to preserve biodiversity (Doris Damyanovic 2017). The excess of nutrients in waterways has led to increased algal bloom in the Neusiedler See in the 1980s and 2003 and shifts in biotic interactions which are still noticeable today. However, phosphorous inputs from agriculture have been reduced from 80 tons in the 1980s to less than 20 tons in 2000. The reed management on the prominent reed belt around the Lake Neusiedl also has an impact on biodiversity, by providing reed areas either too young or too old for reed birds.

Furthermore, the conflicts between interests of tourism, agriculture, and nature conservation impact diversity (Thomas Wrbka et al. 2012).

Other natural resources that are used in Northern Burgenland are soil and water. Groundwater is under high pressure due to contamination with nitrate and pesticides in groundwater, as well as the enormous consumption of groundwater for the irrigation of cultivated areas (Thomas Wrbka et al. 2012). Soil is under high pressure due to degradation, erosion, and sealing (Doris Damyanovic 2017).

The main environmental limit in the region of Northern Burgenland related to non-renewables is climate change. Due to the already hot Pannonian climate, the increase in temperature will lead to increased stress for summer crops. This leads to stagnation of the yield potential and increases water demand. The necessary additional irrigation in the summer months reduces groundwater reserves and the general water supply in the region (Georg Wolfram, Lajos Deri, and Sibylla Zech 2014). The damage caused by the extreme heat and drought in agriculture amounts to well over €20 million. (Doris Damyanovic 2017).

Another effect is the continuously sinking water levels of the Lake Neusiedl. The lake has a positive local climatic effect on crop production due to lower temperature extremes, favouring wine production. It also serves as habitat for wildlife and has high recreational capacity (Georg Wolfram, Lajos Deri, and Sibylla Zech 2014). Even a small decrease in the region's average precipitation of 5% results in a significant accumulation of lower water levels, which in extreme cases would lead to dehydration (Eitzinger et al. 2009). Complete dehydration of the lake has happened several times in the last 1000 years and seems not to have a sustained impact on the ecosystem, but it would have negative impacts on its regeneration and recreational function. A possible supply with water from other catchment areas is widely discussed and would have undesirable effects on biodiversity (Thomas Wrbka et al. 2012).

Finally, the limitation of linear fossil-based economy can be monitored by the Greenhouse gas emissions, which significantly increased from 1990 and reached their peak in 2005 amounting to 2,064 million t CO2equivalents (Table 5). Since 2007 the emissions were decreasing until 2015 where a slight increase could be recorded and finally attained 1,862 million t CO2eq for all of Burgenland in 2019. Hence, in this year, the total share on greenhouse gas emissions compared to Austria amounted to 2.3% (Amt der Burgenländischen Landesregierung 2020).

Table 5: Greenhouse gas emission (CO2eq) after economic sectors, modified after (Statistik Burgenland 2021)

Year	Total	Energy	Industry	Traffic	Building	Agriculture	Miscellaneous
1990	1,595	2	106	511	461	325	190
1995	1,738	21	113	590	511	306	197
2000	1,808	36	103	706	507	278	177
2005	2,064	16	190	950	466	246	196
2007	1,949	18	203	908	405	238	176
2008	1,881	19	185	852	395	259	171
2009	1,813	19	189	831	362	247	167
2010	1,851	17	189	863	385	232	164
2011	1,815	16	207	834	360	243	155
2012	1,745	14	202	833	311	235	151
2013	1,782	8	200	884	306	240	144
2014	1,754	8	209	864	276	258	140
2015	1,776	7	193	883	306	249	139

2016	1,868	8	210	926	322	264	138
2017	1,882	11	212	952	316	252	139
2018	1,860	6	210	957	304	247	135
2019	1,862	10	209	960	306	248	129

Strikingly, in 2019, traffic contributed to 50% of the overall greenhouse gas emissions, which indicates, once again, the relevance of commuter traffic and the increased transport volume due to the low population density in the region. The transformation of the region towards a circular bioeconomy has the potential to greatly enhance the region's value added by establishing sustainable jobs within the bioeconomy sector and a significant opportunity to decrease commuting and reduce reliance on fossil fuels.

Furthermore, when comparing the greenhouse gas (GHG) emissions in various sectors to the reference year of 1990 (as depicted in Figure 13), it is evident that only three sectors have achieved a reduction in GHG emissions. Disturbingly, over a 30-year period, there was no overall decrease in GHG emissions at the regional level, but rather a 17% increase in GHG emissions. This underscores the urgent need for sustainable action and a shift to a circular bioeconomy to address pressing climate challenges.

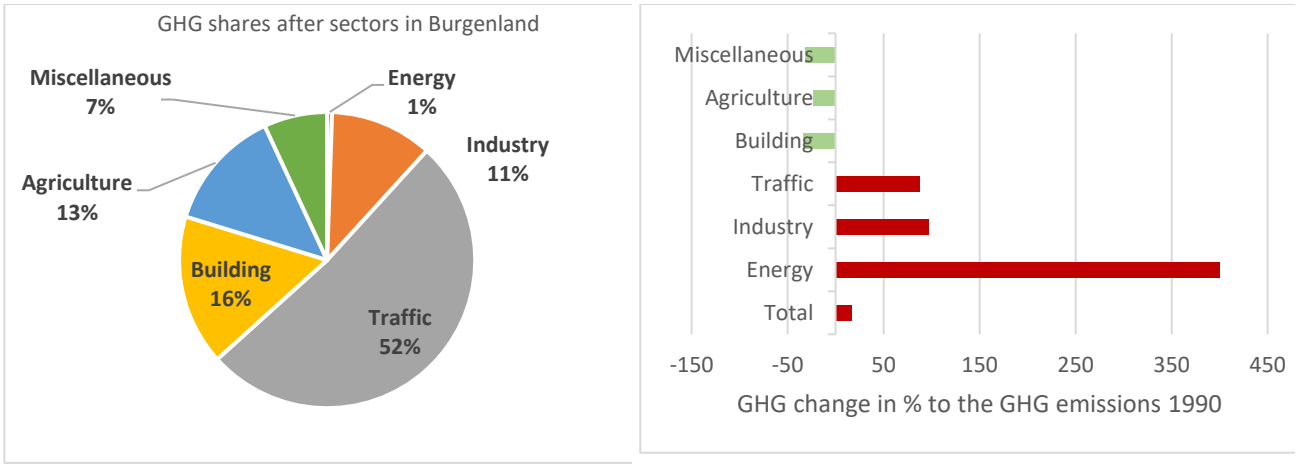


Figure 13: Left side greenhouse gas emission in percent to total emissions in co2 equivalents; right side GHG change after sectors to the baseline year 1990, modified after (Statistik Burgenland 2021)

Economic

Austria's involvement in global supply chains amplifies the reach of its production and consumption, transcending national boundaries. The extraction and production of raw materials frequently occur in locations distinct from where they are ultimately utilized. As a result, Austria's consumption exerts a significant influence on resource consumption in other regions across the globe. Conversely, the resources utilized within Austria also contribute to the advantages experienced by end users in foreign countries through exports. (Nina Eisenmenger et al. 2020).

The resource flow balances depicted in Table 6 provide a quantifiable measure of the major limitation of the fossil-based linear economy. According to the four main categories of material consumption (i.e. Biomass, Metal, Non-metallic minerals, Fossil energy carriers), it is clearly visible that Austrian economy has a very high external dependence on fossil fuels and metals, which means that this sector is especially sensitive to fluctuations in raw resource availability. The demand for non-metallic minerals and biomass can be almost self-sustaining which in turn leads to higher economic resilience.

Table 6: Material demand in Austria

Resource Flows in Austria in 2021 (in Mt) (rounded to the nearest 10,000 tons)				
	Domestic Extraction (DE)	Import (IM)	Export (EX)	Domestic Material Consumption (DMC)
Biomass	37.36	28.92	25.01	41.27
Metal	4.98	20.96	15.13	10.80
Non-metallic minerals	96.30	10.46	9.66	97.10
Fossil energy carriers	1.08	32.16	11.62	21.62
Other products	*	7.46	5.11	2.34
*no data available Based on data from Statistics Austria, accessed via STATcube (STATISTICS AUSTRIA 2022)				

Based on the information from Statistics Austria, it can be said that the most consumed resource groups between the four categories in Austria are crops, wood, crop residues, iron, limestone and gypsum, sand and gravel, and liquid and gaseous energy materials/carriers. The price and availability of these resources can be said to be relatively similar across Austria.

However, recent years have brought a shortage of key raw materials which has led to significant price increases in the market. These fluctuations in availability have affected various industries and have become increasingly noticeable over the past few years. The shortage of these materials has caused companies to pay more for the raw materials they need, which in turn has also led to higher costs for consumers (Nina Eisenmenger et al. 2020). Further on, Burgenland is furthermore described as a net importer of goods (Schremmer et al. 2015). Based on information from Statistics Austria, the most significant commodity chapter of imported goods to Burgenland is "mineral fuels", with a value of approximately 438 million Euros. The most significant commodity chapter of exported goods is "electrical machines, apparatuses, devices", with a value of approximately 484 million Euros (Kalina 2022).

The import of raw materials can have both positive and negative effects on the regional economy in Austria. On the positive side, importing raw materials can help to meet the demand for certain goods and can provide a source of revenue for the country through import tariffs. Additionally, it can lower the price of goods for consumers and can also stimulate competition among businesses. However, on the negative side, importing raw materials can lead to job losses in domestic industries that are dependent on those raw materials. Additionally, it can lead to a reliance on foreign countries for critical resources, leaving the regional economy vulnerable to disruptions in supply. Furthermore, it can also lead to a decrease in the overall economic activity in the region. Overall, it is important for Austria to strike a balance between importing raw materials to meet demand while also protecting and supporting domestic industries.

Given the extremely high dependency Austria has on fossil fuels, the volatility of fossil fuel prices can affect the stability of the economy. There was no specific evidence found that it can act as a growth inhibitor for the economy in Austria, but it can influence the stability and sustainability of the economy.

Social

Burgenland is influenced by the demographic shift, predictions show that in the next 20 years, over 100,000 people in Burgenland will be 65 years or older. As a result, society is expected to become increasingly older, with the current average age being 44.4 years. This will make Burgenland the province with the oldest population in Austria. Additionally, the birth rate is lower than the death rate, yet the population is still growing. This suggests that the population increase is primarily due to a positive net migration balance. The main reason for the recent population increase is, firstly, the suburbanization of Vienna, which has led to more people moving from the city to nearby areas, with Northern Burgenland being a particularly popular destination (internal migration). Secondly, the expansion of the European Union, particularly towards Eastern Europe, has also influenced migration patterns (external migration) (Fachhochschule Burgenland 2015). Especially, due to the vicinity of the region to a second major European capital, Bratislava, further migrations movement are facilitated on the east border to Slovakia (Burgenländische Landesregierung 2022). Enough skilled labour is crucial for the economy and especially for the bioeconomy as it requires specialized knowledge and expertise to develop and implement sustainable solutions. Skilled workers are needed to carry out research, develop innovative technologies, and efficiently manage bio-based processes. Without an adequate supply of skilled labour, the growth and advancement of the bioeconomy sector can be hindered, limiting its potential contributions to the overall economy. Skilled labour acts as a driving force, enabling the bioeconomy to thrive and play a significant role in transitioning to a more sustainable and resource-efficient economy. Furthermore, there is a gender gap in apprenticeship education in Burgenland. In 2023, there are 1,845 males in apprenticeships compared to 712 females. According to the data, the majority of females are not enrolled in STEM fields (the most popular STEM education being metal technology, at 4.78%). This not only limits the potential pool of skilled workers for future technical jobs but also widens the pay gap between female and male workers (Wirtschaftskammer Burgenland 2024). Northern Burgenland is facing a major brain drain, and exemplary as in the case of reed management systems, many skills and knowledge have been lost due to reduced economic importance.

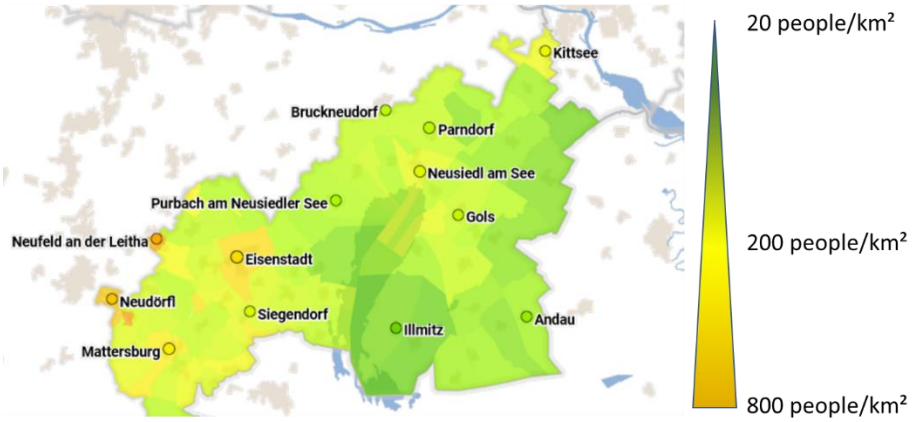


Figure 14: population density north Burgenland, modified after (Brinkhoff 2020)

Although migration is increasing, Burgenland is characterised by its rural structures, which is depicted in Figure 14, highlighting the absence of urbanised centres. Eisenstadt (15,200), the state capital, is

the only municipality with more than 10,000 inhabitants. The next larger municipalities are district capitals, especially in northern Burgenland, such as Neusiedl am See (8,600) and Mattersburg (7,500), and thus belong to the most populous municipalities (Fachhochschule Burgenland 2015).

The Burgenland provincial government conducted a citizen survey. According to this survey, the most important thing is to maintain the unique qualities of the village's landscape, protect farmland for food production, promote the use of renewable energy through photovoltaic parks, expand public transportation, and ensure that there is affordable land for building. Additionally, preserving and supporting small businesses within the village is also considered to be crucial (Burgenländische Landesregierung 2022). This reflects a high interest in building a sustainable community. The fact that local companies should be supported can also have a very positive impact on the implementation of circular solutions in the bioeconomy.

However, an Austria-wide study conducted with stakeholders from different economic sectors, as well as politics, education, and society, shows that there is a lack of knowledge as to what a circular bioeconomy could look like. This is because although 58% of respondents said they were familiar with the concept of the circular economy, 62% said they needed additional information on the subject. When asked about their understanding of the circular economy, 49% indicated classic recycling and 28% waste management. This is in line with the widespread narrative of waste management and other sectors, which predominantly refer to the end-of-life of products and materials (Huber-Heim and Kronenberg 2020).

3.1.3 *Barriers of current economies to achieve relevant sustainability goals*

The conversion from a linear fossil-based economy towards a circular bioeconomy is promoting the implementation of the UN agenda for sustainable development and the EU Green Deal as well as regional strategies. Therefore, a regional development plan “Gemeinsam mehr Horizont” was developed in 2022, which addresses the urgent need to renew and improve the local infrastructure. Especially, consistent broadband expansion and tax benefits for home office workplaces (Burgenländische Landesregierung 2022; Ferreira, Pié, and Terceño 2021; Jonsson et al. 2021). These are objectives in line with **SDGs 8 and 9**, which target generating employment and creating resilient infrastructures.

According to the regional strategy, a very important policy objective with many activities is anchored around tourism. These range from the expansion of the tourism season to landscape-friendly recreational use together with agro- or ecotourism and these activities are reflected in **SDG 8**. However, these ambitions lead to conflicting objectives. For instance, Burgenland has a high percentage of renewable energy production, but the expansion of wind power disturbs the tourism sector through the interference of the landscape. Renewable energy though is needed also for the fossil-fuel-powered public means of transport that are meant to be extended and replaced with green energy alternatives. Either way, the multitude of land-use options, interests, and goals that require their space in the landscape might create barriers and become a challenge to coordinate. Listed among the key objectives of the local development programme as well as in the bioeconomy strategy of Austria (Albert et al. 2019; Burgenländische Landesregierung 2022) are the use of industrial rooftop surfaces for the expansion of solar energy and the electrolysis of green hydrogen which both could contribute to fuel the public transport system and contributes to the clean, affordable and secure energy targeted in the European Green Deal.

Despite that, the north-south gradient of Burgenland gives distinct initial positions for the regions. Therefore, transforming north and south Burgenland come with different challenges. For example, the ‘’FTI Strategie Burgenland 2025’’ (RTD Strategy Burgenland) has the purpose to increase the research intensity in Burgenland, which is the state of Austria with the lowest research rate based on expenses made for research and development in relation to the GDP. There are few higher education institutes (details in the report for T1.2) and a strong ‘’brain drain’’ to Vienna and abroad. Additionally, there is a lack of research conducted in the private sector since the business landscape in Burgenland mainly consists of small- and medium-sized enterprises that don’t have the necessary economic capacities for research.

Thus, one of the boundaries for a transformation towards bioeconomy is the lack of education and business infrastructure. Education must be improved on all levels, to approach ‘’sustainable consumption and production patterns’’ as desired in **SDG 12**. The potential for cooperation to promote research and technological innovation is seen especially in electronics, mechatronics, and advanced materials from wood, metal, and plastics (Huber, Reiter, and Sedlak 2014). In the ‘’Regionalentwicklungsprogramm Burgenland’’ (Regional Development Programme) the promotion of existing technology centres and the creation of new research hubs particularly in the realm of biogenic substances and renewable energy is specifically named as a goal.

Establishing, intensifying, and extending the networks between the few existing actors in the fields of research, innovation, and technology within Burgenland, as well as to other actors national and internationally is a key factor for reaching EU green deal and bioeconomy strategy goals and is connected to the **SDG 17** in fulfilling development assistance commitments (Albert et al. 2019; Huber, Reiter, and Sedlak 2014).

Furthermore, efforts to strengthen the interconnection of townships for operation areas to overcome intercommunal competition, split taxes fair and contribute to successful landscape preservation through optimal land use is in line with **SDG 15** (Burgenländische Landesregierung 2022) and is identified as important activity to overcome current development limitations.

Overall, measures to improve climate change, resilience of agriculture and forestry, increase organic production, and promote local food marketing, are measures to ensure food security and biomass supply. This regional strategy around sustainable food production is also a pillar of the European green deal ‘’farm to fork’’ strategy (Albert et al. 2019; Burgenländische Landesregierung 2022). Necessary measures will tackle multiple solutions, approaching **SDG 13, 14, 15**, and the European green deal at once, as desertification and degradation of land as well as loss of biodiversity are targeted. Figure 15 summarises the identified SDG´s goal.

Figure 15: SDG goals relevant to Burgenland

Nevertheless, the Regional Development Plan lacks information pertaining to the prevention of food loss and waste, a goal that aligns with the farm-to-fork strategy and is emphasized in Austria's bioeconomy strategy. While the utilization and valorisation of wastewater, by-products, and residues

constitute a vital aspect of the circular bioeconomy, these subjects are conspicuously absent from the Regional Development Plan. Although waste reduction and plastic avoidance are acknowledged, there is no mention of ambitions to valorise by-products or recycle nutrients

3.2 Charles Spa Region - Czech Republic

3.2.1 *Current status, trends and future of regional of linear (fossil-based) economies*

In the Czech Republic, no strategic document or statistical survey has yet distinguished between circular, linear or fossil-based economic models. However, if the prevailing mode of functioning of the country and the selected region had to be evaluated, it would be the linear fossil-based economy.

Natural resources and mineral wealth belong to the key assets of Charles Spa Region (hereinafter referred as “region”). There are the following traditional regional industries: glass and porcelain manufacture, building materials, tiles, and musical instruments manufacture. However, these have been slowly losing importance in the last 25 years, due to their high energy demand, high demand of raw materials and human resources. There were some efforts to transform key companies in the region to compete the global market. Nevertheless, there is only a small number of companies that successfully managed the restructuring process, accumulated know-how, and developed new activities, successful in new markets that represent the traditional regional crafts. The structure of the economy is also being transformed by foreign investors, the total amount of foreign investments in the region is lagging other Czech regions; the situation has been slowly improving in the last 4-5 years because of new industrial zones (e.g., in the vicinity of Cheb, in Ostrov, Nový Sedlo, Chodov, and also brownfields in Sokolov). The spa industry and related services play an important role not only in the Charles Spa region, but the regional spa industry is also the biggest on the national scale, it has a long tradition, and it is attracting international clientele (Analysis for RIS, 2018).

The regional economy has been specialised in mining and energy for a long period of time. The region has a long lignite mining tradition, however, the reserves are gradually becoming thinner. The mining industry in the region is gradually closing its activities (the closure is expected within a few years) while there are efforts to replace it with alternative activities (e.g. activities of Sokolovská uhelná, a.s. related to the new use of areas after coal mining). In particular, the activities of engineering companies are linked to traditional industries, where the chemical industry also plays a role (Vozáb, et al., 2020). One of the main pillars of the economy of the region is lignite mining and related industries. The significant concentration of heavy industries has changed the spatial and landscape character of the region. Due to its natural wealth, it was already the backbone of the economy in the past, but the preference for a lower value-added economy now means a loss for the region compared to other regions of the country. In the context of the Czech Republic's move towards a transition away from coal in 2033, the gradual closure of coal mines and quarries can be expected. Concretely local mining is expected to be closed by the end of 2030 (Ministry for Regional Development, 2021).

The region is therefore facing the urgent need for an economic transformation to a climate-neutral economy. As it used to be a coal mining region, it does belong to a Just Transition Region and is entitled to get the EU support to this transformation. The region is the economically weakest region in the Czech Republic, and it is currently facing the following problems:

- The biggest employer in the region is the coal mining industry, besides there are lots of other employers from the related industries (i.e., industries based on lignite mining). It can be expected that a large amount of these companies could be heavily affected by the transition to carbon neutrality.
- This region has the second lowest share of small and medium-sized enterprises (hereinafter refer as “SME”) per capita in the country. As SMEs are the driving force of many manufacturing sectors of the national economy and the backbone of the manufacturing industry (Coyte et al., 2012; Mittal et al, 2018), they are considered an important economic sector. SMEs are source of economic growth and wealth for society and a source of new jobs (Coyte et al., 2012), especially in 'new' economic sectors dependent on as they are more flexible (Kuckertz et al, 2020) and innovative.
- There are large areas of post-mining and downstream activities, mostly without new economic use so far.
- The level of R&D support from both public and private sources is still limited in the region, as well as, the index of R&D employees per 1000 inhabitants is the lowest one in the Czech Republic.
- The region has not experienced an increase in the level of education, as in other regions, creating thus, employment constraints ; the average reaches 5.1% being above the national average of 3.8%, especially in areas undergoing industrial restructuring and lignite mining. The proportion of the population with the university degree is the lowest in the Czech Republic.
- Very high percentage of the population is vulnerable towards the energy poverty, especially in areas affected by coal mining. The region is sadly the second in the national comparison of the percentage of the population is venerable towards the poverty. Almost 17 people out of 100 face high risk, while it is only 9 out of 100 on the national scale.
- The population is getting older (the regional average is 43.5 while the national average is 42.7) that is also caused by a low birth rate and outflow of younger population

Tourism and spa industry has a significant multiplier effect for the region in economic terms. They have a significant impact on the development of the region, help to create gross domestic product and are a source of employment for residents. Tourism has become one of the most affected sectors of the economy in the Czech Republic in 2020 due to the coronavirus pandemic. The importance of tourism for the economy at regional level can also be expressed in terms of its share of the total gross value added for all sectors, always directly in the region. In 2020, tourism accounted for 2.8% of the regional gross value added (CZK 2.5 billion - the highest in the whole country) while a year earlier it was 5.4%.

The Region shows the highest number of persons employed in tourism. In 2019, with 12,191 persons employed, this meant an 8.8% share of the region's total employment. In 2020, 10,600 persons were employed in tourism, accounting for an 8.2% share of the region's employment, again the highest compared to other regions. Around one in twelve people working in the sector were in tourism. The higher volume of human labour in this region is also typically related to the spa services. The importance of the spa and tourism industry to the region's economy is best demonstrated by following Table 7 and Figure 16.

Table 7: Accommodation Facilities and Total Guests

Czech Republic	2018	2019	2020	2021
Accomodation Facilities	526	523	617	625
Total Guests	1118 thousands	1190 thousands	677 thousands	710 thoussands

Source: www.czso.cz

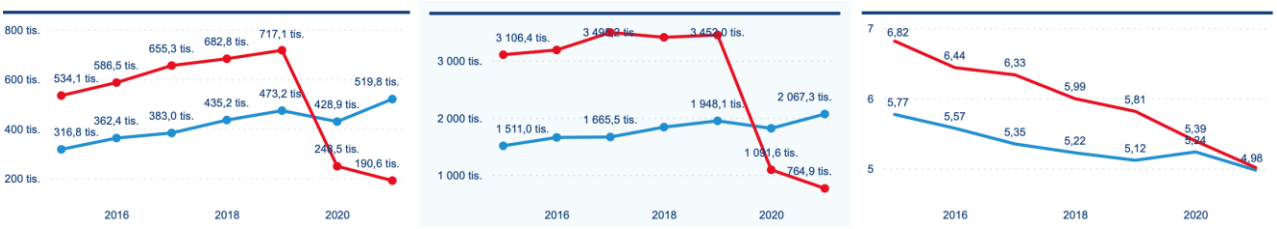


Figure 16: Home and Inbound Tourism - Number of arrivals, Number of overnight stays Average length of stay

Source: www.czso.cz
Legend: Blue Home, Red Inbound Tourism

There are several national and regional policies currently being developed that limit the current state of the linear and fossil-based economy and seek to set new targets that will help begin the transformation to a circular bioeconomy. One of the key documents addressing the regional transformation oriented towards all three pillars of sustainable development from a fossil-based economy is the Just Transition Plan (OPJT 2021- 2027). The main purpose is to improve the economic performance of the region, the quality of life of its residents, and to improve the environment. The plan indicates infrastructure activities, short and long term, investments in the territory and development of people's potential. The primary policy instrument for the OPJT in the Just Transition Operational Programme that address the negative consequences connected with the shift away from coal industry and wants to enhance the development of R&D activities in the region that are vital for the energy transformation and emissions reduction.

Another important document is the Development Programme of the Region 2021-2027 (hereinafter refer as “PR KK2021-2027”). PR KK 2021-2027 is a medium-term strategic document based on the knowledge and understanding of the territorial needs, social conditions that is also considering the current national situation and trends in the EU. PR KK 2021-2027 defines the core strategic vision of the region, i.e., economically prosperous and transforming region, open face European challenges and impulses; region that it is providing for inhabitants’ conditions for quality life using the full potential of attractive natural conditions and a socially friendly environment. Both the OPJT and PR KK 2021-2027 set the frame for the transition and introduce the financial mechanism to implement this transition. Finally, it is also necessary to mention the Regional Innovation Strategy, which focuses on the endogenous development of the region with the primary objective of promoting innovation and cooperation in the quadruple helix framework. We need to mention here that the Czech Republic has developed an update for the National Research and Innovation Strategy. The coordinator of the BIOEAST HUB CZ, Dr. Jan Nedělník, is the coordinator of Cluster 6 of the National Research and Innovation Strategy, he advocated to the responsible governmental body to include bioeconomy as

one of the key topic and story; bioeconomy is one key topic of the national National Research and Innovation Strategy. All regions will now have to update their regional innovation strategies so more focus on bioeconomy in the region can be expected.

3.2.2 *Limits of linear (fossil-based) economies*

Environmental

It may seem that the Charles Spa region does not have a very favourable picture in terms of environmental quality, as some areas are marked by opencast mining of mineral resources and associated energy and industrial enterprises. However, in recent decades, great care has been taken to revitalise the area and to mitigate the effects of mining. **The region is changing significantly and can be perceived as a green region with a high environmental quality.** There is the world-famous triangle of spa towns, lots of natural areas protected on the regional or national level, i.e. in the southern part of the region Slavkovský Les, in the western part Ore Mountains, Doupov Mountains, slopes of the Ohře River canyon (the Ohře River shoulder site is even belong to the area of the European) to name but a few examples. The density of the river network in the territory is 1.4 km.km-2, which slightly exceeds the national average (1.25 km.km-2).

The monitoring carried out by the State Enterprise Ohře River Basin shows that the water quality in selected sections of the Ohře River (Skalka, Citice, Radošov) and the Teplá River is relatively satisfactory. There are following watercourses in the region that have a deteriorated ecological and chemical status: Teplá, Rolava, Svatava, Chodovský potok, Plesná, Libocký potok, Jáchymovský potok, Kosový potok, Střela. Water quality is also affected by low flows. Speaking about the water pollution, in addition to pollution from point sources (sewage and treatment plants, mine water discharges), surface water pollution affects the resulting water quality and thus the condition of water bodies. The most significant source of surface pollution is crop production in agriculture (nitrogen, phosphorus and pesticides), while inputs through atmospheric deposition (nitrogen) are also significant.

A specific phenomenon of the region are natural medicinal resources - mineral waters in the areas of Františkovy Lázně, Mariánské Lázně, Lázně Kynžvar and Karlovy Vary, mainly cold springs together with thermal hot water springs in the Karlovy Vary town (Charles Spa town).[19] Spa industry in the Region is being provided in the traditional linear way, the transformation towards circular economy has been launched in the more traditional industries (mining, manufacturing etc).

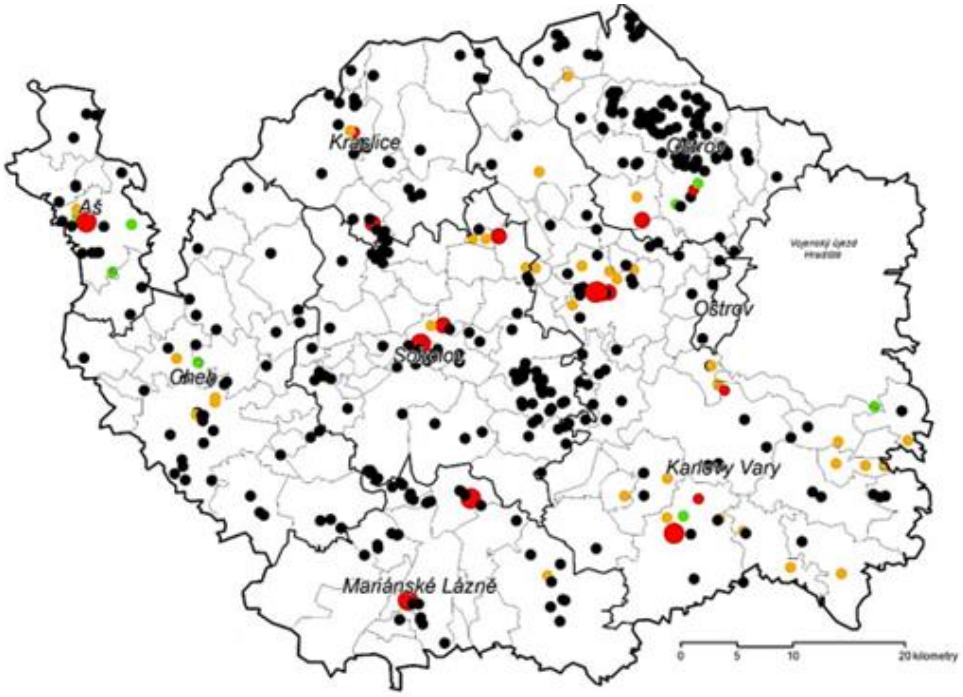
There can be concluded that healthy water, soil and climate is of a vital importance for the key businesses in the Region. Likewise the Mattoni brand builds its business on “bringing the health from the Charles Spa water”, this key player is therefore developing projects to support the transition to more sustainable development.

A significant factor that is changing the landscape character in the region is the extraction of minerals and the associated reclamation of the landscape. Since the end of the 1950s, a total of approximately 4 900 ha of reclamation (1 131 ha of agricultural, 3 033 ha of forestry, 583 ha of hydraulic and 153 ha

[19] The difference is also obvious in the Czech names of the spa towns (in English there is just a “spa” up to our knowledge). In the Czech language there exist “lázně” and “vary”. The latter one is used only in the Charles Spa Town = Karlovy Vary as indeed there are hot mineral thermal waters that reaches up to 72 Celsius degrees here.

of other) has been completed in the Sokolov district, on areas in former deep mines, where mining ended in the 1930s and 1940s, and mainly on areas of external dumps. Further reclamation is currently under way, approximately 1 536 ha. For some of the residual pits (Boden, Medard - Libík, Michal quarries), the procedure of flooding (hydraulic reclamation) was chosen. In this way, Lake Michal and Lake Medard were created near Sokolov. At the same time, however, the lack of preparedness of brownfields areas significantly limits the development of the region. These include size and infrastructural readiness, burdens in the territory - land burdened with unsuitable buildings requiring costs for their removal, environmental burdens - property law barriers, territorial supply given by the defined areas in the spatial planning documentation, land price, territorial limits - among others, limits in the field of mineral wealth protection, geology (undermined areas, etc.), nature and landscape protection, soil fund (Vozáb, et al., 2020). Incomplete revitalisation of brownfields and unused industrial areas and buildings, often with ecological burdens and unclear ownership structure. However, state programmes for the revitalisation of brownfields (for business or non-business purposes) offer several opportunities to prepare brownfields for new use, this has so far been done only to a limited extent and there is little interest from the regions that might be caused by an administrative associated burden. Figure 17 below shows the distribution and frequency of brownfield sites.

Figure 17: Old environmental burdens by risk level



Source: Ministry of Internal Affairs (2017)

Air quality in the region has long been influenced mainly by the industry and also by local domestic heating and transport. From the group regulated pollutants monitored, the following belong to priority in region: primary particulate matter PM10 and PM2.5, benzo(a)pyrene and tropospheric ozone and its precursors. Sulphur dioxide, nitrogen dioxide, carbon monoxide and heavy metals do not create any problem as their concentrations are below the established emission limits in the long term. The worst air situation is in the urban areas of Cheb, Sokolov, Karlovy Vary, Chodov, Vřesová and Ostrov.

The area of the Ore Mountains and the Slavkov Forest has the most pleasant values. The tropospheric ozone is mainly caused by transport.

Overall, however, the emission situation in the region can be assessed as very good. In terms of sectors, the most important sector, given its share in total emissions of priority pollutants and the high potential for emission reductions, is local household heating. There were 121,950 households registered in the region in 2021 (Soukupová, 2021). Of these, the largest share (49.6%) is heated by district heating, with natural gas being the second most common heating method (23.5%). These two heating methods are favourable to the environment as their emissions do not burden it to such a significant extent. The share of solid fuels (coal and wood) is lower in the region (7.9% and 5.2%, respectively, compared to the national average of 8.0% and 6.9%, respectively). These fuels are often combined, but price plays a key role in the choice of fuel for households. Of course, however, as the price of fuel decreases, its quality often decreases as well. As a result, to save heating costs, residents often use fuels that are less environmentally friendly. These heating methods then have a significant impact on heating emissions. However, due to the low population density of the region (37 households.km-2 in 2019 compared to the average of 54 households.km-2) and the favourable fuel mix for household heating, specific emissions from heating are low in the region compared to the national average. The underdeveloped transport infrastructure has its benefit as the emission load from transport is on a relatively low level.

In 2019, 69 major sources of air pollution were registered in region. The most significant point sources of air pollution include Sokolovská uhelná, legal successor, a.s., Elektrárna Tisová, Ostrovská teplárenská, a. s, Synthomer a.s. and Lias Vintířov, light building material k. s. The most important line sources of air pollution are roads I. class R/6 and I/13 between Ostrov and Cheb including the Karlovy Vary transit, the I/21 road in the section Cheb - Mariánské Lázně and Cheb - Františkovy Lázně, the I/6 road Karlovy Vary towards Prague, the I/20 road Doubí towards Plzeň and their most traffic-loaded sections.

Nature and landscape protection

The region is characterised by the high quality of the natural environment in most of its territory, which contrasts with the opposite characteristic given by the intensive urbanisation of the basin areas and the consequences of opencast mining for lignite, ceramic raw materials and kaolin. However, with the phasing out of lignite mining and reclamation, the environment is also changing positively in the mining-affected part of the region. In addition to mining, a major ecological issue is the mass occurrence of invasive plant species.

There are frankly only 3 large towns in the region with a gradually built-up area of industrial burden on the environment, of which the largest area is represented by the complexes around Sokolov and its closer surroundings. Industry is then concentrated in the lignite basin and the axis of the future R6 road. The rest of the area, which, on the contrary, increases the average environmental value, is situated in a wider belt of the border area, which was artificially displaced in the past and has not yet been repopulated in its full population strength, in the protected landscape area Slavkovský les and its surroundings and in the military convoy, which is no longer accessible.

NATURA 2000 sites occupy more than 20% of the territory (the national average is 14.1%), that ranks the region on the third place on the national scale. There are many specially protected areas, which occupy a total of 19.4% of the region's area.

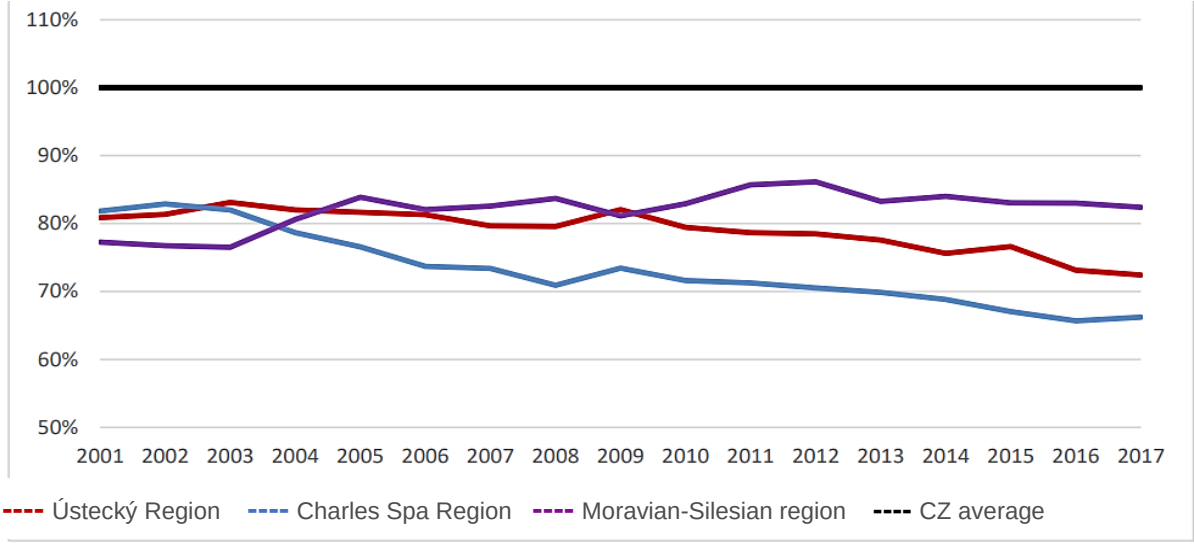
Economic

The key issue of the region is the low economic growth rate, the region is lagging behind other regions of the Czech Republic. Since 2004, the Karlovy Vary Region has been losing its economic growth rate, its position has been deteriorating and even the period of faster growth has not been significantly reflected in the region - the region has not been able to sufficiently benefit from the economic growth of the Czech Republic in the period before COVID-19.

The economic performance and structure of the economy affects not only the economic situation of the region itself, but also the social, cultural, and environmental aspects of development. From a long-term perspective, the Karlovy Vary Region is losing ground slightly but unfortunately steadily, the region has been stagnating economically for a long time, practically for the entire past decade.

The key limit of the current linear fossil-based systems related to the spa industry is the energy dependence on the traditional linear resources.

Figure 18: Gross domestic product per capita 2001-2017



Source: Annual National Accounts, public database

Legend: black indicates the Czech Republic, blue is the region, the remaining two colors stands for two remaining Just Transition Funding regions in the Czech Republic

Table 8: Gross domestic product (GDP) in 2021

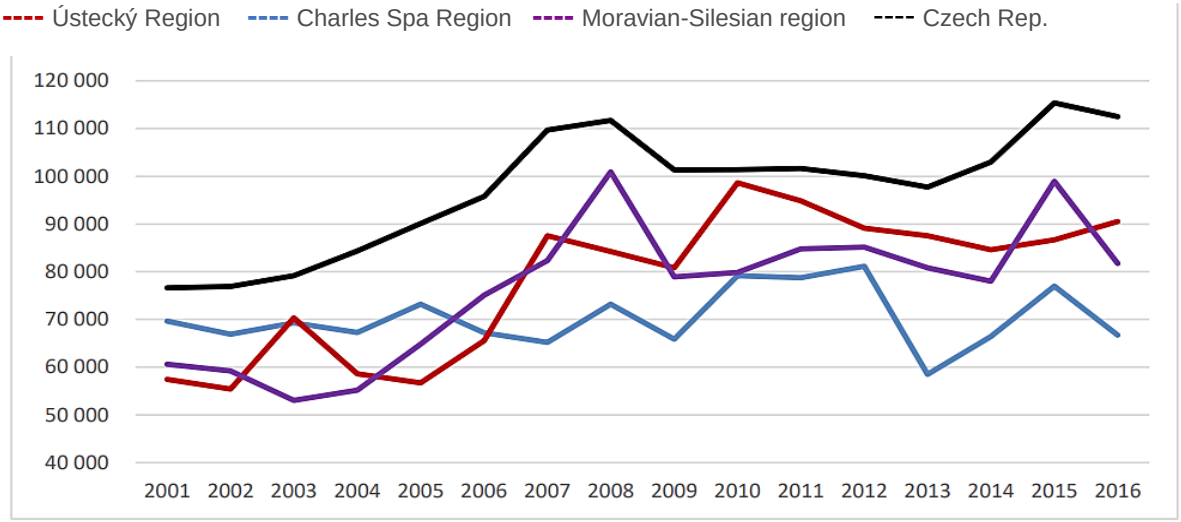
CZ, Region	GDP, total (CZK mil.)	GDP per capita			GDP per the employed (CZK)
		CZK	EUR	Purchasing Power	
Czech Republic	6,108,717	571,051	22,272	29,710	1,140,177
Karlovy Vary region	99,823	339,491	13,241	17,663	817,685

Source: Annual National Accounts, public database

Economic productivity has been stagnating for the last 10 years, that signals serious structural economic problems. Even in 2014-2017, when economic productivity grew very fast in other regions of the Czech Republic, region did not benefit and failed to move forward economically.

Gross fixed capital indicates the level of investment in an economy and largely reflects the economic structure of a region or national economy, it depends, among other things, on the investment of enterprises, both domestic and foreign, which generated most of the investment in the region in the period under review. From the above-mentioned description of rather a gloomy economic situation the stagnation of this factor is perhaps expected.

Figure 19: Gross fixed capital per capita 2001-2016



Source: Annual National Accounts, public database

Legend: black indicates the Czech Republic, blue is the region, the remaining two colors stands for two remaining Just Transition Funding regions in the Czech Republic

Sales and services by manufacturing sector are used to identify sectors that are key to the regional economy in terms of its performance and sectors that have either grown dynamically or, conversely, sectors that are declining in importance in the regional economy. The Table 9 below identifies sales revenues classified by NACE code.

Table 9: Sales of own products and services of an industrial nature in the Charles Spa Region (million CZK)

NACE	Average 2011 -2014	Average 2015 - 2018
Manufacture of metal structures and fabricated metal products, except machinery and equipment	7,971	9,937
Beverage production	3,849	2,980
Manufacture of rubber and plastic products	2,878	4,590
Manufacture of other non-metallic mineral products	2,339	2,891

Manufacture of textiles	2,206	2,366
Manufacture of motor vehicles (except motorcycles), trailers and semi-trailers	2,125	2,188
Manufacture of electrical equipment	775	777
Manufacture of machinery and equipment n.e.c.	892	728
Other manufacturing	325	365

Source: Annual National Accounts, public database

Two following key sectors can be identified in the region: the production of metal products and the production of beverages. The growth in the fabricated metal products manufacturing is evident, its share of manufacturing has almost doubled in the last 10 years and currently accounts for almost 35% of all manufacturing sales. The production of automotive parts, the electronics industry and the plastics industry (i.e. industry linked to the car production) is also showing a rising trend. The opposite trend can be observed in the beverages sector.

The overarching cause of the problem described above is the region's significant specialization in the traditional mining, energy, chemical, heavy metallurgical and non-metallic mineral product industries (glass, porcelain, building materials). These industries have been characterised by high raw material and energy intensity, hard working conditions and the use of a specifically skilled workforce, which has been matched in previous decades by strategic decisions from the central level affecting the region (e.g. immigration policy, very benevolent environmental protection conditions, construction of technical infrastructure and amenities, education system, etc.).

However, in the period of transformation and the return of the market environment, these sectors and the companies operating in them were exposed to rapid changes in the external environment (market conditions, competition, customers, technology), but also to fundamental internal changes (especially the change in ownership and associated new the business strategies,). Many of these companies were forced to reorient their activities to other markets (both geographically and in terms of products) due to the disintegration of their original value chains, which in some cases was accompanied by a so-called downgrading of economic activities[20] and a significant reduction in the scale of production (and thus a reduction in the number of employees). This phase took place with varying degrees of success and speed for firms in the region, often lasting 10 years or more.

A common feature of most domestic industrial firms in the region is the dependence of their production on demand from foreign companies operating in the Czech Republic, as there are suppliers of as intermediate products at rather a low level as subcomponents. The production of such companies is very often of a custom-made nature. Only very few domestic firms focus on the production of final products destined directly for end customers, and these are mainly enterprises in the so-called low/medium-tech sectors of porcelain, ceramics, woodworking or food production, i.e., sectors at an advanced stage of maturity with lower knowledge and innovation intensity, or with a lower need for in-house or external R&D. Foreign investors have also long been discouraged by the poor transport

[20] Firms formerly specialising in the final product began to specialise in supplying components for other manufacturers or branded products for other manufacturers.

accessibility of the region, the peripheral location of the region. Low educated population, minimum R&D activities and with the absence of a strong economic centre is rather discouraging.

The vulnerability of the region has been already discussed; the negative impact of COVID-19 does not perhaps come as a surprise. The need for social isolation hit hard the spa industry and related tourism in region. The unemployment rose to 5.91% in 2020. However compensation programmes perhaps reduce the negative effect.

If we want to try to quantify the impact of the pandemic, this can be illustrated with the example of the Karlovy Vary Transport Company, the amount of CZK 15.5 million corresponds to drop in revenue in the public transport system. The losses of the transport companies connect to tourism (car parks, towing services, the Diana cableway, etc.), a drop in sales was estimated to approximately CZK 20 million CZK.

Social

The low educational level of the population and the qualification structure of people on the labour market and graduates is one of the key challenges. One quarter of people older than over 15 years have only primary education and only 8% of the population received a university degree. Moreover, this unfavourable ratio has not been improving over time. The low rate of university degrees can be explained by the absence of a regional university. There are only a few branches of private universities based in Prague, it is very common that young people leave the region to go to a university and prefer to work and live in a more favourable Czech region or abroad.

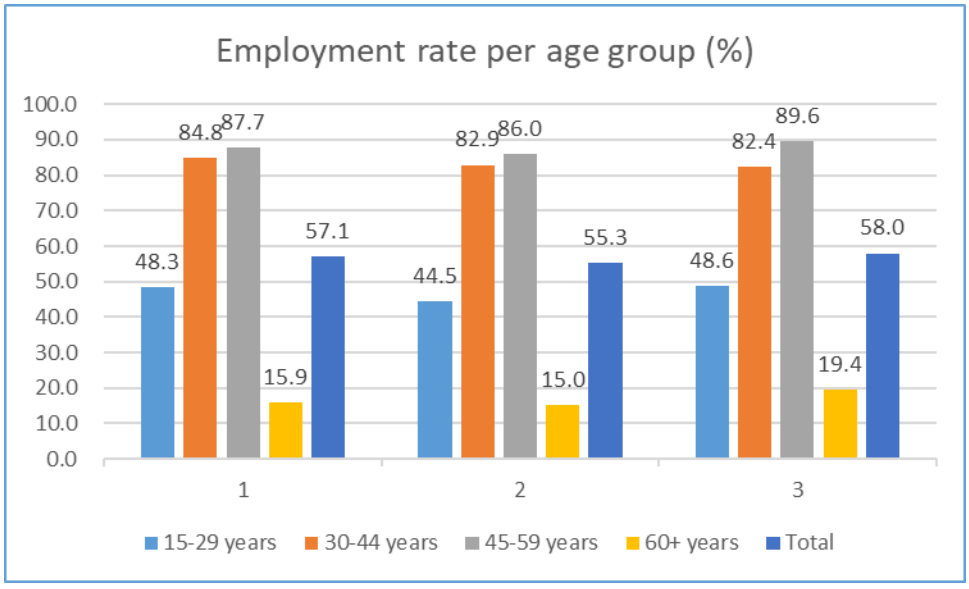


Figure 20: Employment rate in different age groups in Czech republic

The above figure 20 shows the employment rate per age group for the years 2020 (1), 2021 (2), 2022 (3), (data retrieved from the Czech Statistical Office, 2023) showcasing the low absorption of young people from the local labour market. According to EURES.Europa.eu, *"job applicants often do not meet the requirements of employers, which is why employers agree to employ a foreigner from a so-called third country in about 75% of the job vacancy reports."* This is supported by the fact that the group that mostly faces unemployment is the one of people receiving primary education and secondary vocational education with an apprenticeship certificate.

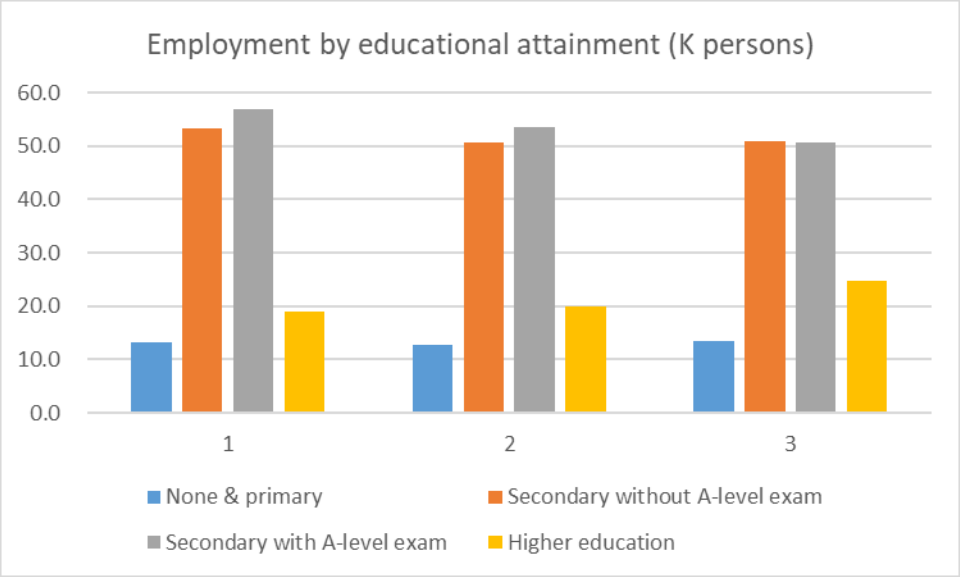


Figure 21: Employment according to the education background

In figure 21 above, it is visible how employment per educational attainment was formed for the years 2020 (1), 2021 (2), 2022 (3). Higher education figures are justified by the fact that the regional economic activities mostly require manual workforce, so the skills of this group do not match the market demand in its current structure. Despite the unemployment rate (4.3% in 2023) factors that impact employment in a positive way are the diversity of traditional crafts and the cooperation between big companies and secondary schools to provide them with graduates.

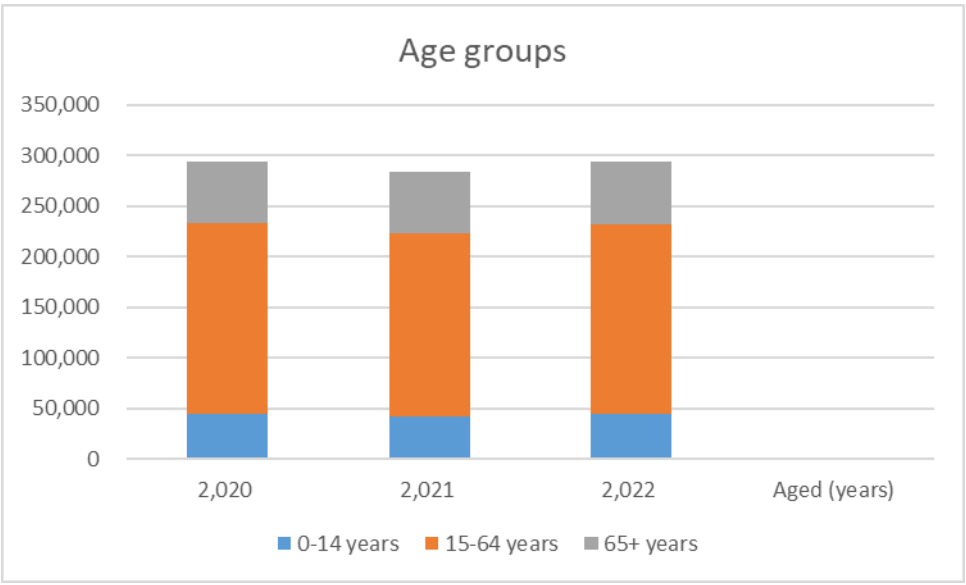


Figure 22: Proportion of the population in the region in different age groups

Problems with the insufficient human resources on the labour market may continue to grow, as demographic projections predict a rapid decline in the number of people of working age. The above figure shows the ratio of people per age group in the region with the 0-14 years old group being very low in comparison to the 2 other groups. In connection with the problem of generational replacement of experienced workers, there is a shortage of human resources on the labour market, especially in the fields of transport, health and social care, education and industry, in the latter case especially in

low-skilled professions - construction and assembly workers and auxiliary professions in agriculture or transport. Entrepreneurs are facing an acute shortage of suitable labour, most often affecting companies operating in the engineering and automotive industries. Moreover, a recent observation occurring from the current energy crisis is that in some cases unemployed people are not motivated to pursue education as they are in debt.

The population and settlement structure of the region still bear the traces of the hardships suffered by the Czech population during the war years; post-war displacement and subsequent resettlement, especially for the needs of heavy industry, have significantly changed the population of the region - villages in the peripheral parts of the region have either disappeared or been marginalised, while selected towns in the basin region have become significantly stronger. The specific labour requirements resulting from decades of artificially promoted industrial specialisation have had and are having impacts on the socio-professional structure and educational attainment of the population. At the same time, environmental impacts are also evident. Although it is improving in the long term and in some respects among the best in the country, there are still several local environmental burdens and brownfields in the region. The long-lasting and still incomplete transformation of the economy is hampering the economic growth of the region and has several other socio-economic manifestations, such as the outflow of mainly young and educated population outside the region, still lower wages than the national average and limited entrepreneurial culture.

The population development of the region is characterised by a slight increase to stagnation of the total population between 1998 and 2010. Since 2011, the region has experienced a slight but steady decline in population, which is mainly due to the intensification of emigration tendencies and supported by the gradual ageing of the population together with a declining birth rate. As in 2023, almost 50% of the population was over 50 years old (*Statistical Yearbook of the Karlovarský Region - 2023*, n.d.). Population ageing according to the projection of the Czech Statistical Authority may transpire to decrease by 12,000 (i.e. 6%) by 2025, while the number of post-working-age population will increase by 9 thousand in the same period, which is almost a 15% increase compared to 2018. These demographic projection numbers can be compared to the labour demand projection. An increase of about 1,000 jobs is assumed accompanied by a decrease of 3,600 jobs in manufacturing. It is obvious that the overall decline in the working age population in the Karlovy Vary region may cause another problem in the labour market and a shortage of human resources for the needs of the regional economy and higher unemployment of the low educated population[21][22].

There is no independent academic centre of any kind beside one department of the University of West Bohemia (with the headquarter in another region). The Institute of Spa and Balneology was established in 2019 by the region with the aim of supporting the development of spa and balneology. It is the only public research institution established by the regional municipality (in the Czech Republic there are lots of research institutions established by the Czech Academy of Science or by a ministry but only one by the regional municipality).

The economic performance in the region is of course negatively affected by the low entrepreneurial activity of people and the low number of established companies (as a consequence of a limited R&D

[21] https://eures.europa.eu/living-and-working/labour-market-information/labour-market-information-czechia_en#karlovy-vary-region
[22] https://www.czso.cz/csu/czso/19-science-and-research-4wb4i0n71i

activity and of course low education). The region is specific in that strong and large enterprises have long been operating here, which further reinforced the employment culture among the people and the low willingness to take risks, which is still evident today. The absence of public infrastructure aimed at the development of entrepreneurship and R&D, e.g. a science and technology park, an innovation centre, etc., is also a negative. The only regional entity that has been supporting the development of innovation, entrepreneurship and human resources development since 2010 is the Karlovy Vary Business Development Agency,

The common cause of the problem is also the low quality of education and skills of the people, which is related to the historical socio-economic circumstances of the development of the region but is also retroactively influenced by the problem of weak economic growth itself. Low educational attainment has several aspects, the more widespread lack of preparation of certain groups of the population for the needs of the labour market, either from a professional (poor qualification orientation) or from a personal point of view (lack of work habits, motivation), or often a combination of both.

Another factor limiting the development of the region is social stratification, increasing polarisation - the structure of society different than in other regions of the Czech Republic (that can partly be explained by the poor transport system)**.** A higher proportion of unemployed in most areas despite the current economic growth, a large number of socially excluded inhabitants and localities and people affected by poverty have a negative impact on the growth potential and attractiveness of the region. As of 2022, women had a larger share of unemployment (4,85%) compared to men (3.66%) according to the labour office register. Related to the above is the set-up of the public welfare system, which is not very motivating, especially for people in debt to find work. It also contributes to the creation and expansion of socially excluded localities.

Education is a key transition factor. There is an urgent need to enlarge opportunities for university level education, develop new programs for the secondary school and last but not least to support the educational activities tailored to entrepreneurs and SMEs also keeping in mind social inclusion and accessibility.

3.2.3 *Barriers of current economies to achieve relevant sustainability goals*

Both the OPJT and PR KK 2021-2027 fully recognize the above-mentioned challenges. The region has been suffering long time by structural changes. The regional barriers for achieving sustainability goals are : 1) The current economic structure: current economic activities of the region (mining, traditional crafts) and predominantly the spa industry have a very long history, rooted in people's identity. 2) Economic decline: the regional sectors have been in decline for the past 10 years with the pandemic resulting to great loses. In a non-flourishing economic environment where investment is limited, locals prioritize survival to sustainability. 3) The lack of high-end infrastructure, technology: going hand in hand with investment, the lack of infrastructure and technology is demands important funding to enhance greener solutions, 4) Lack of know-how, education and research centres: with other regions of the Czech Republic providing more appealing and market oriented studies an internal "brain drain" is inevitable, leaving the region with a workforce that is not up to date to sustainability and technology fields. 5) Social limitations: The aging population is also a hindering factor since with a declining economy it's difficult to re-skill an older generation to achieve sustainability. While the gender gap has not been extensively researched in the region, therefore, not identified as a major hindering factor for sustainability achievement, in the future it would be important to consider women's

involvement in science and sustainability education as a workforce 6) Lack of bioeconomy actors and stakeholder networks: while many actors could contribute to bioeconomy, they don't recognize themselves as part of the field and networks than can raise awareness and involve them are lacking. 7) Lack of entrepreneurial and innovation mentality: a result of limited education possibilities and rooting to the traditional economic activities, the lack of intrapreneurial and innovative spirit in the region reflect how education could inspire new solutions. These are some of the barriers that keep the region in the loop of a very traditional, linear economic model. Consequently, there's a difficulty in achieving EU and UN goals regarding:

The European Green Deal goals

EGD 2	Delivering clean, affordable and safe energy
EGD 3	Activating industry for a clean circular economy
EGD 4	Build and renovate in an energy and resource efficient manner
EGD 5	A toxic-free environment thanks to the ambitious goal of zero pollution
EGD 9	Financing the transformation
EGD 10	No one must be left behind (fair transition)

Sustainable Development Goals (United Nations, 2015) - goals linked to Bioeconomy

UN SGD 1	End poverty in all its forms everywhere
UN SDG 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
UN SDG 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
UN SDG 6	Ensure availability and sustainable management of water and sanitation for all
UN SDG 7	Ensure access to affordable, reliable, sustainable, and modern energy for all
UN SDG 8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all
UN SDG 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
UN SDG 11	Make cities and human settlements inclusive, safe, resilient and sustainable

EU BE strategy goals

EU BE 4.1	Creating jobs and maintaining competitiveness in bioeconomy sectors in rural and urban areas
EU BE 4.2	Reducing dependence on non-renewable resources
EU BE 4.5	Managing natural resources sustainably

Nevertheless, the need for transformation has now been reflected in regional strategic documents that started to address the challenges. Circular bioeconomy can indeed support the transformation, we examined the regional documents and analyse whether and to what extend they reflect the Green Deal Goals and goals identified in the European Bioeconomy Strategy (that are listed in Table 10 below)

Table 10: Analysis of regional strategies and their reflection on sustainability targets

Regional strategies	European Green Deal goals	UN SDGs	EU BE goals
Program rozvoje Karlovarského kraje 2021-2027 Development Plan for the Charles Spa Region	1,2,3,4,5,6,8,9	3,4,6,7,8,9,11	4.2; 4.5
Územní energetická koncepce Karlovarského kraje, Aktualizace 2017 – 2042 Urban concept of Energy	2,3,5,8	7,9,11,13	4.2; 4.3, 4.5
Plán odpadového hospodářství Karlovarského kraje 2016 - 2025 Waste treatment of the Charles Spa Region	3	11	4.3; 4.5
Regionální inovační strategie Karlovarského kraje RIS Strategy	-	4,8,9	-
Přeshraniční regionální inovační strategie Karlovarského kraje a Svobodného státu Bavorsko INTERREG Plan CZ Bavaria	3,5,6,8,9,10	3,4,7,9,11,13	4.3; 4.5
Přeshraniční regionální inovační strategie Karlovarského kraje a Svobodného státu Sasko	-	8,9	-
Programový document INTERREG BAVORSKO – ČESKO 2021–2027 INTERREG Program CZ Bavaria	6,9	4,9,11,13	4.3
Plán spravedlivé územní transformace Just Transition Funding	2,3,4,6,8,9,10	3,4,7,8,9,11,12	4.2; 4.5
Strategie Karlovy Vary 2040 Charles Spa City Strategy	1,2,3,4,5,6,7,8,9,10	3,4,6,7,8,9,11,12,13	4.2; 4.3; 4.5

3.3 Finland

3.3.1 *Current status, trends and future of regional of linear (fossil-based) economies*

In 2021, the material flow of natural resources in Finland consisted mainly of mining industry, metallic ores and non-metallic minerals, and biomass out of which mining of non-metallic minerals represents the largest proportion. The material flows of Finland are presented in figure 23. The figure introduces the amounts of extracted and imported materials and how much of them are either exported, incinerated or used to make products. (Eurostat, 2023)

The proportion of renewable biomass was 26%. Generally, mining industry shifts economy model to linear, which is observed in 24. In year 2021 over 100 million tonnes of the mining material flow is landfilled instead of recycling, which distorts the image of an efficient material usage of Finland in the light of natural resources use. Processed biomass is either used nationally, exported or burned to produce heat and energy. Contrary to mining materials flow, only 7% of biomass has ended up being waste and only a trace (less than 0.1%) of it is landfilled but preferably recovered or incinerated. (Eurostat, 2023)

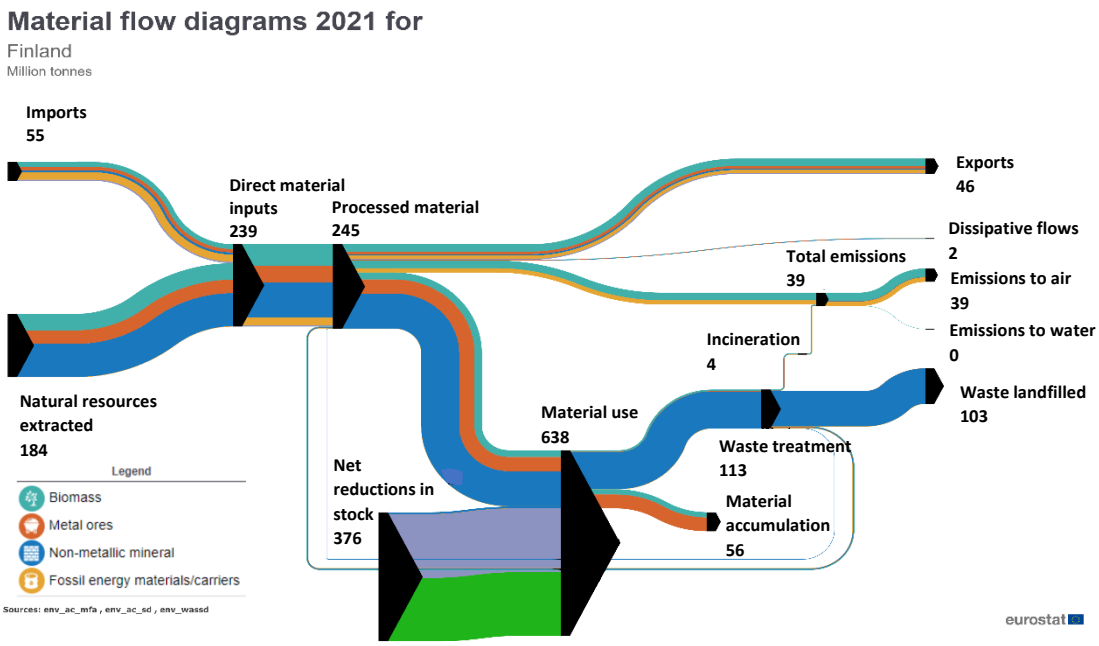


Figure 23. Material flows of natural resources in Finland, 2021. (Eurostat, 2023) (edited)

During the last decade, the extraction of biomass has increased, which indicates of the interest increase towards renewable resources use. Over 20% more biomass was produced in 2021 compared to 2010 (*Table* 11*)*. In addition, the amount of the imported biomass was slightly increased leading to higher direct material inputs. Total emissions have remained in the same order of magnitude, around 58% of biomass being burned to produce heat and energy (Natural Resources Institute Finland, 2021). The harvesting is enabled by vast network of forest roads (130 000 km), which also enables access to put down possible forest fires eliminating those CO2 emissions that are globally 2.1 billion tonnes of carbon of which in Finland 60 000 t/a. As Finnish forest area is about 0.56% of global forest area but of the forest fires only 0.0029%, the reduction of forest fire related CO_2 emissions is to 1/200th part from global average. (Abnett, 2021; Metsähallitus, 2020; Suomen tieyhdistys ry, 2019)

The annual amount of biomass used as material in Finland has been around 20 million tons. However, which is notable, is the change in material accumulation compared to waste treatment. More biomass have been converted to different products instead of ending the material cascade by landfilling or incinerating it. (Eurostat, 2023) Additionally, it should be noted that biomass use in Finland is already quite circular as 99.9% of it is not landfilled and 93% not wasted.

Table 11. The change of biomass material flow 2010-2021 in Finland. (Eurostat, 2023)

Material flow	2010 (Million tons)	2021 (Million tons)	Change (%)
Extracted resources	39.6	47.8	+20.7
Imports	13.6	14.2	+4.4
Processed material	56.0	64.1	+14.5
Exports	20.2	21.4	+5.9
Total emissions	21.6	24.9	+15.3
Material use	24.4	20.0	-18.0
Material accumulation	9.8	15.3	+56.1
Waste treatment	14.6	4.8	-67.1

Waste landfilled	1.2	0.06	-95.0
Waste incineration	8.8	2.8	-68.2
Recycling	4.6	1.9	-58.7

Material flows of forestry in Finland (2013) are illustrated more in detail in *Figure* 24. The chart introduces parts of the circularity of forestry, as the material flows of side streams and recycled materials are separated, e.g., mechanical wood residues are utilised in pulp industry and recycled materials are returned to manufacture. It also delivers the fact, how big portion of forest resources, mainly side streams, ends up to energy conversion processes. During the last decade, side streams of forestry, mostly black liquor and other concentrated liquors, have been the most used renewable energy source in Finland. Since the manufacture of wood products is extremely energy demanding, the direct utilisation of side streams as energy resource has been justified. (Sokka et al., 2015) However, as the circular economy model highlights the cascading of material, improved utilisation of side streams has been in focus lately. Another notable detail is the amount of wood products exported from Finland, since 15.6 million m^3 of paper and board have been exported while only 1.1 million m^3 have remained in domestic use. This affects the recycling rate and recycling potential of wood products in Finland and thus overall circularity of forest industry.

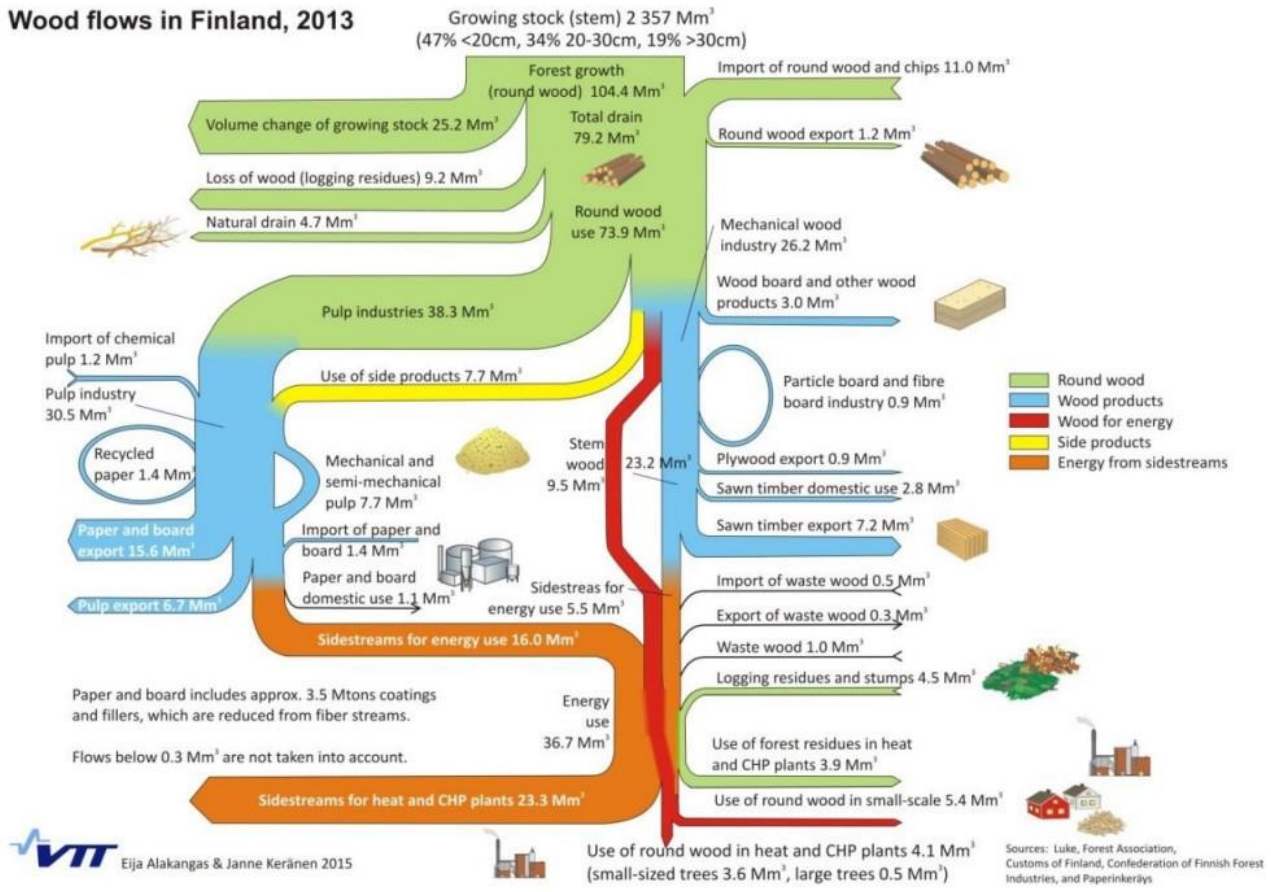


Figure 24: Wood flows in Finland, 2013. (Koponen et al., 2015)

Finland has agreed to follow the European Green Deal and recently, the preparation of Medium-term Climate Change Policy Plan, KAISU 3, was started, that will list actions to reach emission targets by

2030 and climate neutrality by 2035[23]. Associated green transition is a part of the Recovery and Resilience Plan of Finnish Government, and its one major goal is to enhance the circular economy of Finland by using green technologies. (Finnish Ministry of Finance, 2023) The 'Fit for 55' legislative package is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with the climate goals agreed by the Council and the European Parliament. EU's target is to reduce net greenhouse gas emissions by at least 55% by 2030. (European Comission, 2023) 'Fit for 55' contains several proposals relevant for transformation from linear to circular economy in Finland, especially the proposed changes to EU Emissions Trading System (ETS), and Land Use and Land-Use Change Forestry (LULUCF).

Finnish Government has prepared strategic programme for circular economy 2021, which has objectives for utilization of natural resources to promote circular economy model and to assist accomplishment of the targeted carbon neutrality by 2035. (Finnish Ministry of the Environment, 2023)

3.3.2 *Limits of linear (fossil-based) economies*

Environmental

Forests host a major share of Finland's biodiversity. Since the 1990s, protection of the biodiversity has been in the focus and the actions taken since then have successfully led to several species being no longer classified as endangered. Nevertheless, the decline in biodiversity has not yet been halted, which is why new actions are still needed. The obligation to regenerate the forest is the main reason for the continuous increase in Finnish forest biomass. The legislation sets the framework conditions for forest treatment in Finland. The types of felling used in Finland are regeneration felling and intermediate felling. In intermediate felling trees are harvested in a way that the growing conditions of the remaining stand improve. In regeneration felling the whole growing stock, except for the seed and shelterwood trees, is harvested and a new generation of trees grows up on the site. In regeneration felling the forest owner is obliged to regenerate the forest, which is also the case if the stand remaining after intermediate felling does not meet the requirements set by the law. Regeneration can be done by cultivating or through natural regeneration. (Finnish Ministry of Agriculture and Forestry, 2022a)

While the world's forest area is decreasing, Finland's forests are increasing. During the last 70 years the Finnish forest biomass has increased by 70%. See Figure 25. Active and scientific research-based forest management, which is also defined in our legislation, has contributed to this. The current annual increment of the growing stock is 103 million m^3 on forest land and poorly productive forest land, and its total volume of the growing stock totals 2.5 billion m^3. One quarter of the volume of the growing stock is located in peatlands and the rest on mineral soils. Private individuals own two thirds, companies almost one tenth, and the state one fifth of the volume of the growing stock. According to the inventory 2017-2021, the mean growing stock volume is 122 m^3 per hectare and the mean annual increment of the growing stock totals 5.0 m^3 per hectare (*Figure* 26). (Natural Resources Institute Finland 2022)

In Finland trees still grow relatively slowly, the life cycle of a tree in Finland is 80-150 years as a log tree, less for thinning trees. During the last 50 years, our trees have practically been completely renewed, i.e., since the end of the 60s. For this reason, our tree's stunting is now the biggest and the

[23] https://ym.fi/en/project?tunnus=YM033:00/2024

decay is the smallest. Even in the future, the growing wood resources will add value in the bioeconomy, based on the carefully considered use of natural resources.

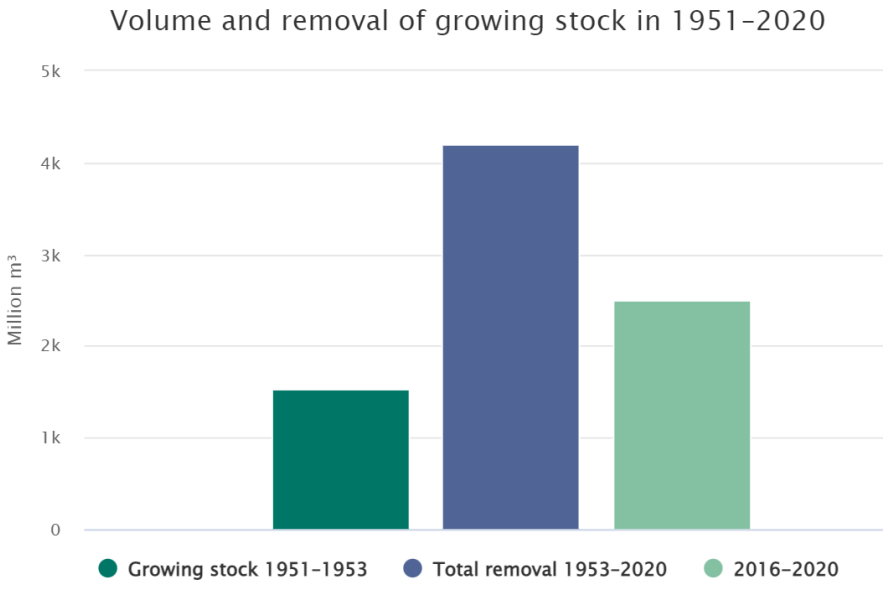


Figure 25: The growing stock in Finland's forests has increased from 1,5 billion m3 to 2,5 billion m3 during last 70 years, although Finland has harvested over 4,1 billion m3 wood during the same time. (Forest.fi, 2019)

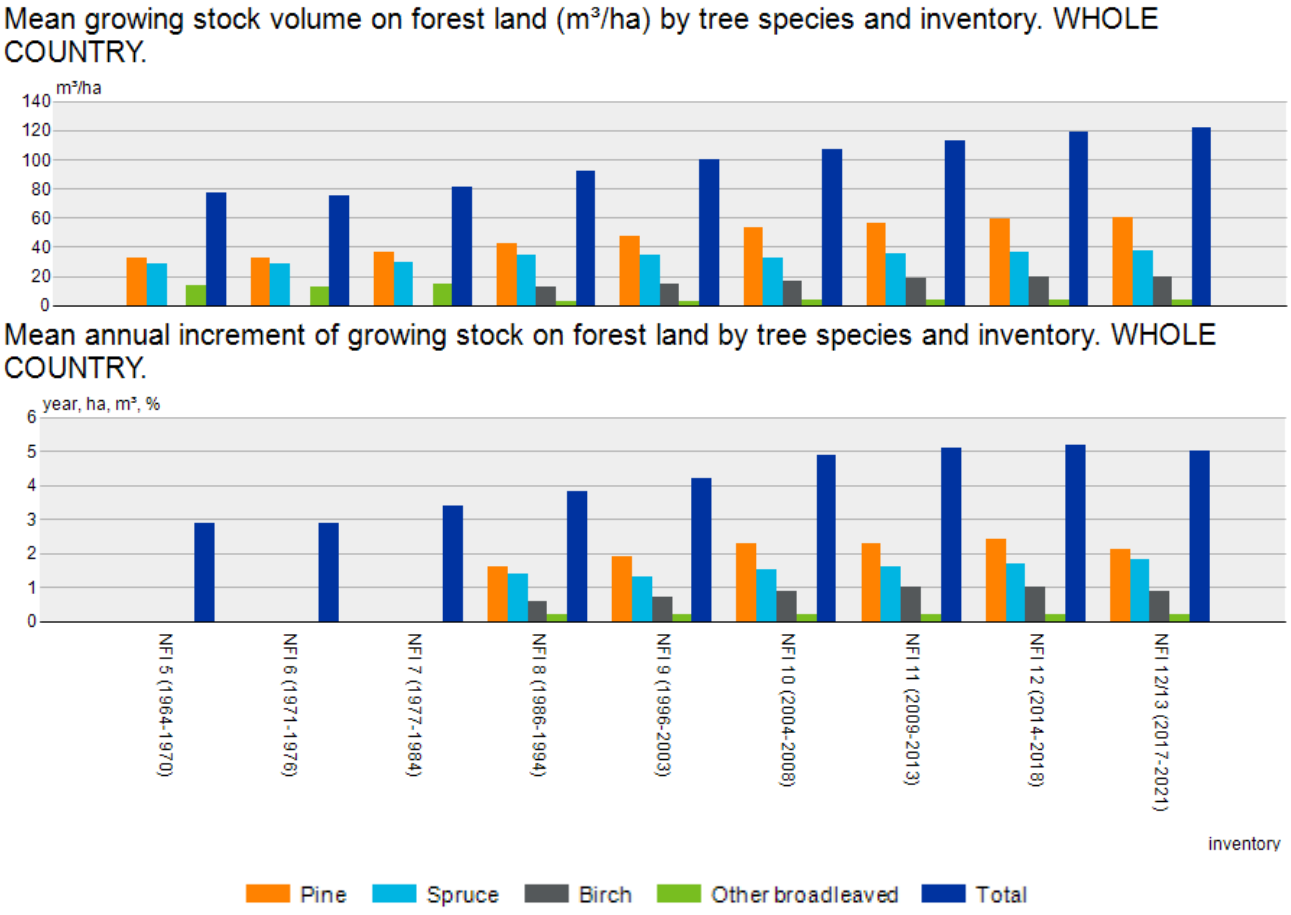


Figure 26: Mean growing stock volume and mean annual increment of growing stock of Finnish wood resources. (Natural Resources Institute Finland 2022)

The EU forest strategy for 2030 is one of the flagship initiatives of the European Green Deal and builds on the EU biodiversity strategy for 2030. (*See also chapter 4.3.3).* The biodiversity strategy aims to put Europe's biodiversity on the path to recovery by 2030 for the benefit of people, climate and the planet. In Finland, a process to prepare a new National Biodiversity Strategy and an action plan to 2030 related to this is currently underway. The strategy and action plan will be linked to the objectives set internationally and within the EU. A new Biodiversity Strategy will be needed as the biodiversity of Finnish natural environments continues to decline. The decline is even faster than earlier, if measured by the number of threatened species. The aim of the strategy is to halt the loss of biodiversity and turn the trend towards recovery by 2035. (Finnish Ministry of the Environment, 2013).

Figure 27 presents the carbon dioxide emissions (CO_2) in Finland in 1990-2022. Total CO_2 emissions in Finland have been decreasing during the last 20 years. The same trend is visible in the statistics of the forest industry emissions (Metsäteollisuus 2024) The graph shows also the influence of Land use, land-use change and forestry sector (LULUCF) on the total CO_2 emissions. LULUCF sector has acted as net carbon sink for decades. After 2010 LULUCF's positive effect on total CO_2 emissions have been decreasing. In 2022, the CO_2 emissions of LULUCF passed the carbon sink by 4.5 million tons CO_2 eq. This is mainly because of the agricultural land use, ditching and increasing degradation of peat due to global warming. Forest land use class and stock wood were defined as carbon sink as they showed total net carbon sink of -8.1 million tons CO_2 eq.(Statistics Finland 2023a)

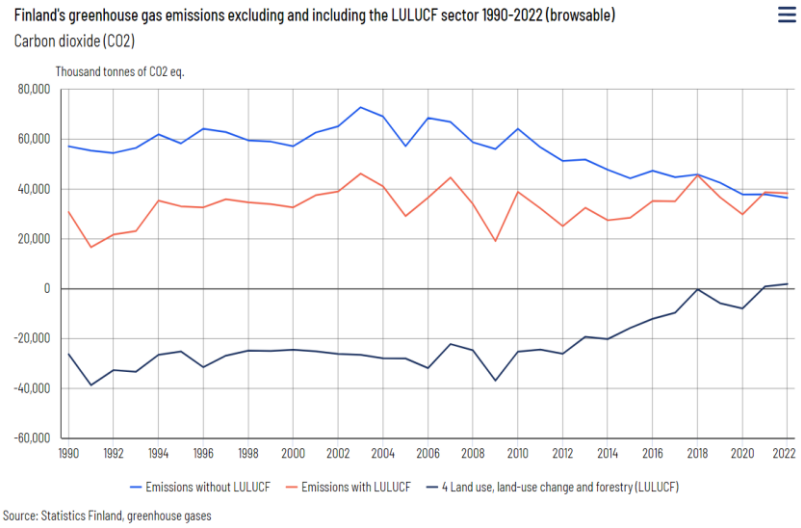


Figure 27. Finland's carbon dioxide emissions 1990-2022 (https://stat.fi/julkaisu/cl8d190lnb47r0bvxg344apf0).

Water is another main natural resource beside wood in forest industry. Wood itself require 450-500 m^3 water per m^3 of wood to grow (Van Oel & Hoekstra, 2012). The pulp and paper industry uses water to transport fibres, to create durable fibre webs and for heating, cooling and maintaining the machines. Use of water has been optimized during the last decades by circulating used water: 50 years ago 1 m^3 of pulp required 250 m^3 of water, while the amount is nowadays 5-50 m^3. (Metsäteollisuus, 2019)

As forest industry is mainly located near water bodies, released pollutions and wastewater treatments must be highly considered. An adverse effect of pulp and paper industry on water bodies is eutrophication caused by phosphorous and nitrogen discharges. The pulp and paper industry

represents 90% of phosphorous and almost 70% of nitrogen discharge within the whole industry in Finland (Finland's Environmental Administration, 2013a). Another challenge of forestry causing water loads is leaching of solids caused by increasing logging, fertilization, ditching and tillage (Finland's Environmental Administration, 2013b). Forestry has invested extensively to the protection of water by developing water treatment technologies and improving prediction of possible faults (Finland's Environmental Administration, 2013a). The change of emissions to water bodies within the years 2000-2019 are visible in *Table* 12. The chemical wood industry, i.e. the pulp and paper industry, is the main source of water loads in forestry and thus the percentual change is milder compared to mechanical wood industry, that has initially lower emission rates. Clear decrease in the amounts of solids in water, used oxygen to break down the micro-organisms (BOD) and organic matter (COD) and the amounts of phosphorus (P) and nitrogen (N) released to waters indicate great development in water treatment and process control in forestry. (Finland's Environmental Administration, 2013a)

Table 12. The percentual change of emissions to water of forestry in Finland, 2000-2019. (Finland's Environmental Administration, 2013a)

	%				
Area	**Solids**	**BOD_7**	**COD_{cr}**	**P_{tot}**	**N_{tot}**
Chemical wood	-41.7	-53.1	-28.9	-35.3	-22.4
Mechanical wood	-69.7	-92.9	-83.1	-88	+23.8

The protection of water bodies is regulated by national Environmental Protection Act and Decree as well as EU directives, e.g. The EU Water Framework Directive and supporting groundwater directive and The Urban Waste Water Treatment Directive (Finland's Environmental Administration, 2013c; Kurrer, 2022). In addition, actors, such as Centres for economic development, traffic and the environment (ELY) and Regional administrative authorities (AVI) have important responsibilities to enforce the environmental and water legislation, e.g. by controlling ditching and conducting environmental and water permits (Finland's Environmental Administration, 2013c). Environmental permits are included in the Finnish Environmental Protection Act and are required for all activities having a risk to pollute air, water or soil (Finland's Environmental Administration, 2013d-a). The lack of environmental permits has disallowed the manufacture of large scale industrial activities, out of which the refusal of pulp mill planned by Finnpulp Oy has been one of the most noticed. Finnpulp Oy aimed to manufacture the world's largest softwood pulp mill in Kuopio in Finland, but the environmental permit was denied, as the ecological status of local water body was predicted to deteriorate against the EU Water Framework Directive. (Salokangas & Veteli, 2019)

The pulp industry uses sulphur chemicals when cooking wood chips to produce pulp. Sulphur oxides caused by pulping have been a reason for odour problems around pulp mill areas. (Metsäteollisuus, 2020a) The amount of odour causing sulphur compounds emitted to air has been decreased (-97%) in 30 years due to developed technologies (Metsäteollisuus, 2020a), but the odour problem still exists, since human can smell even minor concentrations of sulphur oxides (Väisänen, 2015).

Economic

Companies in different industrial areas aspire to fulfil consumers demand and tightening regulations of replacing fossil-based materials with biobased materials in their products. This has induced constantly growing interest in wood-based raw materials. It is evident that the competition of biobased

raw material is increasing, and also wood raw material will be directed to applications with higher additional value (Viitanen et al., 2021).

Prices of wood are influenced by the markets. Also in Finland, the wood prices have increased due to market demand, reduced import (Figure 28) and energy price changes. The variability of forest industry wood use has been between 65 and 75 million m^3 annually during the last decade, mainly driven by global demand of products (i.e., sawnwood, plywood, pulp and paper). Imports have reduced due to reduction of import from Russia, which has increased the use of domestic wood. Production requires electricity for the factories in the forestry area, but electricity and heat from the by-products of the production processes are also produced. Thus Finnish forest industry both benefits and suffers from expensive energy. (Valonen et al., 2022)

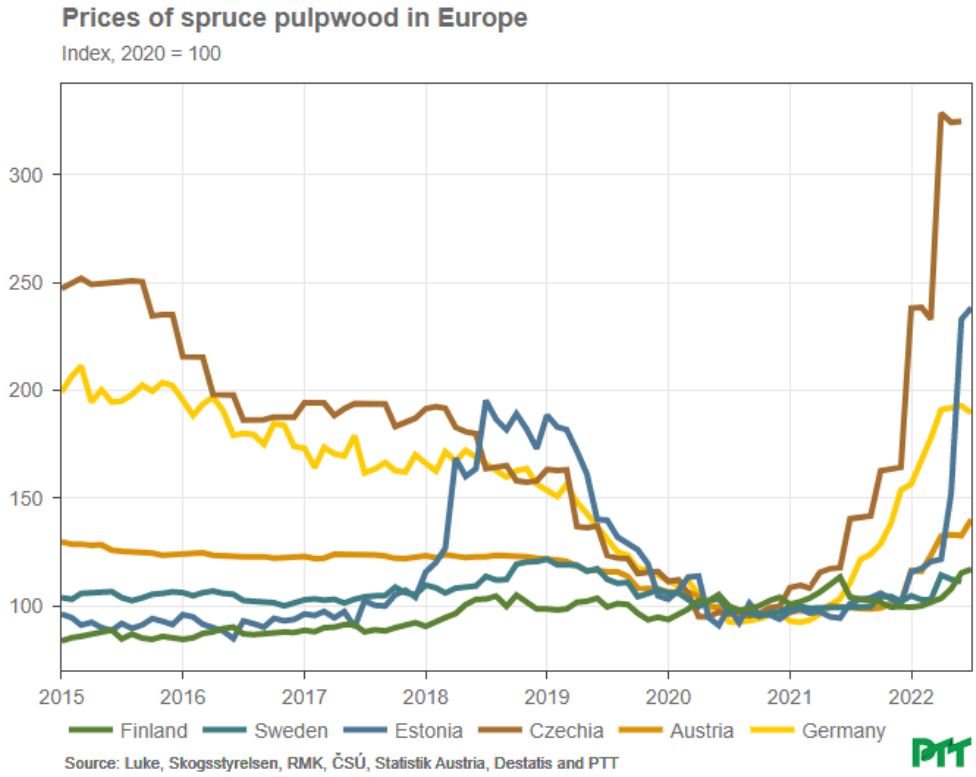


Figure 28. Prices of spruce pulpwood in Europe. (Valonen et al., 2022)

Finland is rather independent considering wood resources (*Figure* 29). At least during the past 20 years, almost 90% of the wood used by the Finnish forestry industry origins from domestic forests. In 2021, the domestic wood supply came from privately owned (~70%), state owned (~10%) and company owned (~10%) forests. (Metsäteollisuus, 2022a)

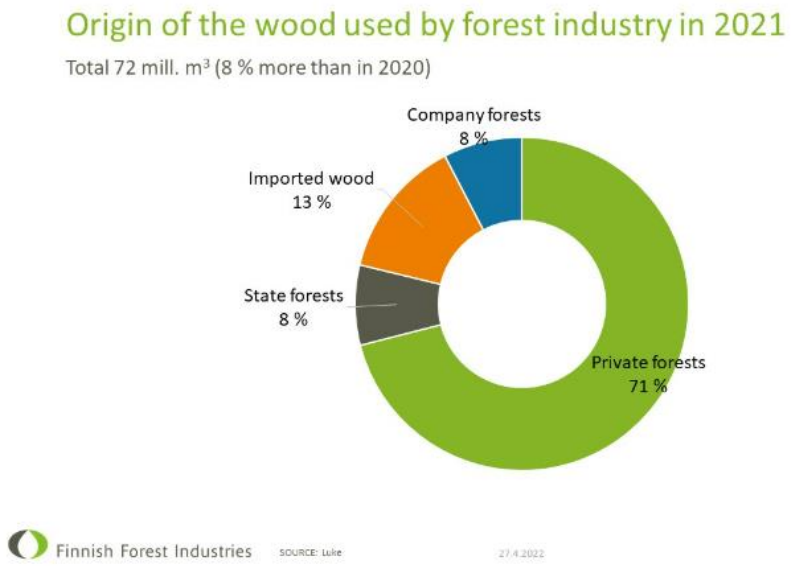


Figure 29. Domestic and imported wood supply of the forest industry in Finland. (Metsäteollisuus, 2022a)

Russia has been a relevant wood provider for the Finnish forestry industry (*Figure* 30). In 2021, Finland imported 9.3 million m^3 of wood as raw material from Russia, amounting to about 10% of the entire raw material use of Finland's forest industry. The most important timber assortments were birch pulpwood and coniferous wood chips, which constituted 75% of all timber imports. Due to the war in Ukraine the wood import from Russia was restricted during 2022, and Finland needs to find alternative wood resources. (Metsäteollisuus, 2022b)

Figure 30. Imports and exports of wood raw material in Finland.

Finnish forest companies are exploring options of increasing domestic wood supply and finding alternative wood resources from the surrounding countries (the Baltics, Sweden and to some extent Germany). These countries however have their own wood processing industry that also depends on import of wood. Sustainable use of Finnish forests can be increased (*Figure* 31). Many forest industry companies in Finland are strengthening their procurement organisations, resulting in genuine demand targeted at Finnish forests. (Metsäteollisuus, 2023a) The new bioproduct mill to be started in 2023 in

Kemi will require 7.6 million m^3 of wood per year (Metsä Group, 2023), which will strongly influence the wood demand in Finland.

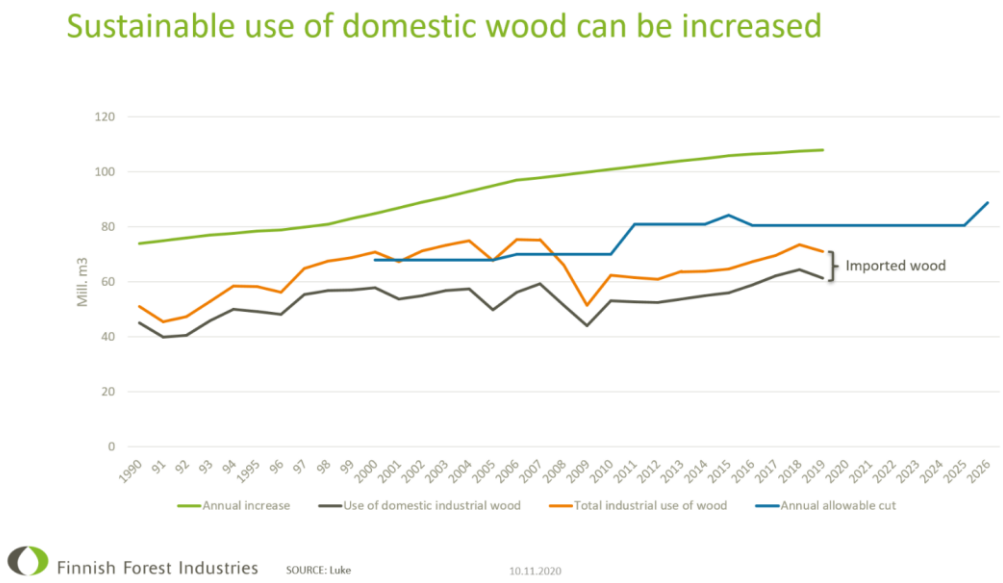


Figure 31. Annual forest increase, industrial use of wood and annual allowable cut of forests in Finland.

Other relevant factors influencing the wood supply and the forestry activities in Finland are logistics and transportation. Logistics is one of the major challenges in the procurement of Finnish raw materials (i.e., road network and condition, railway capacity, logistics terminals and transportation by sea). Log driving has again been reconsidered to be used as an affordable and interesting transportation alternative. There are some concerns on the condition of roads and rails, especially in Northern Finland (*source: interview*).The Baltic Sea is crucial for Finland regarding transportation, both importing of raw materials and exporting products. (Metsäteollisuus, 2023b)

Social

The transition to circular economy will maintain forests to benefit wellbeing of citizens. History and geographic location of Finland has been influenced by its neighbours, like Sweden and Russia. Finnish culture is often seen relatively ascetic with strong European background having quite strong sense of national identity. (InfoFinland, 2023) Rural life is well known also to urban people, as many people, both male and female, have summer cottages, and people enjoy the everyman's rights on the countryside and in the wilderness. This emotional connection creates willingness to understand nature and forests that cover 75% of land area (Finland's Environmental Administration, 2013d-b; Finnish Ministry of Agriculture and Forestry, 2022b; Statistics Finland, 2018). The transition to a circular economy will maintain forests to benefit the wellbeing of all citizens, regardless of their gender. In this transition to a circular economy, it's essential to consider the different roles, experiences, and contributions of all genders.

Equality is quite important, as universal suffrage became already 1906 (Langhoff, 1906), first in Europe. It has created a gender-inclusive approach and contributes to social equity enhancing effectiveness also in circular economy transition. In forest industry women are still underpresented

but the situation is improving as more women are trained in the field[24]. As forest workers women are almost non-existent, despite technology development[25] but women have already 40% share in private forest ownership.

The world class education of Finland, from daycare to compulsory comprehensive school of 9 years followed by secondary general academic and vocational education, up to higher education (university and university of applied sciences), without screening in compulsory stages enables creating similar sense of national identity (Education Finland, 2023). In addition, the results from this education is that mindset towards making is positive, the attitude is that you can do what you know (Anonymous, 2019). These building blocks create great cornerstone for building business environment around forests and their circulation.

Finnish population of 5.54 million people with average population density of 19 inhabitants/km^2 is concentrated to cities (85% of population lives in towns and cities) (Statistics Finland, 2023b). Despite recent increased migration, Finland is relatively ethnically homogenous, only 8% of population is born abroad. Finns are grown near forest and know it well. In addition to this Everyman's rights enable e.g. berry picking from the forests to all (Finland's Environmental Administration, 2013d-b). Finns can move and refresh themselves in nature in a way that is only dreamed of in many countries, and forests are also travelled to see, regardless of the season. Circular economy ensures the continuation of this tradition by maintaining the forests.

The role of forests in enhancing human health and well-being has been studied in Finland for more than a decade, and these benefits are increasingly recognized by the Finnish society. These studies demonstrate that forests and other nature areas are important in reducing stress and add recovery from work. Moreover, field experiments have confirmed that visiting forests have beneficial psychological and physiological effects on human health. These effects can be explained by psychological stress relief with contribution from reduced air pollution and noise exposure during the visits. In addition, studies looking at long-term effects of nature exposure suggest that physical activity has a mediating role in perceived health benefits, particularly among suburban residents. Recent efforts include national policy-science discussions on how the research knowledge can be implemented within various sectors such as public health and land-use planning and forest management. (Tyrväinen et al., 2019)

Ageing population and lowering birth rate put some pressure towards economy, as proportion of people working decreases over time. In 2023, the proportion of Finns aged under 45 years was 51 %. The same value in 2003 was 57 % (Statistics Finland, 2023b). As large generations are approaching the retirement age, new skilled employees are needed. Educational status is also affecting the transition. As people are educated, they are aware of the need to shift away from current linear system. Approximately 35 % of 20-50 years old Finnish citizens have university degree or equivalent (Statistics Finland, 2022a). Some concerns have risen if adequacy of competent professionals and enough employees are received, especially in the rural areas, where most of the forestry industry is based. Large forest industry integrates are centralized in South Karelia in Southwest Finland and the university degree rate is only 30 % (Statistics Finland, 2022a), which is

[24] https://helda.helsinki.fi/server/api/core/bitstreams/f83c2081-5669-4451-8fa9-97000fde5b67/content
[25] https://nordicforestresearch.org/gender-balance-in-the-nordic-forest-sector/

below average. In general, urban areas attract people more. Additionally, most of the academia are located in cities, which raises the threshold to move to the rural areas. The net migration of population aged 20-35 in South Karelia to other regions of Finland is -3.5 %, regardless of the fact that a well-known technical university is located there (Statistics Finland, 2022b). The same value observed in Southwest Finland, which is considered as an attractive region besides capital area, is only 0.3 % (Statistics Finland, 2022b). Education should be available in each region, so that it supports the region locally providing more expertise and labour. Additionally, the attractiveness of rural area should be enhanced for younger labour. Another changed issue is that, previously private owners owned large forest areas, but with the generational change, the forest areas are becoming fragmented. This complicates the management and sales of forest (Source: interviews).

During one decade, the awareness of people on themes, such as carbon footprint, green products and sustainability, has increased. According to customer survey in 2014, only 7% of Finnish customers knew the relation of product carbon footprint to greenhouse gas emissions and climate change (Hartikainen et al., 2014). Nowadays, word 'bio-based product' is directly connected to terms 'eco-friendly', 'recyclable' and 'renewable'. Finnish consumers have mentioned willingness to pay even more on products, that are packed in bio-based options. (Kymäläinen et al., 2022) Major of the packaging materials produced in Finland are exported abroad. Thus, opinions of international customers are also important. A survey conducted for German, French and American people showed an international interest in green packaging. The size of packaging and used materials were considered while choosing an item (Herbes et al., 2020).

3.3.3 *Barriers of current economies to achieve relevant sustainability goals*

The most relevant UN 2030 SDGs for Finland's Forestry case-study are Goal 12 *Responsible Consumption and Production*, Goal 13 *Climate Action* and Goal 15 *Life on Land*. Those SDGs are fully taken to account in EU Green Deal goals and initiatives, and Finland has embedded them in national strategies and will implement/ has implemented EU regulations to national regulations.

The EU forest strategy for 2030 is one of the flagship initiatives of the European Green Deal and builds on the EU biodiversity strategy for 2030. The forest strategy will contribute to achieving the EU's biodiversity objectives as well as greenhouse gas emission reduction target of at least 55% by 2030 and climate neutrality by 2050. It recognises the central and multifunctional role of forests, and the contribution of foresters and the entire forest-based value chain for achieving a sustainable and climate neutral economy by 2050 and preserving lively and prosperous rural areas.

Finland's National Forest Strategy 2035 (Finnish Ministry of Agriculture and Forestry, 2022c) has been completed - the national Forest Council approved the renewed strategy on 14 December 2022. The implementation of the strategy will begin at the beginning of 2024.The need to reform the strategy arose from the rapidly changing environment where the forest sector operates, both nationally and internationally. The new strategy takes into account, in a more up-to-date manner, a comprehensive approach to sustainable development and the role of forests in climate change mitigation and adaptation. The new forest strategy has numerous interlinkages to many other national and international strategies. The forest strategy was drawn up as an extensive and interactive process in cooperation between different experts. The process included workshops, questionnaires, seminars and discussion events. The aim in the work on the forest strategy was to coordinate the regional interests and the needs of different stakeholders in the best possible way.

The strategic objectives are:

-Finland is a competitive operating environment for a responsible forest sector that is capable of renewing itself.

-Forests are in active, sustainable and diverse use.

-We strengthen the vitality, diversity and adaptability of forests.

-We strengthen knowledge-based management and competence in the forest sector.

Some detailed goals in Finland's National Forest Strategy 2035:

-Biodiversity trend in commercial forests is directed onto a path to recovery.

-Climate change resilience of forests is strengthened and risks of damages are in control.

-Environmental risks caused by forestry are managed and in control.

-High-quality research, advancing spatial data and usability of data create a strong knowledge base for decision-making and foresight work.

'Fit for 55' legislative package contains several proposals relevant for forestry and circular economy of forest-based products, especially the proposed changes to EU Emissions Trading System (ETS), Land Use and Land-Use Change Forestry (LULUCF), Renewable Energy Directive (RED) and Energy Efficiency Directive (EED).

EU ministers agreed 27.6.2022 on new 2030 targets on energy efficiency and renewables. EU as a whole plans that, by 2030, at least 40% of its all used energy will come from renewable sources (earlier the goal was 32%). EU also revised the criteria for forest biomass to help protect forests and biodiversity. In the 2019 NECP (National Energy and Climate Plan), Finland reported that its target for renewable energy is 51% by 2030. For transport, the proportion of renewable energy must be 14% in each Member State by 2030. Finland's Distribution Obligation Act will increase the share of biofuels in transport from 18% to 30% in 2021–2029. (Finnish Ministry of the Environment, 2022)

The provisional EU agreement 6.12.2022 to **cut down deforestation** sets mandatory due diligence rules for all operators and traders who place, make available or export timber from the EU market. The rules also apply to a number of derived products such as furniture and printed paper. The co-legislators set the cut-off date of the new rules at 31 December 2020, meaning that only products that have been produced on land that has not been subject to deforestation or forest degradation after 31 December 2020 will be allowed on the Union market or to be exported.

According to the Recovery and Resilience Plan (EU), Finland aims to achieve carbon neutrality by 2035 and to halt the decline in biodiversity by 2030. (Finnish Ministry of Finance, 2023)

At the moment Finland has shortage of wood due to the stopped import of wood from Russia, and additional fellings are needed to ensure material availability. However, the previously mentioned regulations and strategies guide and put pressure on the opposite development. Earlier the question was how to add fellings in a sustainable way to ensure sales. Now the question is how to limit fellings due to biodiversity and carbon sink loss. In some cases, there might be challenges regarding EU regulations, because Finland's situation is not sufficiently understood. Finland does not pursue its

own interests, such as advocacy of forest industry, as well as other EU countries pursue the interests of their main industries. (*source: interviews*)

Circular economy targets and renewable energy targets must be optimized together, since wood-based energy (mainly from the incineration of forest industry side streams and logging wastes) represents 77% of the total renewable energy in Finland (Bioenergia, 2019). The renewable energy share of all energy was 37% in 2019, and the same year Finland reported that its target for renewable energy is 51% by 2030.

Few national- and regional-level policies have been noticed to influence the transition to more circular economy.

- Taxation
- Permit processes
- Standardisation – some standards prevent introduction of new solutions
- Regulations related to environmental issues (Source: interviews)

Barriers to achieve relevant sustainability targets include the lack of funding and adequate other types of support and incentives to create multi-actor circular models to commercialize new concepts and technologies. A good example of this is the already defined ecosystem model for using wood ash from pulp and energy industry as fertilizer in peatland forests, instead the landfilling of the ash (Joensuu, 2022). This would accelerate the growth of trees and thereby carbon sinks when great areas of peatland forests are fertilized (Saavalainen, 2023). However, companies and other actors have not yet succeeded to create a profitable collaboration (financial support is still needed) to utilize all the wood ash, and only one fifth of Finland's peatland forests are fertilized (Centre, 2021). The lack of opportunity confidence is also a recognized barrier for sustainable transformation (O'Shea et al., 2021).

In the simple case, in which only one industry actor is needed for the circular economy change, a well-recognised barrier for the quick transition is the need to invest in new machinery, since new (raw)materials in an industrial process are rarely drop-in materials.

Within the small and medium sized companies in forest sector that create new products for the sector, following opportunities and barriers were identified. Along with successful corporate goals and environmental ideals, the willingness to change the established forest sector is seen as a key factor challenging for rivals to copy were also identified as motivating factors. Partnerships are necessary for circular bioeconomy success in order to acquire the necessary resources and skills. Additionally, the two biggest obstacles were the lack of credibility and technology. These are problems, which can be resolved by working with various market participants. (Salmela, 2019).

3.4 North Rhine-Westphalia Region – Germany

3.4.1 Current status, trends and future of regional of linear (fossil-based) economies

North Rhine-Westphalia (NRW) harbours a strong industrial sector, with a total turnover of 356.8 billion euro and over 1,225,000 employees[26]. With 49.5 billion euro, the chemical sector is one of the biggest contributors to NRW's economic power. While overall turnovers have been declining slightly during 2015 and 2020, the last years showed a strong increase. The number of employees in the sector has constantly grown during the last ten years[27]. Investments in R&D of NRW's industry are distributed quite equally with 1.5 billion euro spent in the chemical industry. Especially the area of pharmaceutical production has seen high investments, compared to the rest of Germany. Concerning the development of new technologies, NRW also holds the lead in Germany in the amount of patent application in the areas of organic fine chemistry, metal chemistry, polymer technologies, pharmaceutical technologies, and biotechnology, again underlining the importance of these industries[28].

Germany's chemical industry depends strongly on fossil resources, especially petrochemical raw materials of which the demand reached 20 million tons in 2020[29]. The main products of the organic chemistry industry are basic bulk chemicals, but also a wide range of products and intermediates for markets like textile manufacturing, fertilisers, food and pharma, polymers, coatings, adhesives, and cosmetics. The majority of these products is sold on European markets (50.2 %; 2021) with the rest being sold worldwide[30]. The resource demand for material production in the chemical industry in Germany was 20 million tons in 2020 alone. This was mainly met by petroleum derivatives (71.5 %) and natural gas (14.2%), but also a share of 13 % renewable resources. Additionally, the chemical industry is among the energy intensive industries in Germany with a share of 9 % of the total energy consumed. Here only minor amounts of the petroleum and roughly 35 % of the natural gases consumed are used energetically, mostly to deliver process heat[31].

About 30 % of the turnover of the German chemical industry is made in NRW. About half of the German primary plastics production is based in the region[32]. While the numbers above are not available by state, the share of NRW will be significant, and roughly a third of the total German chemical industry feedstock use.

About 70 % of products of the chemical industry are further processed by other sectors, the sector is thus heavily integrated into many value chains. It rarely has a direct consumer contact, most often in

[26] https://www.it.nrw/statistik/eckdaten/betriebe-beschaeftigte-entgelte-und-umsatz-im-verarbeitenden-gewerbe-sowie (last accessed 30.01.23)
[27] https://www.it.nrw/statistik/eckdaten/chemische-industrie-betriebe-beschaeftigte-entgelte-und-umsatz-2059 (last accessed 30.01.23)
[28] MWIDE - Innovationsbericht Nordrhein-Westfalen 2022, p. 44
[29] VCI – Energiestatistik 2022
[30] VCI – Branchenportrait 2022
[31] VCI – Energiestatistik 2022
[32] rohstoffstudie_nrw.pdf

the case of large chemical companies fully vertically integrated, or with a pharmaceutical business unit.

The commitment to a more sustainable production can be found across the main contributing industries including chemicals, but also cement and steel, which aim for CO_2 neutrality by 2050 or earlier[33]. The chemical industry already has lowered its CO_2 and greenhouse gas emissions by about 55 % since the 1990s[34]. The further path to CO_2 neutrality of the chemical sector depends on the defossilisation of the feedstock base, but also of the energy sources. The latter is strongly connected to the amount of renewable energies available, as well as the electrification of processes). In 2018, the share of renewable energies in gross electricity consumption in NRW was 14.2 %. The share has increased almost continuously, starting from 0.3 % in 1990. Since the beginning of the 2000s, this increase was significant: from 1.1 % in 2000 to 14.2 % in 2018. This dynamic development can essentially be attributed to the renewable Energy Sources Act (EEG), which first came into force on 1 April 2000 and has since been amended several times.[35]

Linear economies like the chemical sector are moving in the direction of circular systems and there is already measurable commitment inside the company's management. The existing chemical industry sites (*Chemieparks*) are already "Verbund"-sites, where several companies share resources such as water, heat and steam generation, electricity, and waste removal services. They are often also integrated to utilise each other's side-streams as products for different processes. NRW has 13 such *Chemieparks*, some of which are connected to international pipeline networks (see figure 32).

[33] SCI4Climate.NRW - Metaanalyse von Klimaschutzszenarien für die Branchen Stahl, Zement und Chemie, p15
[34] VCI – Energiestatistik 2022
[35] https://www.nachhaltigkeitsindikatoren.nrw.de/a/anteil-des-stroms-aus-erneuerbaren-energiequellen-am-bruttostromverbrauch

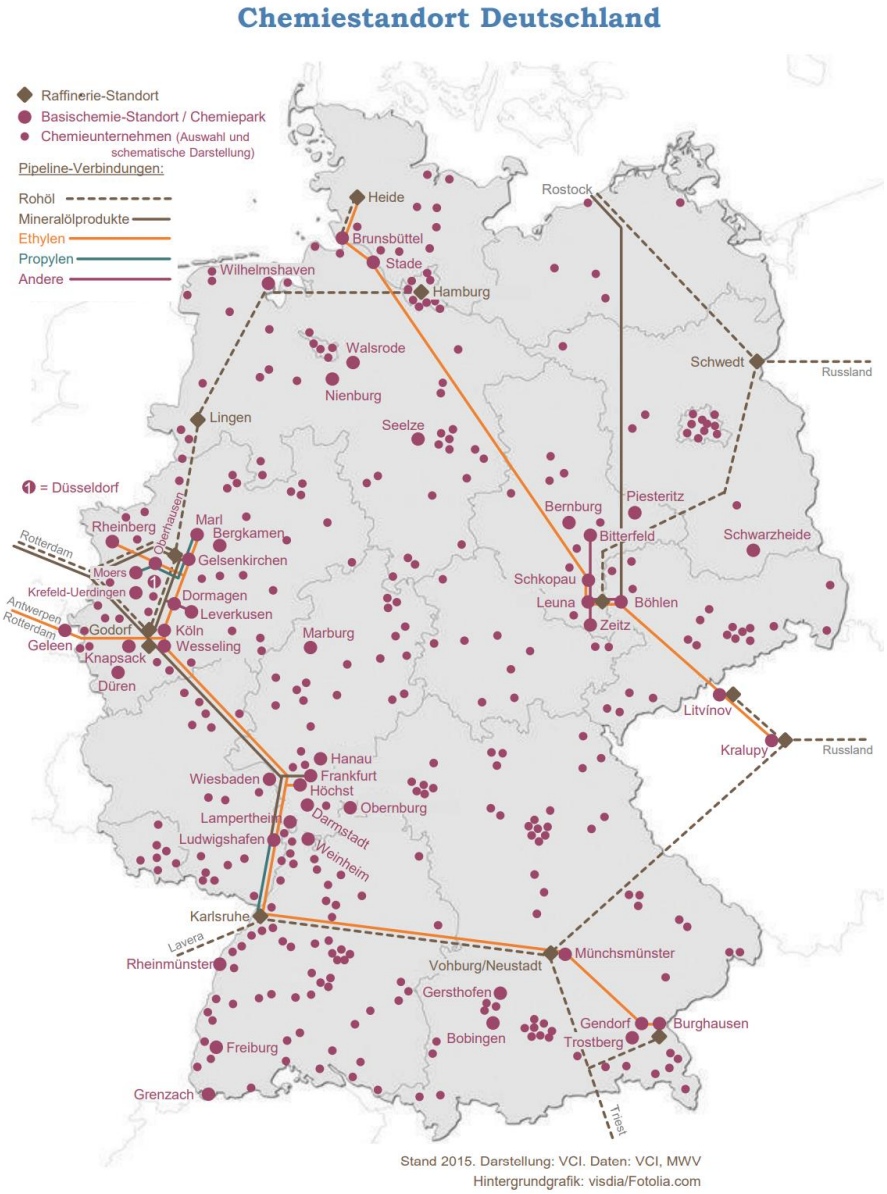


Figure 32: Pipeline network of Germanys base chemical productions and refineries[36]. Large purple dots indicate Chemieparks, where several plants share a common site.

To some degree the principles of circularity are already included in the design of products. This is especially true for the recycling of polymers and will be increased in the future by higher shares of recycled portions of plastics in new products. A good example is the guideline to use 25 % recyclables in new PET products starting 2025 [37],[38]. To achieve this, technical hurdles must be overcome. As it is, the carbon rich naphtha used by the chemical industry is already closing a gap in the linear value chain, because it is a waste product of the mineral oil production. A shortage of raw materials for the organic chemistry is therefore not likely, and other factors will have to drive the shift towards non-

[36] VCI – Branchenportrait 2022
[37] Richtlinie (EU) 2019/904 des europäischen Parlaments und des Rates vom 5. Juni 2019 über die Verringerung der Auswirkungen bestimmter Kunststoffprodukte auf die Umwelt, L155/1, 12.06.2019
[38] Wuppertal Institut für Klima, Umwelt, Energie gGmbH - NRW 2030: Von der fossilen Vergangenheit zur zirkulären Zukunft, 2022

fossil-based feedstocks. Similar to other sectors, like the steel industry, the chemical sector will have to develop solutions to meet the environmental guidelines while still being able to compete on global markets. The future perspective is to reduce the use of naphtha and replace it by hydrogen, or CO_2-based processes. Alternative feedstocks can also be found in plant biomass side streams. Either through extraction of valuable secondary metabolites, or even more versatile, as feedstock for precision fermentation. Especially to produce fine chemicals, biotechnology is a promising enabling technology. Therefore, NRWs[39].

Besides guidelines that are indicatory for Europe, Germany has committed to strategies targeting the development of a strong bioeconomy. The “Bioökonomiestrategie” emphasises on the transition to a more efficient resource management, the introduction of value circles and cascade use of resources. Focussing on biomass as an alternative feedstock, the strategy points out the food first, energy second approach, when using biomass, so (food) waste side streams should be considered specifically. Besides this, the Federal Ministry of Education and Research (BMBF) aims to support the research of new technologies specifically. Details will be published in the “Zukunftsstrategie Research and Innovation” that updates the former High Tech Strategy 2025[40]. Besides other aspects, resource efficiency and environmental protection are highlighted.

Embedded in the strategic plans for Germany, more locally targeted strategies can be found for the 16 federal states. The state government of North Rhine-Westphalia's sustainability strategy is based on the United Nations' Sustainable Development Goals. Within this framework, particular challenges for the region have been identified and explicit strategies developed to meet the 17 SDGs. The further development of the sustainability strategy will be guided by a set of principles, agreed on by all Federal state leaders. These guiding principles are putting the “consistent application of sustainable development as a guiding principle in all areas and in all decisions” in first position[41]. As one of the most present challenges of the region, strategies focus especially on the restructuring of the areas of open face lignite mining by the energy supplier RWE. The end of the lignite mining aera was set to 2038 but was advanced by the current state government to 2030. The following transformation is both a challenge and a chance, since the region is partially shaped by the lignite mining and structural change will impact the landscape, the environment, and the economy in this region of NRW. The federal government has funded this transition in different lignite mining regions in Germany specially to ensure employment[42]. Besides the transformation of the Rhenish Regions the federal state ministries lay out plans for an efficient carbon use and new innovations, which are needed for local transition processes. NRW states in the Innovation strategy NRW and the Carbon Management Strategy, that the regional change to more sustainability and the commitment to the environmental goals has high priority. Especially the chemical industry benefits from a structured transition and an intelligent and sustainable use of alternative carbon-rich feedstocks.

[39] MWIDE, NRW - Die künftige Rohstoffversorgung der NRW-Industrie und Schritte auf dem Weg zur Kreislaufwirtschaft
[40] BMBF - NRW 2030: Von der fossilen Vergangenheit zur zirkulären Zukunft (preliminary 16.11.2022)
[41] Landesregierung NRW - Weiterentwickelte Nachhaltigkeitsstrategie NRW 2020
[42] Strukturwandelstärkungsgesetz Kohleregionen, 08.10.2020

3.4.2 *Limits of linear (fossil-based) economies*

Environmental

The chemical industry in NRW, and indeed Germany, has in recent decades been active in reducing its local impact on ecosystems. Emissions e.g. to waterways and rivers have been drastically reduced, leading to a significant improvement in water quality. Strict regulations on other emissions (noise, sound, wastes) are in place. However, the dependency of the chemical industry on fossil-based resources contributes to climate change and thereby also to a detriment to ecosystem services.

Chemicals themselves are under scrutiny in their effects: the use of pesticides not only "harmful organisms" but also affects many "beneficial organisms". Biodiversity in the agricultural landscape is declining, partly because some animal species are losing their food sources due to intensive plant protection. Biocides from facade plasters and boat paints pollute waterways. Pharmaceuticals help to maintain the health of humans and animals. However, their residues in soil and water pose a risk to the organisms living there. In addition, new effects and risks are coming to the fore: hormonal effects of substances also influence the reproductive capacity of plants and animals at low concentrations. Persistent substances that are difficult to degrade accumulate in the environment and in living organisms. Nanomaterials have a property profile that requires new, adapted investigation methods. Finally, substances do not affect the environment individually, but as mixtures - often their effects add up. As the number one chemical producer in Europe and number four in the world, Germany has a particular responsibility here. Incidentally, increasing international trade also calls for global measures: Many problems of the past in Germany and Europe, such as the insecticide DDT or industrial emissions of dioxins and furans, still await resolution worldwide. Some steps have been taken, but the road to sustainability in chemistry is still long."[43]

As most of the here used fossil resources are imported to Germany, the effects on the environment are not local, but the environmental effects of mining, oil production and transport are felt in other regions around the globe. The same is true for imported renewable feedstocks and other products traded and transported for the use in the chemical industry and beyond. The German government recently passed a legislation that obliges companies to monitor social and environmental standards along the value chain to prevent not only exploitation but also pollution[44].

A local environmental burden is lignite mining with a history of over 100 years in Germany. Locally in NRW, lignite mining had an impact on the whole ecosystem within the 4,300 hectare big mining area, but other regions of Germany are facing similar problems connected to mining operations[45]. In preparation of the mining operations, the ground water level had to be lowered drastically. Pumped water was used for internal processes or relocated. The lowering of the ground water level impacts wetlands in the surroundings and can alter soil quality due to available water, and processes like acidification. As a result of the removal of the upper layers of soil - 355.3 million m^3 in 2019[46] -, farmland and other areas are destroyed, and the material removed is used to create new, artificial

[43] https://www.umweltbundesamt.de/themen/chemikalien#strap1
[44] Gesetz über die unternehmerischen Sorgfaltspflichten zur Vermeidung von Menschenrechtsverletzungen in Lieferketten (Lieferkettensorgfaltspflichtengesetz – LkSG
[45] https://www.nationalgeographic.de/umwelt/2022/02/kohleausstieg-wie-sich-das-rheinische-revier-neu-erfinden-will (last accessed 27.01.23)
[46] Mining Report Glückauf 156 (2020) No. 4

landscapes in former mining areas. The rehabilitation process is not only creation of new landscapes, but also to a certain point the revitalization of the soil to create fertile farmland (Dickmann, 2011). The reduced ground volume from the lignite extraction however remains. Former lignite mining areas in East Germany have been filled partially with water, creating a completely new environment of a series of lakes. This process has to be accelerated by additional pumping and could take many centuries (Freytag & Thiem, 2015). The final level of ground waters, back to pre-mining levels, as well as the fully flooded lakes, may only be reached in the year 2100 in NRW (Krupp, 2015)[47].

Most natural resources have been covered in this section already. Competition in use of all biogenic resources is an issue, as there is no landfill of biogenic wastes and many side streams are already used e.g. in the feed industry, or, as a last valorisation, in incineration plants for heat or power generation. Other resources may include sewage sludge or manure (esp. eastern regions in NRW). These can accrue in large amounts and present a difficult raw material.

Products of the chemical industry are used in applications of everyday life as well as in industrial applications further down the value chain. These products can therefore be found everywhere and contribute to the pollution of the environment. Polluting factors like the accumulation of micro plastics in local rivers and soils or the quality of drinking water are generally monitored in NRW by the LANUV. The load of micro plastic particles was found especially high in rivers running through metropolitan areas like Ruhr or Emscher, however the load in general was not critically elevated[48]. Although they are sometimes considered a significant contributor, waste landfills are not counted as source of (micro) plastic pollution in NRW. Germany follows strict regulations given by DepV[49], which regulates pre-treatment and deposition of wastes that are not recycled or used thermally[50].

Within the analysis of water quality, chemical residues and the temperature of the rivers and lakes are monitored as well, since industrial (not exclusively fossil-based) wastewater streams can have an impact here as well. These wastewater streams are generally channelled into community sewage plants or treated in internal wastewater treatment plants and discharged into rivers. In 2020, roughly 2300 companies were channelling their treated wastewater in rivers in NRW. Problematic are especially chemical residues that are not degraded or filtered in sewage treatment plants. Pharmaceutical residues can have an impact on the environment. As they are usually not coming from the producing industry but the consumers households, the upgrade of water treatment systems (e.g. with ozone based water treatment) is already planned or in progress in NRW[51].

The accumulation of PFAS (per- and polyfluoroalkyl substances, also called forever chemicals) in the environment is a global problem, connected with products that use perfluorated compounds for the treatment of textiles, packaging, cooking supplies and other every day used items. With stricter regulations coming from REACH and other European legislatives, the industry of NRW is, just like its

[47] https://www.lanuv.nrw.de/umwelt/wasser/grundwasser/folgen-des-braunkohleabbaus/tagebauseen (last accessed 30.01.23)
[48] Mikroplastik in Binnengewässern Süd- und Westdeutschlands; Bundesländerübergreifende Untersuchungen in Baden-Württemberg, Bayern, Hessen, Nordrhein-Westfalen
und Rheinland-Pfalz; Teil 1: Kunststoffpartikel in der oberflächennahen Wasserphase, 2018
[49] Deponieverordnung (BGBl. I S. 900) and last revision (BGBl. I S. 2598)
[50] https://www.umwelt.nrw.de/umwelt/umwelt-und-ressourcenschutz/abfall-und-kreislaufwirtschaft/deponien/ (last accessed 31.01.23)
[51] LANUV Entwicklung und Stand der Abwasserbeseitigung in Nordrhein-Westfalen, Vol. 19, 2020

international competitors, searching for alternative solutions that have similar properties to PFAS. Solutions may be biobased materials like modified oils and waxes, that can be sourced locally. These represent interesting applications for bio-based processes.

The abovementioned lignite mining, the burning of coal for electricity, and the associated deterioration of the local environment have a clear impact on climate change. It has been estimated that burning the coal still planned to be mined until 2030 will make it impossible for Germany to stay within the limits required by the Paris Agreement towards the 1.5 °C goal[52].

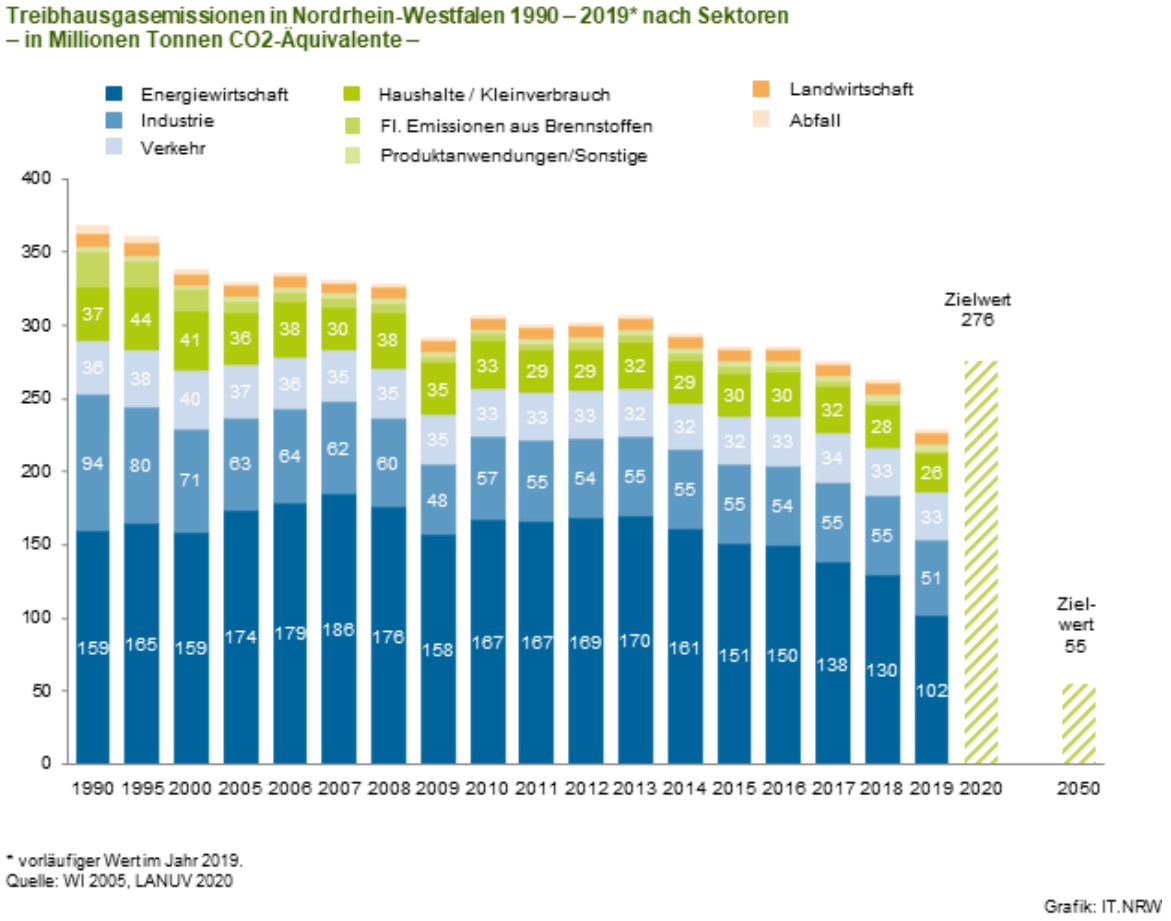
In 2019, around 227 million metric tons of CO2 equivalents of greenhouse gases were emitted into the environment in North Rhine-Westphalia. Compared to 1990, this represents a reduction of 38.3%. The previous 2020 target of reducing GHG emissions by at least 25% compared to 1990 has therefore already been achieved. As can be seen in

Figure ***33***, industry contributed emissions of 51 million tons CO_2 equivalent in 2019. The chemical industry, focus of this case study, contributed 14.9 million tons in 2019 and a reduction was achieved in 2020 with 14.4 million tons CO_2 emitted[53] [54].

The data shown in Figure 33 correspond to the current values at the time of processing. A LANUV publication[55] that has since been published shows the trend in CO2 emissions up to 2021, with total emissions for 2021 amounting to 217.3 million t of CO2eq, of which the chemical sector caused 6.6 %.

[52] EBC/Aurora (bund-nrw.de)
[53] LANUV Treibhausgas-Emissionsinventar Nordrhein-Westfalen Fachbericht 127
[54] LANUV Treibhausgas-Emissionsinventar Nordrhein-Westfalen Fachbericht 131
[55] LANUV Fachbericht 147 Treibhausgas-Emissionsinventar Nordrhein-Westfalen 2021

Figure 33: Greenhouse gas emissions in NRW by sectors 1990 – 2019 by sectors (in million tons CO2 equivalents)



The CO_2 neutrality of the chemistry sector was further investigated in a study for the German Chemical Industry Association (VCI). It proposes different roadmap scenarios, with the nearly complete reduction of emissions as the most ambitious result. This outcome depends mainly on the complete decarbonisation of the German electricity mix and a significantly increased availability of renewable electricity in the immediate future. It would also require investments in technologies that result in CO_2 reduction, no matter the economic outcome[56]. The transition to renewable energy will demand large areas on which wind turbines, biogas plants or solar panels are placed. Especially placement of wind turbines is problematic since NRWs settlement density is high. Possible scenarios of the State Agency for Nature, Environment and Consumer Safety (LANUV) see potential space on up to 1.7 % of NRWs land surface. Optimistic scenarios would however require the installation of wind turbines on conversation areas[57]. Conclusively NRW will see environmental and landscape related changes even in regions that are not directly impacted by the remnants of mining industry.

Although the chemical industry has increased its productivity and at the same time lowered its GHG emissions and the amount of energy consumed, the reduction of fossil raw materials is a rather slow process. North Rhine-Westphalia's industries have proven to be very innovative in the past, however with its focus on fossil fuel derived base chemicals, the transitional challenge is higher than in other sectors. Most of the linear production systems require fossil raw materials, that are rich in carbon

[56] Roadmap Chemie 2050
[57] LANUV Potenzialstudie Windenergie NRW Fachbericht 124

(mainly naphtha). Alternative renewable sources are hard to find, can be difficult to source sustainably, require drastic changes in production lines and heavy investments to compete on the international markets[58]. Solutions that use renewable feedstocks are most used in the production of fine chemicals, or fuels for transportation.

From the environmental perspective the biggest challenge lies in the transition process to renewable, biobased feedstocks. Closed branches of the chemical industry in NRW and Germany might result in alternative productions in other countries with a relocation of environmental burden[59]. The change to bio based raw materials results in higher demands of sugar, starch, and oil crops. These must be imported or grown locally. The latter is viewed critically in regard of the indirect land use change (ILUC), as it is already discussed for energy crops cultivation and a legislature of the EU is regulates the cultivation of crops that are most likely to lead to ILUC[60].

Economic

The materials used are under normal market fluctuations. Since the main raw materials are oil, natural gas, and partially coal, worldwide shortages have high impacts on prices. Recent events, like the Covid-19 pandemic and the invasion of Ukraine and the geopolitical dislocations, therefore, have high impacts on the availability and the price structure of raw materials used in the chemical industry. In general, primary raw materials are bought on international markets and prices are usually bound to the stock market or temporarily fixed via contracts[61]. Companies who recently had to refresh their contracts faced heavily increased prices. There are few deposits of natural fossil resources besides lignite. Shale gas deposits have been explored within the last twenty years, however legislative restrictions and environmental reservations have forestalled access. Additionally, there are small deposits of oil known, however not of economic importance[62,63].

As an energy intensive industry, electricity is a cost relevant factor for the regional chemical industry as well. Prices for electricity fluctuate and the availability of renewables affects the amount of conversion of fossil fuels to electricity. With the end of open face lignite mining and the burning of coal for electricity generation, the reliance on renewable energy, imported from other regions or countries, will increase. As stated above, the industry will have to change processes and reduce the amount of fossil energy fuels for process heat and as a resource base for chemical conversion. Even in a continued linear economy, the amount of energy needed will increase and consequently the extension of renewable energy will be required, since fossil-based energy has been targeted for a phase-out.

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[58] Roadmap Chemie 2050
[59] MWIDE - Rohstoffstudie NRW und Fact Sheets - Die künftige Rohstoffversorgung der NRW-Industrie und Schritte auf dem Weg zur Kreislaufwirtschaft
[60] Commission Delegated Regulation (EU) 2019/807 of 13 March 2019 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council as regards the determination of high indirect land-use change-risk feedstock for which a significant expansion of the production area into land with high carbon stock is observed and the certification of low indirect land-use change-risk biofuels, bioliquids and biomass fuels; L133/1, 21.05.2019
[61] MWIDE - Rohstoffstudie NRW und Fact Sheets - Die künftige Rohstoffversorgung der NRW-Industrie und Schritte auf dem Weg zur Kreislaufwirtschaft, 2021, p.17
[62] https://www.gd.nrw.de/ro_er.htm (last access 26.01.23)
[63] MWIDE - Rohstoffstudie NRW und Fact Sheets - Die künftige Rohstoffversorgung der NRW-Industrie und Schritte auf dem Weg zur Kreislaufwirtschaft, 2021, p.152

Estimations say that the energy demand of a complete decarbonised chemical production in 2050 would reach up to 685 tWh per year, which is more than the energy production of Germany in 2018[64].

The recent and ongoing crises have led to higher prices of primary resources and electricity which in turn have led to higher production costs and in consequence higher prices for consumers. Although price increases and inflation were not as high as feared, the chemical industry is still facing high prices and instabilities. High energy prices will stay problematic and are slowing the economic recovery from the pandemic[65] [66]. These might also impact investment decisions, either by delaying the deployment of capital, or informing decisions on innovations to become more resilient to these external factors.

The chemical industry in Germany already uses renewable resources, these make up 13 % of the total feedstock used (in 2019). These are predominantly plant oils, and sugars. Of the 137 million tons of biomass produced in Germany by agriculture (2015), the largest share of agricultural products used in either for material or energy use were plant oils with 28 % and 34 % respectively. The main feedstock here is rapeseed, which is also used for food, animal feed, and other products. To cover the industries' demands, imports of more than twice the Germany wide production of rapeseed are needed[67]. Compared to other German states, NRW only has a medium sized area for the agricultural production. Instead of rapeseed, NRW focuses on the culture of sugar beet (and potato) with an area under cultivation of 61,000 to 81,000 hectares[68] [69]. Sugar beets are the main local source of sugar, which is mainly used in the food sector, but are also interesting as an alternative feedstock for the chemical sector and pharmaceutical applications. The prices and availability of sugar, 608.000 tons were imported into Germany in 2019/2020[70], depend on the global production and are directly connected to the non-food uses of sugar worldwide, like the production of bioethanol. For the local production of sugar, sugar beets are a direct source, but also potatoes and other starch rich crops are needed to produce sugar via hydrolysates[71]. This use of renewable feedstocks is not yet integrated in a circular bioeconomy, but is rather seen as an extension of the feedstock base in a linear economy.

With the focus on non-food raw materials, especially side streams, or waste streams, are of interest. Sugars and fibres from plant residue side streams and oils or proteins from plant and animal industries are considered interesting feedstocks. Although a lot of research is undertaken, economically feasible solutions are rare. First marketable products can be found in the production of bio-plastics, bio-lubricants and adhesives[72], which is welcomed by the industry itself to create feedstock flexibility and resilience of production pathways.

North Rhine-Westphalia's industries have proven to be very innovative in the past, however with its focus on fossil fuel derived base chemicals the transitional challenge is higher than in other sectors,

[64] Roadmap Chemie 2050, p.9
[65] MWIDE – Konjunkturbericht NRW 2021_1
[66] MWIDE – Konjunkturbericht NRW 2022_2
[67] https://www.ovid-verband.de/artikel/meldungen/deutschland-ist-zunehmend-auf-rapsimporte-angewiesen (last access 27.01.23)
[68] Statistisches Bundesamt, Statistisches Jahrbuch 2019, p. 500
[69] IT.NRW - Landwirtschaft in Nordrhein-Westfalen Ergebnisse der Agrarstrukturerhebung 2016. p22
[70] Bericht zur Markt- und Versorgungslage Zucker, 2022. Bundesansstalt für Landwirtschaft und Ernährung und Bundesinformationszentrum Landwirtschaft
[71] Dr. Wolfgang Heer - Industriezucker – Anforderungsprofil und Märkte
[72] BMBF /BMEL – Bioökonomie in Deutschland 2022

especially for the organic chemistry industry. While production of NRW´s chemical industry moved in parallel with Germanys overall production capacity in the past, high investment costs, a lack of workforce, and high energy prices have hit the organic chemistry sector harder. Investments into production facilities in the past still keep NRW´s chemical industry at the leading edge today, but in the long run the transition of the industry require drastic changes in production lines and heavy investments to compete on the international markets[73].

Social

Currently, the region has 17.9 million inhabitants, who are on average 44 years old (slightly lower than the national average) and 32 percent of which have an immigrational background. The population of NRW is projected to shrink by 5 % until 2050. The number and percentage of older people will increase significantly by then.[74] Legally, women and men have equal rights in Germany and NRW, but in practice, women are underrepresented in many areas of society, politics, and work, as stated by the NRW Ministry for Equality[75]. For example, 46.6 % of women were working part-time, as opposed to 10.4 % of men (2017). For the chemical industry, employees from STEM areas are especially important. Here, a clear gender dimension can be seen, as women are less represented in STEM professions than men. Women make up only 14.5 per cent of employees subject to social insurance contributions in NRW. Among trainees, the proportion of women is even lower at 9.4 per cent. The situation is a bit more balanced in academic education in STEM fields. In 2017, 34.4 % of students were female, 65.6 % male . Overall, the ratio of men to women starting university studies is more balanced, with 52.2 % male and 47.8 % female students commencing in 2017. This is similar for apprenticeships and non-university education, where the fraction of women starting training is 44.2 %, but their participation in STEM-related job training is only 11.1 % (2017). No data about persons identifying as neither male nor female is available.

With the aging community, the demand of more elaborate medical care will increase, as will the need for medicines. The sector of the pharmaceutical chemistry, also partially dependent on fossil-based feedstocks, will benefit from this development and is already showing constant market growth[76]. At the same time, here lies short term potential for a transition to a greener chemistry. As the origin of biopharmaceuticals, the branch of red biotechnology is interesting and has grown rapidly over the last decade. In NRW several companies are researching and producing (bio)-pharmaceuticals and are therefore part of a rapidly growing marked[77] with new jobs being created.

Structural change has been in constant in NRW for the past decades. The Ruhr area has seen coal mining cease completely, and steel production and automotive manufacturing severely reduced. Heavy industry has been wound down, leading to a large workforce in need of retraining and re-skilling. Young people had to find new fields in which to train for and search employment. The Ruhr area has shifted to a service industry. Not all cities benefitted, with some regions still having high

[73] MWIDE - Rohstoffstudie NRW und Fact Sheets - Die künftige Rohstoffversorgung der NRW-Industrie und Schritte auf dem Weg zur Kreislaufwirtschaft, 2021, p. 69
[74] https://www.demografie-portal.de/DE/Fakten/bevoelkerung-altersstruktur-nordrhein-westfalen.html;jsessionid=9CBEB8B672BCE6FB4257296170DE13BD.internet271
[75] https://www.mkjfgfi.nrw/menue/gleichstellung/ziele-der-gleichstellungspolitik/gleichstellung-nordrhein-westfalen
[76] VCI – Analyse Basischemie 2030, p13
[77] Biotech-Report - Medizinische Biotechnologie in Deutschland 2022

unemployment. In the Rhenish mining region, open lignite mining will be phased out by 2030, meaning the structural change is currently ongoing. Again, this means loss of employment, around 14,000 jobs are to be cut. With the funding programme and a shift to circular bioeconomy, policy makers expect over 25,000 new jobs to be generated by 2038[78] (the projected end of the structural change support). Here, the aim is to create a bioeconomy and circular economy model region, drawing on assets of agricultural land and research institutions.

The close proximity to other relevant industrial hubs in The Netherlands and Belgium, as well as an attractiveness to immigrants can bring people into the region, who also bring with them new cultures and potentially a more entrepreneurial spirit. This is seen as an asset of the region and might have a positive impact on the transition to a bioeconomy.

For the transitioning state of NRW the future perspectives of employment, especially in the area of the closing lignite mining structures, are still vague and depend on new structures and businesses being build. It is clear though, that the demand of people qualified in STEM related subjects is high. With a transition to more sustainable production processes new job focusses will arise, which might require new sets of skills. For these skills to be taught in the form of educational programs or further training, the demands of companies and businesses in specific skillsets have to be made transparent to the educating facilities[79].

As region, NRW combines both highly urbanised and industrial areas with large rural regions. For both types, the state has identified local areas in need of specific support (with funding available) - See Figure 34.

[78] Wertschöpfungs-und Beschäftigungseffekte der Strukturförderung im Rheinischen Revier Studie IDW, 2021
[79] BildungsRAUM Rheinisches Revier, 2022, Wilts, H., Berg, H., Seyring, N., Vahle, T., Herrmann, S., Kick, M., Müller-Kirschbaum, T. NRW 2030: Von der fossilen Vergangenheit zur zirkulären Zukunft Impuls für eine wirtschaftspolitische Agenda

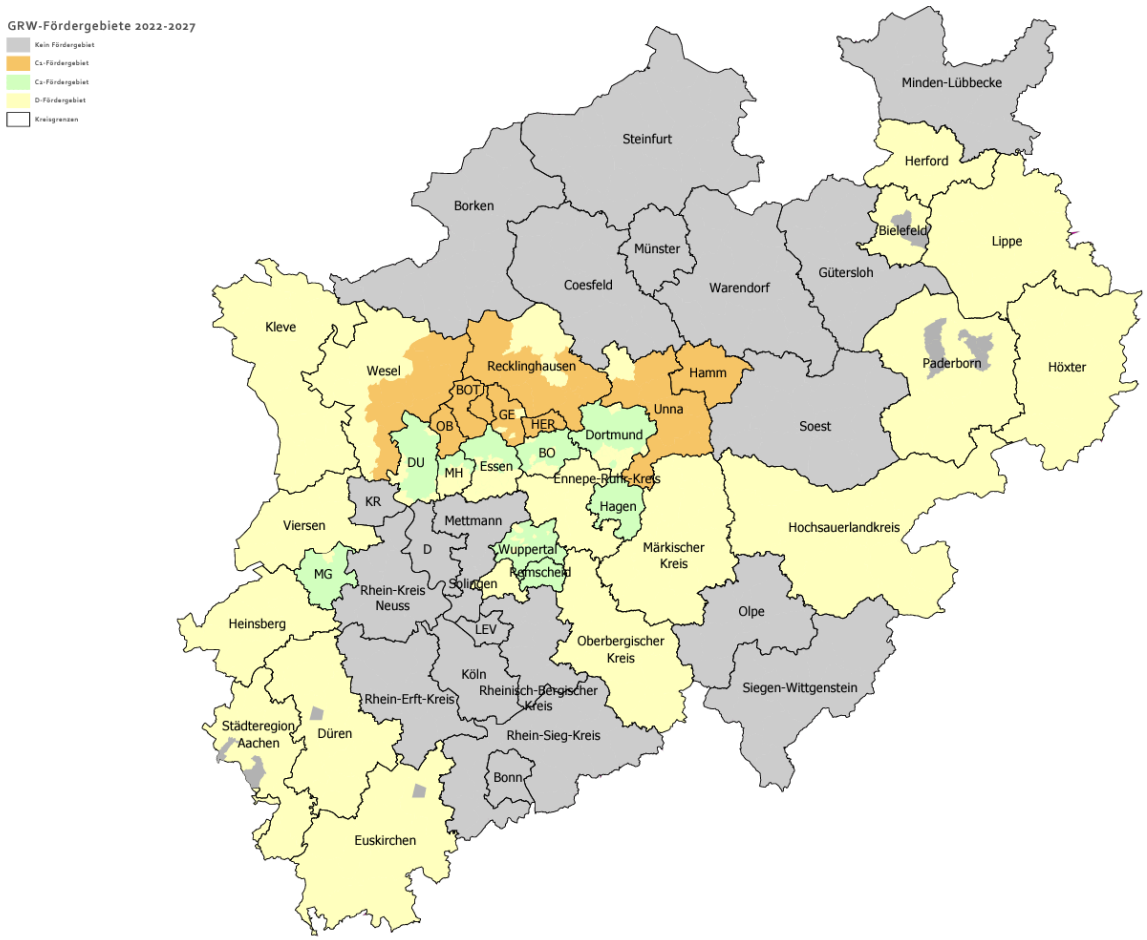

Figure 34: Map of NRW with regions eligible for state funding under GRW (Improvement of local economic structures) highlighted. Grey: no funding, orange level C1, green level C2, yellow, level D.

Whether consumers are interested in greener and more sustainable alternatives heavily depends in the market and consumer perception. In general, there is high interest in ecologically produced food and ingredients and the tendency to invest money in companies perceived as sustainable grows[80]. This is partially a result of better communication and advertisement. The consumers interest in ingredients, properties and ecological impact of consumer goods has increased, especially in the group of so called LOHAS (people aiming for a Lifestyle of Health and Sustainability), which account for roughly 15 % of the population in Germany[81].

The perception of a greener and more sustainable lifestyle varies greatly[82]:

- 72% of Germans see a sustainable lifestyle as key to their own health so sustainable foods and cosmetics are easily approached.
- 82 % are prepared to move away from a throwaway society toward a circular economy and are in favor of longer product life cycles and greater material efficiency.

[80] "Grüne" Produkte: Marktzahlen | Umweltbundesamt (last accessed 30.01.23)
[81] Kamlage et al. HiPerIn project 2023
[82] Otto Group 5. Trendstudie zum ethischen Konsum

- 77 % of Germans are in favor of industrialized countries taking more responsibility in the fight against climate change and support poorer countries in this.
- 63 % are willing to pay more for climate-neutral products.
- 60 % of Germans can imagine paying the "true cost" of environmental pollution and climate change when shopping.
- 46 % can well imagine using more animal-free meat from plant-based production.

Still, reality shows that the price remains the most important criterium for individual consumption and lifestyle decisions. While sustainability is seen as important, the majority lacks the willingness to invest in sustainable actions (Venghaus, Henseleit & Belka, 2022). The general concept of bioeconomy however is not fully understood and buzzwords like “biobased” and “biodegradable” are not clearly separated. Additionally, consumers have a distorted understanding when it comes to value chains[83]. The parts of a products life span that involve the consumer directly (use, disposal, re/upcycling) are often perceived, but not the parts of production, transport and sourcing.

3.4.3 *Barriers of current economies to achieve relevant sustainability goals*

All regional strategies and policy papers in NRW are aligned with the Green Deal and the UN SDGs. The goal of climate neutrality has also been set for NRW, with the region setting itself the target of achieving this in 2045. Progress achieved is monitored for the region by the NRW statistics office[84].

NRW will develop its own bioeconomy strategy as taken first steps towards this. It will also instate a Bioeconomy Council. While the state had developed the first bioeconomy strategy already in 2014, this no longer pertinent or indeed available.

The German National Bioeconomy Strategy 2030 sees bioeconomy as a sustainable model for the economy, which uses biological resources and knowledge, to develop new products and processes via innovative technologies. In the bioeconomy, renewable bio-based resources are the basis for food, materials, and energy. The strategy declares six main goals:

- Develop bioeconomic solutions for the sustainability agenda
- Identify and develop potentials of the bioeconomy within ecological limits
- Expand and apply biological knowledge
- Aligning the resource base of the economy in a sustainable way
- Develop Germany into the leading innovation location for the bioeconomy
- Involve society, intensify national and international cooperation

North Rhine-Westphalia adopted its first sustainability strategy in 2016. In September 2020, the state government released an updated version of this first strategy.[85] It looks at the specific sustainability challenges in the state and provides a roadmap for a sustainable NRW by 2030. The framework for

[83] Kamlage *et al.* HiPerIn project 2023
[84] https://www.it.nrw/europaeischer-green-deal
[85] https://nachhaltigkeit.nrw.de/

NRW's sustainability strategy is provided by the 17 UN SDGs for 2030. Sustainability in NRW means providing everyone with a socially acceptable future in harmony with the environment. NRW has developed a set of 67 sustainability indicators and goals. These are summarised under the respective SDG, formulated with indicators and regional contributions, and allocated to a regional ministry[86]. Relevant SDGs for this case study are 8, 9, 12, 13, and 15. Related to these, the following sub-goals are stated (amongst others) for NRW:

- Use resources economically and efficiently
- Increasing economic efficiency in an environmentally and socially responsible way
- Increase employment levels, especially among women
- Create new solutions for the future
- Support sustainable lifestyle and consumption
- Increase share of sustainable production
- Increase share of sustainable public procurement
- Reduce GHG emissions
- Protect sustainable forestry
- Protect ecosystems, ecosystem services and habitats

The Regional Innovation Strategy[87] covers the period 2021 – 2027 and sets out how innovative solutions can be found to rise to the societal, economic, and global challenges. This sets the framework for funding of research and innovation, thereby paving the way towards innovations which will also help the circular bioeconomy. Of the innovation fields identified, especially “innovative materials and intelligent production” is relevant to this case study. It includes the chemical industry, specifically in areas of bioeconomy/biotech applications and processes, biobased feedstocks; but also innovative process and recycling technologies for biobased materials. Biotechnology is considered one of the key future technologies.

NRW has a climate protection law[88], which stipulates a 25 % reduction in GHG emissions compared to 1990 of 25%, and by 2050 of at least 80%. While the 2020 goal had already been achieved in 2017, the future reduction in emissions will be challenging. A carbon management strategy[89] has been developed to achieve GHG reductions. This is focusing on a) reducing the amount of carbon needed in industry b) alternative carbon sources, prioritising secondary resources over biomass c) climate-friendly production processes and d) design for recycling.

One key goal is the reduction of greenhouse gas (GHG) emissions and increasing the share of sustainable production. A strong focus lies on green hydrogen and renewable energy supply for the

[86] “Die globalen Nachhaltigkeitsziele konsequent umsetzen. Weiterentwicklung der Strategie für ein nachhaltiges Nordrhein-Westfalen”. pp. 79 - 83
[87] Regionale Innovationsstrategie für Nordrhein-Westfalen 2021-2027, MWIDE
[88] https://recht.nrw.de/lmi/owa/br_bes_text?anw_nr=2&gld_nr=7&ugl_nr=7129&bes_id=46232&aufgehoben=N&menu=1&sg=0
[89] Kohlenstoff kann Klimaschutz Carbon Management Strategie Nordrhein-Westfalen. (2021). www.wirtschaft.nrw

industry. Diversification of feedstocks and an improved valorisation of existing side- and waste streams is important to be competitive and improve resource use.

The state bank NRW.Bank has performed an SDG mapping of its activities[90] to transparently show the sustainability effects of its financial support to local companies and entrepreneurs.

The main barriers for the chemical industry in NRW pertain to ecological aspects of sustainability. Decarbonising the energy supply and defossilising the materials supply are necessary to reduce the carbon footprint of the sector. The existing system of industrial symbiosis in the chemical industry is challenging to transform, having grown over decades and having been optimised to the current, strong economy in the region. Changes to this system usually require large, and long-term investment difficult to commit to by any single stakeholder.

The expected increase in cost of CO_2 emissions, and the ECTS will become limiting to the current linear economy.

Expert workshops and previous projects have identified (amongst others) the following barriers to implementing a circular bioeconomy:

Technical barriers

- Diverse feedstocks, heterogenous composition, fluctuations in quantity and quality
- Balance of raw material flows do not fit cascade use.
- Complex conversion routes from biogenic feedstock to chemicals, not yet easy to scale up to industrial processes.

Structural:

- Existence of optimized processes, with assets and pre-existing infrastructure
- Limited connections between the feedstock providers and conversion points
- Limited connection between existing value chains
- Diverse and competing interests between incineration plants, actors in recycling and or composting, competing use of biomass for material use or heat generation
- Diverse local bioeconomy parameters within the region
- Diverse landscape of municipal waste agencies
- Legislative framework governing transport of waste, lack of end-of-waste legislation
- Limited infrastructure such as lab spaces, upscaling capacities/open innovation scale-up plants
- Innovation ecosystem needs to be improved

Other:

- High cost associated with novel technologies.
- Large upfront investment to build new plants for circular bioeconomy
- Products will most likely be more expensive, potential loss of functionality.
- Lack of sufficiently skilled workforce, expected lack of researchers

90 https://www.nrwbank.de/export/.galleries/downloads/Dafuer-stehen-wir/Nachhaltigkeit/Methodenpapier-SDG_Mapping.pdf

3.5 Region of Western Macedonia - Greece

3.5.1 *Current status, trends and future of regional of linear (fossil-based) economies*

Western Macedonia is a mountainous, rural region divided into four regional units and the only landlocked region in Greece. It is approximately seven times smaller than its neighbour region of Central Macedonia, in population, and its GDPs compared to the other regions of Greece, have been between the last 5 last positions historically (ELSTAT, 2024). It is endowed with rich natural resources, as well as natural beauty, although the former has traditionally worked to the detriment of the latter. Major lignite deposits have turned it into the heart of Greek electricity production since the mid-20th century, causing environmental degradation and health issues. Other manufacturing activities include traditional sectors such as marble, saffron, fruits, local wines, furs and leather manufacturing and specialised arts and crafts. In the services sector, retail and wholesale trade, tourism and public administration services are the most important sectors in terms of value-added (Kogut-Jaworska and Ociepa-Kicinska 2020; Maniati et al. 2021).

Since the beginning of the survey of indicators of Elstat regarding employment, in 2000, Western Macedonia has been between the 5 last positions of employment in Greece. The region also has one of the highest youth unemployment rates in the EU. In 2023, according to Eurostat (2024), it had a total of 26.2% considering both genders in the ages of 15 to 29 years old, which was classified between the 8 last regions in a list of 427 regions of NUTS 2 from all the regions that have updated data. Furthermore, comparing with Greece regarding both genders, the region has the last position for young men employed (27.7%) and for young women, is between the 5 last, with 24.7%.

Besides the level of unemployment and low competitiveness, which was magnified by the crisis, as well as discontinuities in local Research and Innovation (R&I) policies, the local economy is characterised by small companies and traditional industries that totalizes 38,240 legal units distributed in the 4 regional units (ELSTAT, 2021). Deindustrialisation and the migration of labour-intensive industries to neighbouring low-cost countries have hit an already weak economy (Reid et al. 2012). This situation is further exacerbated by an ambitious ongoing transition from coal, with the region's power stations scheduled to all shut down by 2028 (Koutsandreas 2021). This threatens to further increase unemployment and poverty, including energy poverty, unless important measures are taken to compensate for it (Karagianni and Pempetzoglou 2021; Karasmanaki et al. 2020; Koutsandreas 2021).

Western Macedonia had four S3 (Smart Specialisation Strategies) priority sectors in total, which simply reflected key activities in the region, including traditional activities. These were (1) Agrofood, (2) Environment and Energy, including integrated waste management and district heating (only in the regional units of Kozani and Florina), (3) Breeding of fur-bearing animals and manufacturing of leather products (only in the regional units of Kastoria and Kozani) and (4) Tourism. This is a low number of priorities compared to most EU regions. Unlike other European regions in a transition from coal, which often focus on technologically advanced priority sectors, the focus in Western Macedonia is on sectors that are related, not very complex and closely aligned to the region's economic profile (Kramer and Sirtori 2021).

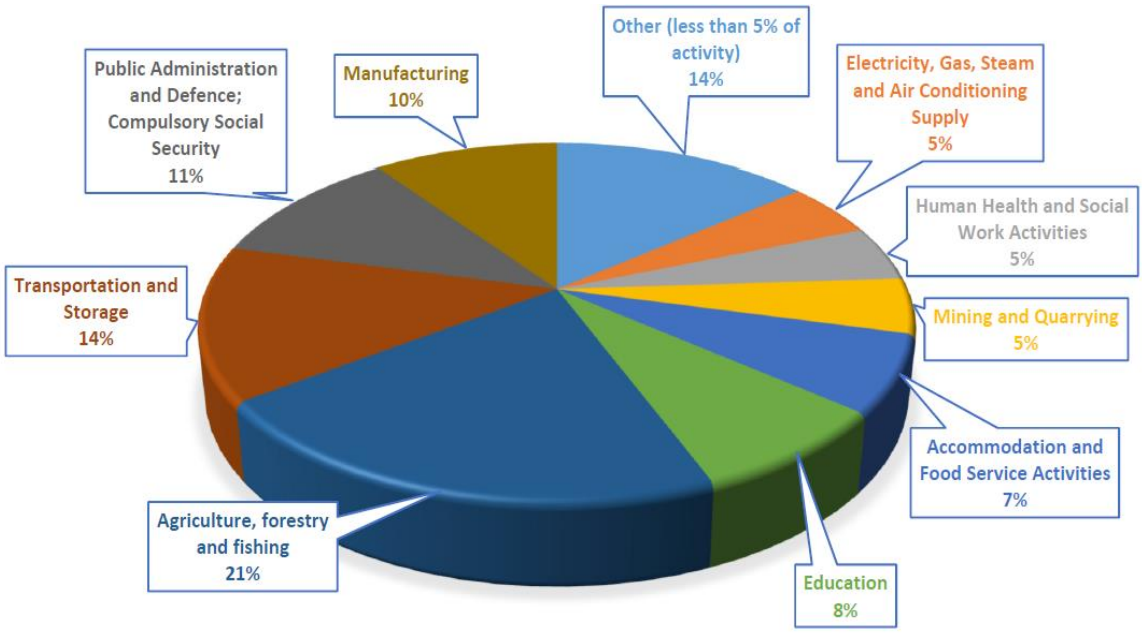

Figure 35: Structure of employment by sector in Western Macedonia (Ziouzios et al. 2021)

The linear fossil fuel-fired electricity system is linked with the increases in carbon dioxide and greenhouse gas emissions over the last decades. This has led to a strong political consensus on the reduction of these emissions. Indicatively, in 2019 natural gas accounted for 33.96%, coal (lignite) for 33.90%, renewables for 21.54% and hydropower for 10.60% in the electricity mix in Greece. Despite this progress, in order to conform to the air pollution prerequisites of the European Union (Integrated Emission Directive 2010/75/EU), the Public Power Corporation proclaimed a large-scale decommissioning schedule which plans the retirement of lignite plants, that involves the closing of 55% of lignite units by the year 2030, in compliance with the air pollution requirements set by the European Union through the Integrated Emission Directive 2010/75/ EU. More specifically, between 2010 and 2016, the Public Power Corporation decommissioned 8 lignite units (6 in Western Macedonia and 2 in Peloponnese) with a total capacity of 913 MW. In addition, PPC had to put 6 lignite units of a total capacity of 1,850 MW (all located at Western Macedonia) under restricted operation. Thus, from January 2016, these units operate around a third of the time they used to, before completely withdrawing at some point until 2023 at the latest. From the remaining 8 units with a total capacity of 2,525 MW that operate at full power, the 6 are located in Western Macedonia, which has traditionally been Greece's main energy producing region (Karasmanaki et al. 2020).

In Western Macedonia, agri-food, environment and energy and tourism remain quite relevant and promising. The breeding of fur-bearing animals, however, is another 20th-century leftover of regional tradition. In addition, it has no prospects of adapting to the 21st and it is no longer relevant. Fur, apart from being environmentally damaging and unethical, can be a risk for the spread of animal viruses to humans (Xia et al. 2020). In addition, European countries have already started to ban fur trading and are on their way to eventually phasing out the practice, with the Netherlands setting the goal of doing so in 2024 (Xia et al. 2020).

This outdated practice can also be replaced in Western Macedonia, where this priority sector can be replaced with bioeconomy, which has a great deal of potential in the region through industrial coexistence, research and innovation activities and the production of innovative or high value-added environmentally friendly materials (Tsipouri et al. 2021). In fact, through the use of new technologies,

online platforms and industrial symbiosis, the region can turn into a bioeconomy hub (Dounavis et al. 2019). Current data testify that there are significant opportunities for the region, as well as Greece in general, to progress towards a lucrative economy based on renewable resources (Papadopoulou et al. 2018). In addition, the region's natural beauty represents an opportunity to add value to the tourism section and orient it towards eco-tourism (Schismenos et al. 2019).

Furthermore, Western Macedonia is aiming at eventually substituting lignite with Renewable Energy Sources (RES) for energy production (both electricity and heat) and bioenergy may provide an important part of this energy. In general, bioeconomy can become one of the decisive factors and major pillars for the post-lignite era in Western Macedonia (Papadopoulou et al. 2018).

Bioeconomy can become a "technological support sector" for many other activities in Western Macedonia, as new developments create opportunities for rural development based on emerging technologies, the relevance of distance in marketing, sales and many other activity domains and business opportunities evolving within the bi-economy and ecosystem services. The realisation of these opportunities needs to build on the simultaneous engagement of various stakeholders in business development, research and public administration (Schiefer 2019), therefore making S3 the ideal instrument for producing this effect in the region. This is also in line with most European regions that are transitioning from coal, which are turning towards more advanced technologies for their strategic priorities (Kramer and Sitrori 2021).

These goals are ambitious but realistic, and several active national, regional and local plans work towards them. These include:

- National Strategy for the Circular Economy 2018-2030
- National Energy and Climate Plan 2030
- Long-term Strategy 2050
- National Air Pollution Control Program 2020 – 2029
- National Development Program 2021-2025
- National Biodiversity Strategy
- Development Plan for the Greek Economy
- National Recovery and Resilience Plan
- National Waste Management Plan
- Regional Waste Management Plans
- Regional Social Inclusion Strategy
- Digital Transformation Bible
- Operational Plan for the Sustainable Urban Development Strategy of Western Macedonia, Municipality of Kozani, Municipality of Florina
- Integrated Spatial Investment for the Utilization of the Lakes of Western Macedonia. (JTDP 2021)
- National Research and Innovation Strategy for Smart Specialization 2021-2027

It is possible to observe that efforts through public policies are being done. Despite that, it is still not enough as it needs a long way to achieve the ideal indicators of sustainability indicated by the Sustainable Development Goals - SDG. According to the indicators from 2022 of the Europe Sustainable Development Report (2024), from the general list of SDGs between all the countries of

Europe and the average of the continent is 72.02 points, Greece is in the 29th position of 35, with 65.71 points.

Except for regional/national policies, the region of Western Macedonia adopts relevant sustainability goals from SDGs, Green Deal and EU Biodiversity Strategy.

In September 2015, in the context of the 70th General Assembly of the United Nations, the 17 universal Sustainable Development Goals were adopted with an implementation schedule until 2030. For their implementation all countries made commitments taking into account different levels of development and national policies and priorities (JTDP, 2021). Most of the Goals are very relevant for Western Macedonia, as they include the implementation of actions to ensure clean energy, environmental protection and adaptation to climate change, innovation and infrastructure, care for the development of quality employment and economic prosperity, sustainable development, and ensuring quality education and health for citizens.

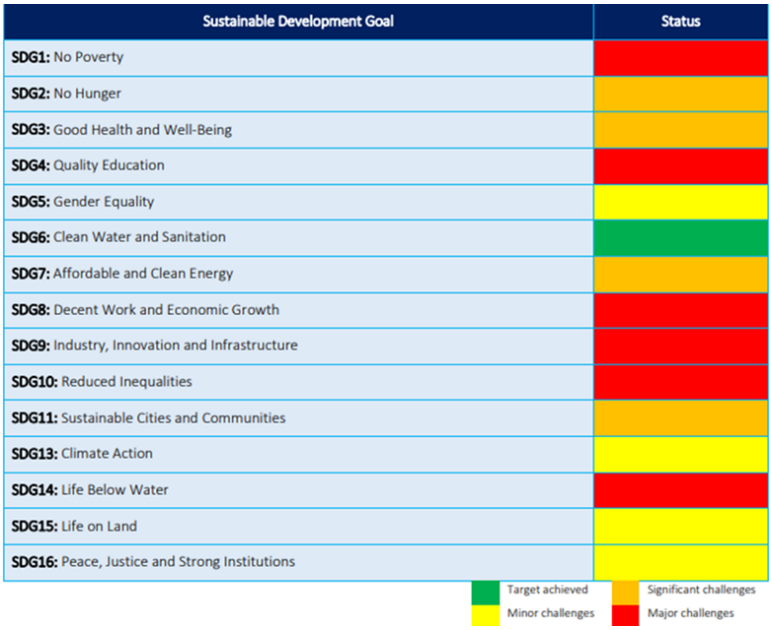

Figure 36: The SDGs status for the region of Western Macedonia (Koundouri, P, et al, 2022)

The region of Western Macedonia faces major challenges in achieving six SDGs (namely 1, 4, 8, 9, 10 and 14), as seen in Figure 36. It is indicative that more than 32% of the inhabitants are at risk of poverty or social exclusion, whereas slightly more than 17% of those living in cities face severe material deprivation (Eurostat, 2020).

The region met SDG 6, whereas there are only minor challenges in order to achieve another four SDGs (namely 5, 13, 15 and 16) (Figure 36). In fact, more than 96% of inhabitants have in-house bathrooms. Moreover, only 2.7% of the land is covered by artificial surfaces and the ratio of forestry to total land use stands at 0.45 (Eurostat, 2018).

The European Green Deal was presented on December 11, 2019. It includes the EU's development strategy with environmental goals and a corresponding road map for their sustainable achievement. It provides for the provision of targeted and structured technical support and funding. In particular, the European Green Deal includes a comprehensive action plan, aiming to strengthen the efficient use

of resources, through the transition to a clean, circular economy, the restoration of biodiversity and the reduction of pollution (JTDP, 2021). Based on the previous sections, this seems key for Western Macedonia in particular.

This plan outlines how a fair and inclusive transition to a clean economy can be ensured, while outlining the investments required and the financial instruments available to achieve it. In particular, the following are expected: investing in environmentally friendly technologies, supporting innovation in the industrial sector, developing cleaner, cheaper and healthier forms of private and public transport, decarbonising the energy sector, ensuring the energy efficiency of buildings, working with international partners to improve global environmental standards. All these are highly relevant goals for the region of Western Macedonia (JTDP 2021).

According to the EU Biodiversity Strategy, key commitments by 2030 include the protection of a minimum 30% of the EU's land area, 30% of the EU's sea area and integration of ecological corridors. Furthermore, strict protection is provided for at least a third of the EU's protected areas, including all remaining EU primary and old growth forests. It also refers to the effective management of all protected areas, defining clear conservation objectives and measures.

Related to the above proposals of the Strategy, the Regional Unit of Western Macedonia, in conjunction with the effort to implement the corresponding previous plan (2020), has set some more specific goals for the needs of the region. A primary concern is the improvement of knowledge about biodiversity as well as the strengthening and management of protected areas. The next goal is highlighting the value of its biodiversity in combination with its connection to the local economy and employment. Finally, Western Macedonia is attempting to organise and operate new structures and services for the management of the natural environment, to achieve the EU's goals.

3.5.2 *Limits of linear (fossil-based) economies*

Environmental

It is well known that human activity, and especially pollution from fossil fuels, has caused an environmental burden that can lead to the reduction or disappearance of part of the biodiversity, soil and water pollution and in many cases risks regarding human public health (Kourkoulouki 2021). Since the future of lignite in Greece, like elsewhere in the EU, seems short, given the stricter European environmental legislation regarding the rest of the air pollutants, as well as the competition with renewable energy sources, the region of Western Macedonia must invest in methods of environmental restoration. In the Region of Western Macedonia, where almost all the country's lignite units are located, pollution is very high (Kourkoulouki 2021).

The intensive exploitation of the lignite deposits of Western Macedonia, which began in 1956, escalated at a very fast pace, covering for decades most of the electricity consumption in Greece. At the peak of lignite activity, between the years 2001–2004, lignite production in Western Macedonia exceeded 55 million tons per year (Figure 37), followed by a decline to the levels of 30–45 million tons in the decade 2005–2015. Assuming that lignite activities will be terminated in 2028 (due to the closure of the lignite power plants), it is estimated that the mined lignite in the period 1956–2028 accounts for 1,792 million tn, which is equivalent to 235 million tn of oil, i.e., as much as the country's oil imports in the last 15 years (Ziouzios et al. 2021).

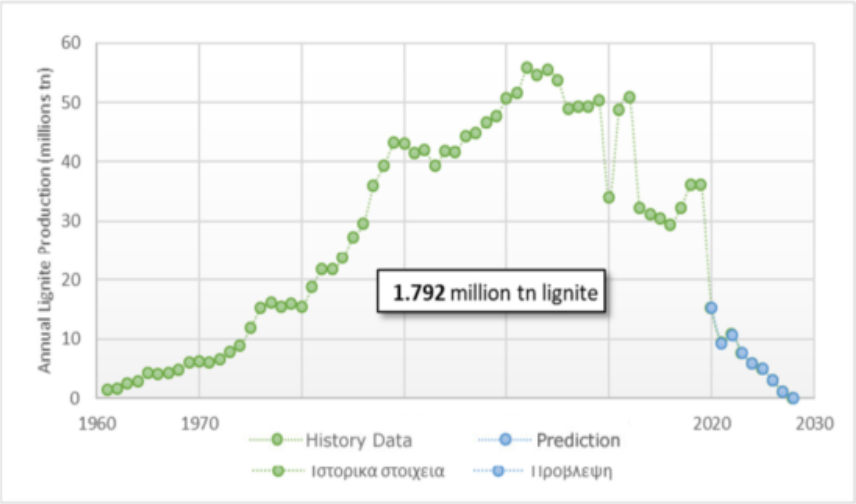

Figure 37: Lignite production in the Mines of Public Power Corporation (PPC) SA in the region of Western Macedonia (Ziouzios et al. 2021)

Mining activities and the burning of fossil fuels have a negative effect on the community prosperity and the environmental sustainability of the Western Macedonia region. According to several reports from regional hospitals and residents in the Western Macedonia region, mining activities negatively affect agricultural activities and the natural environment, as well as residents' physical and mental health. Specifically, the environmental impacts of lignite mining include erosion, sinkholes, loss of biodiversity and contamination of groundwater by chemicals from the extraction process. Land degradation, dust, noise and water pollution also constitute other impacts of mining on the environment (Karasmanaki et al. 2020).

Furthermore, the burning of fossil fuels (e.g. lignite) gradually leads to the pollution of the environment and precipitates climate change due to the release of great amounts of contaminants in the atmosphere. Lignite has negative impacts on the environment, the quality of air and water, biodiversity and human health. The lignite fired plants in the region of Western Macedonia were in complete operation for 70 years and undoubtedly, this long-lasting process has affected the regional climate at a large scale (Gkeka 2022).

For the region of Western Macedonia, there are clear indications that we have entered post-lignite times. Lignites are steadily losing a share of the national energy mix, while the lignite industry struggles or cannot finance new investments in lignite production. There is also a steady surplus of local labour, which shows increasing mobility to other geographical areas. Hence the finding of alternative sources of energy exploitation is considered necessary and, in this role, the environmental factor is considered critical. It should also be emphasized that the motivation for switching to metalignite time is mainly that the environmental burden is huge for the region, which is why there are EU directives that we must come to terms with as a state (Kourkoulouki 2021).

The environmental problems arising from the use of lignite are varied and include the high emissions of methane, carbon monoxide, carbon dioxide, nitrogen oxides and sulfur oxides and general hydrocarbons during lignite mining, transportation and use for power generation. In addition, they include the misuse of land, the production of waste and slag, fires but also the collapse of underground mines and the depletion of resources during the extraction of lignite and use for energy production (Kourkoulouki 2021).

Figure 38 shows the GHGs emissions by industries over the years. Besides the lignite mines have high emissions, sectors such as transportation and storage, manufacturing and electricity, gas and air conditioning supply have been the most emissions, besides they are in a tendency of decarbonization (ELSTAT, 2024).

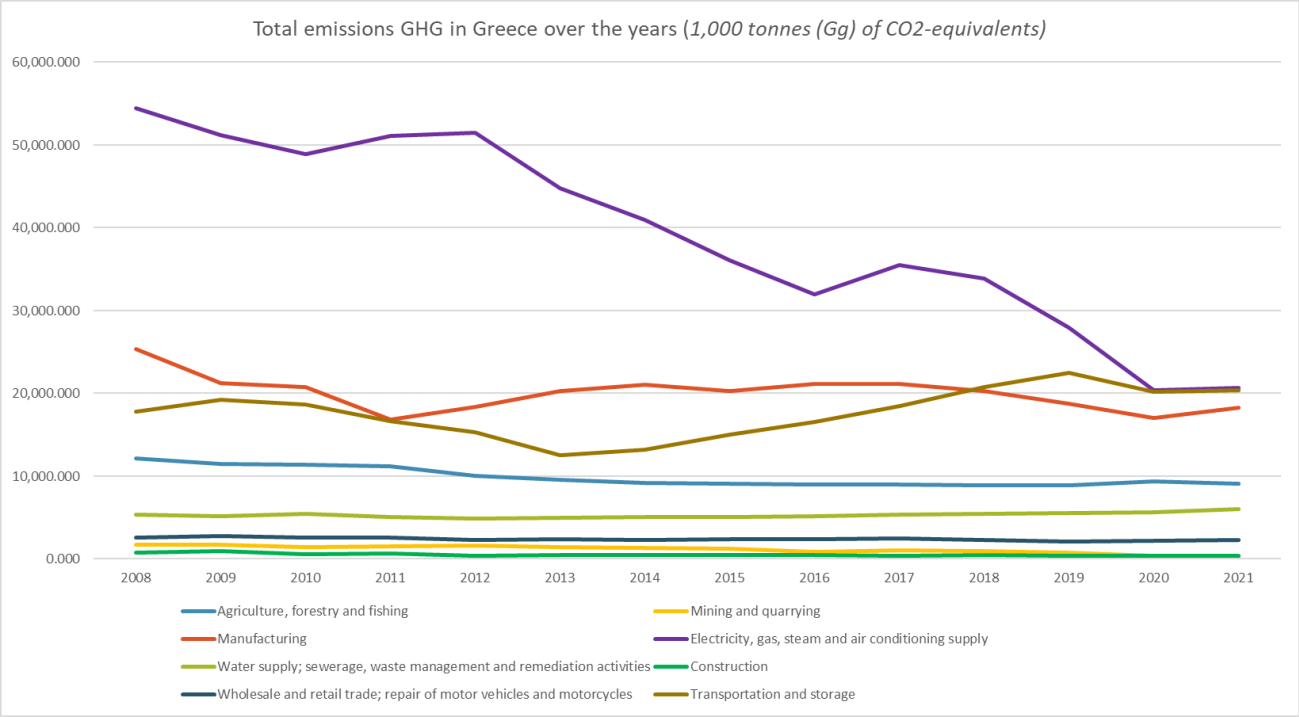

Figure 38: Comparison of the total of GHG between the different industries in Greece (ELSTAT, 2024)

Furthermore, during the last years, the emissions by Net greenhouse gas emissions of the Land use, Land use change and Forestry (LULUCF) sector have been negative, as there are more offset than emissions, shown by figure 39.

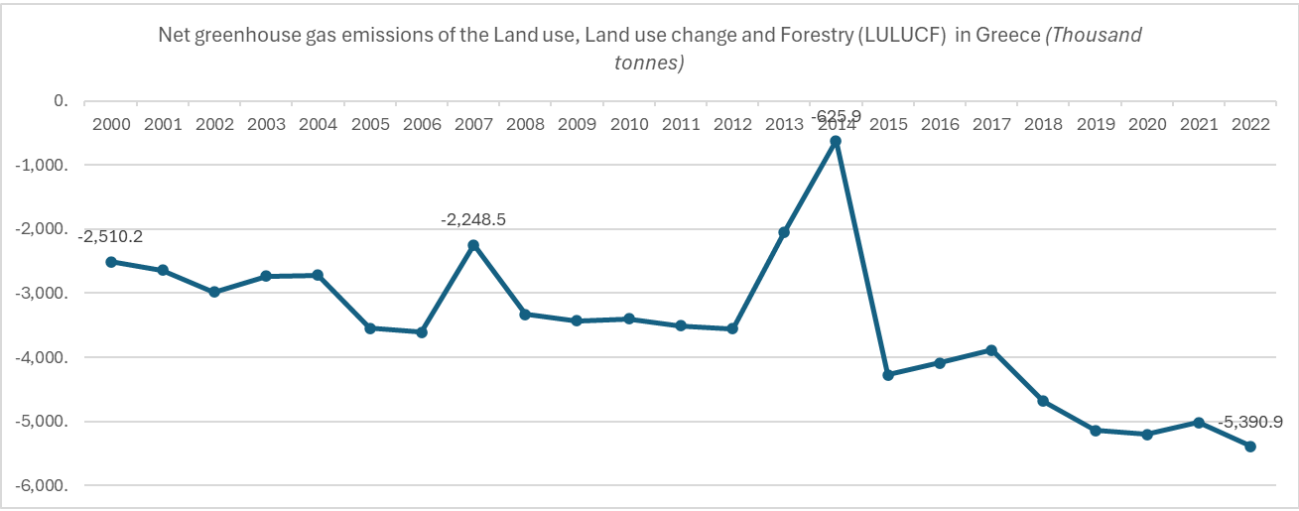

Figure 39: Net greenhouse gas emissions of the Land use, Land use change and Forestry sector (Eurostat, 2021)

Still, many other solid and mainly aqueous wastes are produced by the mining of lignite and the operation of power plants equally harmful to the natural environment. All these wastes and emissions

contribute greatly to many environmental impacts, such as global warming potential, soil and water acidification, and human health. A typical example of the importance of environmental impacts that associated with the electricity generation sector is the fact that more than 70% of the total CO2 emissions in the country come from this sector (Kourkoulouki 2021). It is possible to observe that the waste generation is higher in the Mining sector than Electricity generations and Water Supply & Sewerage, but Water Supply has the higher level of hazard waste than the other options (ELSTAT, 2020), according to the figure 40 below.

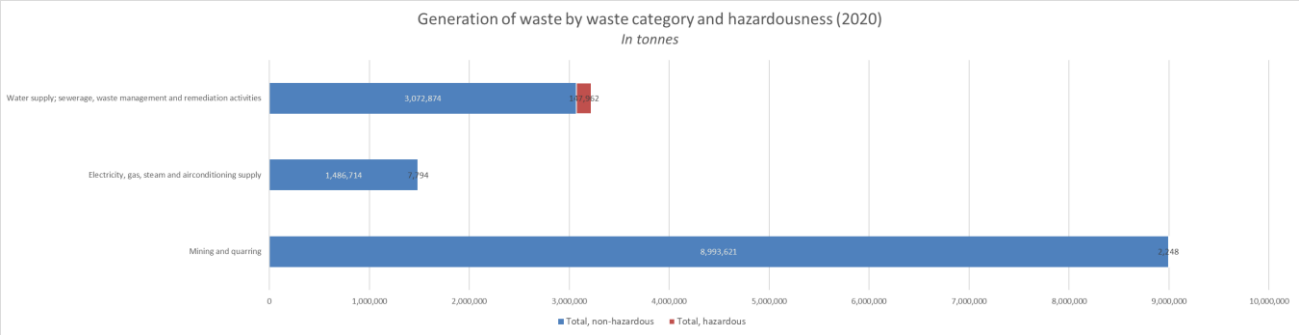

Figure 40: Generation of waste-by-waste category and hazardousness (2020).

In Western Macedonia there has been a significant variation in the production of sulfur oxides during the last decade, which is mainly due to the increased consumption of electricity and the operation of new desulfurization units in the power state. In addition, the dominant contribution of Ptolemais lignite consumption to the total SO_2 production should be highlighted, although the corresponding electricity production represents only 10% of the total annual demand. SO_2, as one of the most common air pollutants in urban areas, is one of the components of smog that often occurs in large cities. SO_2 is colorless with a very characteristic odor and combined with moisture it eventually turns into sulfuric acid, one of the most corrosive acids mainly responsible for acid rain (Kourkoulouki 2021).

NOx gases (NO, NO_2) result from the reaction of high temperature between nitrogen and oxygen in the production stations electricity, industrial facilities and central systems heating. NO_2 is one of the main gases found in smog and is also thought to be responsible for acid rain (Kourkoulouki 2021).

Carbon dioxide (CO2) is produced after its complete combustion of carbon and can therefore be a measure of the amount of fossil fuels used in a country. It is the main culprit of the greenhouse effect, which can change the climate of our planet. In this context, it is important to mention that electricity production in Greece is responsible for almost 55% of CO2 production (Kourkoulouki 2021).

The Greek electricity generation sector continues to generate huge quantities of exhaust gases, while no attempt is made to slow down the corresponding rate of escalation. This result contradicts international and European Union efforts to stabilize air pollutant emissions at the levels of 1990 (Kourkoulouki 2021).

Data related to the emission of GHG is available in detail related to all Greece, for each economic sector (figure 41). Regarding the total emissions, it is possible to observe that they are reducing since 2018. Regarding specifically air, soil pollution and freshwater eutrophication, data for all Western Macedonia is not available yet in the public data collection.

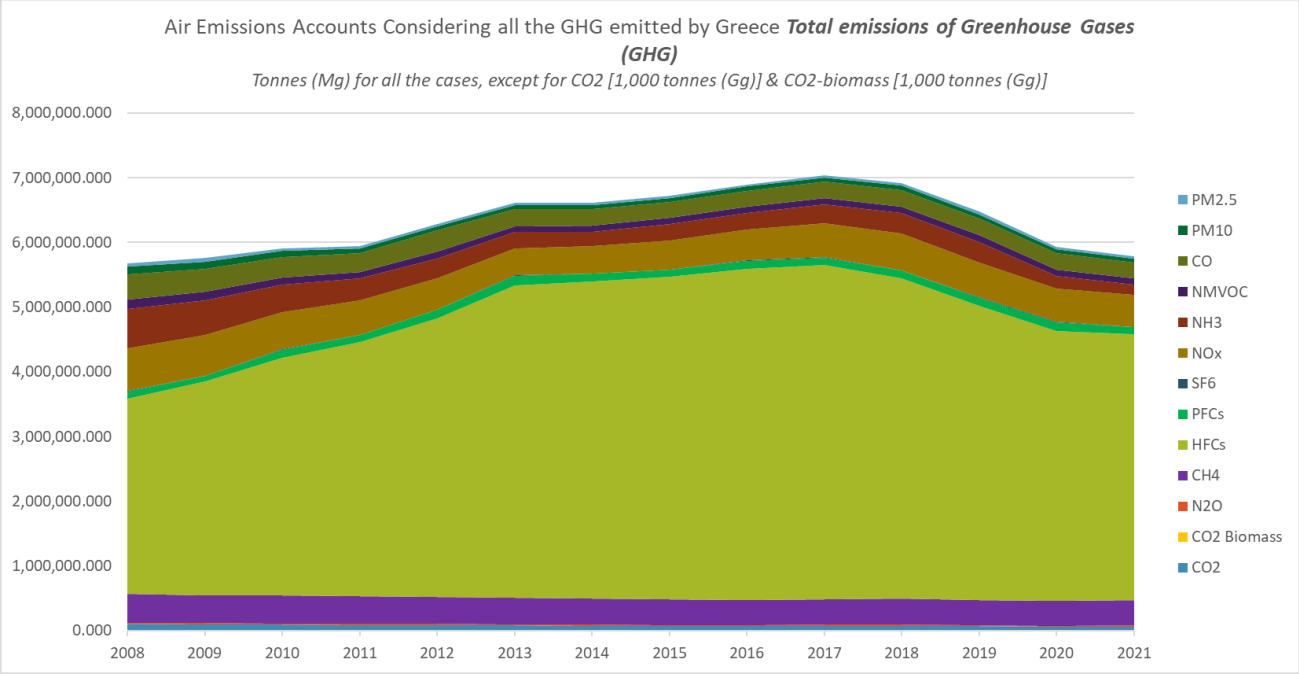

Figure 41: Air emissions accounts considering all the GHG emitted by Greece, in all the industries sectors - Provisional data (ELSTAT, 2023)

Unfortunately, in conclusion, the correlation between pollution and cancer must be mentioned. Specifically in a letter to the Greek Ministry of Health, the deputy regional health director wrote that seven out of ten deaths in Ptolemaida are related to cancer or thromboembolic disease (stroke, stroke, pulmonary embolism). Cancer incidence has increased by 16% since 1950 and the number today stands at 30.5%, while life expectancy in the region has fallen (Kourkoulouki 2021).According to figure 42 below, it is possible to observe that besides the growing tendency of life expectancy until 2018, it has been reduced during the last 5 years from 81.7 to 80.8 years old, considering the total number of people in the country. It follows a worldwide tendency, as well as in Europe.

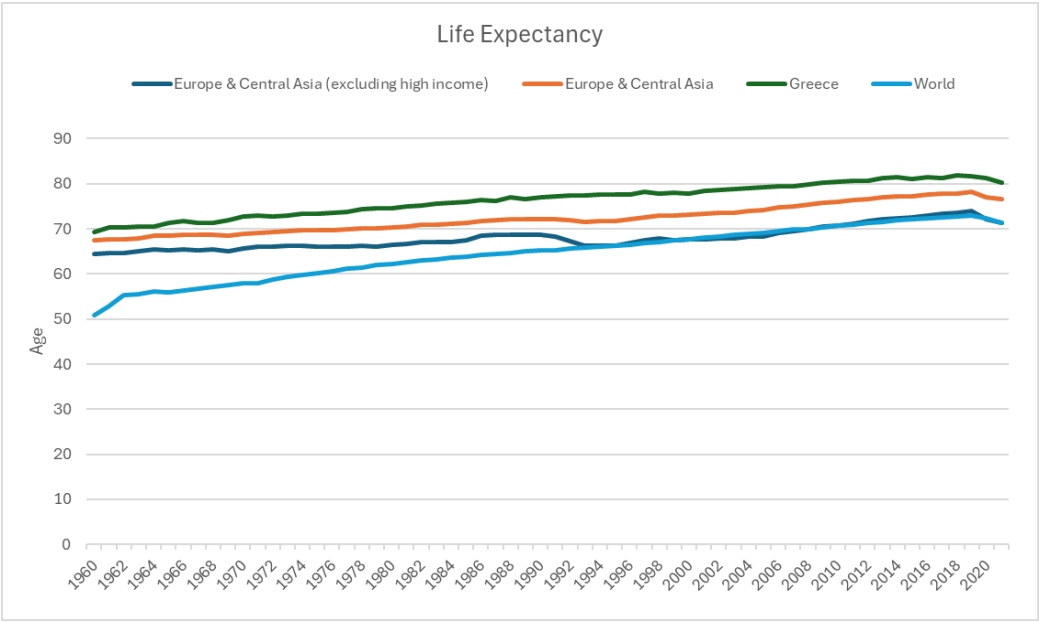

Figure 42: Life expectancy at birth, total (years). World Bank (2024)

Economic

Western Macedonia is lacking in terms of innovation performance, compared to other Greek regions, and this places limits on the development of its linear economy. It is at the bottom of the Greek rankings. This can largely be explained by the fact that Central Macedonia's economy, while large, is focused mainly on low-value-added sectors with little innovation potential. Western Macedonia's already weak economy was primarily focused on electricity production, which is closing down, as well as on traditional sectors, which also have limited potential for innovation (Martinidis et al. 2022).

The competitiveness of a region is linked to that of its businesses. A significant number of competitive businesses is needed. The competitiveness of businesses depends on both the performance of the companies themselves and on the direct business environment in which they operate. While a region typically includes both more and less competitive firms, it is generally accepted that there are some determining factors (local institutions, structures, local society) in each region that influence universally all businesses established in it. This is part of the regional business environment (Exarchou and Kalliontzis 2017).

A country's economic development and economic prosperity are inseparable related to entrepreneurship. During the period 2010-2011, a significant impact on entrepreneurship was caused by the deterioration of economic conditions and the uncertainty about the outcome of the financial crisis. At a rate of 99% the developmental and business activity in Greece is based on small and medium enterprises which for the most part were unprepared to manage this crisis. This is particularly true in Western Macedonia where the linear economy outside the publicly owned power sector was particularly fragile even before the crisis (Exarchou and Kalliontzis 2017).

The economic crisis always creates opportunities, as long as the businesses face a positive regulatory and institutional environment and have organizational readiness and creativity. Unfortunately, in the last decade the Prefecture is characterized by an intense shrinking of its business world. Specifically, from 2005 there is a decline of 18.6% in its active businesses of the Prefecture of Kozani, with a drop of 16.8% from 2011 to 2016. The reason is due to the strong impact of the economic crisis that hit Greece in those years (Exarchou and Kalliontzis 2017).

The business environment in Greece is characterized by high uncertainty, due to the economic crisis that the country is still in and the unending financial impasse, which has dealt serious blows to entrepreneurship in the country. While the country has moved on, its economy is still far from pre-crisis levels and the COVID-19 pandemic has further hurt employment, and the economy in general (Hazakis, 2022). The continuous adverse developments have affected the consumption habits, the liquidity of the consumer public, the business expectations and business turnover with result in many of them not being able to withstand the market conditions and being led to closure (Exarchou and Kalliontzis 2017). For comparison, the GDP of selected regions between 2006-2021 is shown below (figure 43).

	Gross domestic product by Nuts II, III (in million euro)							
Region	**2006**	**2007**	**2008**	**2009**	**2010B**	**2011**	**2012**	**2013**
Western Macedonia	**4,926**	**4,979**	**4,802**	**5,039**	**5,094**	**4,980**	**5,345**	**5,049**
Grevena	359	378	399	369	379	346	336	315
Kozani	2,957	2,955	2,803	3,012	3,095	3,034	3,384	3,207
Kastoria	601	656	679	664	636	602	571	539
Florina	1,009	989	920	993	984	999	1,054	988
Region	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021***
Western Macedonia	**4,944**	**4,705**	**4,313**	**4,298**	**4,159**	**3,908**	**3,403**	**3,692**
Grevena	311	313	311	303	299	301	289	306
Kozani	3,056	2,909	2,603	2,578	2,505	2,293	1,927	2,170
Kastoria	533	521	503	486	487	481	441	480
Florina	1,044	963	895	931	868	834	747	736

Figure 43: Gross domestic product by Nuts II, III (ELSTAT, 2024)

However, although the economic crisis is one of the main factors that fragment entrepreneurship in Greece, it is worth referring to other equally important factors which until now influenced daily the entrepreneurship of the country, such as the difficulty faced by businesses in accessing the markets and making the final product available to the consumer. Also, due to the crisis, there is no investment capital and there is a lack of financing from the banks through loans both to businesses and to consumers who suffered a large income reduction (Exarchou and Kalliontzis 2017).

Most businesses of the region rely on domestic raw materials and play a key role in strengthening the local and national economy. By utilizing local raw materials, the image of the region is enhanced, and the produced product is differentiated and contributes to the general development of the region. However, companies often source raw materials from abroad as well. The reasons for this can vary. In some cases, local producers are relatively small and cannot cover all regulatory, qualitative or even quantitative requirements of local industries. Also, cost plays a major part, since imported raw materials can be cheap enough to more than offset any transportation costs. Import of raw materials is at a rate of 24.2%, as companies, in their effort to stay alive and be competitive, sometimes turn to the foreign market (Exarchou and Kalliontzis 2017).

According to Eurostat (2024), in 2023, the volume of total trade (import plus exports) of raw materials between the EU and the rest of the world was 358 million tonnes. Exports (134 million tonnes) were lower than imports (224 million tonnes). In 2022, regarding Greece, the total imports were $94.5B, while the exports are $55.7B. Exportations for Europe were responsible for more than 50% of the total of exports of Greece, becoming the number 57th exporter in the world (OEC, 2024).

The total of material flow in Greece on the last years can be observed in the table 13. and the figure 44. All the material inputs are destined to several ending uses, being the mainly of them material use, followed by emissions by the production and in last number the export.

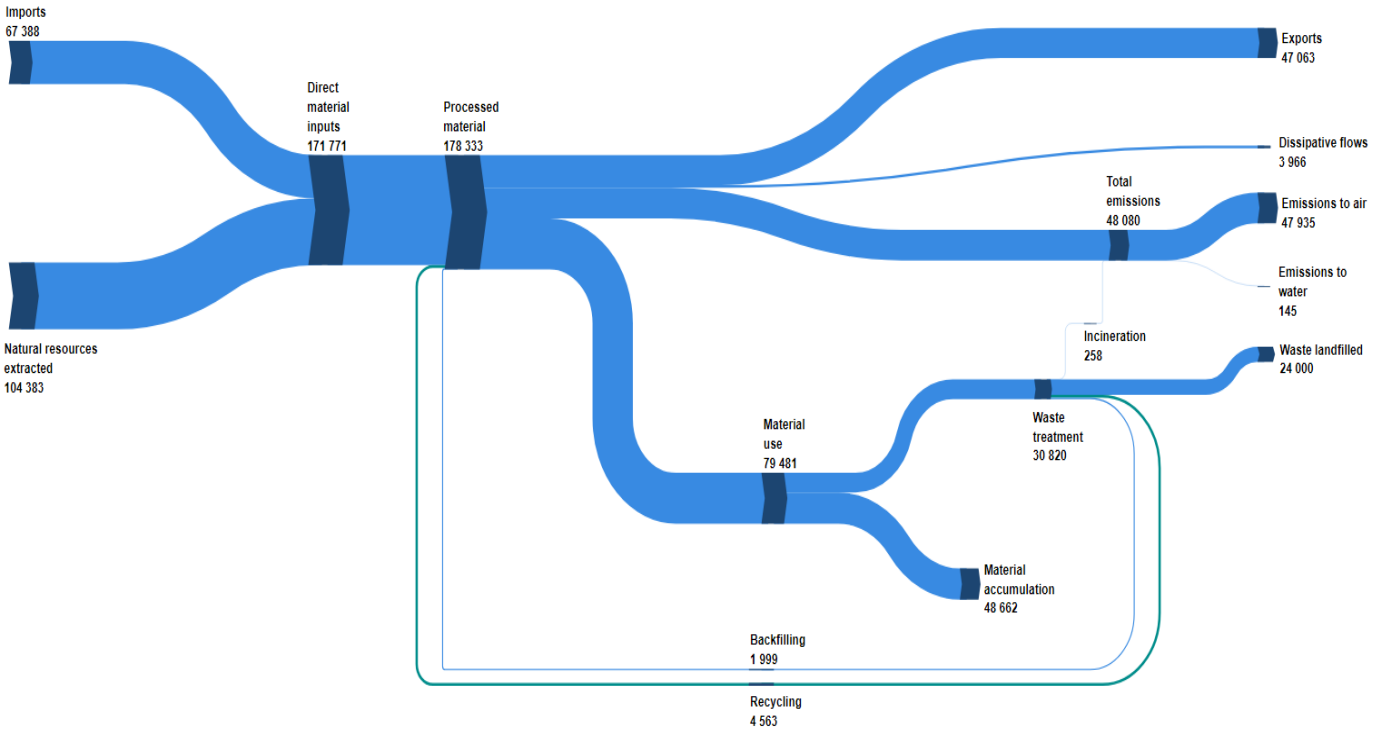

Figure 44: Material flow diagram Greece - thousand tonnes (Eurostat, 2022)

On table 13 it is possible to observe the advancing of the last 10 years of analysis regarding the starting of use of raw material and its final destination.

Table 13: Evolution of the material flow in Greece for intervals of 5 years, 2012, 2017 and 2022 (EUROSTAT, 2024)

Material flow	2012 (thousand tonnes)	2017 (thousand tonnes)	2022 (thousand tonnes)	Change (%)
Extracted resources	144,774	119,646	104,383	-17.36%, -12.76%
Imports	45,171	61,103	67,388	+26.07%, +9.33%
Processed material	198,284	185,414	178,333	-6.49%, -3,81%
Exports	33,648	45,804	47,063	+26.54% +2.67%
Total emissions	92,694	70,828	48,080	-21.87%, -22.75%
Material use	71,083	64,389	79,481	-9.42% +18.99%
Material accumulation	Not monitored yet	9,142	48,662	+532.29%
Waste treatment	71,082	55,247	30,820	-22.23%, -44,21%
Waste landfilled	62,604	50,398	24,000	-19.50%, -52.37%
Waste incineration	139	184	258	-24.46%, -28.68%
Recycling	2,899	3,907	4,563	+25.80%, +14.38%

It is possible to observe that the indicators of extracted resources, that is known of being one of the largest generators of GHGs, is decreasing. This is directly related to the indicator of Total emissions,

but also related to the growing of the indicators of Imports. The number of processed materials in Greece has been decreasing along the last years and the exports have been increasing, in a slower speed during the last years. The material accumulation has been increased more than 5 times since 2017, but in 2012 it is not possible to observe as there is no available data. The waste treatment, waste landfilled, and waste incineration has also decreased, that is directly related to the extraction and processed material, but it contrasts with the recycling indicators, that is increasing along the years.

The region of Western Macedonia has historically had one of the lowest national contribution rates to the total gross domestic product. Taking into account the economic impact brought about by the spread of the Covid–19 virus pandemic, the gross domestic product in the region of Western Macedonia recorded the largest average annual decline since 2015 among the regions (JTDP 2021).

Regarding the economic sector, the mining, energy and water sector contributes 38.65% of the total Gross Added Value of Western Macedonia, as well as 50.36% and 39.4% of the Gross Added Value of the regional units of Kozani and Florina respectively (Figure 45). About 80% of the total Gross National Product of Western Macedonia comes from the regional units of Kozani and Florina highlighting their contribution to the entire economy of the region. These facts point to the significant dependence of both the region of Western Macedonia and mainly of the above regional units on the lignite activity. Given the significant contribution of the regional units of Kozani and Florina both to the mining, energy and water sector of the region and to the economy as a whole, and taking into account the interdependence between the individual regional units and intra-regional transactions, it is perceived that the process of delignitization will affect the entire economic and business activity of the region of Western Macedonia, with a greater and main weight primarily on the regions of Kozani and Florina (JTDP, 2021).

	Agriculture, forestry, fishing	Mining, energy and water sector	Processing	Trade, hotels, catering industry, transportation, communications	Money-credit and insurance activities	Other services*	Total
Regional unity of Grevena	11.37%	2.86%	3.25%	21.24%	3.47%	56.11%	**100%**
Regional unity of Kastoria	12.67%	1.90%	14.11%	21.57%	3.94%	45.37%	**100%**
Regional unity of Kozani	7.12%	50.36%	3.32%	11.47%	2.39%	24.96%	**100%**
Regional unity of Florina	11.48%	39.47%	3.82%	10.89%	1.74%	27.69%	**100%**
Total of Region of Western Macedonia	**9.06%**	**38.65%**	**4.71%**	**13.28%**	**2.52%**	**30.31%**	100%

Source: Data processing (ELSTAT - Gross added value by sector (A10) - NACE REV.2, 2020), *: real estate management, public administration, professional and scientific service provision activities are included, as well as services related to arts and entertainment.

Figure 45: Gross added value by sector (in % of total GAV by regional unity, base year: 2019)

The linear economic activity of the region of Western Macedonia has been limited, which is due to the general economic conditions of the country, taking into account the spread of the Covid-19 pandemic, while it is further burdened by the gradual limitation of lignite power production. In this light, in order to ascertain the degree of correlation of the local economy with the lignite activity, it was considered appropriate to analyse the structure of the local business activity by economic sector/industry. In particular, from the aforementioned analysis, it appears that the energy, mining and water supply sector participates by the largest percentage in the amount of the total gross added value of the region of Western Macedonia and is its main product (Figure 47). However, these sectors are not ideal for the development of the economy, as each of them has certain limitations (JTDP, 2021).

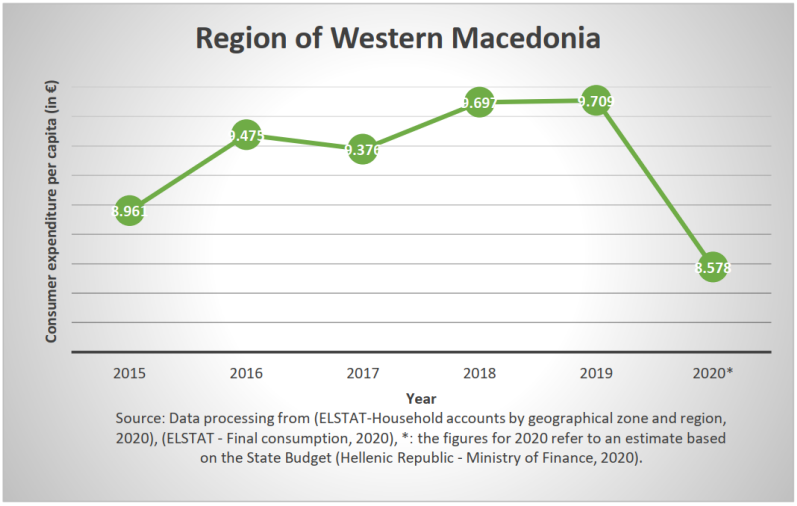

Figure 46: Evolution over the years of consumer expenditure per capita (in €)

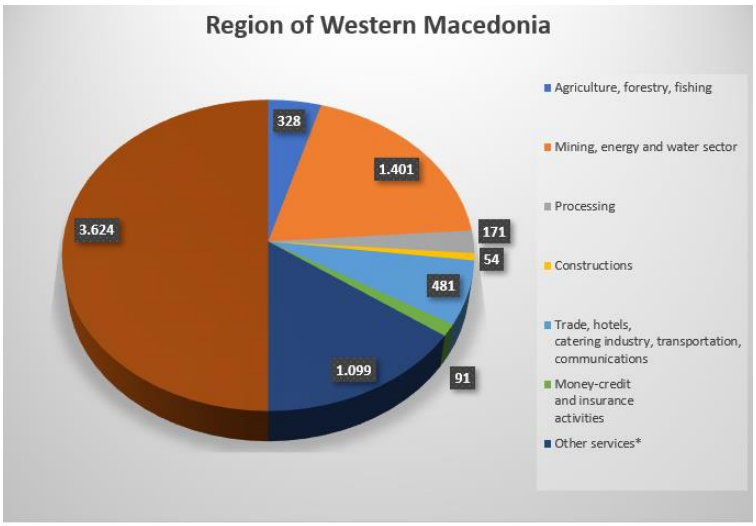

Figure 47: Gross added value by sector in the Region of Western Macedonia (in €m, base year: 2019)

In absolute terms, lignite energy production contributes directly and indirectly to the economy of the regional units of Kozani and Florina ~ €1.7 billion, contributes to the employment of ~ 17 thousand people while supporting the operation of ~ 800 businesses, whose turnover is estimated to exceed €405 million (Figure 48). As a result, from the closure of the lignite units, it is estimated that the region of Western Macedonia will be significantly affected as a whole, both at the level of business activity and at the level of employment and energy supply (JTDP, 2021).

	Gross added value in (in €m)	Employment (people in thousands)	Number of businesses	Business turnover (in €m)
Regional unity of Koz	1.285.43	15.23	596	319.11
Regional unity of Flor	376.29	1.91	201	86.17

Source: Processing data from (ELSTAT - Gross added value by sector (A10) - NACE REV.2, 2020), (ELSTAT - Gross added value by sector, 2020), (ELSTAT - Labor Force Survey, 2020), (ELSTAT - Employed by sector of economic activity, 2011), (EUROSTAT - Employment by NUTS 3 regions, 2020), (IOBE, 2020), (ELSTAT - Statistical Register of Businesses, 2016), (EUROSTAT, 2020), (ELSTAT - Business Cycle by Two-Digit Sector of Economic Activity by Two-Digit Sector of Economic Activity, 2020).

Figure 48: Total effects of lignite activity (base year: 2019)

Declining sectors expected to be directly affected by lignite include core and ancillary lignite mining activities, conventional power generation activities as well as mining waste collection, treatment and management and remediation activities. In this context, the stopping of lignite mining process is expected to negatively affect both the economy and employment. In particular, the employment of the regional units of Kozani and Florina is estimated to decrease by 7.5 thousand and 2.9 thousand people respectively, until 2029, when the withdrawal of all the lignite units of the two regional units will have been completed (JTDP, 2021).

Taking into account all the effects, stopping of lignite mining is estimated to lead to a reduction of the gross added value of the regional units of Kozani and Florina by € 1 billion and employment by ~ 10 thousand people. In addition, the number of businesses and the amount of turnover of the regional units of Kozani and Florina which is estimated to be affected amounts to ~ 610 and € 319 million respectively (JTDP, 2021). In short, the regional economy has been greatly based on lignite mining and power production for decades, and this is no longer viable, seriously limiting the prospects of the linear economy for growth.

Social

According to the Operational Programme 2015-2019 (Strategic Planning) of the Region of Western Macedonia, and regarding the demographics of the region, from the census of 2011 it seems that the main demographic trend is the ageing and shrinking of the population. The population of the Region of Western Macedonia is the third smallest in number after the Ionian Islands and the islands of the North Aegean and is concentrated by 50% in the Regional Unit of Kozani, while increased percentages are found in unproductive age groups (ageing population) and small percentages in the most productive age groups. Another important element is the distribution of the population by its level of education. Western Macedonia lags behind in terms of the level of education of the population compared to the data at a national level (Exarchou and Kalliontzis 2017).

According to Pavloudakis et al. (2023), the elderly population aged 65 and above divided by the percentage of the population aged 15–64, is 39.0% and 34.9% for Kozani and Florina Prefectures, respectively. For comparison, the national average is 34.6%, and the minimum and maximum prefectural values are 26.1% and 69.7%, respectively. Similarly, the young population index, i.e., the percentage of the population aged below 14 divided by the percentage of the population aged 15–64, is 21.1% and 22.0% for Kozani and Florina Prefectures, respectively, while the national average is 22.5% and the minimum and maximum prefectural values are 17.2% and 27.6%, respectively. These figures prove that other Greek territories suffer a more severe demographic crisis than Western Macedonia. However, it should not be overlooked that the population in Western Macedonia aged 45–65 plus have reached 54% and seems to have an increasing trend, while the age group 25–44 appears to be decreasing, evidently due to escalating internal or external labour migration.

Also, it is possible to observe that the population and employability are correlated per region, while the number of students enrolled in tertiary education (levels 5-8) can vary in the regions (figure 49). The % by gender was not available for this analysis.

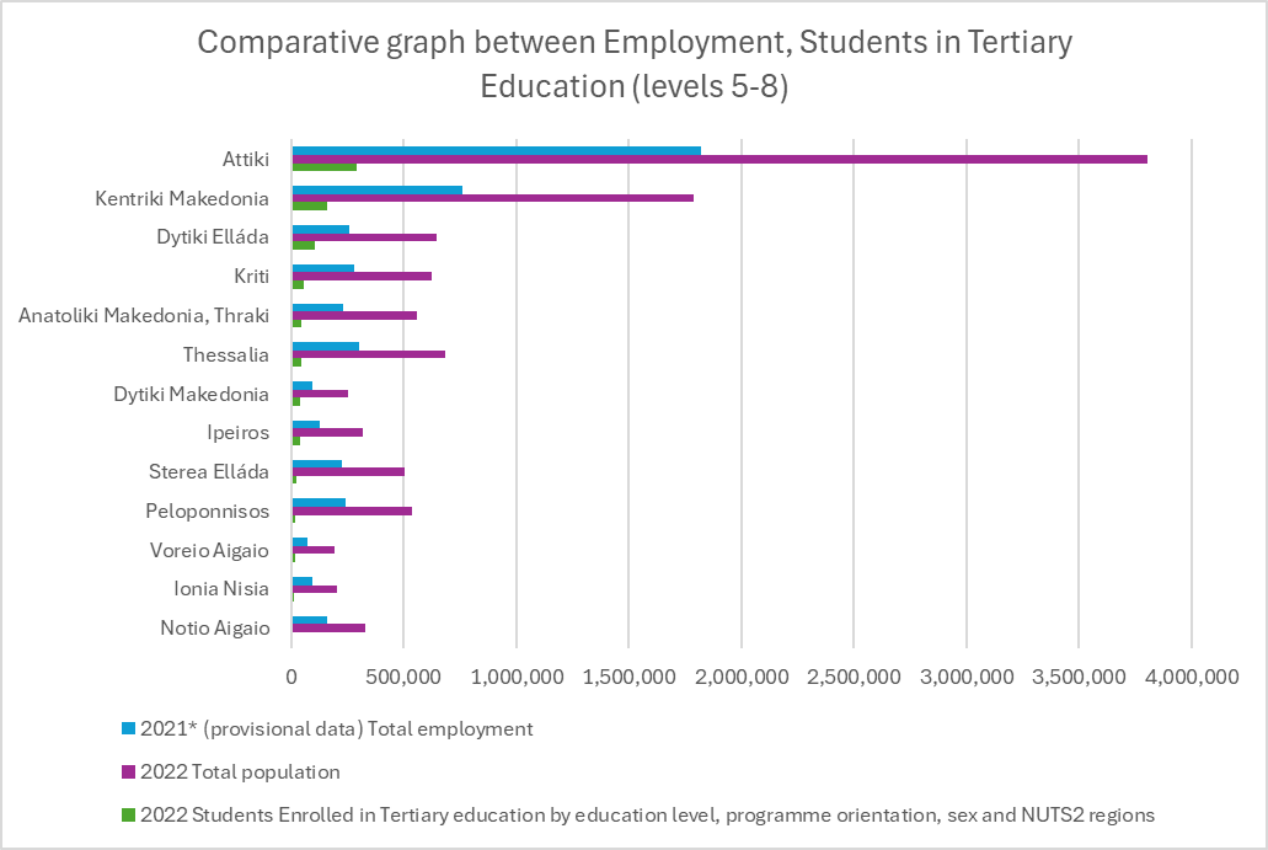

Figure 49: Comparison of total population, employment and students enrolled in tertiary education (Eurostat, Elstat, 2024)

As far as the population is concerned, the region of Western Macedonia is experiencing a population decrease, that in the last 5 years has varied between 0.87% to 3% per year (Eurostat, 2024), with multiplying effects in the employment sector, due to the outflow of a significant part of the human resources. In particular, at the level of regional units, it is observed that the majority of the population of Western Macedonia is concentrated throughout time in the regional unity of Kozani and secondarily in the regional unity of Florina. This fact demonstrates the dependence of the whole of Western Macedonia on the regional units of Kozani and Florina both at the population level and at the level of employability and workforce, directly linked to the employment opportunities offered in the mining activity and the energy sector, which dominate over other productive activities regardless of location (JTDP 2021).

At the same time, other areas are similarly suffering from a focus of the economy on activities that are going obsolete. This is the case for the regional unit of Kastoria, whose economy was traditionally focused on the breeding of fur-bearing animals and is in gradual decline in the last couple of decades as this trade is environmentally damaging, ethically questionable, and is being phased out in many countries (Xia et al. 2020). In summary, the region of Western Macedonia faces the social challenges of having an elderly population, with a lower level of education than the national average, and a general lack of advanced and up-do-date skills. Reskilling and upskilling efforts are necessary to overcome these obstacles, whether these are for the linear or the circular economy.

3.5.3 *Barriers of current economies to achieve relevant sustainability goals*

There are several barriers, regarding the development, use and efficient exploitation of biomass and the promotion of sustainability in the economy, which hinder the achievement of relevant sustainability targets in Greece, and these are valid for the region of Western Macedonia in particular. These barriers include the low training of farmers, the difficulty of introducing new technologies due to the age of the rural population (60% of farmers are over 45 years old), the reduction of employment in the primary sector and the lack of technical knowledge related to sustainable technologies (Papadopoulou 2018; Ziouzios et al. 2021). This limits the potential of the current, linear system to achieve sustainable goals, highlighting the need for a shift towards a circular model.

In this context, it can also be mentioned that an additional problem is caused by the lack of solid supply chains between biomass providers, transporters and end users. Initiatives have often suffered from this, with end users (such as the municipal district heating companies) struggling to find enough locally sourced biomass to fuel their biomass boilers, while local farmers and foresters do not know how to use their waste other than dispose of it in the traditional ways. Several projects in the region have attempted to rectify this and bring providers and end-users in direct contact (aGROWchain 2019).

Apart from that, there are barriers such as a high price of raw materials along with disorganized and costly supply chain of raw materials, bureaucratic licensing difficulties and instability of the institutional and taxation environment. The lack of control mechanisms for the implementation of existing environmental legislation and penalties on offenders as well as the lack of public information on the environmental benefits of the use of biomass, that results in strong local resistance to changes and denying of new technologies, become obstacles to achieve sustainability targets too. Furthermore, the lack of substantial efforts to create a framework for the marketability of “green” innovations could pose a problem in the road towards sustainability as well (Papadopoulou 2018; Papadopoulou et al. 2018).

Another critical barrier is related to the lack of public and private financing resources given the recent economic crisis and the effects of the COVID-19 pandemic, which may delay the adoption of new technologies and innovations and inhibit business development in the region. The low innovation base, the limited technical and human capacity and digital infrastructure of the Western Macedonia region could act as a barrier in achieving sustainabilty targets as well (Ziouzios et al. 2021).

The gender dimension can also be considered as a cultural limit of the linear system to achieve relevant sustainability goals. The green economy affords great potential for women to engage in green jobs and participate in green innovation, but only if there is an enabling policy and social framework in place. More generally, giving women greater access to leadership positions in both the public and private sectors and at all levels of decision-making can help focus priorities on environmental goals (Bonewit and Shreeves, 2015); (Hossain et al., 2017).

The last indicators presented by Eurostat regarding 2023, show that Western Macedonia is in the second position related to young people neither in employment nor in education and training. This indicator is worst related to gender. For young women, the region is in the last position in the country, with 20.8%, while the average of Greece is 11.3%. For men, that is 11.6% the situation is closer to the average of Greece, which is 11.8%, but still needs reduction for both cases.

For a general context, the gender employment gap is high in Greece, with a percentage of 20.4% considering all its regions. The NUTS 2 regions of Europe have an average of 8.85% (Eurostat, 2024). It is possible to analyse that the Western Macedonia region still did not reach linearity to improve its indicators, besides that in the last 20 years, approximately, it has been reducing, as shown in figure 50.

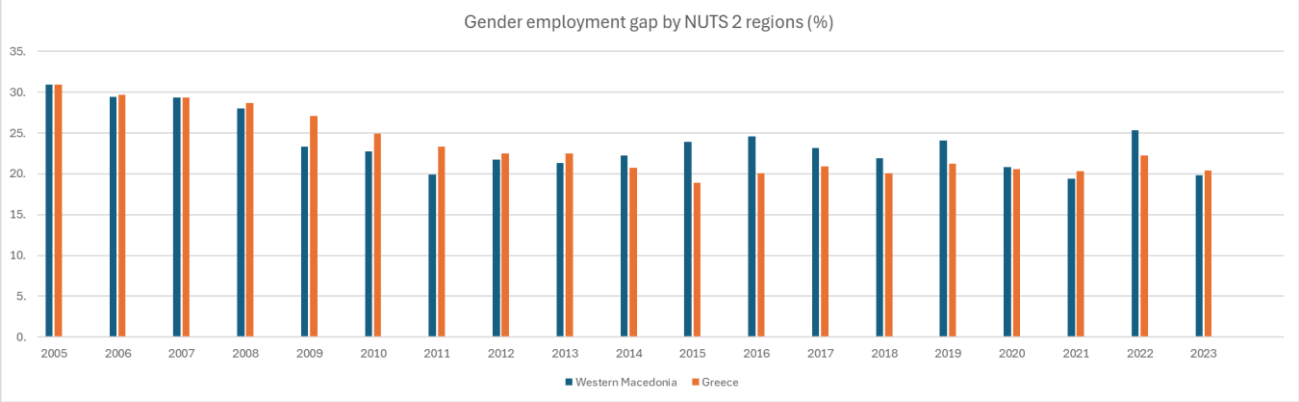

Figure 50: Gender employment gap in Western Macedonia, compared with the average of Greece over the years (Eurostat, 2024)

Finally, it can also be noted that the relatively small size of urban centres in the region of Western Macedonia is an obstacle to the creation of an economy of scale for the adoption of sustainable urban mobility solutions. As the municipalities and villages are relatively sparsely built, most citizens prefer to travel by private car. Public spaces for use by pedestrians or alternative forms of transport are usually limited or have been left poorly maintained (Strategic Study of Environmental Impact 2022).

3.6 Region of Andalusia – Spain

3.6.1 *Current status, trends and future of regional of linear (fossil-based) economies*

Due to its large population and size (1st region in terms of population accounting for 18% of the Spanish population, 2nd region in geographical coverage), Andalusia's economy is a major driving force for Spain as a whole. Andalusia is the Spanish region that provides the third greatest contribution (its economy contributes to 13.3% of the national GDP). In the trends of Andalusia's economic structure during the 20th century, it is worth highlighting (Junta de Andalucía, 2009):

The decrease in the contribution of the agro-fishing sector, which fell from 40.2% of gross value added in 1930 to 18.74% in 1970 and 8.93% in 2000. Industry maintains similar figures, with a decline at the end of the century: 20.4% in 1930, 21.72 in 1970 and 14.24 in 2000. Construction increased from 6.78% of gross value added in 1930 to 9.48% in 2000. The weight acquired by services, and within these, activities related to tourism, a sector whose share in the regional total of gross value added has risen from one third in 1930 to more than two thirds in 2000.

In 2013, the service sector lead the way in Andalusia's economy, and accounted for 70% of its GDP, which is slightly less than for Spain as a whole (about 68%). The most important feature of Andalusia's economy is the marked role played by the primary sector, which despite the fluctuations that characterise agricultural markets, accounts for a much higher percentage of its GDP (5.2% in 2013

and 4.5% in 2014) than in Spain (2.3% in 2013) or the EU (1.7% in 2013 in EU28). At the same time, the weight of the industrial sector is significantly lower than in Spain. The following Figure 51 shows a comparison between the sectoral composition of Andalusia's and Spain's GDP in 2013-2014 (European Parliament, 2016).

2013 AND 2014 DATA (*)		ANDALUSIA		SPAIN		% ANDALUSIA / SPAIN 2014
		2013 (P)	2014 (A)	2103 (P)	2014 (A)	
GDP at market prices (in EUR millions)		138 585	139 099	1 031 272	1 041 160	13.4%
GDP per capita (EUR)		16 523	16 577	22 134	22 412	74.0%
GVA for agriculture, forestry, livestock farming and fisheries (primary sector) (in EUR millions)		7 140.4	6 296.1	26 560	23 903	26.3%
Sectoral share (%) of GDP	Primary sector %	5.2%	4.5%	2.6%	2.3%	---
	Industrial sector %	11.3%	11.1%	15.6%	15.5%	---
	Construction sector %	5.6%	5.4%	5.1%	4.9%	---
	Service sector %	69.3%	70.0%	68.0%	68.4%	---

(*) Data for sectoral composition of GDP calculated on the basis of each sector's contribution to total GVA. Data for 2013: provisional (P). Data for 2014: Advance (A).
Source: Spanish National Statistics Institute (INE) - Spanish Regional Accounts Base 2010 (GDP data updated on 23 December 2015 and GVA data for 3 July 2015).

Figure 51: Data for sectorial composition of GDP (2013-2014)

Andalusia has an economy dependent on low value-added service activities. The service sector is the leading economic activity in the region (75% of regional GDP in 2019), followed by industry (11.6%), agriculture (6.2%) and construction (6.8%). The service subsectors with the greatest weight in the economy are wholesale trade and retail trade (31.5% of total services). Many of the activities of the service are linked to tourism. In fact, the contribution of construction has also been partially linked to the demand for tourism facilities (hotels, secondary houses) (OECD, 2021).

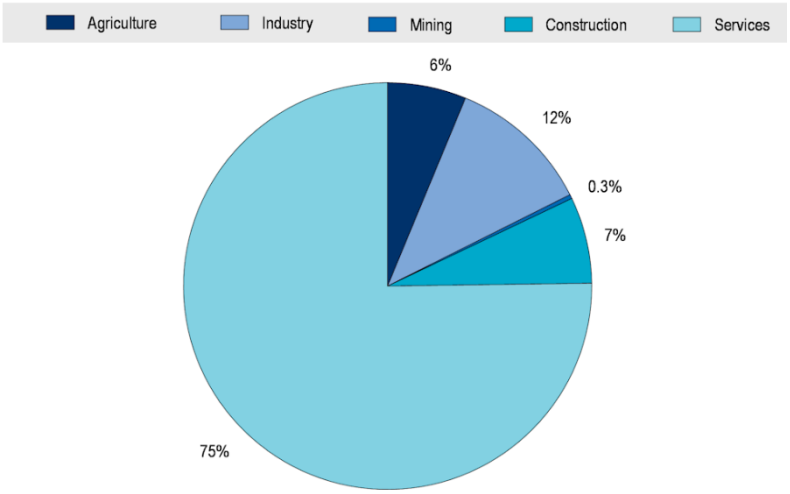

Figure 52: Sectoral GDP contribution to the total regional GDP of Andalusia, 2019

Tourism has thus contributed to the skewed development of associated low-value-added service activities. This strong dependence on the services sector, which is also highly – seasonal, particularly in the case of those associated with tourism, has led to economic fluctuations in periods of uncertainty, with direct impacts on regional unemployment rates. In Andalusia, the consolidation of tourism allows concluding that transport needs in Andalusia will increase, despite the fact that it is already one of the

main sources of polluting emissions. Tourism in Andalusia brings great socio-economic benefits, but at the same time it puts pressure on resources (Junta de Andalucía, 2018)

During the financial crisis, Andalusia underwent slow industrialisation in favor of other sectors such as the tertiary and **agricultural** sectors (over 44.3% of its surface and 8.4% of its work-force are dedicated to this sector).Therefore, the agricultural sector and the agri-food industry (which includes mining) are the backbone of regional economic activity, especially in rural areas, thus representing a total of a quarter of Spanish agri-food exports. Together with tourism, both are the pillar of the region's production system.

The Andalusian **logistics and transport** sector plays a key role in the economy, both in terms of import/export traffic and commerce, as well as in national and international mobility of people. The development of this industry is linked to the economic development of other production sectors, namely those requiring more movement of primary materials, processed products or consumer goods. Andalusia's logistics network covers an area of 1,800 hectares and includes 11 logistics centers (7 in ports and 4 inland) connected by land and sea with other markets, providing companies with a significant logistical efficiency (Invest in Andalucía, 2021).

Regarding the non-renewable resources used, Andalusia records a primary energy consumption of 18,672.9 ktoe, 14.7% of the national total. By source, the largest consumption is of oil derivatives, a consequence of the high weight of the transport area, although it has been losing weight in the structure of final consumption in favour of others such as electricity and renewable energies (Agencia Andaluza de la Energía, 2021).

Figure 53 shows the evolution of the structure of final energy consumption, by source and by sector since 2000:

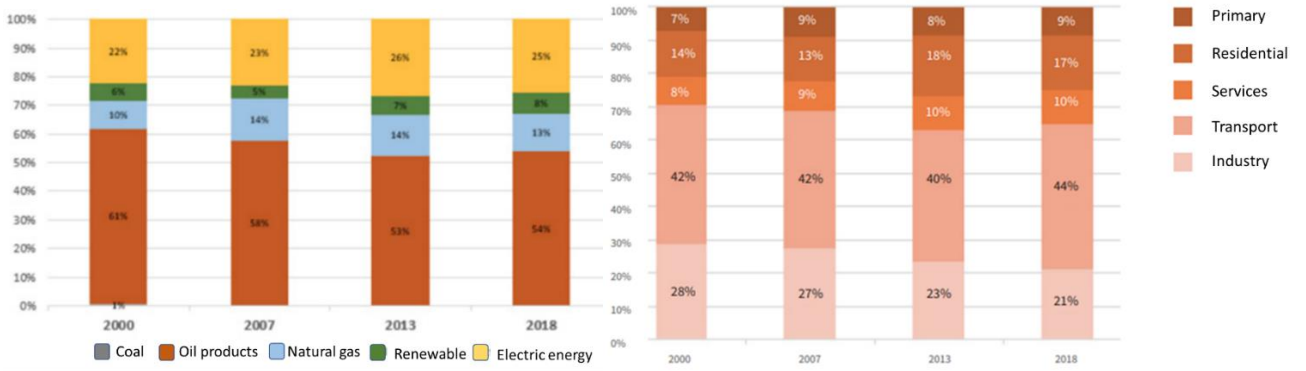

Figure 53: Evolution of the structure of final energy consumption, by source and by sector

In Andalusia, the use of fossil resources affects and limits the quality of the regional environment, the bulk of their use is related to energy. Concretely, petroleum and oil products continue to account for the largest share of the final energy consumption structure in Andalusia in 2020 while the contribution of natural gas remains the second most consumed energy source and the amount of coal is much lower in comparison. Figure 54 shows the different balances for final energy consumption structure in Andalusia, Spain and Europe during 2020.

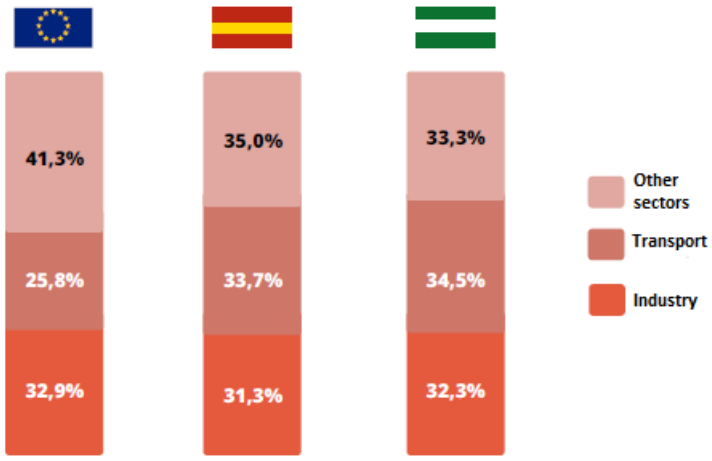

Figure 54: Balance of final energy consumption by sectors (Agencia Andaluza de la Energía, 2021)

At the regional level, the Government of Andalusia developed a series of initiatives related to the energy transition:

- The 2021 Andalusian Climate action Plan: promoting initiatives that allow the region to adapt and face climate change and its consequences on the territory and society (Junta de Andalucía, 2021).
- The 2018 Andalusian Circular Bioeconomy Strategy focuses on the production of renewable biological resources and processes (Junta de Andalucía, 2018).
- The 2018 Strategy for Sustainable Development 2030 conceives the circular economy as an opportunity to achieve sustainable goals at the regional level and as a key element of the green economy (Junta de Andalucía, 2018).
- The 2019 Integrated Waste Plan of Andalusia - Towards a Circular Economy by 2030 seeks to: i) encourage industrial symbiosis for the reuse of generated by-products; ii) analyse the efficiency of current collection systems, optimise treatment processes and carry out an evaluation of the management processes; and iii) promote the construction of recovery and disposal facilities to make Andalusia self-sufficient in the management of all of its waste (Junta de Andalucía, 2021).
- The 2022 Circular Economy Law aims to create an appropriate regulatory framework to promote the rational use of resources, extend the useful life of products and minimise waste generation (Junta de Andalucía, 2022).
- Andalucía energy strategy 2030: it collects the strategic guidelines governing the regional energy policy in coming years towards an adequate energy model, low in carbon, intelligent and of quality, without losing sight of the horizon 2030-2050 (Junta de Andalucía, 2021).

Regarding how the region performs relative to relevant sustainability goals the regional government is fully committed towards the implementation of the European Green Deal premises as well as any other European Commission sustainability directions. Specifically, and concerning SDG, Andalucía is

one of the 10 pilot regions selected for the 'REGIONS2030 monitoring the SDGs in the EU regions - filling the data gaps' project sponsored by the European Commission Joint Research Centre (JRC). The Institute of Statistics and Cartography of Andalucía (Instituto de Estadística y Cartografía de Andalucía, IECA) and the Andalusian International Cooperation Agency (Agencia Andaluza de Cooperación Internacional, AACID) in partnership both expressed their interest in participating in this project with the aims, among others, to improve the regional and spatial perspective of the SDGs, and connect JRC's proposals with the Andalusian development cooperation activities in partner countries.

In December 2021, a Delegate Commission for the 2030 Agenda was created in order to plan, promote and coordinate actions for the effective implementation of the 2030 Agenda, and the evaluation of their contribution to the achievement of the SDGs. Previously to the Delegate appointment, in July 2021, the Government of Andalucía released 'The Andalusian Path on the 2030 Agenda' (La Senda Andaluza en la Agenda 2030), a thorough report mapping all the activities in execution by the Regional Ministries and Entities towards the implementation of the SDGs, sketching their contribution and including SDG targets aligned to each budgetary program.

However, the main effort by Andalucía in terms of regional SDG monitoring is the development of the Andalusian Sustainable Development Indicators System for the 2030 Agenda. Its aim is to establish a framework of statistical indicators, based on those established by the United Nations and by the Statistical Office of the European Union (Eurostat), in order to monitor the objectives and goals of the 2030 Agenda at Regional level. The system is currently composed of 276 indicators covering all the SDGs. 8 The development of regional SDG indicators in Spain is coordinated through a working group set up by the statistical bodies of the Autonomous Communities, in the form of a collaborative network with the aim of agreeing on the calculation methodology of the United Nations indicators for the Autonomous Communities, seeking alternatives to problems of territorialization or relevance and guaranteeing, in any case, comparability (Cabañero 2023).

3.6.2 *Limits of linear (fossil-based) economies*

Environmental

Andalusia ranks 16th in number of inhabitants in the ranking of the regions of the European Union and according to EUROSTAT, the Andalusian territory´s economy divides in agriculture, forestry and fishing (6.3%), industry and construction (18.6%) and services (75.1%). The fact that over half the population is concentrated in 29 municipalities with over 50,000 inhabitants and the impact of the **different sectors such as tourism, retail, transportation, underdeveloped industry, agriculture** determine clearly the environmental limits and the extent of impacts to the environment (Junta de Andalucia, 2019). It's also interesting to notice that, currently, more than 35% of the Andalusian territory (2.9 million hectares) is protected under different protection figures, being these a result of regional legislation or of international conventions (Natura 2000 Network).

Concretely, in Andalusia, the environmental qualification and the responsible declaration of environmental effects are two fundamental legal instruments regulated by the Andalusian Integrated Management on the Environmental Quality Act 7/2007, 9 July 2007. These instruments are used to measure and act on the environmental impacts caused to the environment (Ayllón Díaz-González, 2020). The challenge of integrating the environment into the economic sectors is becoming more and more necessary, and the efforts being done to achieve this are more and more obvious. In Andalusia, the commitment to create green businesses and employment is gradually showing results, and

sectors such as organic farming or sustainable tourism are significantly evolving and creating hopeful expectations.

Focusing on the environmental limits linked to **agriculture** in the region, it could be stated that there is not a great impact generated since it tends to be localised in very specific areas. However, there are problems derived mainly from the more intensive agriculture that oblige both the production sector and the administrations involved to make efforts to solve them. Regarding impact, ecological agriculture in Spain and Andalusia is less harmful to the environment than any other. During 2018, there were 2,246,475 hectares in Spain and 1,024,475 hectares in Andalusia which is a clear indicator of the how the current situation is evolving to prevent a high environmental impact. It is relevant to indicate that agro-industry accounts for 25% of industrial employment (Junta de Andalucia, 2019).

On the other hand, in order to determine the environmental limits and impact caused by **tourism** in Andalusia, it must be taken into account that it is the region with the higher number of visitors in the country (30,654,796 tourist/year in 2018) (Junta de Andalucia, 2019). The most significant area affected by tourism massification specially in summer periods is the coastal area environment. In these tourist areas, due to damage caused by the construction of human structures and related economic activities, the loss of beaches has increased, also aggravated by the climate change and its effect on sea tides and balance. Over the last decades, the Andalusia Mediterranean coast recorded one of the fastest rates of urban development along the Spanish littoral and even in Europe. For example, in the Costa del Sol (Málaga province), population has continuously increased significantly at an annual rate and that increment along with the 10,000,000 visitors per annum (35% of all Andalusia visitors) that receives caused an important impact in the environment since it is one of the most important tourist destinations in Europe (Molina, 2019).

There is a lot of room for improvement especially in the sectors related to **industry, transport and/or retail** which are the most directly involved with polluting emissions into the atmosphere and generating waste difficult to eliminate or reduce. In addition, the energy balance between energy production and energy consumption of the industrial sector clearly has a significant weight in generating CO_2 emissions and climate change. During 2017, Andalusia registered a final energy consumption of 12,988.9 kilotons of oil equivalent (Ktoe). More than two thirds of this consumption was linked to transport and industrial activities while the remaining third was linked to the primary sectors, services and residential areas (Junta de Andalucia, 2021). In the following Figure 55 (Agencia Andaluza de la Energía, 2021) the balance of final energy consumption by sectors in 2020 is depicted, were the tendency described previously continues.

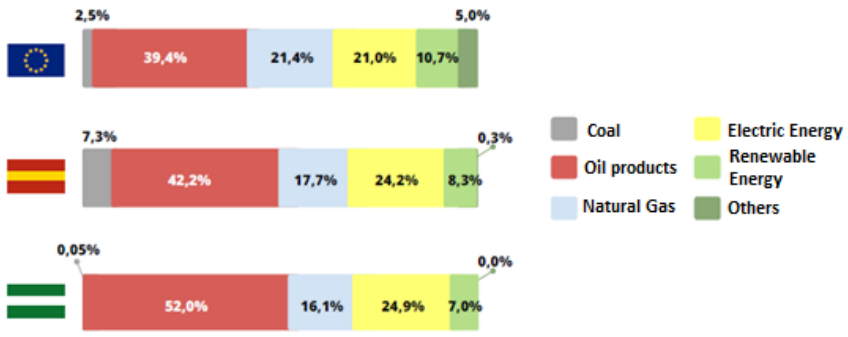

Figure 55: Balances for final energy consumption structure in Andalusia, Spain and Europe during 2020 (Agencia Andaluza de la Energía, 2021)

Regarding the sector of **transport**, the degree of motorization in Andalusia during 2018 was 69.3 vehicles/100 inhabitants while the national average was 72.2 (Junta de Andalucia, 2019). The impact of transport in the environment can be estimated in generating 14.263.174 t CO_{2eq} of diffuse greenhouse gas emissions in 2019, clearly

representing a very relevant factor for the region current environmental situation (Agencia de Medio Ambiente y Agua de Andalucía, 2021).

In the case of **industry**, there are sectors such as concrete production, oil refining or ceramic which along with electricity production have a very significant impact on CO_2 emissions and climate change. The value of emissions produced by the concrete industries in Andalusia in 2021 was 2,600,545 tCO_2, in addition, the value of emissions from the oil refining sector was 2,945,667 tCO_2 (mostly generated in the provinces of Cadiz and Huelva). Finally, regarding the ceramics sector the value of emissions during 2021 was 82,401 tCO_2. On the following Figure 56, it is shown the comparison for Greenhouse Gas Emissions in both Andalusia and Spain.

	1995	2000	2005	2010	2015	2016	2017
GHG emissions in Andalusia (kt CO_2 eq)	43,074	52,882	66,60	55,232	51,898	48,629	51,760
GHG emissions in Spain (kt CO_2 eq)	328,614	387,528	441,038	357,677	337,599	326,383	340,231
GHG emissions in Andalusia *per capita* (tCO_2 equiv/inhabit.)	5.95	7.20	8.36	6.58	6.18	5.80	6.7
GHG emissions in Spain *per capita* (tCO_2 equiv/inhabit)	8.28	10.88	9.93	7.59	7.25	7.01	7.29
GHG emissions in Andalusia per unit of GDP (kg/euro)	0.70	0.61	0.51	0.38	0.36	0.32	0.33
GHG emissions inSpain per unit of GDP (kg/euro)	0.47	0.45	0.44	0.34	0.32	0.29	0.29

Figure 56: Comparison of the evolution of total greenhouse gas emissions in Andalusia and Spain (Junta de Andalucia, 2019)

In 2021, emissions in Andalusia were 39,503.95 kt CO_2 eq, an increase of 5% compared to 2020, a year in which GHG emissions decreased largely due to the mobility restrictions imposed by the COVID-19 pandemic. Excluding emissions in 2020, emissions in 2021 represent a significant decreased compared to those produced in the years immediately prior to the pandemic, this suggests a trends towards moderation in emissions of the gases.

At the same time, considering the evolution of the intensity of greenhouse gas emissions in relation to the economy (emissions generated to produce a unit of GDP), it can be seen that Andalusia continues to decouple its economic growth from its emissions, which determines an increase in eco-efficiency (Environment in Andalusia Report 2023). Emissions have grown less than GDP, from 0,59 kg CO_2 eq/€ in 2000 to 0.23 kg CO_2 eq/€ in 2021. Based on 2007, the year with the highest emissions value in the series, emissions in 2021 decrease by 42.6% while GDP increases by 11.4%.

Regarding air quality, in general, the evolution data for 2022 were better than those recorded for the previous year. In 2022, the annual limit values were not exceeded at any point for either NO_2 or PM_{10}. The PM_{10} value was 23 µg/m³, so it has not yet reached the annual limit value recommended by the World Health Organisation of 20 µg/m³. The main unit used to measure SOx emissions in the air in Andalucía is kilotonnes of sulfur dioxide (SO2), and the region has seen a significant decrease in SOx emissions over the past three decades, from 147.4 kilotonnes in 1990 to 19.5 kilotonnes in 2020, as a result of regulatory efforts to control air pollution.

The negative situations in 2022 were mostly caused by ozone (73.5%), particulate matter (9.1% PM_{10} and 7.4% $PM_{2,5}$) and nitrogen oxide (9.9%), with only 0,1% being caused by SO_2. In absolute terms, the largest share of emissions in 2021 was from NO_x (74.5%), while NH_3 (16.2%) and SO_x (9.3%), were lower.

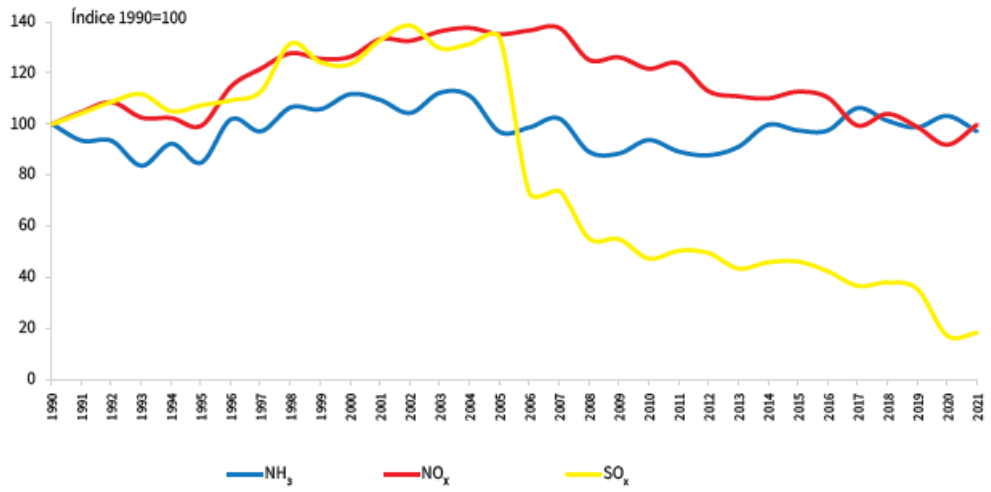

Figure 57: Evolution of emissions in Andalusia (Environment in Andalusia Report 2023)

According to the provisional data of SIOSE 2020, the evolution of land use between 2016-2020 highlights the loss of agricultural land (-95,418 ha), which has probably been partly transformed into artificial land (+49,108 ha), as well as forest land (+48,015 ha).

CHANGES IN LAND USE IN ANDALUSIA

	2005	2009	2011	2013
Forest and natural areas	4,555.8	4,399.2	4,385.6	4,418.4
Constructed and altered surfaces	3,541.9	3,665.1	3,650.7	3,516.8
Agricultural areas	359.2	390.3	409.2	510.5
Water bodies and wetlands	302.9	305.0	314.1	311.9

(Thousands of hectares)

Figure 58: Source: "Basic Environmental Data of Andalusia 2019"

In Andalusia, the works reviewed in relation to the study of OCS (Organic Carbon in Soil) content on a regional scale have not only focused on determining its amount (Muñoz-Rojas et al., 2012), but also on studying the impact of land use, calculating its evolution and variation over a period of 50 years (Muñoz-Rojas et al., 2011; 2015). According to these authors, and based on the information provided by more than 1,450 soil profiles and several digital terrain maps, the OCS content in Andalusia for a depth of up to 75 cm results in a total of 415 Tg C. From the study of this value at different depths, they determined that 55% of the OCS (222.7 Tg) was found in the first 25 cm. The average OCS concentration for the Andalusia area corresponds to 48 Mg C/ha, with these values varying according to the type of land use considered.

Table 14: Land use and organic carbon in soil

Land use	OCS (Mg C/ha)	OCS (Tg)
Arable land	55.20	84.59
Permanent crops	43.12	94.65
Heterogeneous agricultural areas	48.09	48.27
Forests	45.21	67.60
Scrub and/or bush areas	55.23	115.92
Open spaces with little or no vegetation	16.96	1.00

Maritime wetlands	69.60	3,19
Total	333.41	412.03

Table 15: OCS content in the first 75 cm of soil in Andalusia (Source: Soil organic carbon as a tool for climate change mitigation and adaptation in Spain, 2018)

In terms of soil contamination, according to different research at European level, including a study carried out in 2021, based on samples taken between 2015 and 2018, 83% of Spanish agricultural soils still show traces of pesticides. However, in soils dedicated to organic farming, the levels of toxic residues found were between 70% and 90% lower than in conventional fields. In Spain, 34% of the food consumed currently contains pesticide residues, which is lower than the European average of 48%.

As in previous years, the climatic profile of 2022 in Andalusia was eminently dry, although the increase in rainfall in spring and early winter made it possible to quantitatively overcome the drought situation. Precipitation in 2022 totalled 458 mm, compared to 400.8 mm in 2021. In December 2022, the amount of water in reservoirs was 3,364.7 hm3, 28.23% of the total capacity. Compared to 2021, the amount of water in reservoirs has decreased by 8.63%. Except for the Andalusian Mediterranean basins, which have increased their capacity by 18% with respect to 2021, the rest of the river basin districts have decreased it. The worst performer was the Guadalquivir, which decreased its capacity by 15%, followed by the Tinto-Odiel-Piedras, with 7%, and Guadalete-Barbate, with a fall of 2.8%.

In the year 2022, 4% of the samples analysed showed a nitrate concentration above 50 mg/L; 9% showed a concentration between 25-50 mg/L; and 87% showed a concentration below 25 mg/L, with the highest concentrations in the Guadalquivir and Guadiana River basins.

	Surface waters	Groundwater
Andalusian Mediterranean River Basin	5.1	23.0
Tinto-Odiel-Piedras River Basin	4.0	36.2
Guadalete-Barbate River Basin	9.6	46.0
Guadalquivir River Basin	9.5	44.4
Guadiana River Basin	3.9	78.6
Segura River Basin	3.1	22.3

Units in mg/l

Figure 59: Source "Basic Environmental Data of Andalusia 2019"

Economic

In terms of Andalusia's main economic limitations, these are largely conditioned by the region's dependence on raw materials. Firstly, and according to the Ministry of Industry, Trade and Tourism in the Economic Report of Andalusia 2021 (Junta de Andalucía, 2021), some of Andalusia's foreign trade figures reveal those economic sectors, and particularly, the products that suffer from a higher dependence among those consumed in the region. Defining the "trade balance" as the difference between the monetary value of exports minus that of imports, those cases in which this operation is negative (trade deficit) reflect the fact that a region/country is dependent on foreign supplies of a certain product.

According to the classification by major sectors, purchases of "Energy products" amounted to 12,697.9 million euros, raising their share in overall figures to 38.3% of total imports. This was followed

by "Semi-manufactures" and "Food, beverages and tobacco", both with approximate weights of 16%, over 5,000 million euros. More specifically, there are some products and raw materials that reflect significant import dependence figures in Andalusia. These can be found in the following Figure 60:

	Million euros			% GROWTH 21/20	
Sector	**Exports**	**Imports**	**Trade balance**	**Exports (%)**	**Imports (%)**
Food, beverages and tobacco	12217,4	5163,3	7054,0	9,9	26,5
Energy products	5439,6	12697,9	-7258,4	73,5	57,8
Raw materials	2168,0	3675,6	-1507,6	41,9	33,0
Semi-manufactures	7832,1	5350,0	2482,1	46,2	36,1
Capital assets	4171,1	3797,6	373,4	-7,2	3,6
Automotive sector	247,6	392,7	-145,1	2,1	17,5
Consumer durables	312,7	502,9	-190,2	14,3	32,6
Consumer manufactures	1240,5	1557,1	-316,6	56,3	11,7
Other goods	923,0	56,4	866,6	4,1	-26,4
TOTAL	**34551,9**	**33193,6**	**1358,3**	**24,1**	**34,5**

NOTES:
Provisional data for the year 2021. Variation rates calculated with provisional data for the year 2020. (Junta de Andalucía, 2021)

Figure 60: Foreign trade of Andalusia by economic sectors (Junta de Andalucía 2021)

In 2021, following the trend of previous years, imports continued to be highly concentrated in four products, accounting for almost half (44.6%) of total imports. In first place, "Crude petroleum oils", which accounted for 25.2% of total imports, after registering a growth of 56.9% compared to the previous year. It was followed by "Petroleum gas and other gaseous hydrocarbons", which accounted for 7.7% of the overall figure, and increased by 53.6%; "Copper ores" (6.9% of the total) and a rise of 158.6%; and "Petroleum refining" (4.8% of the total). Andalusia's energy dependence is striking, which is also reflected in the growth figures compared to previous years.

Furthermore, imports in 2021 of the four products mentioned above are taking place in a context of a sharp increase in the price of oil (71.2%), which causes a considerable volatility in prices. Although the purchase of these materials is usually centralized at the national level, their price plays a key role. One of the examples of price fluctuations is that of crude oil, which last quarter peaked at over US$120/barrel, and currently standing at around US$87.5/barrel. As evidence of the instability of the region's dependence on this resource, Spain has recently unblocked the veto on oil purchases from Venezuela, conditioned by the import cut-off from Russia. Another example is petroleum gas and other gaseous hydrocarbons, which have shown a similar behaviour in terms of price instability. With the outbreak of the war in Ukraine, prices skyrocketed. Something similar is happening with copper ores and oil refining.

It is of particular concern that the four products on which the region of Andalusia is most dependent are exported in their totality (over 98%) from countries outside the European Union, and therefore with regulations and policies of a more unstable nature, and over which there is a lesser degree of influence. Only in the case of oil refining do European imports have a significant weight (around 42%).

Andalusia's exports of goods abroad amounted to 42,957.7 million euros in 2022, an all-time high and exceeding by more than 10 billion euros the export figures before the pandemic (31,774.5 M€ in 2019). Compared to 2021, exports experienced a growth of 24.3%, above that recorded by exports in the Spanish economy (22.9%) and the EU (20.8% in euros), and similar to that recorded worldwide

(24.9% in euros). The increase in exports in Andalusia was explained by the rise in both non-energy exports (19.5%) and, more intensely, energy exports (50%).

According to the classification of products by major sectors and sub-sectors of foreign trade in goods, which is prepared and published by the Ministry of Industry, Trade and Tourism, Andalusia's exports of 'Food, beverages and tobacco' products reached 13,930.8 million euros in 2022 (32.4% of the total), with an increase of 14% compared to 2021. They were followed by exports of 'Semi-manufactures' (21.6% of total exports), with an increase of 18.5% and an amount of 9,282.6 million euros. They were followed by: 'Energy products' (8,161.2 M€), which, accounting for 19% of the total, grew by 50%, in the context of the aforementioned rise in oil prices (45.8%); 'Capital goods' (5,805.7 M€), after increasing by 39.2%; 'Raw materials' (2,400.6 M€), with an increase of 10.7% compared to the previous year; and 'Consumer manufactures' (1,057 M€), after decreasing by 14.8% (Junta de Andalucía, 2023)

With regard to imports, and according to the classification by large sectors or sub-sectors, purchases of 'Energy products' recorded an increase of 74.6% with respect to 2021, with an amount of 22,169.2 million euros, and raising their share in the overall figures to 47% of total imports. This was followed by imports of 'Food, beverages and tobacco' and 'Semi-manufactures', both with approximate weights of 15% in the overall figures, above 7,000 million euros, and with growth of 39% and 31.4%, respectively. After them, purchases of 'Capital goods' (9.3% of the total), with a rise of 15.2%; and 'Raw materials', with a fall of -4.9%, accounting for 7.4% of purchases abroad. Andalusian imports continued to show a strong concentration, so that more than half (52.9%) of Andalusia's purchases abroad were of just five products (crude oil, petroleum gas, petroleum refining, copper ores and biodiesel) (Junta de Andalucía, 2023).

With regard to trade balances, and differentiating Andalusia's trade with foreign countries between energy and non-energy products, the deficit balance recorded by Andalusia's trade balance in 2022 (-4, 210.3 million euros) was explained by trade in energy products, with a deficit of -14,008 million euros, almost double that of the previous year (-7,262.3 million euros); for its part, the non-energy trade balance showed a surplus of 9,797.7 million euros, 14.9% higher than in 2021, Figure 61 (Junta de Andalucía, 2023).

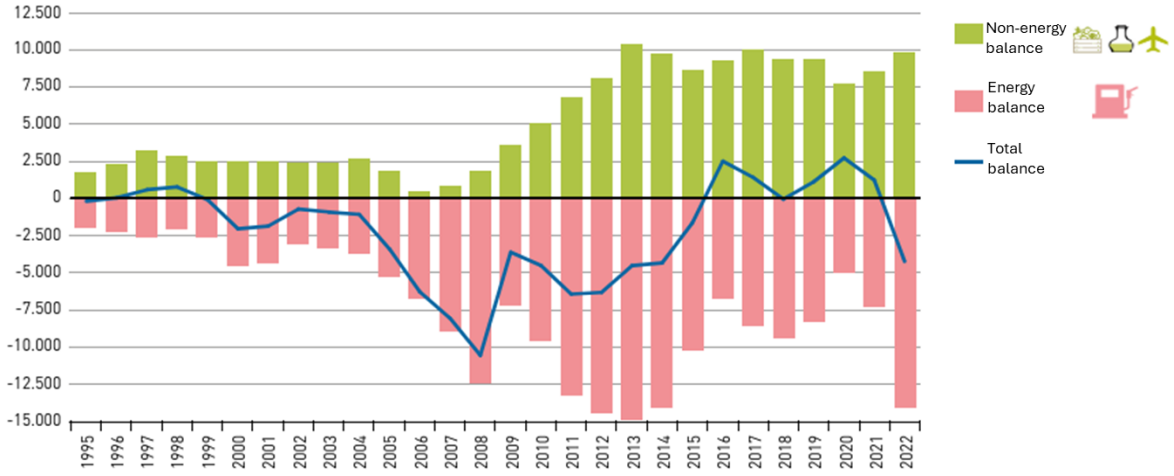

Figure 61. Andalusia's foreign trade balance in 2022

In 2023, Andalusia achieved exports worth 38,537 million euros, making it the third autonomous community in the national ranking, only surpassed by Catalonia and the Community of Madrid. This figure represents a drop of 10.3% on 2022, a year that saw an unusual 24% growth, but it also means a 10.9% increase on the foreign sales recorded in 2021. The drought affecting agri-food products and the international context have significantly affected the price of energy products and raw materials for industry, all of which are very important items for Andalusia. The two products that have experienced record sales were copper and copper products, with 9.9% more than in 2022, up to 1,701 million euros, and machinery, apparatus and electrical equipment, with a growth of 18.5% and a turnover of 1,636 million. Fuels continue to be the main sales item, with 6,173 million euros, 16% of the total, despite a drop of 18.2%, due to the fact that international tensions are having a decisive effect on their price. Andalusia's imports also fell by 12.45% in 2023, to 41,296 million (Andalucía TRADE, 2024).Thus, Andalusia obtained a surplus of 7,769 million euros in its non-energy trade balance with the exterior, with a positive coverage rate of 132.3%, up 34.4 points more than the average for Spain, which continues to suffer a deficit of 7,480 million, with a coverage rate of 97.9% (Andalucía TRADE, 2024).

With regard to the vision of the **transport** sector, this is one of the forms of complex appropriation of natural resources in which the relationship between economic activity and resources is less evident. The inputs of the sector are basically fuels and materials. In the case of fuels, these are energy minerals mostly imported from the rest of the world, linked to a national energy supply strategy. For the other materials, the relationships can be even more complex. The networks used (roads, railway branches, etc.) or the reception infrastructures essential for certain modes of transport (airports, stations, etc.) are related to the supply of the construction materials used. Some are owned and surplus in the region (industrial rocks, cement, etc.), while others are created from imported raw materials (e.g. oil-derived tars) (Agencia de Medio Ambiente de la Junta de Andalucía).

Finally, for the **agricultural** sector in the Andalusian region, the recurrent appearance of drought during different times of the year is of great influence. As a result of this, the amount of a vital resource such as water stored in reservoirs is reduced, bringing with it significant inconveniences. As of October 1, 2021, it was 4,004 Hm3, 33.28% of its capacity and 3.55% below the level registered in the previous campaign. With this situation of water deficit, the data indicate a negative behaviour of the olive sector (the most representative crop of the sector in Andalusia, accounting for 38.3% of total agricultural production, experienced a fall of -12.4%), with a decrease in the production of both olives and olive oil. Production of legumes, cereals, non-citrus fruit trees, arable industrial crops and fodder crops also fell. Against this, the increases in flowers and ornamental plants stood out (Junta de Andalucía, 2021).

In the agri-food sector, Andalusia maintains its export strength, also achieving its second best year in history, 13,707 million euros, only 2.5% less than in 2022, despite the intense drought suffered by the community, which especially affects products of great weight such as olive oil or fruit. Even so, the trade balance of agro-industry contributes a surplus of 6,335 million to Andalusia's foreign trade balance. Vegetables achieved a turnover of 4,198 million euros, olive oil, Andalusia's most exported product, maintained a turnover of 3,286 million, the same figure as in 2022, while vegetable fats and oils as a whole fell by 2.6% and reached a turnover of 3,815 million (9.9% of the total). The fruit sector also suffered a drop of 8.1%, with sales of 2,704 million, down from fourth place (Andalucía TRADE, 2024).

The value of agri-food imports is clearly on an upward trend, having doubled in just two years, from 302 million euros imported in January 2021 to 612 million euros imported in January 2023. (Junta de Andalucía, 2023).

Figure 62 shows the evolution of the value of agri-food imports in Andalusia.

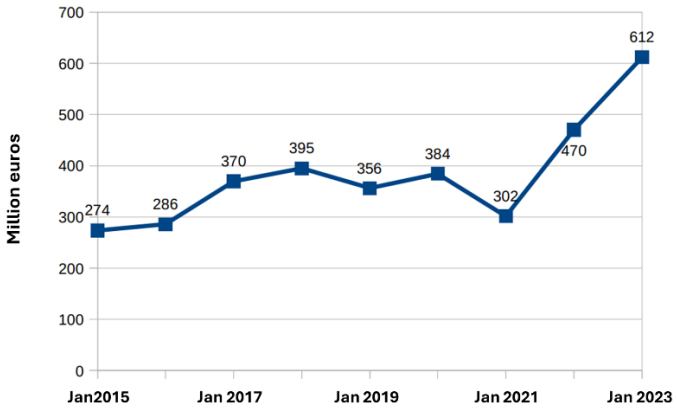

Figure 62: Evolution of the value of Andalusia´s agri-food imports

Social

According to the 2022 Purchasing and Consumption Habits survey conducted by the Consumer Associations Participation Table (MPAC) (Mesa participación Asociaciones Consumidores, 2022), today's consumers are increasingly aware of companies that are environmentally conscious because they are committed to a large extent to sustainable consumption that respects the planet. Hence, 57% value this aspect positively when buying food. Along the same lines, 88% of consumers believe that food waste is a major problem. In terms of sustainability, 89% of consumers surveyed said that eating habits affect the environment depending on how sustainable the food is.

More and more people are choosing to be more environmentally responsible. Today, separating organic waste from plastic and glass (80%), reusing plastic bags (73%) and using multi-purpose bags (63%) are the most widespread habits. In addition to environmental practices such as recycling or measures to reduce water consumption, there is also an increase in the importance given to factors such as energy efficiency, eco-labelling and proximity of production (Junta de Andalucía, 2018).

According to the data obtained in the XIV edition of the Ecobarometer of Andalusia (EBA) (Junta de Andalucía, 2022), published in 2022, for the Andalusian population over the years, concern for the environment has gradually become a priority for a significant group of the population. Issues relating to the environment, climate, energy issues and climate change are presented as a priority problem for the region by 16.2% of the population, with no differences by sex,

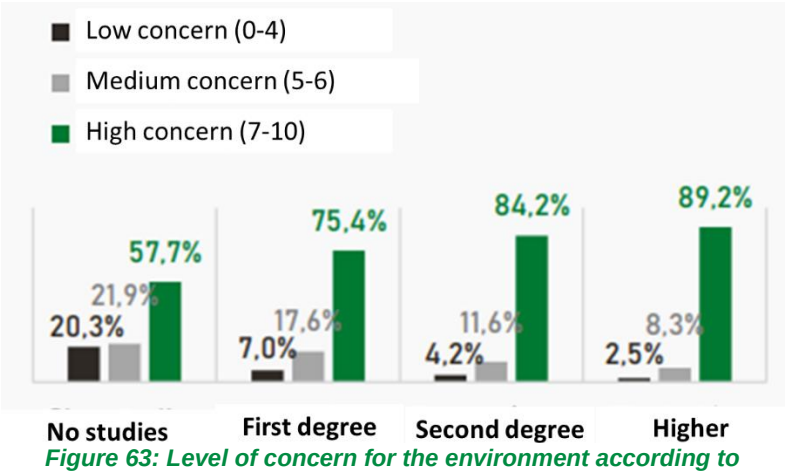

Figure 63: Level of concern for the environment according to educational level (Ecobarómetro)

although a slightly higher priority is given to the 18-29 age group (17%) and the 30-44 age group (19%). It is also a problem that becomes more important for the population as their level of formal education increases, reaching 20% of those with higher education qualifications. Some characteristics of the Andalusian population differentiate their concerns and worries about the environment. Educational level is a key variable: as people's level of formal education rises, so does their concern for the environment. Thus, 57.7% of those with no formal education are highly concerned, a proportion which rises to 75% of those with a first degree, 84% of those with a second degree and 89% of those with a higher education.

Finally, more than half of the Andalusian population agrees (or strongly agrees) that their consumption habits have a negative effect on the environment in Andalusia and the rest of the world (60.1%).

In 2024, Andalusia has a population of 8,620,120 inhabitants, making it the first Community in Spain in terms of population. It has become one of the communities with the highest proportion of children in the country, with 15.85%. People over 65 years of age account for only 14.76% of the total population, with an average age of 41 years. The foreign population of Andalusia has experienced continuous growth, reaching 8.13% of the Andalusian population, according to data from the Andalusian Institute of Statistics. In 2022, 48% of the population was under 45 years of age (Instituto nacional de estadística, 2022)

In terms of educational attainment, in 1980, 15% of Andalusians were illiterate; today, this percentage has fallen to 2.7%. Education has been one of the most substantial advances in the last 40 years. Progress in education has practically eradicated illiteracy. Moreover, the number of Andalusians with higher education has almost tripled, from 89,556 to 234,789.The active population in Andalusia averaged 4,025,108 people in 2022, its highest level since 2015, slightly above the previous year (+0.1%), while in Spain the increase was slightly higher (0.9%). By sex, the entire increase in the active population was due to women, adding 18,200 more active people in 2022, up 1%, the same as in Spain as a whole. Differentiating by age group, the active population in Andalusia increased in the youngest (1.1% in the under 25s) and in the over 44s (2%), while in the 25-44 age group it fell by 1.9%. By nationality, the foreign labour force increased by 4%, while the Spanish labour force decreased by 0.4%, unlike in Spain, where both grew (3.5% and 0.5%, respectively). Finally, if we analyse the level of education, there were only increases in the labour force in the group with higher education, 3.3%, and, within them, in those with university studies, the increase was 2.1%. As a result, almost forty percent of the Andalusian labour force has higher education (38.2%), and more than a quarter (25.7%) have university studies. This percentage of the working population with university studies is 10.8 points higher among women than among men (31.5% and 20.7%, respectively) Table 16, (Junta de Andalucía, 2023).

Table 16: The Andalusian labour market in 2022

	2022		Changes from 2021	
	People (thousands)	% of total	Absolute (Thousands)	Relative (%)
TOTAL	**4025.1**	**100.0**	**2.2**	**0.1**
Gender				
Women	1,854.0	46.1	18.2	1.0
Men	2,171.1	53.9	-16.0	-0.7
Age				

<25	275.2	6.8	2.9	1.1
25-44	1,878.6	46.7	-36.7	-1.9
>45	1,871.3	46.5	38.0	2.9
Nationality				
Spanish	3,613.1	89.8	-13.6	-0.4
Foreign	412.0	10.2	15.9	4.0
Economic activity				
Agriculture	323.2	8.0	-56.7	-14.9
Industry	323.1	8.0	6.5	2.0
Cosntruction	248.0	6.2	-4.7	-1.9
Service	2,757.8	68.5	122.0	4.6
No previous employment	373.0	9.3	-64.8	-14.8
Education degrees				
Uneducated	90.4	2.2	-17.3	-16.1
Primary school	221.8	5.5	-4.2	-1.8
Secundary school	2,176.4	54.1	-24.8	-1.1
Higher education	1,536.4	38.2	48.6	3.3
University studies	1,034.6	25.7	21.6	2.1

In 2022, the activity rate for women increased slightly to 51%, one tenth of a percentage point higher than in the previous year, the highest since 2016. Figure 64 shows the activity rate by gender in Andalusia since 2002.

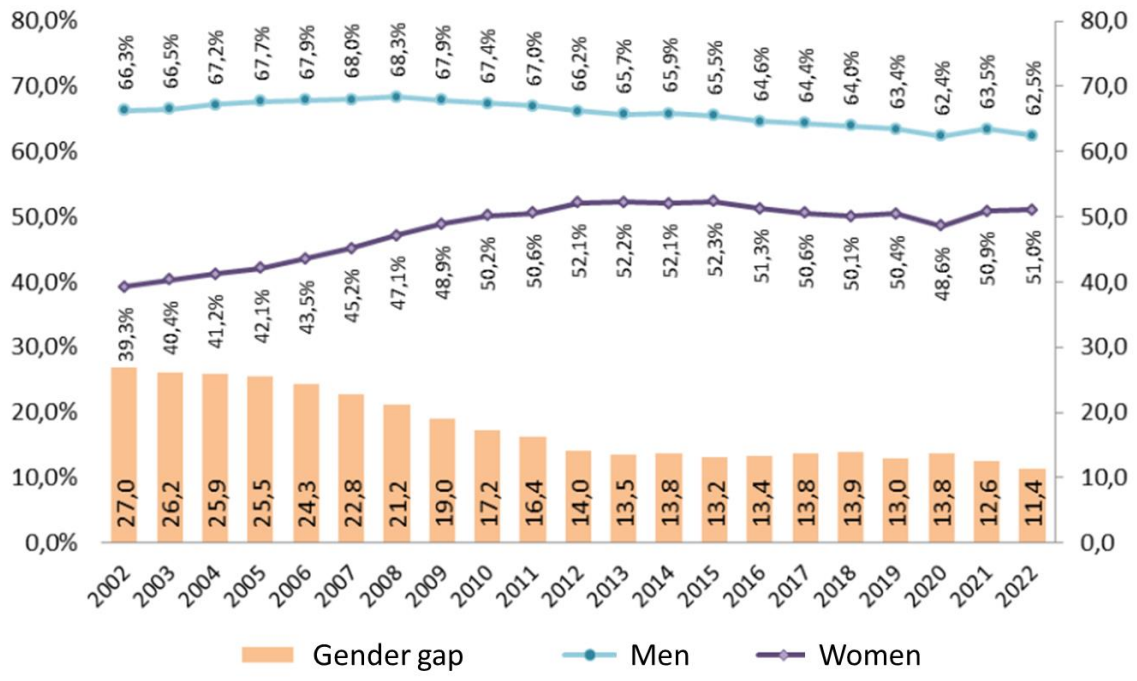

Figure 64: Activity rate by gender in Andalusia. Comisiones obrera Andalucía, 2023)

According to data published by the Economic Observatory of Andalusia (IOEA), the region has experienced a significant increase in the number of employed persons. In 2022, there were 3,259,531

employed persons in Andalusia, its highest level since information has been available. This represents 108,446 more people than in 2021 and a relative increase of 3.4%, In the first quarter of 2024, the region reached a total of 3,377.7 thousand employed, representing an annual growth of 0.9%. This increase, although slightly lower than the national average of 3.0%, is very much conditioned by the evolution of the primary sector. Regional unemployment also showed a positive evolution, with the unemployment rate standing at 17.8%, compared to 18.4% a year earlier, while unemployment fell by 3.1% year-on-year to 730,000 unemployed. By sex, the number of employed women increased by 65,650 persons, an increase of 4.8% over the previous year, twice as many as men (2.4%) and 1.5. (Observatorio económico de Andalucía, 2024).

By age group, the largest relative increase in employment in 2022 was in the younger population (17.7% in the under-25s), at 177,918, its highest level since 2011. Employed persons aged 45 and over grew by 4.1% and those aged 25-44 by 1.4%, with each of these two groups accounting for around 47% of the total employed. Figure 65 shows the employment rate by different age groups over the last 10 years, (Junta de Andalucía, 2023).

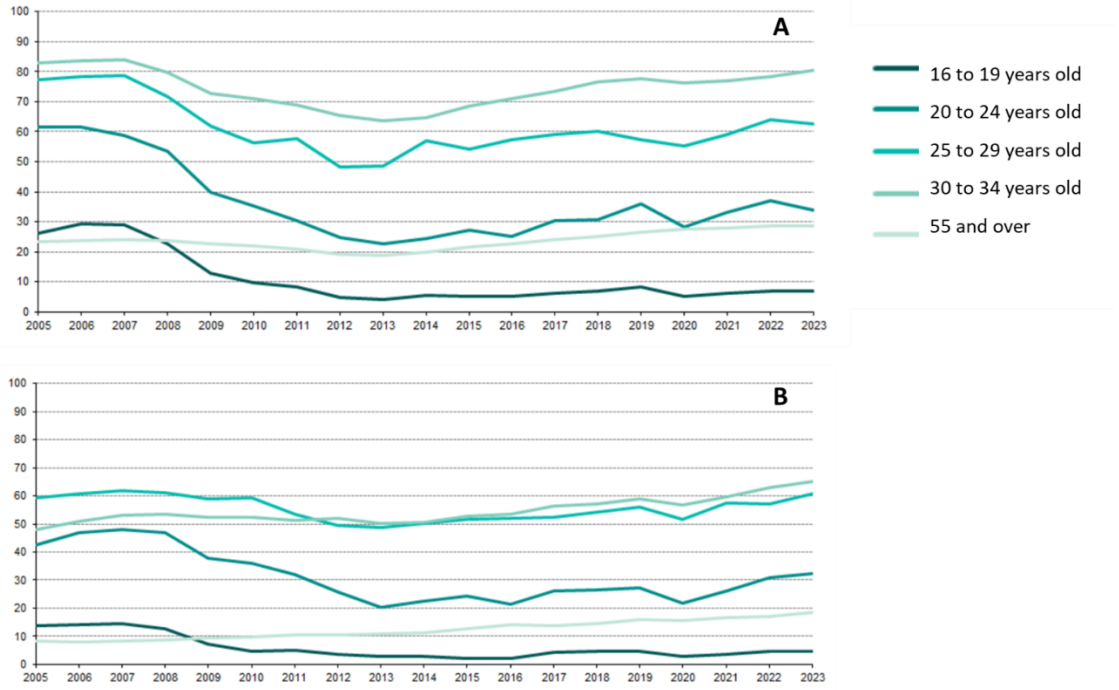

Figure 65: Employment rates in different ages groups A: Men, B: Women. (Junta de Andalucía, 2023)

3.6.3 *Barriers of current economies to achieve relevant sustainability goals*

Andalusia, as one of the most populated regions in Europe, is considering the integration of most of the Green Deal goals into its future agenda. In particular, some of those most directly related to their regional economy are (European Council, 2022):

- From farm to fork: high interest for the agricultural sector, which is so relevant in the region as mentioned in previous sections. Support sustainable food production is one of the most pursued objectives.

- Accelerating the shift to sustainable and smart mobility & Zero pollution ambition for toxic-free environment: for the transport sector in Andalusia, the transition to sustainability, the reduction of emissions, and in general, the shift to smart and clean mobility is a priority objective.
- Climate ambition, preserving and restoring the biodiversity or building and renovating in an energy and resource efficient way: this objective has an important impact on some of the more cross-cutting linear economies of the region, such as tourism or the retail sector.

Besides the considerable efforts that Andalusia dedicates to comply with the Green Deal goals by moving towards sustainability, it also has a strong commitment aligned with the SDGs proposed in the UN 2030 Agenda. In terms of those that affect the main linear economies of the region, the following can be mentioned:

Goal 8: "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" (Instituto de Estadística y Cartografía de Andalucía, s.f.): this is one of the most demanding goals for the Andalusian region, which is among the 3 (out of 20) Spanish regions with the highest unemployment rate. At the end of 2021, this figure exceeded 20% (Datosmacro, 2022). Even so, some of the results of the most relevant indicators of this goal are the increase in GDP compared to 2020 (affected by the pandemic situation), but also surpassing values of previous years of the decade. Regarding tourism-related indicators of this goal, Andalusia is making progress in the implementation of policies promoting sustainable tourism. This commitment is related to being one of the 10 regions with the highest volume of tourists in Europe, within Spain, which leads this ranking at the national level (Eurostat, 2022).

Goal 9, "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" (Instituto de Estadística y Cartografía de Andalucía, s.f.): this is a very important SDG for the region, which unfortunately is not doing well. Related to SDG 8, "Manufacturing value added as a share of GDP" has declined, as well as employment figures within the sector. However, in terms of SMEs, these values reach upward figures in the sector. A key tool to further enhance the development of the sector is the dedication to R&D expenditure as a proportion of GDP, and the Andalusian region with a figure of 1.04% (2020) is above several European countries, although far below the EU average (2.31).

Goal 12, "Ensure sustainable consumption and production patterns" (Instituto de Estadística y Cartografía de Andalucía, s.f.)*:* reducing waste generation through prevention, reduction, recycling and reuse activities has been essential for Andalusia in recent years. Since 2014, the national recycling rate data collected in the region measured by the proportion of municipal waste recycled in relation to the total waste generated and treated has increased from 30% to 35%. This represents continued growth and reflects awareness through sustainability reporting and the degree of involvement of large companies adopting sustainable practices and incorporating sustainability information into their reporting cycle.

As a result of the alignment of the aforementioned objectives, Andalusia has drafted its own strategic plan (The Andalusian Strategy for Sustainable Development 2030 (EADS)) by the Regional Government of Andalusia as an instrument for guiding public and private policies affecting Andalusia, by defining lines of action and measures in strategic areas for sustainable development. The promotion of a green economy and the reinforcement of social cohesion are the two ideas that are the basis of the strategy as a whole. Within the 13 thematic areas distinguished in the document, the

linear case-study economies are collected, and barriers of different categories are identified (Junta de Andalucía, 2018):

- Within the area of "Sustainable agriculture and livestock" (13th area), the main barrier that can be found is the insufficient inter-administrative coordination mechanisms to facilitate the integrated management of policies converging in rural areas. Also, the changing and demanding regulatory frameworks (environmental, food safety, traceability) hinder entrepreneurship, flexibility and rapid adaptation to changes in the sector.
- Regarding "Sustainable Mobility" (ninth area), there is a historical problematic with the orography of the territory, since the mountain areas occupy an area much larger than the average of the Spanish and European regions, so that the creation of the communications network has always meant a high cost. However, the most relevant barrier is reflected in the urban environment, which is the cultural one. The habit of society to use individual and unsustainable transports is very strong. This, coupled with insufficient alternative solutions, has led to cities such as Seville, capital of Andalusia, achieve values around 40% in terms of total number of trips (Ayuntamiento de Sevilla, 2021), being much higher if referring to daily commuting to work.
- Tourism is an important element for the social, economic and political development of Andalusia. However, it is an ambivalent activity, since it can bring great advantages in the socioeconomic field, but at the same time, it produces a pressure on the resources. A structural barrier to the development of sustainable tourism is the lack of review of the current regulatory framework, which lacks sufficient incentives for tourism facilities based on their degree of respect for the environment. New fiscal figures should be considered to promote a new model of sustainable tourism. Likewise, the lack of coordination between tourism, environmental and urban-territorial policies can lead to an increase in the negative effects of tourism.

4. Overview of the main limits and barriers identified and regional stakeholders opinion

This chapter presents an overview of the main limits identified for each region according to the available literature and also the ones raised during the interviews conducted with relevant policymakers and other stakeholders. Gender and age dimensions were considered during the desk research regarding the limits of the current linear and/or fossil-based economies but these aspects were not raised by the interviewees. This could be attributed to their own gender, educational background, professional position or other reasons. Such an analysis regarding this discrepancy is out of the scope of this deliverable. At the end of the chapter, we highlight the main common limits and issues related to the current linear economic systems identified in all case study regions that represent the main issues at the EU level as well as provide specific indicators for the status of the regions that can act as KPIs to evaluate the effectiveness of the transition pathways developed in WP2.

4.1 Burgenland and Northern Burgenland Region, Austria

Burgenland has undergone a remarkable catching-up process in terms of infrastructure, economy, and education. The region has managed to generate average annual growth of around 3.5 % since the year 2000 but despite this growth, still the majority of the population relies on commuting to the city of Vienna and surrounding areas on a daily basis for employment. In parallel, most of the industries that have grown strongly in the region (Table 3) are based on linear systems and depend on fossil-fuels. In order for the region to continue this growth, increase employment of the population and its resilience it needs to address the limits of the current activities. The main limits of the current economic activities in the region were similarly identified in the literature but also by stakeholders (Table 17). CO_2 emissions, nutrient loading from agriculture, habitat loss, impacts on biodiversity and impacts on water resources where the main environmental limits addressed. Additionally, stakeholders raised climate change as a challenge to wine production but also soil degradation from agricultural activities. Related to economic limits of the established systems, the availability of raw materials, their prices and the dependency on imports are the main limitations. Stakeholders additionally raised geopolitical issues impacting raw materials availability and aiming to obtain raw materials at cheap prices at the expense of other countries. When it comes to social limits of the linear economic systems, there is a controversy related to population changes whereas there is an influx of population that is straining the local ecosystem (due to the increased demand on resources) but at the same time, younger and more skilled people are moving away from the region. Additionally, citizen demand for more eco-friendly products and services sets a serious limit to the established systems. Stakeholders identified additional limits related to awareness, creativity, openness and innovation needs to boost the local economy. As to the barriers to achieve relevant sustainability goals, competition related to land use, limited research and measures to address environmental challenges along with lack of awareness, interest and enforcement of federal and state laws were the main ones identified. These challenges pinpoint that the economy of the region needs to address the limits of the existing economic activities, while considering also the identified barriers to achieve relevant sustainability goals. Conclusively, the region needs to move towards more circular and bio-based economic systems.

Table 17: Main limits of the current linear economy in Burgenland, Austria

	Desk research	Interviews
Environmental limits	• High CO_2 footprint predominantly due to high mobiility Phosphorus, nitrogen and pesticide load from agriculture • Habitat loss and impact on biodiversity from agriculture • Waterway sedimentation, groundwater contamination and water overconsumption from agriculture • Climate change and the sinking water level of lake Neusiedl due to nearby activities and water use • Water resource use and availability including future scenarios shows that local agriculture is highly dependent on groundwater wells and needs appropriate water and farming management	• CO_2 emissions from pig farms and transportation. • Climate change affecting wine production • Depleting and contamination of groundwater levels from agriculture • Sinking water level of Lake Neusiedl (surface sealing and climate change). • Habitat destruction and impact on biodiversity from various activities • Indirect environmental impacts from soil degradation.
Economic limits	• High external dependence on imported raw materials (fossil fuels and metals • Shortage of key raw materials the recent years and significant increase in prices. • The dependency on imports can lead to job losses and vulnerability of the regional economy	• Dependency on imported raw materials (availability subject to e.g pandemics, wars, geopolitical problems), affecting prices, availability and import process. • High energy prices and geopolitical problems • Aiming to buy everything at the cheapest price, with an expense of other countries, neglecting true production costs
Social limits	• Ageing population but still increasing population density due to migration and suburb urbanisation of Vienna. • Skilled people are lacking, brain drain in the region and skills and knowledge has been lost due to reduced economic importance. • Citizen survey has indicated that there is high interest in building a sustainable community.	• Younger people working in Vienna not in the region – loss of skilled people • Lack of awareness, creativity, openness and innovation needs to boost the economy. • Growing citizen interested in environmentally friendly and sustainable products. • The influx of people from other regions is straining the local ecosystem.

Barriers to achieve sustainability goals	• The multitude of land-use options, interests, and goals that require space • Low research rate and few higher education institutes • Lack of research contacted in the private sector. • Limited measures to improve sustainability challenges (e.g. climate change, resilience of agriculture and forestry, food loss and food waste) • Gender gap in higher positions/STEM positions •	• Lack of awareness and knowledge (often related to lack of interest) among the population regarding sustainable practices. • Limited resources for implementing sustainability initiatives (High cost, lack of knowledge). • Limited investment in research infrastructure. • Lack of enforcement and implementation of federal and state laws.

4.2 Charles Spa Region - Czech Republic

Natural resources and mineral wealth belong to the key assets of Charles Spa Region (glass and porcelain manufacture, building materials, textiles and musical instruments manufacture) but these assets have been slowly losing importance in the last 25 years, mainly due to their high energy demand, high demand of raw materials and human resources. There were some efforts to transform key companies in the region to compete the global market but there is only a small number of companies that successfully managed the restructure process, accumulated know-how and develop new activities that are successful in new markets and represent the traditional regional crafts. The structure of the economy is also being transformed by foreign investors, the total amount of foreign investments in the is sadly lagging other Czech regions. The current situation in the region is strongly linked and depend on the limits of the current economic activities as summarised here.

In the Charles Spa region, the main limits of the linear economy are described in Table 18. Regarding environmental limits of the current economic activities, pollution caused to the watercourses (that is critical for the Spa industry), the ecological burden of brownfields and air pollution related to house heating and solid fuels are the most critical ones. Additionally, stakeholder raised issues about soil and forestry pollution. As to economic limits here as well the dependency of imported raw materials and energy dependence on fossil fuels are the main limitations identified in the literature. Another dimension is the fact that personnel in the various industries are too specialised which makes adjustment to market changes difficult and thus the economy less resilient. To this adds up the non-existing environment for start-ups and the low innovation culture as identified by stakeholders. The lack of skilled people because of migration to other regions for employment, and the mismatch of education offerings are main social constraints of the current economic activities combined with low social responsibility by companies and citizens. Finally, the main barriers related to achieving relevant sustainability goals are related to the lack of highly educated people, limited research and technological innovation in the region and the existing legislative framework. The region needs to address the limits of the existing economic activities, while also considering the identified barriers to achieve relevant sustainability goals and move towards more circular and bio-based economic systems.

Table 18: Main limits of the current linear economy in Charles Spa region, Czech Republic

	Desk research	Interviews
Environmental limits	• Deteriorated ecological and chemical status in certain watercourses - water pollution from point sources and agriculture. • Ecological burdens of brownfields and unused industrial areas. • Air pollution from house heating & solid fuels (coal & wood)	• Soil pollution • Forestry pollution
Economic limits	• Energy dependence of the spa industry on the traditional linear resources. Pandemics are also affecting and limit the spa industry. • High dependency on imported resources of traditional industries in the region. • Difficulties in transforming economic activities depending on market demands in the field - too specialized personnel	• Dependence on fossil resources • Non-existing start-up environment • Low level jobs in the region • Low innovation culture
Social limits	• Market demand not reflected in the education offers of the secondary schools in the region. • People are migrating and there is a shortage of human resources for the labor market.	• Low educational level • Ageing population • No universities in the region • Low social responsibility of companies and individuals • Absence of experts
Barriers to achieve sustainability goals	• Limited R&D capacity in the region • Not any technological center • Too specialized skills - low ability to transform the existing system • Low level of education	• High acquisition costs • Outdated thinking and technology • Limited research infrastructure • Lack of knowledge • Legislative framework

4.3 Finland

During the last decade, the extraction of biomass, used for the forestry industry, has increased which indicates the interest increase towards renewable resources use. Over 20% more biomass was produced in 2021 compared to 2010. Finland has agreed to follow the European Green Deal – the strategy to make Europe climate neutral by 2050. Associated green transition is a part of the Recovery and Resilience Plan of Finnish Government, and its one major goal is to enhance the circular economy of Finland by using green technologies. (Finnish Ministry of Finance 2023). This shift of Finland towards greener and more circular economic system is due to the various limits of the current economic system. The main limits of the current economic activities in the forestry sector in Finland were similarly identified in the literature but also by stakeholders (Table 19). Forestry in general has

a high impact on biodiversity, release of nutrients and solids in the water and also impacts air quality via emissions. In Finland, the pulp and paper industry represent 90% of phosphorous and almost 70% of nitrogen discharge within the whole industry (Finland's Environmental Administration 2013a). Another challenge of forestry causing water loads is leaching of solids caused by increasing logging, fertilisation, ditching and tillage (Finland's Environmental Administration 2013b). Additionally, stakeholders identified as a limit of the current system the need to consider carbon sinks seriously as well as to maintain sufficient fertilisation and nutrient return to the forest. Related to the economic limits, the halt of imports from Russia was a crucial issue identified, the prices increase and energy along with ensuring stable supply of wood for the industry. Stakeholders additionally identified the potential of recycled fiber. Recycled fibers should be globally used more. The limit is that the major of the fiber-based products produced in Finland are exported and the material is not returned to Finland. Finnish recycling rates of paper and board are extremely good.

The main social limits identified in literature was related to the importance of preserving the forest for human wellbeing and conserving the environment. People are also more educated now and understand better the need to shift from linear systems, and thus demand more eco-friendly products and are willing to pay more for them. Stakeholders additionally identified the lack of skilled professionals in rural areas for the forest industry along with issues related to the raw material purchasing because of the increasing number of forest owners. According to the literature, the main barriers to achieve sustainability goals are related to lack of funding and adequate other types of support and incentives to create multi-actor circular models to commercialise new concepts and technologies, using the side streams and waste mainly to energy recovery as well as challenges in decreasing the harvested forest area. Additionally, stakeholders identified that environmental permits and EU regulations pose a major barrier as well as limited advocacy for the sector. These challenges pinpoint that the forestry sector needs to address the limits of the existing economic activities, while also considering the identified barriers to achieve relevant sustainability goals. To achieve this, the sector needs to move towards more circular economic systems.

Table 19: Main limits of the current linear economy in Finland

	Desk research	Interviews
Environmental limits	• Biodiversity loss from forestry activities • Eutrophication from phosphorus and nitrogen used in forestry • Solids released in the water	• Biodiversity loss from forestry • Maintaining sufficient fertilisation and return of nutrients back to nature (ash) • Carbon sink issues
Economic limits	• Wood prices are increasing due to market demand and reduced import (raw material availability) • Energy prices fluctuations. • Challenges related to logistics and transportation to ensure supply of wood for the forestry sector • Raw material availability	• Imports from Russia have stopped causing 10 % shortfall in raw material • Energy price increases • More financing is needed for new investments & maintenance of transport infrastructure

Social limits	• Emotional connection to nature creates a willingness to understand nature and forest • Health benefits from visiting the forest and preserving it for recreational purposes • People are more highly educated nowadays and recognise the need to shift away from linear systems	• Not enough skilled professionals and staff for mills in rural areas in the future • Keeping forests as conservation areas and not using them for forestry (human wellbeing needs) • The number of forest owners is constantly increasing that makes raw materials purchase challenging
Barriers to achieve sustainability goals	• Lack of funding and adequate other types of support and incentives to create circular models • The willingness to change the established forestry sector • Effective utilisation of waste and side streams in producing bioenergy instead of using them in circular economy. • Difficulties with decreasing the harvested forest areas	• Lack of knowledge and capital on how to commercialize new solutions • The current environmental permit process is slowing down new solutions • Challenges regarding EU regulations and permits - Finnish forestry sector is not sufficiently understood. Poor forest industry advocating.

4.4 North Rhine-Westphalia Region – Germany

North Rhine-Westphalia (NRW) harbors a strong industrial sector, with the chemical sector being one of the biggest contributors to NRW's economic power. While overall turnovers have been declining slightly during 2015 and 2020, the last years showed a strong increase. The amount of employees in the sector has constantly grown during the last ten years. Concerning the development of new technologies, NRW also holds the lead in Germany in the amount of patent application in the areas of organic fine chemistry, metal chemistry, polymer technologies, pharmaceutical technologies, and biotechnology, again underlining the importance of these industries. Germany's chemical industry depends strongly on fossil resources, especially petrochemical raw materials of which the demand reached 20 million tons in 2020 and therefore, addressing the current limits of the linear system and this dependency is critical for the long term well-being of the region.

The main limits of the current economic activities in North Rhine-Westphalia (NRW) were identified in similar ways in the literature but also by stakeholders (Table 20). Mining of lignite is harmful to the environment, as it causes degradation to the soil and surface waters, leads to biodiversity loss and the burning of the derived coal leads to high GHG emissions. This sector will be wound down entirely by 2030, leading to challenges in energy provisions for the energy-intensive industries in the region. Production of fossil-based chemicals can have negative environmental effects, especially when fossil carbon is released during production or the products themselves. Related to the economic limits of the activities in the region, the dependency on imported raw materials, their shortage (and consequently increases prices) and electricity cost are highlighted in the literature. Stakeholders identified additionally that the fluctuations in availability are increased by geopolitical issues and that environmental regulations will require a change in the operations of the chemical industry. At the same time, the increased demand of consumers and citizens for green products and lifestyle, in conjunction with investments focusing on sustainability set social limits to the existing linear systems.

Stakeholders also discussed the lack of available workforce, not only in academic, but also vocational training. As to the barriers of the linear industries to achieve related sustainability goals, the complexity of conversion routes in the chemical industry, low investment and lack of sufficient skilled workforce were identified in the literature. Stakeholders also identified the unwillingness to change the system as a barrier along with issues of the regulatory framework and the multi-actor value chains. These challenges pinpoint that the chemical industries of the region need to address the limits of the existing economic activities, while also considering the identified barriers to achieve relevant sustainability goals. To achieve this, the sector needs to move towards more circular and bio-based economic systems.

Table 20: Main limits of the current linear economy in North Rhine – Westphalia Region, Germany

	Desk research	Interviews
Environmental limits	• Degradation of ground and surface waters • Removal of upper layers of soil creating changes to landscape due to lignite mining • Reduction of biodiversity • High GHG emissions that affect the climate when lignite is burnt • Use of fossil carbon raw materials, for organic chemistry and materials	• Intense raw material production is toxic for the environment - influence on neighbored ecosystems • Biodiversity loss in the sourcing regions
Economic limits	• Dependence on the import of raw materials (fossil and renewable) • The worldwide shortages of the main raw materials: oil, natural gas, and partially coal, have high impacts on prices • High electricity cost for the chemical industry.	• Strong dependency on imports of raw materials due to limited regional resources • Fluctuations in availability due to geopolitical issues • Environmental regulations that will require changes in the operations of the chemical industry
Social limits	• High interest of consumers in ecologically produced food and ingredients • Investment to companies perceived as sustainable grows • Citizens aim for a greener and more sustainable lifestyle	• Limitation of available workforce as there is a lack of employees in craftsmanship vs. a potential surplus of those in academia • Consumers in the region, especially younger generations, display a large interest in more sustainable products

Barriers to achieve sustainability goals	• Complex conversion routes from biogenic feedstock to chemicals, not yet easy to scale up to industrial processes • Innovation ecosystem needs to be improved • High cost and limited investments associated with novel technologies • Increase in prices due to more stringent sustainability practices • Lack of sufficiently skilled workforce - new technology and innovation require new skillsets both in research and workforce. • Gender gap in higher positions/STEM positions •	• Regulatory side of the legislative frameworks • Economic strength is built upon high efficiency processes and quality products both in linear processes • Fear that the change of the production system will affect the economic strength • Lack of funds to divert existing infrastructure and invest into those helping them achieve sustainability goals • Multi stakeholder value chains

4.5 Region of Western Macedonia – Greece

Western Macedonia has consistently had the highest unemployment rate in Greece and one of the highest youth unemployment rates in the EU, and one of the lowest per capita GDPs in Greece. The local economy is characterised by small companies, traditional industries, high unemployment and low competitiveness. Deindustrialisation and the migration of labor-intensive industries to neighboring low-cost countries have hit an already weak economy (Reid et al. 2012). This situation is further exacerbated by an ambitious ongoing transition from coal, with the region's power stations scheduled to all shut down by 2028 (Koutsandreas 2021) due to the limits and impacts of the current economic system. The main limits of the lignite industry in Western Macedonia were similarly identified in the literature but also by stakeholders (Table 21). The environmental limits of the current energy production system in the region are multiple with high environmental impacts (e.g. biodiversity loss, groundwater contamination), emission of toxic chemicals and GHGs and air pollution. These impacts are known to cause cancer and other health issues. The region also faces many economic limits of the current linear system as there is limited innovation, access to markets, dependency on imported raw materials and local actors cannot fulfill all regulatory requirements. Additionally, stakeholder addressed that certain pollutant taxes make lignite exploitation unprofitable. The region is still focusing on economic activities that are going obsolete (environmental and ethical reasons) and the population is ageing with low level skills while the young generation is moving out. However, there is demand for more green options and greener economic activities and thus, a shift to such activities appears to be one way road for the region. The barriers to achieve relevant sustainability goals for the current linear system are related to the lack of necessary expertise, technical knowledge, licensing issues and sufficient funding opportunities. These challenges pinpoint that the lignite industry of the region need to address the limits of the existing economic activities, while also considering the identified barriers to achieve relevant sustainability goals and to move towards more circular and bio-based economic systems.

Table 21: Main limits of the current linear economy in Wester Macedonia, Greece

	Desk research	Interviews
Environmental limits	• Lignite extraction process causes erosion, sinkholes, loss of biodiversity, contamination of groundwater by chemicals, land degradation, dust, noise and water pollution • Burning of fossil fuels (e.g. lignite) enhances climate change due to the release of contaminants in the atmosphere • High emissions of methane, carbon monoxide, carbon dioxide, nitrogen oxides and sulfur oxides and general hydrocarbons from energy production • Soil and water acidification • Large quantities of exhaust gases • High percentages of cancer or thromboembolic diseases due to the pollution from energy production	• Continuous depletion of the earth's reserve • High pollution in the environment due to emissions • The environmental impact of lignite use for energy production includes land degradation, erosion, contamination of water, noise pollution and waste production • Air pollution leads to respiratory problems, avascular disorders and coronary heart disease, as well as high rates of premature death from cancers and thromboembolic events
Economic limits	• Low innovation performance • Businesses' difficulty in accessing the markets and making the final product available to the consumer • Import of raw materials • Local producers are relatively small and cannot cover all regulatory, qualitative or even quantitative requirements of local industries • The process of stopping lignite mining affects the entire economic and business activity	• Limited development of innovations or competitiveness • Stopping lignite mining creates a suffocating economic environment in the absence of other developed economic branches because of lack of new investments, reduced incomes, no adequate local raw materials and no accessibility to markets • Special taxes on pollutants makes the exploitation of lignite unprofitable.
Social limits	• Focus of the economy on activities that are going obsolete due to environmental and ethical reasons • Elderly population, with a low level of education and lack of advanced and up-do-date skills	• Reduction and aging of the region's population • Interest in greener economic models • Migration of young people to big cities or abroad weakens the Region's qualified human resources • Consumers are very interested in greener and more sustainable products

Barriers to achieve sustainability goals	• Reduction of employment in the primary sector and lack of technical knowledge related to sustainable technologies • Lack of solid supply chains between biomass providers, transporters and end users • Bureaucratic licensing difficulties and instability of the institutional and taxation environment, lack of control mechanisms, lack of public information on the environmental benefits of the use of biomass • Lack of public and private financing resources and limited infrastructure • Gender gap in higher positions/STEM positions •	• Low technical training of productive people • Difficulty to introduce new technologies to aged people with no basic education • Lack of supply chains and skills • Lack of investment in new environmentally friendly technologies • Lack of liquidity for companies • Ongoing brain-drain

4.6 Region of Andalusia – Spain

Andalusia's economy is a major driving force for Spain as a whole and it is the Spanish region that provides the third greatest contribution to the national GDP. In Andalusia, the use of fossil resources affects and limits greatly the quality of the regional environment, the bulk of their use is related to energy. For that reason, the Government of Andalusia developed a series of initiatives related to the energy transition as a result of the limits and impacts of the linear economy. The main limits of the current economic activities in Andalusia were similarly identified in the literature but also by stakeholders (Table 22). The environmental limits of the region are mainly related to tourism, industry and transport as they generate waste, emit GHGs and use a lot of energy. Additionally, tourism has led to losses of beaches that are important for biodiversity. The main economic limits are related to the dependence on imported raw materials, their availability and prices as well as water prices needed for irrigation. Additionally, stakeholders mention that the low diversification of the economic activities make the region less resilient to shocks. At the same time, immigration to the region has led to increased waste production that is putting additional pressure on the current economic structure. Consumers demand more eco-friendly products and consequently, markets shift towards more eco-friendly options. As to barriers of the current activities to achieve relevant sustainability goals, the orography of the region, poor inter-administrative coordination and the current regulatory framework (related to tourism) were identified in the literature. Stakeholders additionally think that the environmental impacts of the regional activities act as a barrier as well as bureaucratic obstacles, lack of interest my politicians and lack of sufficient financial means. These challenges pinpoint that the relevant industries and activities of the region need to address the limits of the existing economic activities, while also considering the identified barriers to achieve relevant sustainability goals. To achieve this, the sector needs to move towards more circular and bio-based economic systems.

Table 22: Main limits of the current linear economy in Andalusia, Spain

	Desk research	Interviews
Environmental limits	• Ecological agriculture in Spain and Andalusia is less harmful to the environment than any other • Due to tourism and man-made constructions there is loss of beaches - impact on biodiversity • Industry, transport and retail cause the most pollution with emissions • Climate change due to energy production & consumption	• Large generation of waste, largely toxic • Impact of extracting raw resources • GHG emissions
Economic limits	• Dependence on raw materials and imports - main imported category is crude petroleum oils • Increased prices of imported raw materials (oil) • Price of water needed for irrigation in the agriculture sector.	• Shortages due to global problems (import of raw materials) • Relocation of the means of production, loss of sovereignty and dependence on critical raw materials • No diversification of the sector (less resilient system) - vulnerability to external economic shocks (pandemics, wars, other geopolitical issues) • Water resources prices are limiting the economic activities
Social limits	• Increased population in the region has led to increased waste that needs to be addressed - more resources and energy consumed • Consumer increased awareness on environmental issues and choosing to be more environmentally responsible	• The market demands sustainable products • Waste generation due to economic growth and pressure to the current system • Consumers are more interested in sustainable products
Barriers to achieve sustainability goals	• Insufficient inter-administrative coordination mechanisms • The orography of the territory (related to transportation and mobility) • A structural barrier to the development of sustainable tourism is the lack of review of the current regulatory framework • Gender gap in higher positions/STEM positions •	• Energy, transport, depletion of raw materials, microplastics, waste generation, CO2 emissions • Bureaucratic obstacles for the effective development of the region • Lack of political interest to address the issues (e.g. waste) • Lack of social awareness about responsibilities for sustainable consumption • Financial limitations to acquisition of high-tech equipment with lower environmental impact

4.7 EU overview of the limits of linear economic systems and status of related indicators

The case-study regional analyses presented in this chapter provided insightful knowledge on the challenges faced in them with many limits and barriers found in common in all or most of them.

Summarizing the main limits of the regions explored we can gather a general overview of the situation of linear economies at EU level as seen below:

1. Environmental limits:
    - Impacts on biodiversity
    - Contamination/overuse of water resources
    - Air and soil pollution
    - Climate change
2. Economic limits:
    - Dependence on imported raw materials
    - Energy prices
    - Supply and price instability caused by geopolitical issues, wars or other sudden shocks
    - Heavily interlinked material use and GDP
3. Social limits:
    - Migration of skilled people from rural to urban regions, away from former fossil-based industrial regions
    - Lack of specific transition expertise
    - Shift of citizens towards more eco-friendly products and practices
4. Barriers to achieve sustainability goals:
    - Lack of bringing innovation and new technology to market/industrial scale
    - Hesitation in adopting new technologies, fear of change
    - Limited funding opportunities
    - Difficulties with existing legislative and regulatory framework
    - Gender gap in higher positions/STEM positions

In relation to the above mentioned commonly identified limits and barriers by the extensive regional desk research, the current status of selected indicators to represent them for each of the case-study regions is depicted in Table 23 below. These indicators can act as KPIs to evaluate the effectiveness of the transition pathways developed in WP2 as it is anticipated that shifting to circular bioeconomy in our focal region, improvement will be observed in them.

Table 23 Current status of selected indicators in the case study regions

Indicator	Burgenland	Charles Spa region	Finland	North Rhine-Westphalia	Western Macedonia	Andalusia
GHGs (CO_2 eq.)	1.8 million tons CO_2 eq.	No data available	1.8 million tons (fossil) + 18 million tons (biogenic)	217.3 million tons CO2-eq. (2021)	76,592.608 - [1,000 tonnes CO2-e (Greece total, 2021)].	39,503.95 kt CO_2
Freshwater eutrophication (N, P)	10-40 kg N/ha	As retrieved from waste treatment plants before and after treatment 2023: BOD (inflow: 6135/ outflow: 113), COD (inflow: 11,660/ outflow: 838), Nitrogen: (inflow 1,202/ outflow 285), Phosphorus (inflow 181/ outflow 31)	N 1800 tons, P 100 tons	12% of measuring stations > 50 mg/l nitrate in groundwater 230,000 ha eutrophied area (P), 350,000 ha nitrate (2020, NRW)	No data available	4%: >50 mg N/L 9%: 25-50 mg N/L 87%: <25 mg N/L

Water resources use	Ground & spring water only: 29.6 m^3/a (BML 2021 & calculation)	Production of drinking water supplied from public water supply system, 18.245 thous. m^3	BOD7 <10,000tons	5,526.4 million m^3 (2019, NRW)	9,187.67 10^6 m3 (ELSTAT, 2021)	water in reservoirs 3,364.7 hm^3
Air pollution (NOx)	4,430 tons	5,710 tons (2020)	14,000 tons	209,000 t (2020)	49,231.051 tonnes (Mg) (GR)	19 µg/m^3
Air pollution (PM2.5)	535 tons	1,573 tons (2020)	<2,000 tons	Emissions: 8,500 t (2020) measured every 4 years Average urban particulate matter pollution : 10µg/m3 (2022)	36,479.013 tonnes (Mg) (GR 2021)	PM_{10} : 23 µg/m^3
Air pollution (SOx)	197 tons	3,462 tons (SO_2 2020)	<1,500 tons	1-2 µg/m^3 for Germany (2023) Annual mean 3,8 – 9.7 µg/m3 in 6 measuring stations (2023)	162,932.688 tonnes (Mg) (GR 2021)	19.5 kt SO_2

Land use change	Degree of soil sealing 44% - 147km² (BEV 2023) Increase in 160% of industrial real estate areas between 2000-2018 (UBA 2023)	For CZ there's a tendancy to decrease agri-land for the past 10 years. But for Charles Spa is almost stable (124,155 in 2019)	no changes due to forest industry	5.6 hectares per day (2022)	-5,390.90 thousand tonnes (GR)	47.99 OCS (Mg C/ha)
Soil pollution (Pesticides)	0.2 µg/l glyphosate, 0.1-0.9 µg/l dimethenamide, all measured pesticides found in traces	No data available	no changes due to forest industry	9,000 t of pesticides used in 2017 (NRW)	No data available	83% of Spanish agricultural soils show traces of pesticides
Soil pollution (other contaminants)	17 µg/kg As, 18 µg/kg Pb, 0.42 µg/kg Cd, 55 µg/kg Cr, 17.2 µg/kg Co	No data available	Ash use for forests as fertilizer[91]	No data available	No data available	Lead, mercury, cadmium
Imported raw materials	Only available on national level in monetary values	No data available	3.3 million m^3 of wood	Abiotic raw materials (2020) : 57,145 [ktons]	67,388 thousand tonnes (Country level, Eurostat, 2022)	7.4% of total raw materials

[91] Lannoitevalmisteet - Maa- ja metsätalousministeriö (mmm.fi)

Cost of raw materials	Total value of imported materials: € 3.6 billion in 2022 vs. € 3 billion of exports	No data availab ;e	pulpwood stumpage price 30 €/m^3	84.13 USD/barrel fossil oil (OECD, 04/2023)	No official data available regarding the regional level	3,497 M€ (2022)
Resource efficiency	122 (GDP/DMC, since 2000, Austria. UBA 2024) Material footprint 2017: 33t/cap/a (Austria.	Waste treated in tons 2022: 34,091,539, waste recovered in 2023: 29,498,653, 86.5% recovery	waste 50,000,000 kg annually (0.7% waste from pulp production)	108,0 (GDP/direct material input, NRW 2021)	No data available	No data available
% of population aged <45	45% (2023)	50% of the population was over 50 years old in 2023	51%	50% (2022)	45.14% in Western Macedonia (Eurostat, 2023)	48% (2022)
% of citizens with higher education degrees	16% in rural areas of Northern Burgenland, 27% in capital	11.9% (2018)	35% of working age	29.7 % (25-64 year old: M 32.0 %, W 27.3 %)	28.5% of people between 26-64 years old (Eurostat, 2024)	58.9% of the active population aged 16 and over (2023)

Employment rates in different age groups	138,532 employable persons in 2021 54% M, 46% W), 75% leave their municipality for work, 38% leave the federal province	44.5% (15-29 years), 82.9% (30-44 years), 86% (45-59 years), 15% (65+ years) as in 2021	76% (20-64 years old)	Unemployment in 2023: 15-20: M 9.3 %, W 8.7 % 20-25: M6.6 %, W 5.2 % 25-30: M 4.5 %, W 4.2 % 30-35: M 4.2 %, W 3.4 % 35-40: M 4.0 %, W 3.1 % 40-45: M 3.4 %, W 2.7 % 44-50: M 3.1 %, W 2.7 % 50-55: M 2.8 %, W 2.0 % 55-60: M 2.3 %, W2.0 % 60-65: M 2.8 %, W2.3 %	62.3% of people between 20-64 years old (Eurostat, 2024)	5.5% (≤25); 47.3% (25-44); 47.2% (≥45) (2022)

Job loss and job creation	119,246 employed in Burgenland in 2022, 7,492 unemployed (6.3%) in 2022		39,000 persons employed, forest industry creates jobs in rural areas	Unemployment rate 7.8 % (12/2023, NRW)	16.7% of unemployment for people with 15 years and over in Western Macedonia (2023). During the last 11 years, the unemployment rate was reduced 13% (Eurostat, 2024).	17.8% unemployment rate (2024)

5. Conclusions

This analysis provided insightful information on the limits and barriers to achieve EU sustainability goals the current linear and fossil-based economic activities pose for the six case-study regions of the BIOTRANSFORM project. Each region has a different background in its economic growth, level of awareness on sustainability issues and existing policies and initiatives related to achieving sustainability goals and circular (bio)economy. Moreover, the industries represented in each region are very diverse and thus, we were able to obtain valuable information of the different challenges faced in each of them and their effects on the limits of the current linear systems and the transition to circular bioeconomy.

The current analysis revealed many similar challenges across the regions, despite the differences in the industries they represent, and we can thus, conclude that they represent the main limits and barriers of linear economic systems at the EU level. Those include environmental limits such as climate change and biodiversity loss, economic limits such as dependence on imported resources and high prices and social limits such as the migration of skilled people and the shift of citizens to more environmentally friendly products and services. Additionally, reaching relevant sustainability goals is very challenging with the existing linear systems as identified by various common barriers (e.g. lack of innovation & new technology and funding opportunities). Our results highlight the need to transition to circular and bio-based systems to alleviate the environmental impacts and to create more sustainable and resilient economies. However, for such transitions to be successful and sustainable, it is vital to ensure they are just and the benefits and burdens are evenly distributed in the society.

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7. Annex I

7.1 Reporting template for regional analysis

7.1.1 *Current status, trends and future of regional other linear and fossil-based economies*

Please describe in 1.5 - 2 pages what is the current situation of other linear and fossil-based economies in your region. Try to elaborate on the share of the economy that is using other raw materials and fossil-fuels the trends in development of such economies in e.g. the last 50 years and what is the forecasted future for them in the region, while considering climate change and policy regulations.

Indicative questions to guide the literature search:

- What portion of the total regional economy is based on linear systems?
- What are the historical trends in this share and the amount of non-renewable resources used?
- What is the long-term plan of the region for the evolution of linear economies?
- Are there any national/regional policies that impact/limit the future development of linear and fossil-based systems?

7.1.2 *Environmental limits of <region name> linear case-study economy*

Please elaborate in 1.5 - 2 pages what are the environmental limits of the regional linear case-study economies that are the main bioeconomy topics of BIOTRANSFORM. Discuss their impacts as a whole but also for more specific issues such as biodiversity loss, pollution, climate change, land-system change, use of natural resources and their non-renewable nature in your region.

Indicative questions to guide the literature search

- Do the case-study economies jeopardise the provision of ecosystem services?
- Is there an impact on biodiversity from the operation of the case-study systems? On what scale? Locally or also beyond your region?
- Is there any evaluation, report, or analysis available in your region mapping the environmental impact of the extraction of non-renewable resources? (If applicable)?
- What other natural resources are used in the case-study economies and what is the pressure on them?
- Which is the main environmental limit related to fossils that concern your region and affects the life quality of the inhabitants?
- To what degree the use of fossils affects the quality of the regional environment? Are some of these impacts irreversible?
- How the specific industrial activities in your region (Table 2) impact climate change?
- How the specific industrial activities in your region (Table 2) impact CO_2 emissions?

7.1.3 *Economic limits of <region name> linear case-study economy*

Please elaborate in 1.5 - 2 pages what are the economic limits of the linear case-study economies that are the main bioeconomy topics of BIOTRANSFORM. Discuss the financial issues related to them and how these can limit the future development of such activities in your region.

Indicative questions to guide the literature search:

- What are the prices of required raw materials in your region? Do they fluctuate?
- Is there regular availability of raw materials? Or are there any fluctuations?
- How does trading in the region affect the availability of raw materials?
- Is there any evidence about regional dependency on the import of raw materials?
- Are there any examples how the import of raw materials affects the specific economies (If applicable)?
- Which is the main economic limit related to the development of the case-study economies that concern your region? Is there evidence that it can act as a growth inhibitor for the economy?
- Is there any evidence/study/publication that map any financial effects of pandemics, wars and other geopolitical issues on these economies?

7.1.4 *Social limits of <region name> linear case-study economy*

Please elaborate in 1.5 - 2 pages what are the social limits of the linear case-study economies that are the main bioeconomy topics of BIOTRANSFORM. Discuss the societal issues related to them and how these issues can limit the future development of such activities in your region.

Indicative questions to guide the literature search:

- Does the demographic evolution in your region put more pressure on the current economic systems? Is there a relation between changes in population (e.g., ageing, migration, higher economic status) that impact linear economic activities?
- Is there any evidence indicating that consumers are interested in greener and more sustainable alternatives?
- Which is the main social limit related to the current linear economic system that concern your region? What evidence indicate that?
- Is there any difference in consumer's perception about linear economies related to their educational/other background?

7.1.5 *Technical, structural and social barriers to achieve relevant sustainability targets*

Please elaborate in 1.5 -2 pages the technical, structural and social-cultural barriers of the linear case-study economies that are the main bioeconomy topics of BIOTRANSFORM, to achieve relevant sustainability goals. First describe the related goals from the EU Green Deal and the UN 2030 Agenda from the relevant SDGs (Goal 8, Goal 9, Goal 12, Goal 13 and Goal 15) and then the respective barriers of the case-study economies.

Indicative questions to guide the literature search:

- What Green Deal goals are important for your region and the related linear economies?

- What SDGs are relevant for your region? Are they embedded in regional strategies and what is the target of such strategies?
- What do the above identified relevant Green Deal goals and SDGs mean in terms of new developments/direction in the regional economies?
- What barriers (technical, structural and social) do you see in achieving them (e.g. production processes, legislative framework, outdated technology, high cost, lack of knowledge etc.)?

7.2 Synopsis

Using the following table, please summarize in 3-5 bullets each, **the conclusions related to the limits of the linear case-study economies** related to: 1) national/regional policies, 2) environmental aspects, 3) economic aspects, 4) social aspects and the barriers to achieve relevant sustainability targets.

Limits of fossil based economies	
National/regional policies	3-5 bullet points (max 2-3 lines each) related to the barriers that national/regional policies set on the future development of the linear case-study economies.
Environmental	3-5 bullet points (max 2-3 lines each) for the main environmental impacts of the linear case-study economies in your region.
Economic	3-5 bullet points (max 2-3 lines each) to address the main economic limitations for the future development of the linear case-study economies in your region.
Social	3-5 bullet points (max 2-3 lines each) to highlight the most important social limits of the linear case-study economies.
Barriers of fossil-based economies to achieve relevant sustainability targets	
EU Green Deal	3-5 bullet points (max 2-3 lines each) to highlight the main barriers (and the type) to achieve relevant EU Green Deal targets
SDGs	3-5 bullet points (max 2-3 lines each) to highlight the main barriers (and the type) to achieve relevant SDGs targets (mention specific SDG)

8. Annex II

Questionnaire

Interviewee	[First Name] [Last Name]	Title
Date	[Date]	
Interviewer	[First Name] [Last Name]	Region

Introduction: You have been invited to participate in an interview that will be carried out by the BIOTRANSFORM project with a view to identify the perceptions of policymakers and other stakeholders on the current linear fossil-based economies and the potential transition pathways to a circular bioeconomy for your region.

Total estimated duration: 35'- 40'

Part 1: Background Information | Est. duration 1'

1) What is your occupation?
   - ❑ Policymaker
     Please specify _____
   - ❑ NGO
     Please specify _____
   - ❑ SME
     Please specify _____
   - ❑ Research organization
     Please specify _____
   - ❑ Other stakeholder
     Please specify _____

2) Your Gender:
   - ❑ Female
   - ❑ Male
   - ❑ Diverse / Non-binary
   - ❑ Rather not to say

3) Your region: _____

4) What is your highest educational degree achieved?
    - ❑ Less than high school diploma
    - ❑ High school diploma
    - ❑ Some college, but no degree
    - ❑ Bachelor's degree or equivalent
    - ❑ Master's degree or equivalent
    - ❑ Doctorate or Professional degree

Part 2: Existing/ future limitations of the linear fossil-based economy | Est. duration 20'

The questions are targeted to your region and specifically the industries described in the case-study.

What are the main environmental limits related to fossil use that concern your region?

Consider for example the following:

- Is there an immediate impact on biodiversity from the operation of linear fossil-based systems in your region?
- How activities in your region impact climate change and CO_2 emissions?

_____

_____

_____

What are the economic limits related to the linear fossil-based economies in your region?

Consider for example the following:

- How dependent is the regional economy on the import of raw materials? Is there availability of raw materials at all times?
- Which is the main economic limit related to fossils that concern your region and acts as a growth inhibitor?
- How do pandemics, wars and other geopolitical issues affect financially your regional fossil-based economy (e.g. in terms of prices, availability of materials, imports)?

_____

_____

_____

What are the social limits related to linear fossil-based economies in your region?

Consider for example the following:

- Does the demographic evolution in your region puts more pressure on the current economic system?
- Is there any interest for greener and more sustainable products by consumers in your region?

What, in your opinion, are the main (technical, structural and social-cultural) barriers of the current fossil-based economy model in your region to achieve relevant sustainability goals (e.g. production processes, legislative framework, outdated technology, high cost, lack of knowledge etc)?

Consider for example the following:

- What are the main barriers to achieve relevant EU Green Deal targets?
- What are the main barriers to achieve relevant SDGs
    - ***Goal 8.*** *Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.*
    - ***Goal 9****. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*
    - ***Goal 12****. Ensure sustainable consumption and production patterns.*
    - ***Goal 13.*** *Take urgent action to combat climate change and its impacts*
    - ***Goal 15.*** *Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*

Are there any national/regional policies that impact/limit the future development of fossil-based economies in your region?

Part 3: Existing patways to support the circular bioeconomy transition | Est. duration 20’

The questions are targeted to your region and specifically the industries described in the case-study.

Are there any regional bioeconomy strategies or regional strategies related to bioeconomy and if are there any programmes/ instruments to operationalize them?

Are there already interesting networks on the bio-economy on-going in the region (NGOs focused on circular bioeconomy – HUBs, clusters, platforms etc.)?

Is the public government currently using any motivations: are there any competitions / awarding policies / green procurement in practice?

Are there any existing R&D infrastructure (ESFRI, eDIH, R&D parks - in operation)?

Are there any overview (e-map) of existing technologies processing biomass or residues to necessary commodities (existing network of biogas plants, composting units, renewable energy plants)?

Is there any evidence about the amount of biomass residues, unexploited biomass, study about the potential of biomass utilisation?

Would you like to share any final thoughts? Anything you consider important to highlight?

9. Annex III

9.1 Reporting format to complement Task 1.1 and Task 1.2 deliverables – Austria

Part 1: Background Information

Please summarize in one paragraph or figure the background information of all interviewees .

alchemia-nova conducted 5 interviews with stakeholders from the target region of Nordburgenland. The composition of stakeholders is diverse. They represent the following areas:

1. Chairwoman of an association (NGO)
2. Professor of Innovation and Sustainability (Research institution)
3. Model region manager for a KLEM region (Other)
4. Regional manager for a KLAR region (Other)
5. Specialist advisor in the regional administration of the state of Burgenland (Political decision maker)

Part 2: Existing/ future limitations of the linear (fossil-based) economy

Question 1. What are the main environmental limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) that concern your region?

Interviewee One:
Climate change is affecting wine culture by depleting groundwater levels and increasing water requirements for vineyards. Despite efforts to conserve water, awareness among farmers, especially conventional ones, remains limited. The drying up of Lake Neusiedl poses economic risks, and experiments with alternative crops and vine varieties are being conducted to adapt to the changing conditions. The region would benefit from innovative stakeholders, such as urban career changers, to revitalize fallow land and sustain the local economy.

Interviewee Two:
The excessive use of petrochemical fertilizers has led to the contamination of groundwater with high levels of nitrates, requiring the installation of expensive nitrate filters in wells. Insecticide usage has also resulted in a decline in insect diversity. Around 25% to 30% of farmers in the region practice organic farming, but many winegrowers struggle to obtain organic certification due to the narrow strips of land they cultivate, which makes them susceptible to pesticide drift. The high rate of surface sealing, particularly in Burgenland, has led to habitat destruction, and the region has the highest land sealing per capita in Austria. While efforts have been made to address this issue, larger farms, such as pig farms, contribute to CO2 emissions, and commuting is a significant source of carbon emissions, with public transportation still needing improvement.

Interviewee Three:

The main challenge in Burgenland is related to mobility, with the region having the highest number of cars per household in Austria. This is attributed to underdeveloped public transport and the continued perception of cars and motorcycles as status symbols. While the direct impact on Lake Neusiedl is not significant, the drying up of the lake is influenced by a combination of climate change and surface sealing. The reduced flow of rainwater from surface waters, due to increased surface sealing, contributes to the declining water levels in the lake.

Interviewee Four:

The current operation of linear and/or fossil economic systems in the region has significant immediate impacts on biodiversity, with conventional agriculture being the main contributor. The loss of species diversity is a major problem, as it destroys insects and disrupts the entire food chain. Another sector with a significant impact is transportation. Additionally, there are indirect effects through soil degradation. Addressing these issues is crucial for promoting a more sustainable bioeconomy in the region.

Interviewee Five:

The Burgenland region, particularly in recent decades, has become heavily reliant on fossil fuels, resulting in the primary use of fossil energy sources and natural gas for regional heating. The transition to renewable energy is more feasible in Burgenland compared to other Austrian states due to its favourable geographic location. The North Burgenland, specifically the Pandorferplatte area, benefits from ample sunshine and windy conditions, making it ideal for the expansion of wind and solar energy installations. However, this shift towards renewable energy and its extensive development may potentially impact the region's biodiversity and ecological diversity. The conversion of agricultural land for renewable energy projects, such as photovoltaic installations, means these areas are no longer available for food production.

Question 2. What are the economical limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Interviewee One:

The regional economy in Burgenland, like other regions in Austria, relies on the import of raw materials. The availability of raw materials is subject to various factors, including pandemics, wars, and geopolitical problems. These external factors can impact the regional economy financially, affecting prices, availability of raw materials, and the import process. The effects of such events on Burgenland's economy are similar to those experienced by other regions

Interviewee Two:

The regional economy in northern Burgenland is not heavily dependent on the import of raw materials. However, there is potential for utilizing existing gas lines for hydrogen, particularly in the context of industry and air traffic, although discussions regarding its use for heating houses are ongoing. The main economic constraint related to the current linear economic system is the high energy prices, which are driving the development and promotion of wind energy and photovoltaics in the region. Geopolitical problems like the war in Ukraine and energy price increases have

impacted the regional economy, leading to higher purchase prices for organic food and increased costs for items like oil. (10l canister of oil costs 50 € today, this cost 30 € 2 years ago.)

Interviewee Three:

The regional economy in Burgenland's dependence on the import of raw materials and the continuous availability of such materials is uncertain. The main economic constraint related to the current linear economic system in the region is the focus on buying everything at the cheapest price, which comes at the expense of other countries and neglects the true costs of production. Pandemics, wars, and geopolitical problems have had a relatively small impact on the regional economy in northern Burgenland, with challenges faced by the catering industry in terms of lost workers and retraining. Additionally, high energy prices pose a problem for businesses, although some sectors may benefit from these conditions.

Interviewee Four:

Activities in the region have a significant impact on climate change and CO2 emissions. While the industrial sector has a relatively small role, tourism and transportation are the main contributors to emissions. The lack of well-developed public transportation leads to a heavy reliance on private cars, particularly among tourists. Agriculture is also a major emitter of greenhouse gases, with soil releasing gases like nitrous oxide due to practices such as nitrogen fertilization. Additionally, there are a few large-scale animal farming operations, such as turkey farms and pig breeding facilities, which contribute to emissions.

Interviewee Five:

Due to the current economic system, Burgenland has become heavily dependent on imported goods, as locally produced goods have become highly specialized and no longer cover everyday necessities. One of the major economic dependencies lies in the energy source of natural gas. The dependence on natural gas, particularly from Russia, has been highlighted during the Ukraine conflict. In the Burgenland region, the Ukraine conflict has led to a reduction in production within manufacturing companies. In the residential sector, it has become evident that energy prices have been at a historically low level in recent years/decades. Many single-family houses were built with large living spaces, and the heating costs for these houses have become unaffordable for many residents. The COVID-19 crisis has already shown that in times of emergency, goods may not be delivered or could be withheld, emphasizing the importance of diverse regional production.

Question 3. What are the social limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Interviewee One:

The demographic development in the region has led to a rural exodus, with the younger generation seeking an easier lifestyle and becoming commuters, particularly to Vienna. There is a lack of awareness, creativity, openness, and innovation needed to boost the regional economy, despite the untapped potential for eco-tourism. The historical "victim consciousness" and fear of losing everything hinder the perception of eco-tourism as an opportunity. In terms of consumer

preferences, there is a small but growing clientele interested in environmentally friendly and sustainable products, primarily limited to regional, seasonal, and organic food.

Interviewee Two:

The region of Northern Burgenland is facing pressure on its current economic system due to demographic growth resulting from its proximity to Vienna. The influx of people from both Vienna and southern Burgenland, coupled with construction activities, is straining the local ecosystem. Unfortunately, consumer interest in environmentally friendly and sustainable products has declined due to inflation, leading to a shift towards non-organic products. These factors highlight the social limits of the current linear economic system in the region, emphasizing the need for sustainable and environmentally conscious practices.

Interviewee Three:

The demographic development in the region has put pressure on the current economic system. Certain areas, like Weiden, are experiencing a decline in regional infrastructure, such as kindergartens and supermarkets. Many young people from rural communities are moving to Vienna, leading to a decrease in local population. However, there is a significant influx of people, particularly from Vienna, into sought-after areas like Neusiedl am See. In terms of consumer interest, the region, particularly Seewinkel, showcases a strong affinity for environmentally friendly and sustainable products. The Seewinkel National Park has been actively promoting sustainable practices for the past 30 years, making it an ideal ground for implementing climate model regions (KLEM, KLAR). The region boasts a wide variety of innovative biological and regional providers, making it a fertile ground for sustainable initiatives. The involvement of multiple stakeholders is seen as a positive development in this area.

Interviewee Four:

In the region, the current demographic development, including migration from Vienna, contributes to the pressure on the existing economic system. The proximity to Vienna and the high quality of life attract newcomers, benefiting the local economy. There is an increasing interest among consumers in the region for environmentally friendly and sustainable products, although it is primarily observed within a specific group of individuals. Overall, the demand for such products is slowly but steadily rising.

Interviewee Five:

The Northern Burgenland is still a very rural region, so I would say that the demographic pressure is not very high. However, the demand for goods and resources, like in the rest of the Western world, is very high and therefore difficult to meet regionally. Due to the COVID-19 crisis, there is an increased influx of people. Throughout Austria, there is a growing interest in environmentally friendly and sustainable products, although it may be slightly lower compared to the rest of Austria.

Question 4. What, in your opinion, are the main (technical, structural and social-cultural) barriers of the current fossil-based economy model in your region to achieve relevant sustainability goals (e.g. production processes, legislative framework, outdated technology, high cost, lack of knowledge etc)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

The current economic model in the region faces several barriers to achieving relevant sustainability goals. One key barrier is the lack of awareness and knowledge among the population regarding sustainable practices. The region's relatively weak economic power in the Austrian context also limits resources for implementing sustainability initiatives. High costs, whether real or perceived, discourage the adoption of sustainable approaches, and a lack of imagination hampers the transformation of villages into more sustainable spaces. While there are positive developments, such as the work of Research Burgenland (www.burgenland.at) in building technology and sustainable energies, further investment in research infrastructure is needed. Initiatives like the use of demo plants from EU projects are already benefiting the region by creating local jobs and improving infrastructure.

Interviewee Two:

The main barriers to achieving relevant sustainability goals in the current economic model of the region include a lack of acceptance and knowledge, often resulting from a lack of interest. There is a prevalence of spreading conspiracy myths, which further hinder progress. The deteriorating condition of Lake Neusiedl has sparked widespread concern, leading to increased interest in questioning the long-term viability of a one-dimensional linear economy. Overcoming these barriers requires addressing the lack of interest, combating misinformation, and emphasizing the need for sustainable alternatives to protect the environment and ensure long-term well-being.

Interviewee Three:

The main barriers of the current economic model in the region to achieve relevant sustainability goals include the lack of enforcement and implementation of federal and state laws. Despite existing regulations, such as idling engines and maintaining safe distances, non-compliance persists without consequences. Egocentrism and ignorance pose significant obstacles, with a lack of awareness and delayed perception of climate change impacts until it's too late. Effective awareness campaigns reporting facts are necessary, as mainstream free newspapers often fail to provide this information but can be accessed in rural areas. Overcoming these barriers requires stronger enforcement, addressing egocentrism, and improving information dissemination.

Interviewee Four:

The main obstacles in the current economic model in the region to achieve relevant sustainability goals include high costs and a lack of financial incentives, as well as limited knowledge and information. There are no significant technological barriers, but there may be challenges related to supply chain disruptions. These obstacles hinder the achievement of relevant EU and UN sustainability goals.

Interviewee Five:

I believe the greatest problem lies in the high demand for goods and higher living standards. In the current economic system, growth is the pursued objective. Alongside the heavy reliance on natural

gas, the transportation sector poses another challenge. Due to rural structures, individual transportation, particularly cars, remains the largest CO2 emitter in Burgenland.
To decarbonize the transportation sector, it is essential to expand the electric infrastructure. However, these are long-term and costly projects. The approval of the 110k power line was a significant step in the right direction for Burgenland. Nevertheless, I consider the expansion of public transportation to be crucial as well.

Another issue is that Austrians are convinced that Austria is doing well in terms of climate protection. However, this is no longer the case. Therefore, I believe that raising awareness plays an essential role in achieving climate goals.

Question 5. Is there any national/regional policy that impact/limit the future development of the targeted linear economies in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

- *no answer*

Interviewee Two:

There are national and regional policies that have an impact on the future development of targeted linear economic sectors in the region. Recently, the provincial governor and the deputy collaborated with renowned climate scientist Dr. Helga Kromp-Kolb to publish a climate strategy. Additionally, there is an organic strategy in place to support farmers in transitioning to organic practices, along with a mandatory organic quota for kindergarten lunches. The state energy supplier has also made investments in wind farms, emphasizing the involvement of the public sector in renewable energy initiatives.

Interviewee Three:

- *no answer*

Interviewee Four:

The future development of desired linear economic sectors in the region is influenced and limited by national and regional political measures. The current financial incentives are inadequate and need to be redirected to support sustainable practices. The responsibility lies with policymakers at the regional and national levels to address issues such as land sealing, water management, and promoting soil-friendly farming practices. Subsidies and other financial incentives can encourage farmers to transition to more sustainable and soil-friendly cultivation methods. However, there is a need for greater knowledge dissemination and support to facilitate the transition to organic farming, which is financially viable but requires significant effort and system-wide changes.

Interviewee Five:

In my field (just a small excerpt):

Country: Building laws, energy spatial planning, grant systems...

Federal: EGG (draft for consultation), EWG (draft for consultation), EEffG (draft for consultation), changes in the GWG (Trade Act) and GewO (Industrial Code)

EU: EPBD (Energy Performance of Buildings Directive), EED (Energy Efficiency Directive) etc.

Part 3: Existing pathways to support the circular bioeconomy transition

Question 6. Are there any regional bioeconomy strategies or regional strategies related to bioeconomy that exist in your region and what programmes/ instruments operationalize them?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

- no answer

Interviewee Two:

No, there aren't any regional bioeconomy regional strategies or regional strategies related to bioeconomy.

Interviewee Three:

In the region, there are no existing regional bioeconomy strategies or specific programs/instruments to operationalize them. However, there are some individual businesses, such as certain agricultural and cattle farming enterprises (e.g., Angus Beef), that are actively promoting bioeconomy practices. These businesses engage in activities like direct sales, regional value chains, and recycling of biomass waste and byproducts, such as utilizing waste from red rice or converting grass clippings into pellets for heating greenhouses. These examples demonstrate localized efforts towards circular economy principles and resource utilization within the bioeconomy.

Interviewee Four:

No, there aren't

Interviewee Five:

- no answer

Question 7. Are there already interesting networks on the bio-economy on-going in the region (NGOs focused on circular bioeconomy – HUBs, clusters, platforms etc.)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

- no answer

Interviewee Two:
In the region, there is a notable bioeconomy network called freu-raum that serves as a small pioneer in the field. However, there is a lack of technology centers with cluster technology similar to the Green Tec Cluster in Styria. The existing technology center in the region is primarily an office building offering affordable rents to various businesses and public entities, highlighting the need for a dedicated cluster technology center for bioeconomy initiatives.

Interviewee Three:

In the region, there are some interesting networks related to bioeconomy and circular economy, primarily facilitated through KEM (Climate and Energy Model Region) regional managers and their projects. These networks focus for example on connecting schools with businesses and exploring opportunities for acquiring funding. KEM managers play a crucial role in coordinating these efforts, often providing consulting services without direct charges to customers, as it is part of the KEM services.

Interviewee Four:

No networks are known

Interviewee Five:

- no answer

Question 8. Is the public government currently using any motivations: are there any competitions / awarding policies / green procurement in practice?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

- no answer

Interviewee Two:
Yes, the public sector is using motivational measures and implementing competition/procurement policies with ecological procurement practices in certain areas. For instance, in kindergartens and schools, there is a mandatory requirement for a proportion of organic food. Additionally, in Eisenstadt, there have been successful efforts to implement the Federal Guideline for Sustainable Procurement. However, despite these measures, awareness of sustainable procurement practices remains limited, and there is a lack of training on the subject in the region.

Interviewee Three:

It is unclear whether the public sector is currently implementing motivational measures or if there are competitions, procurement policies, or ecological procurement practices in practice. The situation appears to be complex, and there are local champions who divide or address these issues among themselves.

Interviewee Four:

Not known; selectively green procurement policies at hospitals and kindergartens are put in practice.

Interviewee Five:

Yes, they exist - however, I cannot provide a complete list.

Question 9. Are there any existing R&D infrastructure (ESFRI, eDIH, R&D parks - in operation)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

- no answer

Interviewee Two:

The existing R&D infrastructure in the region is relatively limited. However, there is a small research initiative centred around hydrogen and energy storage that is developing around Burgenland Energie in Eisenstadt. While this initiative shows promising developments in the field, the overall R&D infrastructure in the region is not extensive and does not include ESFRI (European Strategy Forum on Research Infrastructures), eDIH (European Digital Innovation Hubs), or dedicated R&D parks that are currently in operation.

Interviewee Three:

The availability and implementation of motivational measures, competitions, procurement policies, and ecological procurement practices in the public sector remain uncertain. However, it is noted that there are local champions who handle these matters among themselves.

Interviewee Four:

At Research Burgenland, there the topics are already anchored.

Interviewee Five:

- no answer

Question 10. Are there any overview (e-map) of existing technologies processing biomass or residues to necessary commodities (existing network of biogas plants, composting units, renewable energy plants)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

- no answer

Interviewee Two:

- no idea

Interviewee Three:

There is currently no existing overview or e-map of technologies for processing biomass or waste into necessary raw materials, such as biogas plants, composting facilities, or renewable energy installations. However, the development of a biomass network is being considered for the next KEM (Climate and Energy Model Region) period, although it involves challenges such as adjusting the land use plan. The focus is on establishing regional district heating networks from biomass combustion plants. Biogas is less prominent in the region. There are several composting facilities in the Neusiedl/Seewinkel region (which represents a part of the Northern Burgenland Region), and the data on these facilities is available through Burgenland Energie and the Burgenland Waste Association.

Interviewee Four:

- *no idea*

Interviewee Five:

- *no answer*

Question 11. Is there any evidence about the amount of biomass residues, unexploited biomass, study about the potential of biomass utilisation?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

- *no answer*

Interviewee Two:

- *no idea*

Interviewee Three:

There is information available on the quantity of biomass residues, unused biomass, and studies on the potential of biomass utilization. One can find this information at the Burgenland Waste Association or on the KEM (Climate and Energy Model Region) website. In the past, there has been limited interest in utilizing biomass residues, but the interest is now increasing. Municipalities are becoming more interested in utilizing biomass for heat generation. Only a few heat networks operate economically without combined heat and power (CHP). The KEM prioritizes the CHP utilization of biogenic residues.

According to the implementation concept of the KEM, prepared in 2020 and covering the 11 municipalities, a new version will be created this year. The biomass potential of the Neusiedler See - Seewinkel region is explained, considering the methodologies presented. The calculated biomass potential includes agricultural and forestry biomass. The energy potential for solid biomass from the agricultural and forestry sectors in the model region is approximately 432.77 GWh/year. The energy potential for biogas in the same region is 279.98 GWh/year. These calculations were made without considering the competition between different potential sources due to land availability. The figures and calculations are presented in Figures 3.11 and 3.12 of the implementation concept.

Interviewee Four:

- *no idea*

Interviewee Five:

To my knowledge, there is no specific study for the Nord Burgenland region. Most studies are focused on Austria as a whole and follow a top-down approach. It would be great to have studies specifically for Burgenland.

Question 12. Would you like to share any final thoughts? Anything you consider important to highlight?

Please summarize in max one page the comments of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewee One:

- *no answer*

Interviewee Two:

In conclusion, it is important to simplify the questions related to bioeconomy and sustainability to ensure that NGO representatives and political decision-makers can provide meaningful answers. The questions should be more accessible and less academic in nature to facilitate broader engagement and understanding. Thank you for bringing attention to this aspect and for the opportunity to assist with the translations.

Interviewee Three:

All the discussed topics are important. The crucial point is to obligate local authorities to implement energy and bioeconomy measures. What is important is to focus on mobility, particularly on micro public transportation (municipal and regional buses operated with electric vehicles, infrastructure expansion is necessary). The education sector, especially schools, should also prioritize raising awareness on these topics. Currently, the subject is not adequately addressed in schools, and students show limited interest.

Interviewee Four:

The transition to organic agriculture is a significant aspect of the discussion, along with the possibility of transforming conventional agriculture to be more resource-efficient. The key question is whether a complete shift to organic farming can sustainably feed the global population. It is important not to overlook conventional agriculture but instead incentivize and provide knowledge to them to facilitate transitions towards more organic and resource-friendly practices. Meeting people where they currently stand and taking small steps towards a full conversion to organic farming is crucial. Cost savings can be a persuasive argument, considering the expenses associated with fertilizers and energy. Both small and large steps play a vital role in this transition.

Interviewee Five:

- *no answer*

9.2 Reporting format to complement Task 1.1 and Task 1.2 deliverables – Czech republic

Part 2: Existing/ future limitations of the linear (fossil-based) economy

Question 1. What are the main environmental limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) that concern your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: Distrust of some types of circular economy, the Charles Spa region traditionally belong to the mining region with primarily heavy industry. This development of course had a negative environmental impact and yes, the region belongs to the Just Transition Funding program. However, making any changes take time in our region.
I2: It is certainly the use of areas that is indicated in the spatial planning documentation, or the connection to the electrical network as well as the dependence on the fossil resources (brown coal). We are struggling with the soil and forestry pollution.
I3: "Not using new technologies, small investments in the development of new technologies, not connecting supply and customer chains that could mutually support a circular bioeconomy, waste processing - it's one thing to show statistics, another thing is to actually sort waste."
I4: not using R&D, not using new technologies, zero investment in development, not connecting supply and customer chains. An important factor is also the unfinished D6 motorway and the missing connection to the D9 motorway to Leipzig. Poor transport connections, railway, airport not working. This all has negative effect on the environment and for the well-being of the inhabitants in the long run.
I5: I feel that there is a misconception of internal cooperation and very low innovation culture, that has many implications. We can see that the environmental issues are not being discussed properly by all relevant policy makers and are in my opinion not reflected in the regional strategies. I just hope the new policy instrument related to the Just Transitions Strategy as I can see a huge potential in the innovative culture and perhaps to promote technologies know about the technologies that work in other regions.

Question 2. What are the economical limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: Unwillingness to draw subsidies for this type of project.
I2: same as question no.1, I would also point the unfavorable situation for the energy price.
I3: "Unwillingness or even the impossibility of having enough funds – for many companies, the implementation of the circular economy is expensive, they do not properly understand the potential and benefit (valorization of site streams)
I4: for companies, it is necessary to better define the customer and develop the business base, the environment for start-ups is not created. The regional administration has nothing to focus on in the region. Many companies have their management in Germany, only simple jobs work in the region, local companies are "daughter" companies of international ones and their added value is to produce on a very low cost.
I5: Low innovation culture means low regional added value, the current economic crisis makes the situation even more complicated.

Question 3. What are the social limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: Lack of willingness and awareness of alternative sources; Conservative approach of business entities.
I2: Low level of education, absence of professional companies, absence of experts.
I3: Lack of education and low social responsibility of companies and individuals
I4: There are no universities in the region - universities only have branches here. However, students still leave the region (to Germany) after they graduate. A company culture open to research and education is lacking.
I5: Low added value means limited low possibilities of creating new jobs.

Question 4. What, in your opinion, are the main (technical, structural and social-cultural) barriers of the current fossil-based economy model in your region to achieve relevant sustainability goals (e.g. production processes, legislative framework, outdated technology, high cost, lack of knowledge etc)??

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: High acquisition costs; Distrust of some types of circular economy, low awareness among policy makers and also wide public.
I2: Lack of knowledge about the possibilities and potentials of the bioeconomy. Outdated thinking and also outdated technology.
I3: All of the above
I4: all of the above mentioned - production processes, legislative framework, outdated technology, high cost, lack of knowledge, the value change approach that requires systemic thinking is a novel approach not commonly known in this region.
I5: The main problem of the region is the non-existent research infrastructure. Students leave for other cities and often never come back.

Question 5. Is there any national/regional policy that impact/limit the future development of the targeted linear economies in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: Standard legislation

I2: no.

I3: Now there is a Foresight study of the chemical industry - where is the part about the circular economy"

I4: Apparently not for the specific region, the Just Transformation policy.

I5: No.

Part 3: Existing pathways to support the circular bioeconomy transition

Question 6. Are there any regional bioeconomy strategies or regional strategies related to bioeconomy that exist in your region and what programmes/ instruments operationalize them?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1. No.
I2: Certainly the Plan for the Just Territorial Transformation of the Charles Spa Region and touches on the Regional Innovation Strategy of the Karlovy Vary Region.
I3: I don't know about them
I4: I don't know about them
I5: I don’t know any.

Question 7. Are there already interesting networks on the bio-economy on-going in the region (NGOs focused on circular bioeconomy – HUBs, clusters, platforms etc.)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: I don't know about them
I2. They do not exist in the region.
I3. Innovation platform for strategic opportunities
I4: No.
I5: Apparently I have just heard about BIOEAST HUB.

Question 8. Is the public government currently using any motivations: are there any competitions / awarding policies / green procurement in practice?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: Yes, in accordance with applicable legislation (e.g. passive buildings, etc.)
I2: As far as I know, I don't know about them
I3: I do not know about it
I4: No, they do not use any motivation.
No, that I know of.

Question 9. Are there any existing R&D infrastructure (ESFRI, eDIH, R&D parks - in operation)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1. Yes, see KARP activities (www.karp-kv.cz)
I2. It is generally known that the Charles Spa Region lacks R&D&I infrastructure for a long time. There is only Charles Spa business development agency, p.o. (above mentioned as “KARP”), which develops innovative business and R&D, and for a short time there is the Institute of Spa and Balneology v.v.i. Business incubators in the region are only private and do not provide services for R&D development in the region.
I3: There is no infrastructure available here, I would appreciate the information.
I4: here is ILab, a public research institution – the Institute of Spa and Balneology. But in the 6 years of their existence, they lacked a vision of what they wanted to do in research - they gradually focused only on educating people - they had nothing to offer. R&D park is empty (not functioning).
I5: As I said I don’t see any infrastructure in Charles Spa region.

Question 10. Are there any overview (e-map) of existing technologies processing biomass or residues to necessary commodities (existing network of biogas plants, composting units, renewable energy plants)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: I don't know about it

I2: I don't think so.

I3. No, no one wants this data

I4. No.

I5: I wish they were.

Question 11. Is there any evidence about the amount of biomass residues, unexploited biomass, study about the potential of biomass utilisation?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: Probably this data could be in the territorial analysis documents of the regional office

I2: No.

I3: I don't know about it and I would appreciate the information

I4: No.

I5: I wish they were.

Question 12. Would you like to share any final thoughts? Anything you consider important to highlight?

Please summarize in max one page the comments of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

I1: -

I2: Acceptance of rules and conditions "from above" (by policymakers), including support, specific steps, setting tools and benefits for users.

I3: -

I4. -

I5: No.

9.3 Reporting format to complement Task 1.1 and Task 1.2 deliverables - Finland

The information gathered from the interviews with policymakers and other stakeholders will be used to enhance the desk research results described in D1.1 and D1.2. For our purposes, a summary of all interview responses for each question is needed and not a detailed transcript of the interviews. Should questions or other ambiguities arise, Task 1.1 and Task 1.2 leaders could request interview transcripts to complete D1.1 and D1.2. The summarizing report format should be as follows:

Part 1: Background Information

Please summarize in one paragraph or figure the background information of all interviewees.

Interviewee	Occupation	Gender	Region	Education
1	Policymaker in municipal level	Female	Central Finland	Master's degree
2	Policymaker in Ministry	Male	Southern Finland	Two Master's degrees
3	Founder of SME related to side streams of forestry	Male	Central Finland	Vocational secondary education
4	Circular economy and environment manager in forestry related association	Male	Southern Finland	Master's degree
5	Ecosystem leader in public organisation	Male	Southern Finland	Master's degree

Part 2: Existing/ future limitations of the linear (fossil-based) economy

Question 1. What are the main environmental limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) that concern your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

- Generally Finnish forest industry is already considered circular but discussions are ongoing, whether current forestry is sustainable enough and could it be more efficiently integrated to circular economy model with higher value-added products.
- Regeneration of forests is important
    - Key issues are to take care of biodiversity and strengthening/ growing the carbon sink.
- At the moment Finland has shortage of wood due to the stopped import of wood from Russia, and fellings are needed to ensure material availability. Opinions varied about the status of fellings:
        - "Pinewood is over-felled in Central Finland, in Northern Finland and Karelia fellings are more moderate"
        - "Fellings might be excessive for some time, but forest regeneration helps in the long run"
- Environmental impacts on water bodies caused by forestry are minimal nowadays
- Fossil-based emissions to air are already at low level in respect of national economy
    - Shifting to circular bioeconomy, helps to defuse climate crisis
- Current actions that are supporting shifting towards more circular forestry and the state of nature
    - Regulation on nature conservation and land use
    - Sustainable forest management
        - Balance between material availability and the status of forest
        - To enhance biodiversity some decayed trees should be kept in the forests, since they are vital for many special species
        - Carbon sinks have to be considered seriously
        - Sufficient fertilization and return of nutrients back to nature (ash)
    - Side stream products, such as green liquor dregs, should be utilized more and not be landfilled

Question 2. What are the economic limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

- Finland has imported about 10% of wood used in the forest industry. The major part of the imported wood was from Russia, which was stopped in 2022. Material availability limits Finland both economicly and ecologically. Earlier the question was how to add fellings in a sustainable way to ensure sales, now the question is how to limit fellings to maintain the biodiversity and carbon sinks.
- Opinions:
    - Corresponding wood amounts, especially birch, are hard to import from other countries
    - The major challenges in raw material availability are in the energy sector, not with material availability
- Wood material markets have lately changed due to energy price level and high demand. Material is bought where the prices are reasonable.

- Recycled fibers should be used more to ensure material availability without damaging nature
  - Limit is that major of the fiber-based products are exported and the material is not returned to Finland
  - Finnish recycling rates of paper and board are extremely good.
- More financing is needed for new investments and maintenance of transport infrastructure
  - Funds are needed for development of new technologies and projects regarding the change of processes toward more circular models.
  - There are some concerns about the conditions of roads and rails, especially in Northern Finland
    - More transportation is expected if raw materials are transported for refining.
    - The size of timber lorry has increased.

Question 3. What are the social limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

- How does the information about new possibilities reach all?
- Adequacy of competent professionals and staff for mills in rural areas
- Forest owners are more and more urbanites in the future. Does the level of managing forests as raw material/ well-being reserves change from a distance? Do they perhaps leave the forests as conservation areas?
- The restructuring of forest owners is essential. Previously, private owners owned large forest areas, but with the generational change, the forest areas are becoming fragmented. This causes e.g. that raw material availability becomes more difficult as the forest owners are further away and more numerous than before.

Question 4. What, in your opinion, are the main (technical, structural and social-cultural) barriers of the current fossil-based economy model in your region to achieve relevant sustainability goals (e.g. production processes, legislative framework, outdated technology, high cost, lack of knowledge etc)??

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

The general opinion was that forest industry companies strive for changes and improvements; the will is found, and the green transition is supported.

The following barriers were mentioned:

- Lack of solutions on how to commercialize new solutions
- New solutions require capital e.g. for investments
- The current environmental permit process is slowing down new solutions
- Carbon sink interpretation
- Too detailed "black-and-white" regulation
- There will be challenges regarding EU regulations, because Finland's situation is not sufficiently understood. Finland does not pursue its own interests (forest industry advocacy) as well as other EU countries pursue the interests of their main industries.

Question 5. Is there any national/regional policy that impact/limit the future development of the targeted linear economies in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

The interviewees mentioned the following national/ regional policies and processes that have impact in the transition from linear economy to circular economy.

- Taxation
- Permit processes
- Standardisation - dismantling of certain standards is needed (certain standards prevent the introduction of new solutions)
- Regulations related to biodiversity, nature and environment
- Water regulations (water body load and water use)

Part 3: Existing pathways to support the circular bioeconomy transition

Question 6. Are there any regional bioeconomy strategies or regional strategies related to bioeconomy that exist in your region and what programmes/ instruments operationalize them?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

The following regional bioeconomy strategies or regional strategies were mentioned:

- A strategic programme to promote a circular economy (by the Ministry of Environment)
- Regional forest programmes 2021-2025
- The bioeconomy strategy
- The circular economy road map
- The low-carbon road map
- The Regional Council of Central Finland's strategy
- Äänekoski city's strategy

Business Finland programmes, especially the so called Veturi programmes (funding for leading companies and ecosystems) are a funding instrument for those strategies. In addition RRR House-funding (EU funding distributed through Business Finland).

Question 7. Are there already interesting networks on the bio-economy on-going in the region (NGOs focused on circular bioeconomy – HUBs, clusters, platforms etc.)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers

There are several networks:

- Plänet B, an ecosystem to support forest-based bioeconomy in Central Finland
- The network of eco-industrial parks organised by the Circular economy center in Northern Finland
- Interreg project to enhance circular economy at EU level
- The INKA programme (Innovatiiviset kaupungit, eng. Innovative cities) is an innovation platform for companies, academia and cities
- ExpandFibre, Business Finland, an ecosystem for development of sustainable bioproducts
- Forest Biofact, A digital learning environment for professionals in forestry
- FinnCERES, Academy of Finland, a competence centre related to biomaterials
- 4Recycling, an ecosystem to enhance recycling and replacement of plastics.
- CLIC Innovation, an innovation cluster of bioeconomy and circular economy
- Beyond Circularity, Business Finland, R&D programme to support carbon neutrality and green transition of several companies
- VTT Bioruukki, open access pilot centre for bio-based products and circular economy
- Additionally mentioned, continuous co-operation between stakeholders, academia's own innovation platforms regarding bioeconomy and EU Biotransform
- One comment concerning the importance of development of platforms.

- Narrow platforms for side stream availability already exists but they cannot be utilised in larger scale yet.

Question 8. Is the public government currently using any motivations: are there any competitions / awarding policies / green procurement in practice?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

National and EU -funding available for research:

- Business Finland is financing and awarding new businesses
  - Fundings are granted via Sustainable Growth Programme for Finland
    - RRF funding is granted only if receiver is targeting the goals of green transition
- JTF (Just Transition Fund) financing to compensate financial losses of green transition
- Local hackathons are organised to boost bioeconomy and find partners for innovations
  - Students are also taking part of these events.
- Some concerns how amount of funding affects international competitiveness
  - "New innovations should be added more to public procurements"

Question 9. Are there any existing R&D infrastructure (ESFRI, eDIH, R&D parks - in operation)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

- R&D infrastructure of VTT
  - Laboratory facilities
  - Bioruukki pilot centre
- Pilot centres of academia
- Centres of National Resources Institute of Finland
- Smart Chemistry Park
- SynBio PowerLab
- Companies' own R&D facilities

➢ Co-operation within different networks is connected to R&D infrastructures

Question 10. Are there any overview (e-map) of existing technologies processing biomass or residues to necessary commodities (existing network of biogas plants, composting units, renewable energy plants)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

- Generally, interviewees were not aware of existing e-maps
- Couple of e-maps were mentioned
  - Motiva Materiaalitori, a platform to search and offer existing waste and side streams for commercial use
  - Karttapalvelu, a map showing information on forest resources
- Mentioned comments:

- "The availability of precise data will be important in the future, maybe with assist of AI"
- "Companies could have common database for existing patents, that are not yet utilised commercially. Patents could be sold between companies"

9.4 Reporting format to complement Task 1.1 and Task 1.2 deliverables - Germany

Part 1: Background Information

Please summarize in one paragraph or figure the background information of all interviewees .

We interviewed 2 female and 3 male stakeholders from the NRW region. They came from different backgrounds, such as waste management, food processing, start-up support, as well as cluster, and legismative work. All of them are mutlipliers, meaning they are active in umbrella organisations.

Part 2: Existing/ future limitations of the linear (fossil-based) economy

Question 1. What are the main environmental limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) that concern your region?

Lignite and coal mining comes to a hold and shapes the region within the transformation. Raw materials with intense production are taxing for the environment. Limitations connected to land use, as NRW is a highly urbanized area. Influence on neighboured ecosystems. Air, soil, environment.

The imported resources needed to supply the local industry (Naphtha) have a high environmental impact outside of the region.

Areas in between urbanized areas are limited and occupied by agricultural and forestry. The biomass available is not enough to supply regional demand, depending on feedstock and utilisation (food / feed, vs. fuels, vs. material use)

In case of waste management, a holistic view is lacking, current system is very expensive and keeps established infrastructure locked in.

Current fossil-based economy leads to biodiversity losses in the sourcing regions.

Question 2. What are the economic limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

The regional resources providing raw materials for the chemical industry are limited, leading to a strong dependency on imports and functioning supply chains. These are prone to exogenic shocks like geopolitical issues and other exogenic factors. This creates an economic limitation of the fossil-based system, that might additionally be increased by environmental regulations and monitoring, because with newfound alternatives an economic competition is created.

This pressure is however not yet high enough to fully push forward the transition.

On the other hand, the fossil industry creates economic hurdles, that limit the foothold of renewable based value chains.

The currently established linear fossil system is highly efficient in itself, due to decades of optimisation, making it hard for novel processes and value chains to be competitive.

The use of side streams (wood, grass, …) could be an option. New sources might be biotech, plants, marine-based (in other regions beyond NRW). Right now, the necessary supply chains for novel renewable resources (beyond starch, oils, sugars) are not in place, making it hard to build business models on these resource streams. It is still not clear whether drop-in solutions feeding into the established value chains and processes are more promising, or if completely novel molecules with new functionalities that demand for new processes and value chains offer bigger potential for bio-based products. in generall processes are not ready to be used or are not competitive against fossil-based value chains.

Question 3. What are the social limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Germany has a limitation in available workforce: the country is a high price sector (the work force is expensive), at the same time the knowledge base/experienced professionals are an important resource for the economy (knowledge-generation, as opposed to raw material production). Currently, there is a lack of professionals in all sectors, slowing down development.

There is a lack of jobs in craftsmanship vs. a surplus of those in academia. While academic research is important, for economic benefit it needs to be focused, in collaboration with industry, to lead concepts to realisation.

Cost-driven and very price conscious consumers are limiting the market. Products currently do not display the true production costs and so consumers do not know the actual production cost, including external factors of an item.

There is an expected increase in municipal waste, especially furniture - a) people are more mobile, frequent moves lead to renewal of furniture b) demographic change, as elderly citizens leave their homes, their old furniture is usually thrown out.

Consumers in the region, esp younger generation display a large interest in more sustainable products. They see climate change as a risk. This is impacting industry, food sector is changing, supermarket shelves are changing (e.g. less meat)

Older population might be less flexible, need behavioural change, aging society hinders transformation, we tend to get less flexible as we age.

With the aging society, more particular need in medical sector that will become increasingly important in the region and will see growth.

Products with a better environmental footprint (e.g. organic food, sustainable fashion) are in most cases more expensive than their less environmentally friendly competitors. There is a risk that parts of the population with lower incomes cannot afford to buy these products. This leads to a risk, that sustainable products and sustainability in general are recognised as a topic of the upper class in parts of society.

Question 4. What, in your opinion, are the main (technical, structural and social-cultural) barriers of the current fossil-based economy model in your region to achieve relevant sustainability goals (e.g. production processes, legislative framework, outdated technology, high cost, lack of knowledge etc)??

One main barrier can be seen in the regulatory side of the legislative frameworks. New technologies such as green plant biotechnology for example need easier and more stream-lined regulatory processes, so they can be brought to the market.

Germanys economic strength is built upon high efficiency processes and quality products both in linear processes.

The current status of the production systems is hindering the quick transition. Multi stakeholder value chains hinder quick change and decision making. It is feared that the change of production systems endangers the economic strength, so first steps are not readily made.

Strict following of SDGs is connected to higher efforts on the production side and might not be remunerated. Price is the relevant factor. The leverage is not necessarily to follow the SDGs on the production side, but how the SDG impact the consumers choice and consequently the production processes.

With respect to waste management, the current economic model benefits from linear value chains and has limited economic incentive in working towards SDGs. There is pressure to offer services at low price, municipalities lack the funds to divest of existing infrastructure and invest into those helping them achieve SDGs.

Structural barriers: no price tag on natural resources, ETS scheme will help with this, but the price is still too low to bring about change. No realistic price - exploitation is expected.

Need societal behaviour change, we've been educated to consume. Way of living has to change; consumers need to consider end of life of products. The resistance to change is high and it is hard to be the first mover in changing behaviour.

Many technical parameters have to be met, hard to say which one stands out.

CO_2 fixation from air would help solve problems but is still to underdeveloped.

There is no adequate pricing of fossil carbon, as the external costs of fossil oil and gas are not fully internalised in the current prices. This makes it – apart from niche applications – hard for renewable alternatives to be competitive. Novel processes and biogenic resources carry a high regulative load and have to prove that they provide clear sustainability benefits (think of LCA, avoidance of land use change, competition with food/feed, monoculture,…). In contrast to this, the existing environmental damage of the established system is rarely put into proper perspective.

The established linear fossil system is highly efficient and integrated, making it very hard to transform it, as there are extremely high entry barriers. The challenges associated with renewable raw materials and biotechnological processes are considered highly critical by experts within the established fossil value chains, partly due to reluctance for change, partly due to lack of knowledge and expertise. Building up this expertise in the industry is a lengthy process, especially since this expertise is necessary not only in R&D, but also in business development, production and strategic management, involving many different disciplines occupational areas.

Question 5. Is there any national/regional policy that impact/limit the future development of the targeted linear economies in your region?

At EU level, the circular economy framework and the circular economy action plan are setting limits to linear economy. Municipal actors in waste management are required to build the necessary infrastructure towards circular bioeconomy.

A strategy with concrete goals both on global and local level is needed.

There is missing infrastructure and missing funding for transformation to a circular bioeconomy. Especially Start-Ups and SME structures struggle with costs to make a change. Specific funding needed. Processes have to be developed, where they are needed.

All climate targets, legislative target climate neutral NRW by 2045. EU Green Deal. Incentives for change are given.

Ban of cars with combustion engine/ Phase out of combustion engines.

EU Chemicals strategy / REACH Amendments

EU Sustainable Finance directive / taxonomy

EU Industrial Emissions Directive

Part 3: Existing pathways to support the circular bioeconomy transition

Question 6. Are there any regional bioeconomy strategies or regional strategies related to bioeconomy that exist in your region and what programmes/ instruments operationalize them?

On the regional level, strategies are under development, these include the waste management strategy.

On a federal level, there is a bioeconomy strategy, with the BMBF as implementing actor. A national biomass strategy is in preparation.

A real strategy is still missing. The goal is clear, but the way has yet to be described. Endogenous potentials have to be used and the focus should be regional, since it is not easy to harmonise strategies.

NRW will implement a bioeconomy council which will advise the state on which actions to take. This council will develop a strategy. Interactions with different stakeholders to get input has begun.

Requires coordination of 5 governmental departments, holistic approach, broad topic.

Question 7. Are there already interesting networks on the bio-economy on-going in the region (NGOs focused on circular bioeconomy – HUBs, clusters, platforms etc.)?

Yes. The following examples were given:

- metabolon (waste management)
- HOOP project on biowaste
- CLIB (CLIB is locally and internationally)
- Modellregion Bioökonomie im Rheinischen Revier with the flagship projects Bioökonomie.Revier und Bio4MatPro

- ingrain.NRW (local in Heinsberg)
- BioSC
- Bioindustry Fond with a role in Westphalia

There are more, but others sometimes lack the focus on transformation and knowledge transfer. The singular solutions (like technology transfer centres) in universities lack specialisation.

Question 8. Is the public government currently using any motivations: are there any competitions / awarding policies / green procurement in practice?

- EFRE funding (ERDF funding), including for ERDF for circular cities.
- Rheinisches Revier
- Zukunft.BioNRW (MWIKE)

In general, the funding is still to scarce. or hard to acquire due to regulations in the application process.

Good funding options available for lower TRL, but especially at higher TRL / for investments in demo or pilot plants, funding is missing.

Question 9. Are there any existing R&D infrastructure (ESFRI, eDIH, R&D parks - in operation)?

Yes, the following were mentioned:

- metabolon
- INZIN Institut
- Fraunhofer IME (Schmalenberg and Aachen) environmental compatibility as cross topic, PFAS
- NGP2 RWTH Aachen
- Yes, at the universities. Focus on bioprocess techniques. There are however to little opportunities to bring the proof of concept to the next stage, or even into scale up.

Technology Centers give the opportunity to realise projects on mid-scale level. More are needed.

Question 10. Are there any overview (e-map) of existing technologies processing biomass or residues to necessary commodities (existing network of biogas plants, composting units, renewable energy plants)?

Here, interviewees gave different responses. Some were not aware of any data, others mentioned data being available for general side stream and residue processing and disposal (e.g. biogas). The representative from an association mentioned that the regional authority LANUV has extensive datasets. These however are difficult to interpret and need more in-depth knowledge about data collection to make them meaningful.

Data on biomass potential for energetic use is available, general statistics on biomass production in agriculture and forestry are also available. Almost no data on residual biomass streams / side streams except for biogenic waste streams.

Question 11. Is there any evidence about the amount of biomass residues, unexploited biomass, study about the potential of biomass utilisation?

The answers were similar to the ones to question 10.

Data is provided by LANUV as well as Eurostat, although the numbers are not always comparable. Data at LANUV are only for private waste streams, not industrial side- or residue streams. These are in some cases self-reported.

Referring to the biomass potential study by Prognos, which concluded there is a large potential of organic side streams in the “Rheinische Revier” region, one interviewee questioned the findings. In their view, this is not realistic since the producing parties would have to handle immense amounts of biomass already at this time.

An interviewee pulled into question the potential of using food waste – while this has potential, the high logistical costs make its use not feasible.

Another interview was not aware of specific studies but would be interested in the information and also platforms to combine information on usable side streams.

In conclusion – there is no clear, unambiguous evidence, the data available is hard to interpret, and its existence not well communicated.

Question 12. Would you like to share any final thoughts? Anything you consider important to highlight?

Not all interviewees offered closing remarks.

Technology Centres are the cutting edge between Industry and university. They should be prioritised, and their capacities increased.

It would be very helpful to map all biogenic side- and residue streams for a city or municipality and analyse their processing. The effect of changes made in this system could then be evaluated more clearly, and actions as well as roadmaps derived.

When elaborating new strategies in circular economy, relevant other strategies should be taken into account, also to identify possible incentives for stakeholders to act. Example: take advantage of the fact that all municipalities have to elaborate heating strategies and connect these to waste management.

Policymakers, often have problem trying to strategically change a complicated system. They need to be well informed, don't have the study/numbers right now to make decisions, general lack of data.

How to change a social capitalistic economy to a circular economy is a fundamental question.

NB: all interviewees had difficulties focusing on linear, fossil-based value chains and their limitations, since their mindset was already geared towards the transition towards a circular bioeconomy. They gave more information about chances and hurdles in transitioning to a bioeconomy.

9.5 Reporting format to complement Task 1.1 and Task 1.2 Deliverables - Greece

The information gathered from the interviews with policymakers and other stakeholders will be used to enhance the desk research results described in D1.1 and D1.2. For our purposes, a summary of all interview responses for each question is needed and not a detailed transcript of the interviews. Should questions or other ambiguities arise, Task 1.1 and Task 1.2 leaders could request interview transcripts to complete D1.1 and D1.2. The summarizing report format should be as follows:

Part 1: Background Information

Please summarize in one paragraph or figure the background information of all interviewees.

Interviewee	Occupation	Gender	Region	Educational degree
1	Policymaker in regional level related to digital transition and green transformation	Male	Western Macedonia-Greece	Master's degree or equivalent
2	Policymaker in regional level related to the geotechnical field	Male	Western Macedonia-Greece	Master's degree or equivalent
3	Policymaker in municipal level related to the geotechnical field	Male	Western Macedonia-Greece	Master's degree or equivalent
4	Policymaker in regional level related to rural development	Male	Western Macedonia-Greece	Master's degree or equivalent
5	Policymaker / project officer at a local public authority	Male	Western Macedonia-Greece	Bachelor's degree or equivalent

Part 2: Existing/ future limitations of the linear (fossil-based) economy

Question 1. What are the main environmental limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) that concern your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

For 70 years now, the region was depending on lignite mines and the production of energy from fossil-based systems. This has led to many negative effects, with high pollution being the most

important. Apart from the continuous depletion of the earth's reserves, many contaminants are being emitted to the atmosphere, the quality of air and water changes leading to climate change and negative effects on biodiversity. The whole lignite mining process affects the region's degradation of the land with erosion and land collapse, it causes noise pollution as well as dust and waste production. The natural environment is being destroyed and life expectancy is falling because human health is burdened with enormous physical and mental problems, with cancer being the main one. The whole environmental sustainability is jeopardized, and this affects the whole region's welfare for many years.

Interviewer 2:

The decades-long use of fossil fuels for energy production has led the region to significant environmental degradation, negatively affecting biodiversity and the health of the inhabitants with simultaneous effects on climate change.

Interviewer 3:

The operation of the DEDDIE-HEDNO S.A. (Hellenic Electricity Distribution Network Operator) factories in the Region of Western Macedonia with the combustion of lignite and, subsequently, the emission of pollutants, has a negative impact on managing climate change and CO_2 emissions. Bioeconomy can, with biological/biotechnological solutions, directly deal with problems and challenges, such as reducing dependency on fossil fuels.
In addition, emphasis should be placed on the funding of research and biotechnology as well as on the promotion of education in the field of bioeconomy and its applications at an interdisciplinary level.

Interviewer 4:

The long-term energy production by fossil-based systems has resulted in the depletion of reserves and high pollution in the environment due to emissions, leading to climate change. The environmental impacts include land degradation, erosion, contamination of water, noise pollution and waste production. The amount of the contaminants in the atmosphere is getting greater during the past 70 years and the pollution has a big impact on the biodiversity and on the health of the people of the region, with increased rates of cancer being the greater problem.

Interviewer 5:

In the beginning, the energy use of lignite in Western Macedonia started as a substitute for wood. Now there are six lignite-fired power plants in the region. Lignite is the main fuel in Western Macedonia, and this has a significant impact on the environment and the economy. Firstly, many people migrate, resulting in the desertification of some areas, millions of cubic meters of water are consumed, and hazardous chemicals and heavy metals are transported into the atmosphere, water and soil, damaging public health. In short, the air pollution caused by mining operations can lead to respiratory problems, an increased risk of vascular disorders and coronary heart disease, as well as high rates of premature death from cancers and thromboembolic events. Larger quantities of radioactive substances are accumulated during the combustion of lignite, but they are not dangerous. Over time, however, there is environmental pollution. The ash resulting from the burning of lignite contains much larger quantities of radioactivity (4-5 times more radioactivity than lignite). This ash is used in fertilizers, as a substitute for cement in concrete, etc.

Question 2. What are the economic limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

The economic crisis which began in 2011 affected the whole country, including the region of Western Macedonia. Western Macedonia has been for many years one of the Greek regions with the highest unemployment rates and limited development of innovations or competitiveness. Except for the economic crisis, we recently faced pandemic and war in Ukraine which both led to enormous difficulty in the availability of raw materials, income reduction, business closures and entrepreneurship decline. Even though regional businesses try to rely mostly on regional raw materials this cannot be realistic most of the time due to the limited availability and the price competitiveness. The current linear economic system relies on the lignite mines which produce energy and are going to completely close in the next few years. Delignitization will economicly affect the whole region and will further increase unemployment in many sectors.

Interviewer 2:

The economic crisis, the pandemic and the war affected the region more than the rest of the country in terms of prices, availability of materials, imports. At the same time, delignitization creates a suffocating economic environment in the absence of other developed economic branches.

Interviewer 3:

The lack of industries and raw materials in Region of Western Macedonia results in them being imported, as well as in issues of continuous availability. For example, the operation of district heating by burning forest biomass and biomass in general, has a huge problem with its continuous availability.

Also, pandemics, wars and other geopolitical issues result in changes in the prices of raw materials creating problems in the stability of the prices of manufactured products.

Interviewer 4:

The region of Western Macedonia has been dependant on fossil-based systems for many years and this means that not many other competitive businesses have been developed in this time. Lignite mines are closing during the past few years, and as there are many businesses that are based on the energy production from lignite mines in the area, the unemployment is increasing, and the economy is getting weaker. The economic crisis in Greece began in 2011 and the pandemic followed, affecting even more the region's economy. With delignitization in process, no new investments in the region, reduced incomes, no adequate local raw materials and no accessibility to markets, the region of Western Macedonia already faces many economic problems that must be solved through entrepreneurship and innovation for the general development of the region.

Interviewer 5:

The Region of Western Macedonia has been the energy core of Greece for many decades and has contributed significantly to the country's electrification and development. Lignite has been a fuel of strategic importance, easily mined, cheap and abundant in the Region of Western Macedonia. However, it is polluting, and its exploitation is unprofitable after the additional special taxes on pollutants. Western Macedonia is a socially burdened region, as shown by the ageing and low educational level of its population, compared to the rest of Greece. Capital investment in energy

has worked by attracting investment across the whole scale of the region's economy. However, burning lignite for power generation has increasingly high economic costs. The secondary sector is characterized by the development of some strong activities, such as the lignite-energy circuit, which shows the need for immediate targeted action for the transition to the post-lignite period.

Question 3. What are the social limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

The latest census of 2021 showed that the region's population is constantly decreasing and ageing. This means that the vast majority of the people belong to an age group that are not productive, and this puts more pressure on the current economic system. The employment sector is shrinking. If we take in consideration that the energy sector is closing and the educational level of the population of the region is low enough, this leads to the gradual death of entrepreneurship in the whole area. Many obstacles must be overcome to be able to have a just transition, and education and training will help with this. Thankfully, there are many initiatives concerning greener and more sustainable products in the region, consumers and businesses are interested, so this can help to open the horizons of entrepreneurship in other sectors and lead to a brighter future for the region.

Interviewer 2:

The continued decline and aging of the region's population is inevitably putting more pressure on the current economic system. The interest in greener economic models is intense but it depends on the economic conditions that occur among consumers.

Interviewer 3:

The decrease in population of the Region of Western Macedonia as well as the migration of young people to big cities or abroad weakens the Region's qualified human resources.
The inhabitants of the Region of Western Macedonia and Greek citizens in general do not seem to understand the concept of bioeconomy or how it can improve their quality of life without consuming the planet's natural resources. It is of primary importance to carry out the right communication campaigns.

Interviewer 4:

According to the census of 2021, the population of the region of Western Macedonia is decreasing and getting older. This fact unavoidably leads to more pressure on the current economic system. There are fewer young people, that means there are fewer productive people and considering that more of these people are skilled in sectors that have to do with the fossil-bases systems, the transition from linear systems will take time and effort. Consumers in the region of Western Macedonia are very interested in greener and more sustainable products and they participate in related programs, but the local authorities have to support this interest with more actions.

Interviewer 5:

According to the 2021 Census, Western Macedonia will suffer a population decline of -10.1%. The permanent residents are currently 255,056. The just transition to a new sustainable production model is not only a very complex undertaking but mainly a conscious choice, which is based on the

one hand on the need of the place to keep up with the new development and environmental standards and, on the other hand, on the demand of our times, which wants the decoupling of the lignite regions from a moribund economic activity, inversely proportional to the quality of life.

Question 4. What, in your opinion, are the main (technical, structural and social-cultural) barriers of the current fossil-based economy model in your region to achieve relevant sustainability goals (e.g. production processes, legislative framework, outdated technology, high cost, lack of knowledge etc)??

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

There are several barriers in order to achieve the relevant sustainability goals in the region of Western Macedonia. Bioeconomy has to be promoted, new technologies have to be introduced, entrepreneurship has to be strengthened and unskilled workers must be trained. The industrial sector needs to get help so as to make transformations to more clean forms such as environmentally friendly technologies. Transportation has to change to greener forms and the buildings have to become energy efficient. It is essential to develop new businesses and make sure that there is adequate supply of low-price raw materials to support the local supply chains. It is important to mention that biomass is a key solution to the achievement of the relevant sustainability goals. Thankfully, many steps are being made over the last years towards this direction and many efforts are being made in order to create the appropriate legislative framework without obstacles due to bureaucracy.

Interviewer 2:

The imminent change of the production model of the region without a clear framework, combined with the reduced introduction of new technologies, the insufficient strengthening of entrepreneurship and the insufficient training of the unemployed people.

Interviewer 3:

Although the importance of the bioeconomy has been recognized globally from an economic, social, environmental, and touristic dimension, in Greece the bioeconomy model has not received the attention it deserves. The enormous potential of the agricultural sector, the rich water resources and the endless kilometers of coastline in Greece can give the country a leading role in the development of the European bioeconomy. However, given that Greek citizens do not seem to understand the concept of bioeconomy or how it can improve their quality of life without consuming the planet's natural resources, it is of primary importance to carry out the right communication campaigns.

The integration of bioeconomy into the development model of Greece requires the optimal cooperation of the political leadership with the country’s scientists and the social partners, as well as the harmonization with the European directives on the bioeconomy.

Interviewer 4:

One of the main barriers of the current economic model in the region of Western Macedonia to achieve sustainability goals, is the low technical training of productive people. It is very difficult to introduce new technologies, related to sustainable technologies, to aged people with no basic

education. Besides that, barriers include the lack of supply chains. There is not enough local biomass being exploited, as there is neither the necessary technology nor the necessary end users available. There must be great investment in new environmentally friendly technologies, support the transition to energy efficient buildings and cleaner means of transportation, support industries to make the transition to sustainable systems, strictly implement the current environmental legislation and inform the public.

Interviewer 5:

In the weak points, the elements that are identified are the lack of liquidity for companies, the difficulty in approving loans and the increase in unemployment, while a similar course is visible for the ongoing brain drain. Also, no culture of innovation is observed, only the culture of business expands at the local level. The COVID pandemic and the war in Ukraine are undoubtedly threats, since due to them and the corresponding absorption of resources to support the viability of businesses, the planning and implementation of other actions, beneficial to the region, are delayed. However, the pandemic has undoubtedly created opportunities in the adoption of digital solutions. Also, the fact of the more mature infrastructures supporting innovative actions of the neighboring regions is also a threat in terms of attracting incentives from the Region. Finally, although the de-lignification actions of recent years have created high expectations among potential investors, there is a steady stagnation in terms of the growth rate, because of which demand is also decreasing.

Question 5. Is there any national/regional policy that impact/limit the future development of the targeted linear economies in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

There are many national/regional policies that impact/limit the future development of the targeted linear economies in the region of Western Macedonia:

- Long-term Strategy 2050
- National Strategy for the Circular Economy 2018-2030
- National Waste Management Plan
- National Biodiversity Strategy
- National Energy and Climate Plan 2030
- National Development Program 2021-2025
- National Air Pollution Control Program 2020 – 2029
- National Recovery and Resilience Plan
- Development Plan for the Greek Economy
- Digital Transformation Bible
- Regional Waste Management Plans
- Regional Social Inclusion Strategy
- Operational Plan for the Sustainable Urban Development Strategy of Western Macedonia, Municipality of Kozani, Municipality of Florina
- Integrated Spatial Investment for the Utilization of the Lakes of Western Macedonia.

Interviewer 2:

There are many policies that impact/limit the future development of the targeted linear economies in the region of Western Macedonia:

- Long-term Strategy 2050
- National Strategy for the Circular Economy 2018-2030
- National Waste Management Plan
- National Biodiversity Strategy
- National Energy and Climate Plan 2030
- National Development Program 2021-2025
- National Air Pollution Control Program 2020 – 2029
- National Recovery and Resilience Plan
- Development Plan for the Greek Economy
- Digital Transformation Bible
- Regional Waste Management Plans
- Regional Social Inclusion Strategy
- Operational Plan for the Sustainable Urban Development Strategy of Western Macedonia, Municipality of Kozani, Municipality of Florina
- Integrated Spatial Investment for the Utilization of the Lakes of Western Macedonia.

Interviewer 3:

The circular economy in Greece can feed a qualitative leap in the economy, which will constitute a developmental transformation. It creates new jobs, feeds small and medium entrepreneurship, the creation of new professions and the social economy, which is still at a very low level in Greece. At the moment, at a regional level, for the Region of Western Macedonia, such policy is in its infancy and very few companies apply bioeconomy practices.

Interviewer 4:

There are many national strategies and programs such as the:

1) National Energy and Climate Plan 2030
2) Long-term Strategy 2050
3) National Development Program 2021-2025
4) National Strategy for the Circular Economy 2018-2030
5) National Waste Management Plan
6) Regional Waste Management Plans
7) National Air Pollution Control Program 2020 – 2029
8) Development Plan for the Greek Economy
9) National Biodiversity Strategy
10) National Recovery and Resilience Plan
11) Digital Transformation Bible
12) Regional Social Inclusion Strategy
13) Operational Plan for the Sustainable Urban Development Strategy of Western Macedonia, Municipality of Kozani, Municipality of Florina
14) Integrated Spatial Investment for the Utilization of the Lakes of Western Macedonia

Interviewer 5:

There are Strategies and Action Plans which aim to limit the development of targeted linear economies in the region. Some of these are the Western Macedonia Region Strategy for Biomass Utilization with emphasis on district heating, the Regional Climate Change Adaptation Plan for Western Macedonia and the Western Macedonia Region Biodiversity Action Plan. There is also the Just Transition Development Programme, whose main priorities are: Strengthening and promoting entrepreneurship, Energy transition - climate neutrality, Land use adaptation - circular economy, Fair labour transition and human capital empowerment, Integrated small-scale interventions - Smart Communities.

Part 3: Existing pathways to support the circular bioeconomy transition

Question 6. Are there any regional bioeconomy strategies or regional strategies related to bioeconomy that exist in your region and what programmes/ instruments operationalize them?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

In line with the European Green Deal, the EU and Hellenic Republic's commitments and according to the global climate action under the Paris Agreement, Kozani aims to be climate-neutral with net-zero greenhouse gas emissions by 2030. To achieve this goal, the Region has many bioeconomy strategies and regional strategies related to bioeconomy, such as:

- The Operational Program of the Region of Western Macedonia 2014-2020
- The climate action for climate neutrality by 2030
- The Regional Smart Specialization Strategy Plan which will lead to the Smart Specialization Strategy 2021-2027
- The Sustainable Energy and Climate Action Plan (SECAP)
- The Municipality of Kozani's Action Plan on Circular Economy (CEAP)
- The Regional Social Integration Strategy (PESKE)
- The Regional Waste Management Plan (PESDA)
- The Green City Accord
- The Sustainable Urban Development Strategy Operational Plan of Western Macedonia
- The Sustainable Urban Mobility Plans (SUMPs)
- The Municipality of Kozani Action Plan
- The "Covenant of Mayors" European Initiative
- The Integrated Spatial Investment (ISP) for Utilization of the Lakes of Western Macedonia

The Municipality of Kozani, among its other initiatives, participated in the European Programs SCALIBUR and STARDUST and has a constant cooperation with the Cluster of Bioeconomy and Environment of Western Macedonia (CluBE) and the University of Western Macedonia.

Interviewer 2:

The Region has many bioeconomy strategies and regional strategies related to bioeconomy, such as:

- The Operational Program of the Region of Western Macedonia 2014-2020
- The climate action for climate neutrality by 2030
- The Regional Smart Specialization Strategy Plan which will lead to the Smart Specialization Strategy 2021-2027
- The Sustainable Energy and Climate Action Plan (SECAP)
- The Municipality of Kozani's Action Plan on Circular Economy (CEAP)
- The Regional Social Integration Strategy (PESKE)
- The Regional Waste Management Plan (PESDA)
- The Green City Accord
- The Sustainable Urban Development Strategy Operational Plan of Western Macedonia

- The Sustainable Urban Mobility Plans (SUMPs)
- The Municipality of Kozani Action Plan
- The "Covenant of Mayors" European Initiative
- The Integrated Spatial Investment (ISP) for Utilization of the Lakes of Western Macedonia

The Municipality of Kozani, among its other initiatives, participated in the European Programs SCALIBUR and STARDUST and has a constant cooperation with the Cluster of Bioeconomy and Environment of Western Macedonia (CluBE) and the University of Western Macedonia.

Interviewer 3:

Through the "Horizon 2020" program.
Through financial mechanisms such as the European Fund for Strategic Investments and Innovfin.
Through the LIFE programme.

Interviewer 4:

Kozani will be one of the first European cities to become climate-neutral by 2030 so there are many regional bioeconomy and regional strategies related to bioeconomy, such as the:

1) Sustainable Energy and Climate Action Plan
2) Operational Program of the Region of Western Macedonia 2014-2020
3) Climate action for climate neutrality by 2030
4) Regional Smart Specialization Strategy Plan which will lead to the Smart Specialization Strategy 2021-2027
5) Municipality of Kozani's Action Plan on Circular Economy
6) Regional Waste Management Plan
7) Regional Social Integration Strategy
8) Sustainable Urban Development Strategy Operational Plan of Western Macedonia
9) Sustainable Urban Mobility Plans
10) Green City Accord
11) Municipality of Kozani Action Plan
12) Covenant of Mayors European Initiative
13) Integrated Spatial Investment for Utilization of the Lakes of Western Macedonia
14) Action plan on circular economy

The Region of the Western Macedonia collaborates with policymakers, stakeholders, members of research and educational institutions and clusters to operationalize the above strategies.

Interviewer 5:

A bioeconomy strategy is the Biodiversity Action Plan of the Region of Western Macedonia. The government also decided to prepare an integrated Just Transition Development Plan aiming at the total developmental transformation of the country's lignite regions through the creation of strategic opportunities to maintain and strengthen their social fabric.

Question 7. Are there already interesting networks on the bio-economy on-going in the region (NGOs focused on circular bioeconomy – HUBs, clusters, platforms etc.)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

There are not many initiatives in the Region on the bioeconomy field but thankfully this has started to change during the last years. Currently there are:
-The Cluster of Bioeconomy and Environment of Western Macedonia (CluBE) which is a non-profit organization based in Kozani where the three pillars of the regional economy can cooperate. The three pillars of Western Macedonia Region are the public sector, public administration, research and entrepreneurship. CluBE develops R&D and business activities in the fields of bioeconomy, circular economy, bioenergy and environment, in order to strengthen the green economy in the region.
- The Greek Bioeconomy Forum which includes actors from the Region of Western Macedonia
- Life M3P project will study and implement an on-line platform to promote exchanging of industrial waste among the companies of manufacturing districts and DIADYMA which is the waste management company of Western Macedonia takes part in it.
- The Institute of Bio-Economy and Agri-Technology (iBO) of the Centre for Research and Technology Hellas (CERTH).

Interviewer 2:

There are already some interesting networks on the bio-economy on-going in the region of Western Macedonia such as the Cluster of Bioeconomy and Environment of Western Macedonia-CluBE, the Greek Bioeconomy Forum with actors from the Region of Western Macedonia and the Institute of Bio-Economy and Agri-Technology (iBO) of the Centre for Research and Technology Hellas (CERTH).

Interviewer 3:

CluBE-Cluster of Bioeconomy and Environment of Western Macedonia.

Interviewer 4:

There are already some interesting networks on the bio-economy on-going in the region of Western Macedonia such as the Cluster of Bioeconomy and Environment of Western Macedonia-CluBE, the Greek Bioeconomy Forum with actors from the Region of Western Macedonia and the Institute of Bio-Economy and Agri-Technology (iBO) of the Centre for Research and Technology Hellas (CERTH). Additionally, there is the project Life M3P which studies the implementation of an on-line platform to promote exchanging of industrial waste among the companies of manufacturing districts, with the waste management company of Western Macedonia (DIADYMA) taking part in it.

Interviewer 5:

The Cluster of Bioeconomy and Environment of Western Macedonia (CluBE) is a platform for cooperation of the three pillars of the regional economy: the public sector, research and entrepreneurship. The Cluster seeks to develop synergies between local and regional players and businesses in bioenergy and the environment, aiming at introducing and developing innovation in the sector and increasing its added value.

Question 8. Is the public government currently using any motivations: are there any competitions / awarding policies / green procurement in practice?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

The public government is currently using some motivations such as:
-The "Green Transition" program of the NSRF which includes two individual actions: Action 1 "Green Transformation of SMEs" and action 2 "Green Productive Investment of SMEs" which cover specific needs of SMEs. The new set of actions "Green Transition" of the NSRF aims at the operational upgrading of small and medium enterprises.
-The action "Skills upgrading and retraining programs in high-demand industries with an emphasis on digital and green skills" which is implemented within the framework of the National Recovery and Resilience Plan "Greece 2.0" with funding from the European Union - NextGenerationEU.
-The National Action Plan for the promotion of Green Public Procurement (2020 – 2023).

Interviewer 2:

The public government is currently using some motivations such as:
The "Green Transition" program of the NSRF, the action "Skills upgrading and retraining programs in high-demand industries with an emphasis on digital and green skills" which is implemented within the framework of the National Recovery and Resilience Plan "Greece 2.0" with funding from the European Union – NextGenerationEU and the National Action Plan for the promotion of Green Public Procurement (2020 – 2023).

Interviewer 3:

Unfortunately, no.

Interviewer 4:

The public government is currently using motivations like the "Green Transition" program of the NSRF. This program has two individual actions. Action 1 is the "Green Transformation of SMEs" and action 2 is the "Green Productive Investment of SMEs". This "Green Transition" actions of the NSRF aim at the operational upgrading of small and medium enterprises. There is also the action "Skills upgrading and retraining programs in high-demand industries with an emphasis on digital and green skills", within the framework of the National Recovery and Resilience Plan "Greece 2.0", funded from the European Union-NextGenerationEU.

Interviewer 5:

Yes. The National Action Plan for Green Public Procurement has been adopted. The objectives of the National Action Plan for the promotion of Green Public Procurement are: To establish and implement a minimum level of adoption of green criteria in public procurement of goods, services and works. To gradually increase the procurement of green products and green services over the next three years in defined sectors of goods, services and works. The wider integration of life-cycle cost assessment of products in public procurement. The dissemination of the environmental and economic benefits of Green Public Procurement. Raising awareness and active participation of stakeholders, such as contracting authorities and economic operators, in the GPP process. Monitoring of the achievement of the objectives and their updating.

Question 9. Are there any existing R&D infrastructure (ESFRI, eDIH, R&D parks - in operation)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- The University of Western Macedonia conducts a lot of research and has a technology transfer office as well as some spin-offs, such as:

- METAMIND INNOVATIONS IKE
- SURE AE
- ENERGY CAPABILITY CENTER
- Innovative Research Applications – INNORA I.K.E.
- Private Equity Company for Regional Development Studies – RED CONSULTING I.K.E.
- INDUSTRY4forENERGY I.K.E.
- ACTIVECODE I.K.E.
- Omega Innovations
- Innovative Network and Systems I.K.E – INSYS I.K.E
- Social Cooperative Enterprise for Public Utility and Development Initiatives – HELIX 4

- CERTH is the Centre for Research and Technology Hellas and is a leading research centre in Greece and in the EU, based in Western Macedonia.

Interviewer 2:

METAMIND INNOVATIONS IKE
- SURE AE
- ENERGY CAPABILITY CENTER
- Innovative Research Applications – INNORA I.K.E.
- Private Equity Company for Regional Development Studies – RED CONSULTING I.K.E.
- INDUSTRY4forENERGY I.K.E.
- ACTIVECODE I.K.E.
- Omega Innovations
- Innovative Network and Systems I.K.E – INSYS I.K.E
- Social Cooperative Enterprise for Public Utility and Development Initiatives – HELIX 4

Interviewer 3:

No.

Interviewer 4:

There is CERTH which is the Centre for Research and Technology Hellas. It is a leading research centre in Greece and in the EU, based in Western Macedonia. Also, there is the University of Western Macedonia which conducts a lot of research and has a technology transfer office as well as some spin-offs, such as Metamind Innovations I.K.E., Sure A.E., Energy Capability Center, Innovative Research Applications – Innora I.K.E., Private Equity Company for Regional Development Studies–Red Consulting I.K.E., Industry4forEnergy I.K.E., Activecode I.K.E., Omega Innovations , Innovative Network and Systems I.K.E – Insys I.K.E., Social Cooperative Enterprise for Public Utility and Development Initiatives–Helix 4.

Interviewer 5:

In the context of the Innovation Zone, three flagship projects have been set for implementation. The Technology Park, the Innovation Hub for hydrogen and energy storage and the Green Data Center, which will support the development of entrepreneurship in the ICT sector. Emphasis is given to the Just Transition Observatory, which is expected to play a key role in monitoring the whole project through indicators as an independent organization and as a living example of the fact that the research projects and European programs of the respective bodies are connected to the needs of society.

Question 10. Are there any overview (e-map) of existing technologies processing biomass or residues to necessary commodities (existing network of biogas plants, composting units, renewable energy plants)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

There are some scattered private facilities which process biogas and biomass in the region but there is nothing fully organized yet so that it can be officially recorded and mapped.

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Interviewer 2:

There are not any overview (e-map) of existing technologies processing biomass or residues to necessary commodities because the facilities which process biogas and biomass in the region of Western Macedonia are not organized. They are private and scattered and there hasn't been yet an official mapping or record about them.

Interviewer 3:

While there are biogas, composting and renewable energy units in the Region of Western Macedonia, what I know is the Geoinformational map of the Energy Regulatory Authority (RAE) where all RES are recorded.

Interviewer 4:

There are not any overview (e-map) of existing technologies processing biomass or residues to necessary commodities because the facilities which process biogas and biomass in the region of Western Macedonia are not organized. They are private and scattered and there hasn't been yet an official mapping or record about them.

Interviewer 5:

There is no overview (e-map) of existing biomass or residue processing technologies into necessary products.

Question 11. Is there any evidence about the amount of biomass residues, unexploited biomass, study about the potential of biomass utilisation?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

OPEKEPE is the Greek Payment Authority of Common Agricultural Policy (C.A.P.) Aid Schemes. OPEKEPE has records for all the crops produced and can convert it into biomass quantity by mathematical formula. However, this is not fully official and accurate. There are some EU projects running at the moment in the region, which have as an object to calculate the amount of biomass residues, unexploited biomass and the potential of biomass utilisation and maybe soon we will be able to have more complete and accurate records.

Western Macedonia in Greece is a region with significant potential for biomass utilization. The region has abundant agricultural land and a rich forestry sector, which generates a large amount of waste biomass that could be used for energy production.
Large-scale biomass power plants that use biomass as fuel could be constructed in the region. These plants could use agricultural waste, forestry residues, or energy crops as fuel.
Biomass could be also used to provide heating to buildings and homes through district heating systems especially for rural areas where there is no natural gas infrastructure and it can be converted into liquid biofuels such as ethanol or biodiesel, which could be used as transportation fuels.
The biomass utilization in Western Macedonia could provide a range of economic and environmental benefits to the region. However, careful planning and implementation will be needed to ensure that, besides the benefits, biomass utilization is sustainable and does not have negative impacts on the region's natural resources and ecosystems.

Interviewer 2:

OPEKEPE keeps the records for all the crops produced. from time to time some studies have been prepared for the use of biomass

Interviewer 3:

In the past, the Region of Western Macedonia has implemented some programs such as GABE (Greek – Albanian cross border cooperation in Biomass Exploitation) as well as PROFORBIOMED (PROMOTION OF RESIDUAL FORESTRY BIOMASS IN THE MEDITERRANEAN BASIN). The Regional Development Fund of Western Macedonia has the deliverables of the above projects.

Interviewer 4:

The region of Western Macedonia is very rich in agricultural land and forests. That means that it can produce large amounts of biomass for energy production. However, this potential has not yet been exploited. The Greek Payment Authority of Common Agricultural Policy (C.A.P.) Aid Schemes (OPEKEPE) keeps records with all the produced crops in a national lever, but these records are not fully accurate. Biomass utilization will provide many benefits to the whole region so currently studied are being conducted in the region. Those studies will analyze the potential of biomass utilisation along with the exact amount of biomass residues and unexploited biomass, so in the near future we will have more data in hand.

Interviewer 5:

There are indications of the amount of biomass residues because the area of Western Macedonia has very fertile agricultural land which can produce big amounts of biomass.

Question 12. Would you like to share any final thoughts? Anything you consider important to highlight?

Please summarize in max one page the comments of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

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Interviewer 2:

-

Interviewer 3:

No.

Interviewer 4:

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Interviewer 5:

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9.6 Reporting format to complement Task 1.1 and Task 1.2 Deliverables - Spain

The information gathered from the interviews with policymakers and other stakeholders will be used to enhance the desk research results described in D1.1 and D1.2. For our purposes, a summary of all interview responses for each question is needed and not a detailed transcript of the interviews. Should questions or other ambiguities arise, Task 1.1 and Task 1.2 leaders could request interview transcripts to complete D1.1 and D1.2. The summarizing report format should be as follows:

Part 1: Background Information

Please summarize in one paragraph or figure the background information of all interviewees.

Interviewer	Occupation	Gender	Region	Educational degree
1	Research Organization – University of Jaen	Female	Andalucía	Doctorate or Professional degree
2	Research Organization – Technological Center Andaltech	-	-	Doctorate or Professional degree
3	Policymaker – Andalusian Circular Economy Law	Male	Andalucía	Bachelor's degree or equivalent
4	Public Administration	Female	Andalucía	Bachelor´s degree or equivalent
5	Policymaker - Drafting of regional energy planning and bioeconomy documents, as well as analysis and presentation of allegations and comments to regional and national legislation of an energy nature	Female	Andalucía	Bachero´s degree or equivalent
6	Other - Environmental and Forest Administration Technician	Male	Andalucía	Doctorate or Professional degree

Part 2: Existing/ future limitations of the linear (fossil-based) economy

Question 1. What are the main environmental limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) that concern your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- Supply of raw materials given the current complex situation.
- High generation of waste in manufacturing, with little positive impact of that manufacturing at the local level.

Interviewer 2:

- High generation of waste, largely toxic, generated or not at the local level where it is produced.
- Linearity does not benefit the potential of Andalusia offered by the circular bioeconomy.

Interviewer 3:

- Environmental impact extraction of raw materials. Inadequate waste management, with GHG generation of 2,645,887 tCO2 eq in 2020 (10% of total diffuse emissions).

Interviewer 4:

- The generation of biomass through agriculture, livestock, fishing, forestry, etc., depends directly on natural resources (water, soil,...) and also on the environment, so the depletion of these resources beyond the sustainable limits would undermine the future of generating sectors, directly influencing the benefits and functions they perform for society.
  Achieving a circular economic model in which the full value of biomass resources (sustainably obtained) is used is the path to economic growth, job creation and environmental sustainability.
  The average temperature in Andalusia has increased, while the forecasts for increased temperatures and decreased rainfall are not optimistic; having devastating effects on the environment.
  In addition, it must be added that our extensive coastline is densely populated with a risk to the population due to the rise in sea level.
  With especially sensitive areas such as Doñana and other areas with low levels that are already being affected by the real rise in sea level and with a significant impact on all the biodiversity it hosts.
  These conditions will also have a negative impact on economic activities in Andalusia, which are equally important for tourism and agriculture.

Interviewer 5:

- The use of energy coming mostly from fossil sources is the greatest cause of impacts to climate change and CO2 emissions.
- In terms of tourism, retail and transport, a common factor of immediate impact is the consumption of fossil fuels in transport. These are sectors where the linear economy prevails, and the examples of circularity of resources used are very specific, although the tourism sector is dedicating a great effort to the reuse of water resources.
- A change in trend is being promoted towards the electrification of modes of transport in the tourism and retail sectors, where it is intended that the distribution of the last mile and the movement of visitors be carried out with an electric vehicle.
- In the transport sector there are important differences in terms of road transport, with the aim of achieving its complete electrification and use of H2, compared to air and sea

transport, which is easy to electrify, and where advanced biofuels and hydrogen are going to be the options for decarbonization.
The agricultural sector does use circular bioeconomy in several of its activities. The use of biomass as fuel for thermal uses is a reality in livestock farms, in greenhouses and in the agri-food industry.

Interviewer 6:

At the level of supply of forest biomass:

- Availability of supply, both in quantity and in technical and economic feasibility of making it available (example: existence of forest formations whose potential use for biomass would be very convenient from the forestry and ecological point of view, but whose remoteness, orographic difficulties, etc, make it difficult to value them.

- Need to define technical criteria to guarantee the rational use of biomass.

- The need to define a framework supported by principles such as the cascading use of timber materials.

At the level of integration of economic activities:

- The need to develop technological solutions in different areas (packaging, bioenergy, etc.) that favor the substitution of products of fossil origin.

- Offer distributed in the territory that makes it more difficult to work according to economies of scales that allow the economy based on fossil sources

Question 2. What are the economic limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- The economic and social benefits of production in the region are produced outside of it as they are exporters of raw materials.
- Shortages due to global problems.

Interviewer 2:

- Andalusia is highly dependent on raw materials of external origin and has been accentuated by the war.

Interviewer 3:

- Relocation of the means of production, loss of sovereignty and dependence on critical raw materials.

Interviewer 4:

- Among the most important sectors in Andalusia: agriculture, livestock, fishing, energy, or construction require the availability of raw materials. The concern, therefore, is the lack of availability of raw materials.
  The Andalusian economy depends to a large extent on the import of raw materials, especially for its many industries. Despite the region's large agricultural sector, there is a need to import many raw materials due to a lack of local resources. The availability of raw

materials is usually continuous, although there may be occasional interruptions due to pandemics, wars, or other geopolitical issues.

The main economic limit related to the current linear economic system that affects Andalusia, is the lack of diversification of its economy. The region is highly dependent on a few industries, such as tourism, for its economic activity. This makes the region vulnerable to external economic shocks, such as pandemics, wars, and other geopolitical issues. These can financially affect the Andalusian economy in various ways. For example, prices may increase due to the interruption of supply chains, the availability of materials may decrease, and imports may become more expensive, which may have a negative effect on economic activity in the region.

Interviewer 5:

- Andalusia has a global external energy dependence of 76%, (49% oil, 29% natural gas, 4% coal) (source https://www.agenciaandaluzadelaenergia.es/info-web/loginController)
- This dependency represents the main economic limit, which has been exacerbated by the war situation in Ukraine, where the price of natural gas has skyrocketed the costs of electricity generation and therefore that of all economic activities.
- In response to this, and although energy planning has contemplated the increase in energy self-sufficiency for many years, the search for biomethane projects is currently being promoted to try to reduce dependence on natural gas.

Interviewer 6:

- Economic limits: mainly linked to water resources in a large part of the region (and increasingly, extending to the entire region), which is limiting for all economic activities and the habitability of the territory itself

- Apparently good aptitude for the energy transition, but counterproductive effects may be caused by occupying land with optimal agricultural vocation (future competition with food).

- Eccentric situation of Andalusia in relation to the main flows of communication, energy and materials, which implies a disadvantageous starting situation in the face of evolution towards broad circular economy systems.

- Environmental stresses derived from the southern location of Andalusia and the proximity to centers of high pressure that originate desert or sub-desert climate regimes.

- The agricultural vocation of the region is compromised in times of economic turbulence due to the difficulty of passing on costs at the beginning of the value chains.

Question 3. What are the social limits of the current linear economic system (related to BIOTRANSFORM's bioeconomy topics) in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- The market already demands sustainable products and plastic has a bad reputation.

Interviewer 2:

- Sustainability is a marketing element at the same price. The market already demands sustainable products and plastic has a bad reputation.
- There is a lack of knowledge of the real impacts of manufacturing many products (eg glass versus plastic pollution).

Interviewer 3:

- Clear link between economic growth and waste generation.

Interviewer 4:

- There is a growing interest in more ecological and sustainable products on the part of Andalusian consumers. They are increasingly aware of the environmental impacts of their consumption and seek to reduce their carbon footprint. As a result, there is a growing demand for sustainable and ethical products, such as organic food.
  Andalusia has 33% of ecological activities, according to a study carried out by the Ministry of Agriculture, Fisheries and Food.

Interviewer 5:

- N/A

Interviewer 6:

- Demographic evolution comparable to other Spanish and European areas in terms of the concentration of the population in the main urban centers and on the coast and the depletion of the rural population, especially in marginal areas in relation to the main axes of communication.

- Progress towards a dual territory, with some large hyperpopulated spots and other empty ones that will increase their tendency to become more natural spaces. However, this transit will not be easy due to the increase in risks, mainly fires, associated with this type of spaces that have lost the ability to dampen the advance of fires in large cultivated spaces.

- Depletion of the rural employed population in primary tasks (agriculture, forestry, livestock) which is partly being offset by the immigrant population, but this replacement has limits, associated above all with the critical thresholds of minimum inhabitants that rural settlements must have to make them attractive to welcome new population.

- This dichotomy presents relevant nuances such as the process of gerintrification of the historical nuclei of the cities, the nuclei of marginality, etc.

- Opportunities such as ecological orientation or under other forms of differentiated quality of agricultural and forestry productions arise and mature, sometimes linked to the image of naturalness of rural environments (such as production in Natural Parks). However, these windows of opportunity tend to have a moderate participation in the regional context, among other reasons due to the greater specialization of management (and, therefore, greater demand for knowledge and dedication), the supply of adequate inputs (especially linked to fertilization), the capacity of the market to accept the offer, etc.

Question 4. What, in your opinion, are the main (technical, structural and social-cultural) barriers of the current fossil-based economy model in your region to achieve relevant sustainability goals (e.g. production processes, legislative framework, outdated technology, high cost, lack of knowledge etc)??

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- Barriers to the SDGs: 8, 12 and 15.

- European green deal: energy, transport, depletion of raw materials, microplastics
- .

Interviewer 2:

- SDGs: Virtually all.
- European green deal: profitability of the circular model, waste generation, CO2 emissions.

Interviewer 3:

- Bureaucratic obstacles for the effective development of CE in the productive field.
- Lack of political interest in waste management, mainly at the local level.
- Absence of social awareness about responsibility regarding sustainable consumption and waste management.

Interviewer 4:

The main barriers are:

- Drought, water scarcity.
- Pollution.
- Deforestation.
- Artificial cultivation methods.
- Awareness issues.

Interviewer 5:

- The average income in Andalusia harms the acquisition of electric vehicles and renewable energy installations for self-consumption, heating and ACS, in comparison with other Spanish communities, as well as

Interviewer 6:

- The aging of the rural population and the unattractiveness of occupations linked to primary production (or, in general, linked to agricultural and forestry uses).

- Despite the great progress that has been made in Andalusia so that the towns have decent infrastructure (roads, telephones, communications, health establishments, etc.), the attraction of fully urban environments continues to be very intense.

- Water demand for agricultural activities; It is not only about water to intensify production (for which demand is also growing): also to carry out the most basic uses (water for consumption, for livestock...)

- Difficulty for the regeneration of ecosystems and forest formations due to the effect of high temperatures and lack of water on plants from natural restoration or repopulation.

- Imbalances in ecosystems and production systems due to the incidence of pests and diseases, as well as the effects of extreme thermal or rainfall events

Question 5. Is there any national/regional policy that impact/limit the future development of the targeted linear economies in your region?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- I only know of one European directive promoting the use of recycled plastic and taxing the use of new plastic.

Interviewer 2:

- Plastic tax.
- Directives of the CE of the automotive sector towards the increase of recycled/recyclable materials in the automobile (25%).

Interviewer 3:

- Circular economy law of Andalusia, Comprehensive waste management plan of Andalusia PIREC2030, Law 7/2022 on waste and contaminated soils for a CE, State Strategy for CE.

Interviewer 4:

- Andalusian Circular Economy Law (LECA): to facilitate the reuse of waste by regulating its reintroduction into production cycles, which entails less extraction of raw materials, less waste in landfills and a reduction in environmental impact, in addition to reduce production costs.

Interviewer 5:

- N/A

Interviewer 6:

- Yes. Planning and regulations (laws, decrees) have been developed related to the promotion of the circular economy, bioeconomy, etc., in addition to numerous regulations and sectoral planning instruments (forestry, agriculture, industries, land use planning) and the framework overview of the Climate Action Plan. But, in any case, it will be necessary to adapt these efforts to the changing conditions derived from the effects of climate change (example: eventualities derived from the abrasion of the coastline; areas of new desertification and depopulation due to lack of water, etc.)

Part 3: Existing pathways to support the circular bioeconomy transition

Question 6. Are there any regional bioeconomy strategies or regional strategies related to bioeconomy that exist in your region and what programmes/ instruments operationalize them?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- I am not aware of regional strategies or programs/instruments, but I have detected a greater interest in companies, which may lead to the development of regulations in this regard.

Interviewer 2:

- Yes, the Andalusian Circular Bioeconomy Strategy and European directives.

Interviewer 3:

- Andalusian Circular Bioeconomy Strategy (2018), Andalusian Circular Economy Law (2023).

Interviewer 4:

- The Andalusian Circular Bioeconomy Strategy, approved by agreement of the Governing Council on September 18, 2018, focuses on the areas of bioeconomy activities that are less developed in the community and, therefore, need greater institutional support.

through the implementation of specific actions that facilitate its takeoff and consolidation in the medium-long term.

Interviewer 5:

- Andalusia has a 2030 circular Bioeconomy strategy approved in December and a Circular Economy Law of Andalusia (LECA) recently approved by Parliament (March 22, 2023).
- For the implementation of the measures included in the LECA, the regional administration offers aid for local entities to develop and implement waste management planning instruments, for which 43 million euros are allocated.

Interviewer 6:

Yes, examples:

- Recent approval by Parliament of the Circular Economy Law

- Andalusian Circular Bioeconomy Strategy https://www.bioeconomiaandalucia.es/documents/1056091/1056698/Estrategia+Andaluza+Bioeconomia+Circular+%5BEABC%5D+%5B18.09.2018%5D/e0b87df0-73a8-43f2-ba9d-da0ad9b312e9

Question 7. Are there already interesting networks on the bio-economy on-going in the region (NGOs focused on circular bioeconomy – HUBs, clusters, platforms etc.)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- I don't know regionally.

Interviewer 2:

- Platform of the European project SCALE UP.

Interviewer 3:

- Circular Bioeconomy Cluster of Andalusia.

Interviewer 4:

- *Bioeconomy Cluster: https://www.bioeconomiaandalucia.es/cluster-de-bioeconomia*

Interviewer 5:

- *Chair of Circular Economy of the University of Seville _https://catedraeconomiacircular-us.es/*
- *Circular bioeconomy cluster https://www.bioeconomiaandalucia.es/cluster-de-bioeconomia*

Interviewer 6:

- Hub de innovación digital andaluz ICT-Biochain https://juntadeandalucia.es/organismos/agriculturapescaaguaydesarrollorural/servicios/actualidad/noticias/detalle/216778.html
- Clúster andaluz de Bioeconomía Circular https://www.bioeconomiaandalucia.es/cluster-de-bioeconomia

Question 8. Is the public government currently using any motivations: are there any competitions / awarding policies / green procurement in practice?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- SDG presence in regional grants and calls (NDHS).

Interviewer 2:

- Presence SDG regional and national calls as the operational groups.

Interviewer 3:

- LECA. TITLE II. CHAPTER III. GREEN PUBLIC PROCUREMENT.

Interviewer 4:

- The *Junta de Andalucía* has incorporated social and environmental clauses into public contracting processes to favor the achievement of better working conditions, environmental protection, promotion of SMEs, efficient use of resources, fight against inequalities or promotion of innovation.
  To facilitate its implementation, a Guide has been prepared that includes the mandatory clauses, as well as general recommendations that facilitate decision-making in all phases of the procedure, from the presentation of offers, to the award and execution.
  Circular Procurement Guide in Andalusia: https://juntadeandalucia.es/export/drupaljda/circpro-guia_compra_circular_andalucia.pdf

Interviewer 5:

- Yes, in the purchasing policies, both centralized and individual, the award criteria include the acquisition of renewable fuels, energy efficiency equipment and elements, and electric and biofuel vehicles.

Interviewer 6:

Although at this time I do not have updated information, the *Junta de Andalucía* has participated in projects and has promoted this type of purchase. Example:

https://www.cma.junta-andalucia.es/medioambiente/portal/landing-page-%C3%ADndice/-/asset_publisher/zX2ouZa4r1Rf/content/gpp4growth-green-public-procurement-for-resource-efficient-regional -growth-/20151

file:///D:/Users/jrga/Downloads/guide_good_practices.pdf

Question 9. Are there any existing R&D infrastructure (ESFRI, eDIH, R&D parks - in operation)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- It does not exist, and it is not consistent with the amount of waste and infrastructure at the laboratory level (initial TRL).

Interviewer 2:

- They are not enough. Companies demand them, but there is no supply, so value chains cannot be generated. The semi-industrial tests have to be done outside Andalusia (in other regions of Spain and other countries), despite having a large amount of usable waste.

Interviewer 3:

- Yes.

Interviewer 4:

- Lifewatch ERIC
- JRC (Joint Research Centre)
- Andalusia Agrotech DIH (EDIH)

Interviewer 5:

- Yes, there are infrastructures for Technological and Scientific Parks: https://juntadeandalucia.es/organismos/universidadinvestigacioneinnovacion/areas/empresas-emprendedores/parques-cientificos.html

Interviewer 6:

- Of course. This question can be better answered by Innovation colleagues.

Question 10. Are there any overview (e-map) of existing technologies processing biomass or residues to necessary commodities (existing network of biogas plants, composting units, renewable energy plants)?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- There are no process maps, only cultivation maps, or I don't know them.

Interviewer 2:

- I don't know them.

Interviewer 3:

- CONSULT WITH A COMPETENT ADMON AT THE EABC.

Interviewer 4:

- Resource map and biomass facilities in Andalusia https://www.agenciaandaluzadelaenergia.es/es/informacion-energetica/cartografia-energetica-de-andalucia/recursos-y-potencial-de-energias-renovables/mapa-de-recurso-e-instalaciones-de-biomasa- In Andalucia

Interviewer 5:

- Yes, there are online maps of existing technologies for energy generation, as well as waste management and composting:
  - Map of energy infrastructures in Andalusia that include biomass and biogas electricity generation plants, pellet factories and biofuel factories: https://www.agenciaandaluzadelaenergia.es/es/informacion-energetica/cartografia-energetica-de-andalucia/mapa-de-infraestructuras-energeticas-de-andalucia-miea
  - Map of termal facilities in Andalusia: https://www.agenciaandaluzadelaenergia.es/es/informacion-energetica/cartografia-energetica-de-andalucia/recursos-y-potencial-de-energias-renovables/mapa-de-recurso-e-instalaciones-de-biomasa-en-andalucia
  - Map of waste management and composting facilities: https://www.cma.junta-andalucia.es/medioambiente/portal/web/guest/areas-tematicas/residuos-suelos-contaminados-economia-circular/gestion-de-residuos/instalaciones-tratamiento

Interviewer 6:

There is information of interest in:

- Andalusian Energy Agency. Example:
https://www.agenciaandaluzadelaenergia.es/sites/default/files/Documentos/3_2_0068_20_LA_BIOENERGIA_EN_ANDALUCIA.PDF
https://www.agenciaandaluzadelaenergia.es/es/informacion-energetica/cartografia-energetica-de-andalucia/recursos-y-potencial-de-energias-renovables/mapa-de-recurso-e-instalaciones-de-biomasa- In Andalucia

- Composting in agriculture:
https://juntadeandalucia.es/organismos/agriculturapescaaguaydesarrollorural/areas/produccion-ecologica/insumos-utilizables-produccion-ecologica/paginas/compostaje-ecologico.html

Question 11. Is there any evidence about the amount of biomass residues, unexploited biomass, study about the potential of biomass utilisation?

Please summarize in max one page the responses of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- Yes, there are studies of biomass potential in the region.

Interviewer 2:

- Yes, there are different studies in Andalusia.

Interviewer 3:

- CONSULT WITH A COMPETENT ADMON AT THE EABC.

Interviewer 4:

- https://www.agenciaandaluzadelaenergia.es/es/informacion-energetica/cartografia-energetica-de-andalucia/recursos-y-potencial-de-energias-renovables/mapa-de-recurso-e-instalaciones-de-biomasa-en-andalucia

Interviewer 5:

- Yes, the biomass potential in Andalusia amounts to 4,303 ktoe and represents approximately 22% of the primary energy demand in Andalusia.
- The potential is available on the web by the type of biomass and municipal level.
https://www.agenciaandaluzadelaenergia.es/es/informacion-energetica/cartografia-energetica-de-andalucia/recursos-y-potencial-de-energias-renovables/mapa-de-recurso-e-instalaciones-de-biomasa-en-andalucia

Interviewer 6:

- Biomass potential map:
https://www.agenciaandaluzadelaenergia.es/biomasa/biomasa/init.do?prefix=/biomasa&name=potential

Question 12. Would you like to share any final thoughts? Anything you consider important to highlight?

Please summarize in max one page the comments of all interviewees. Provide also a figure if/when meaningful to better illustrate the answers.

Interviewer 1:

- There is NO financing for the industrialization of value chains already tested at the R+D+i level. This happens in Andalusia but not in other regions of Spain. Even having a final customer for the bioproducts that could be developed.

Interviewer 2:

- There is no support to promote the use of biomass in pre-industrial TRLs in the region. This affects the academy-industry transfer.
- Financing in the bioeconomy is promoted by the public administration in terms of funds and types of programs, but not in matters related to investment in pilot plants and support for the industrialization of new value chains.

Interviewer 3:

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Interviewer 4:

- N/A

Interviewer 5:

- N/A

Interviewer 6:

- Receive information about the results of the project.
- Thank you so much.