CIRCULAR FOAM

Stakeholder map and regional readiness for a systemic territorial solution

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I. Technical References

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II. Executive Summary

The Regional Readiness Report analyses regional conditions for developing systemic solutions for cooperation that is needed to establish *hubs for circularity* for polyurethane (PU) hard foam. Its goal is to assess which factors foster or hamper cooperation along the expected material flows.

The framework used to assess the readiness of the region is based on a new concept of regional readiness and focuses on non-technological dimensions in transition processes by analysing societal, political and economic dimensions in each region. Key aspects are the state of transition, policy frames, economic set-up, cooperation and innovation culture, and consumer perspectives.

The three case study regions are *Rheinisches Revier* in Germany, *Upper Silesia/ GZM* in Poland, and *Amsterdam Metropolitan Area* in the Netherlands. The analysis shows that they have a strongly differing status in implementing circular economy solutions on the ground. The *Amsterdam Metropolitan Area* is best suited to move forward on the establishment of circular economic solutions in the near future. *Rheinisches Revier* finds itself in the middle of a fundamental transition towards a green and sustainable economy supported by a basic positive regional set-up that can potentially lead to functioning collaboration schemes and industrial symbiosis in the region. The *Upper Silesia / GZM* region is instead in a very early stage of a green transition with only soft policy goals and public awareness, though it is supported by a mentality of change in the region and a culture of industrial cooperation. The major factor for all three regions for a successful establishment of *hubs for circularity* is the need for stakeholder alliances that can give momentum to the transition towards a circular value chain of PU hard foam.

The regional readiness report is intended to lay the groundwork for the development of a blueprint model of cooperation that can be used to formulate a roadmap for the creation of *hubs for circularity* for PU hard foam in the pilot regions.

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III. Disclaimer

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1 Joint Introduction

A key task in work package (WP) 1 is to assess regional conditions for developing systemic solutions for cooperation that is needed to establish *hubs for circularity* for polyurethane (PU) hard foam on the ground. This shall lead to a blueprint model of cooperation that can be used to formulate a roadmap for the creation of such hubs in the pilot regions. A ***hub for circularity*** is a key concept for the European Union and for our work in WP 1. We define it as a physical and/or digital space in which an intertwined and mostly symbiotic value chain is formed along a specific circular material flow – as part of the overall goal of engineering a net-zero circular economy in a region.

An important first task (1.1) of WP 1 is to analyse the **regional potential** to introduce *hubs for circularity* in PU hard foam – following two key **research questions**:

- Which basic conditions in a region can be identified that potentially affect establishing PU hard foam *hubs for circularity*?
- Which factors foster or hamper cooperation along the expected material flows?

To answer these research questions as systematically and thoroughly as possible we make use of a **new concept of regional readiness** that has not been widely used as an analysing framework for delving deeper into the context of establishing circular economy solutions in EU regions so far. It decidedly differs from well introduced concepts of technological readiness which can be measured by a Technological Readiness Level (TRL) that has been widely adopted at EU, national and regional levels as a tool for decision making when financing investments with public grants (Bruno et al., 2020). The concept of regional readiness supplements assessments of TRL. It focuses on non-technological dimensions in transition processes by analysing societal, political and economic dimensions in each region that have the potential to shape the introduction of PU hard foam *hubs for circularity*.

In this report we will work with a suitable **framework** that assesses regional readiness by analysing the following **key aspects**:

- *Transition*:
  - History of transformation processes in a region;
  - attitudes towards and the cultural understanding of change in a region;
  - current transition paths and projects in a region.

- *Policy*:
  - Legislation and regulations that set the frame for the transition towards circular economy solutions in each region;
  - policy goals or action plans for the introduction of a circular economy;
  - priority for circular economic solutions on the regional political agenda.

- *Economy*:
  - Key economic set-up and dynamics in each region;
  - business sectors with relevance for establishing *hubs for circularity* for PU hard foam;
  - status of public infrastructure to suit economic progress in a region;
  - capability of the regional workforce to support this transition.

- *Cooperation*:

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- Ability and motivation of stakeholders to co-work and co-create in each region;
- willingness to share information and align business interests;
- existence of regional networks to build upon.

- *Innovation:*
  - Cultural openness towards innovation in each region;
  - regional spaces and initiatives to create marketable innovations out of R&D ideas;
  - financing of innovation in each region.

- *Society:*
  - Public awareness of the need to introduce circular economy concepts;
  - willingness to support a sustainable system of waste separation and management;
  - consumer acceptance of new products which include upcycled materials.

Key to understanding the present report is how we **define a *region***. Our understanding is that a region is defined as a space with

- a significant proportion of the material flows and waste at stake and
- a sufficient variety of stakeholders along the PU hard foam material flow.

A region is henceforth not primarily defined by its strict geographical borders but as a permeable space in which PU hard foam material flows and in which we register a complex set of different stakeholders along the value chain.

To have a sufficient variety of regional **case studies** we choose to investigate three particular EU regions that have a strongly differing status in implementing circular economy solutions on the ground. These regions are:

- *Greater Amsterdam*: The metropolitan area with currently 2.5 million inhabitants will see a major residential, commercial and industrial development up to 2040 – expanding its significance as a major centre for European and global business. Sustainability is key in all prospected growth plans. As part of it, the Greater Amsterdam region is following a firm circular economy vision and action plan.

- *Rheinisches Revier*: The lignite mining area with currently 2.5 million inhabitants is in the middle of a major transformation process precipitated by the decision to end the extraction of coal in 2030. The urban-land transitional space is changing from a conventional energy powerhouse to a sustainable economic region with key activities in the fields of regenerative energy production, sustainable resource usage and future mobility.

- *Upper Silesia / GZM*: The hard coal region is – comparable to *Rheinisches Revier* - in the middle of a major structural change from *black* to *green industries*. As a border region with 2.2 million inhabitants it is not only the most densely populated area in the country but also a vibrant commercial region generating 12 % of Poland's GDP. It lacks significant policy initiatives towards the introduction of circular economic solutions.

Framed by a **joint introduction** (chapter 1) the report assesses the readiness for establishing PU hard foam *hubs for circularity* in each of the three **pilot regions** (chapters 2 to 4). This analysis starts with

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broadly introducing each region with the help of regional biographies and subsequently follows the above-mentioned analytical framework by examining key readiness factors in depth. In a **joint summary** (chapter 5) our findings are reviewed by comparing which factors foster or hamper regional readiness for introducing PU hard foam *hubs for circularity*.

We strive for a **multidisciplinary and mixed-method approach** (Hay, 2016; Kelle, 2014). In our mixed method design we use different qualitative and quantitative sources of information and data. We combine these methods to make use of the respective advantages and disadvantages of each account. The report is thus methodically based on a broad review of secondary literature on the region as well as a deep desktop research which makes regional data, documents and media reports accessible for analysis. Additionally, we conducted qualitative field interviews with relevant stakeholders and carried out a representative regional survey on public awareness on circular economy solutions and consumer attitudes towards upcycled PU hard foam products in each of the regions.

The regional readiness report can be understood as a starting point for more detailed and in-depth analysis following later on in the course of the project. It delivers the necessary contextual information and interpretative resources for understanding regions, actors, actions and cultures. It thus builds the **groundwork** for the development of the blueprint model. It is important to note that the following report is designed as a **living document** which can be continuously extended - meaning that it will have to constantly be developed, fed with new information and revised in the course of the project.

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2 Pilot Region A: Rheinisches Revier

2.1 Introducing the Region: Rheinisches Revier

Rheinisches Revier (English: *Rhenish mining area*), close to the Benelux borders, is Europe's largest lignite mining area. It encompasses several regional administrative bodies and municipalities. Around 2.5 million people live there (as of May 2020; ZRR, 2022). The region is urgently confronted with massive economic, cultural and social challenges due to the ongoing transition towards a sustainable region: Germany has recently decided upon an early coal phase-out until 2030 (MWIKE.NRW, 2022), when all coal power plants will be shut down in *Rheinisches Revier*. Lignite mining and related energy-intensive industries constitute the "centre of the economy" in the region (Gärtner, 2014, p. 69). Accordingly, its economic focal points are mainly on industrial production such as chemicals and aluminium and its accompanying services (Stognief et al., 2019, p. 9; Gärtner, 2014, pp. 68–70; Vallentin et al., 2016, p. 12; KWSB, 2019, pp. 76–77). Moreover, and due to the high quality of soil in the region, there used to be a strong focus on agriculture and still is on the food sector. The region has an elaborated landscape of technology and research institutions of applied sciences, which serve as an incubator for innovation and growth. Further economic and cultural effects result from the proximity of the Rhine and the region's close economic ties to prospering urban areas such as Aachen, Cologne and Düsseldorf as well as to the neighbouring markets of Belgium, the Netherlands, and France. The broader Rhineland region is considered an important hub for goods because the relevant transport infrastructure is already in place.

2.1.1 Geography

The region of *Rheinisches Revier* is located in the Lower Rhine Embayment, in a triangle between the cities of Aachen, Mönchengladbach, Cologne and Bonn. The area covers 4800 km^2 (as of May 2020; ZRR 2022) and includes three large lignite mining areas (from smallest to largest): Inden, Garzweiler and Hambach.
All three open-cast mines produce a total of up to 65 million tons of lignite annually. The latest figures available (source: RWE) are from April 2022 and production is already being gradually reduced. In addition to lignite, loess, quartz sand and clay are also mined to a lesser extent in the area (ZRR, 2022).

The region's seven districts encompass 65 municipalities, 20 of which are directly neighbouring an open pit mine or a power plant and are therefore particularly affected by the coal phase-out (marked in dark grey on the map as shown in Figure 1).

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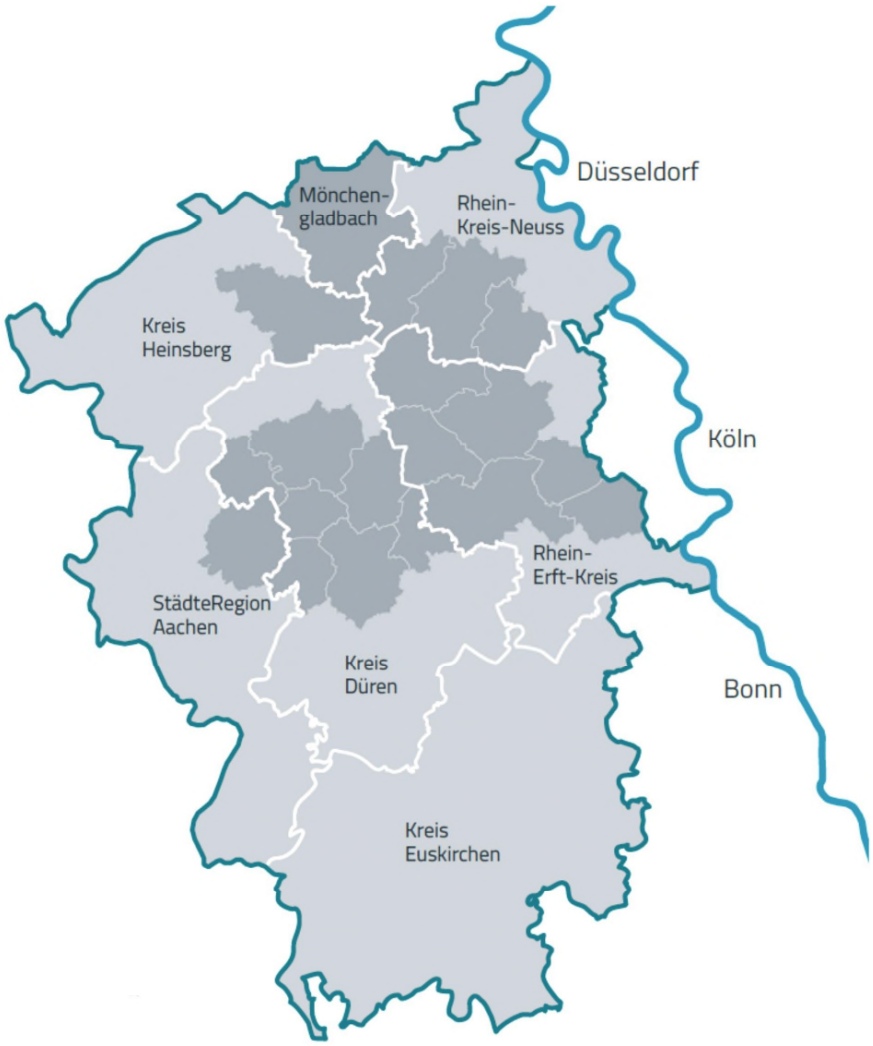

FIGURE 1: DISTRICTS OF RHEINISCHES REVIER AND PARTICULARLY AFFECTED MUNICIPALITIES IN DARK GREY ("ANRAINERKOMMUNEN") (SPOTH, KLAR AND SCHURR, 2021, P. 7)

Rheinisches Revier can be described as an urban-rural transition zone that is located within the triangle between the surrounding major cities (Aachen, Mönchengladbach/ Düsseldorf, and Köln/ Bonn). It also touches another geographical triangle on the international level: The city of Aachen is in close proximity to the border triangle between Germany, the Netherlands and Belgium.

Landscape changes

The current loss of land due to open pit mining in *Rheinisches Revier* is at 8 % (Spoth, Klar and Schurr, 2021, p. 9). With approx. 57 % of land loss compared to their original surface area, Jüchen and Niederzier are among the municipalities with the highest land consumption due to lignite mining.

The region is characterised by fertile soil (loess), frequently referred to as “best soil in Germany” (e.g. Koordinierungsstelle BioökonomieREVIER, no date) and therefore has a high agricultural value.

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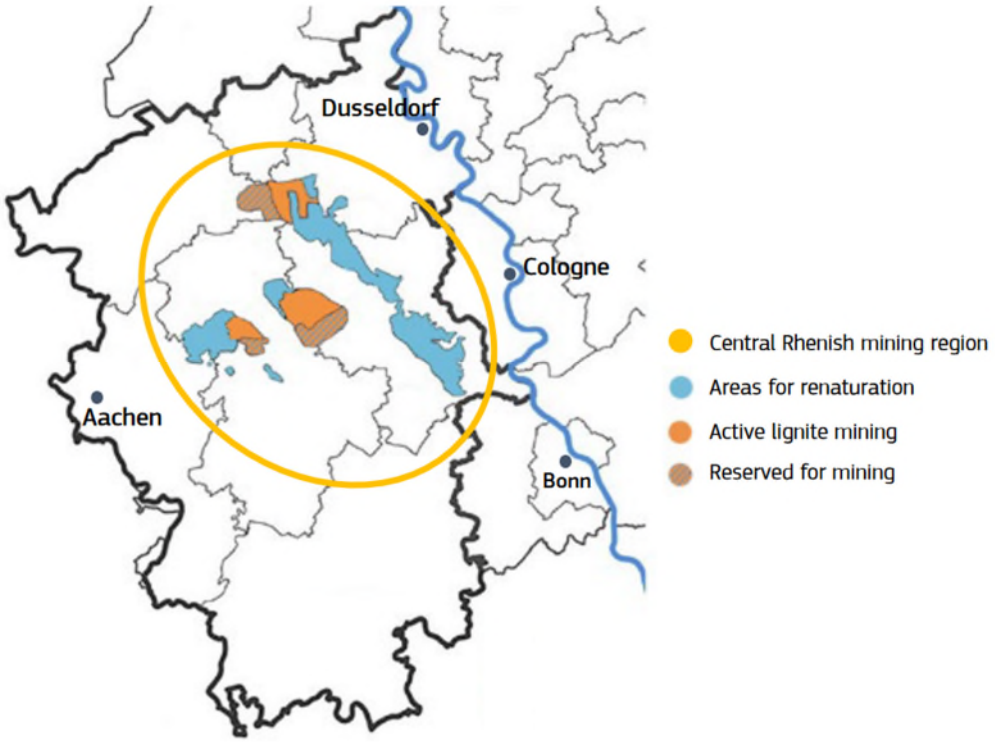

FIGURE 2: MAP OF LIGNITE MINING IN RHEINISCHES REVIER (EUROPEAN COMMISSION, 2020, P. 3)

All three mining areas (Figure 2) will be recultivated largely by flooding after the coal phase-out is completed in 2030. Estimates assume a duration of about 40 years that it will take to fill the mining pits with water from the rivers Rhine and Ruhr. As a result, the *Rheinisches Revier* will be transformed into a landscape characterised by three large lakes that will be among the deepest water bodies in Germany (LANUV, no date).

The agricultural land use in the region *Rheinisches Revier* is below the German and above the North Rhine-Westphalian (NRW) share, while the forest area is much lower with just under 20 % as the German share of total area amounts to around 31 % and NRW to 24.8 % (Figure 3). The traffic area, however, is higher (8.1 %) in comparison to the NRW level of 7 % and the German level of 5.1 %. Settlement areas make up 5.7 % of the country's total surface area whereas they are both above 10 % in NRW and in the case study region.

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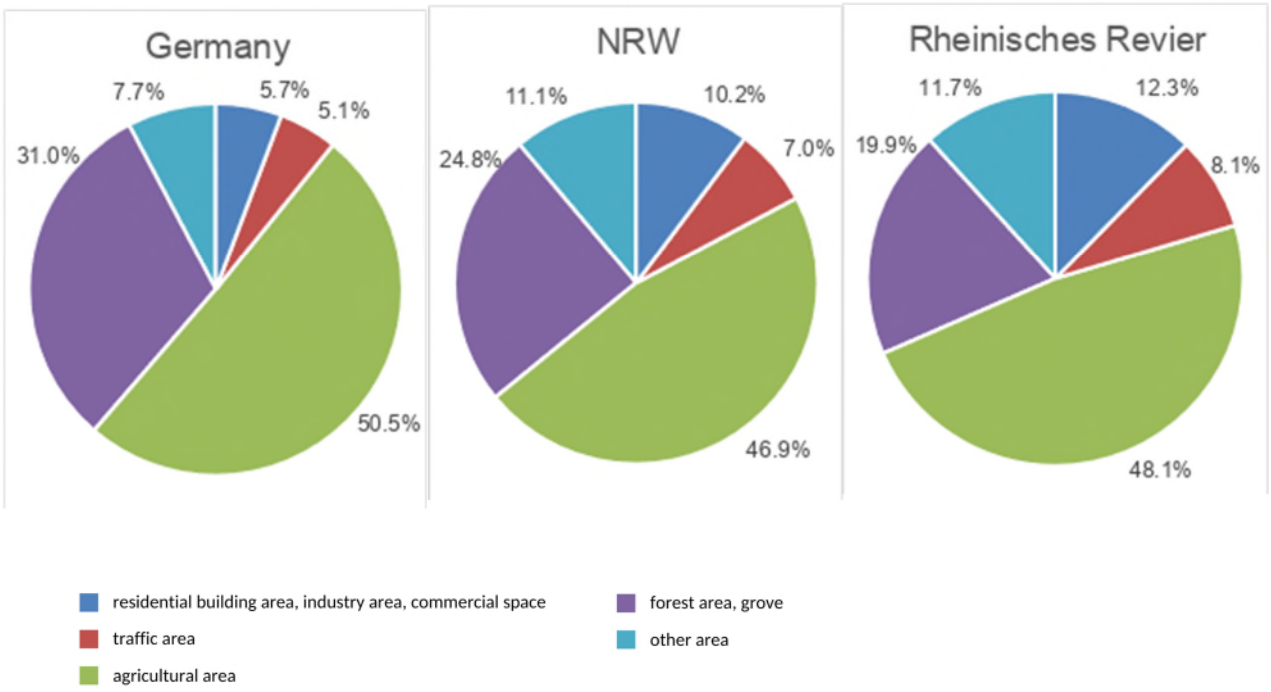

FIGURE 3: AREA OF RHEINISCHES REVIER ACCORDING TO TYPE OF USE IN 2021 (OWN PRESENTATION AND CALCULATIONS, BASED ON: IT.NRW, 2022A, P. 3; IT.NRW, 2022B, P. 3; IT.NRW, 2022C, P. 3; IT.NRW, 2022D, P. 3; IT.NRW, 2022E, P. 3; IT.NRW, 2022F, P. 3; IT.NRW, 2

2.1.2 Polity

Position in the federal system

The federal system in Germany is made up of the federal government and 16 federal states. These and the municipalities have different responsibilities and powers. While most legislation is enacted at the federal level, the federal states are predominantly charged with administrative powers (European Committee of the Regions, no date).

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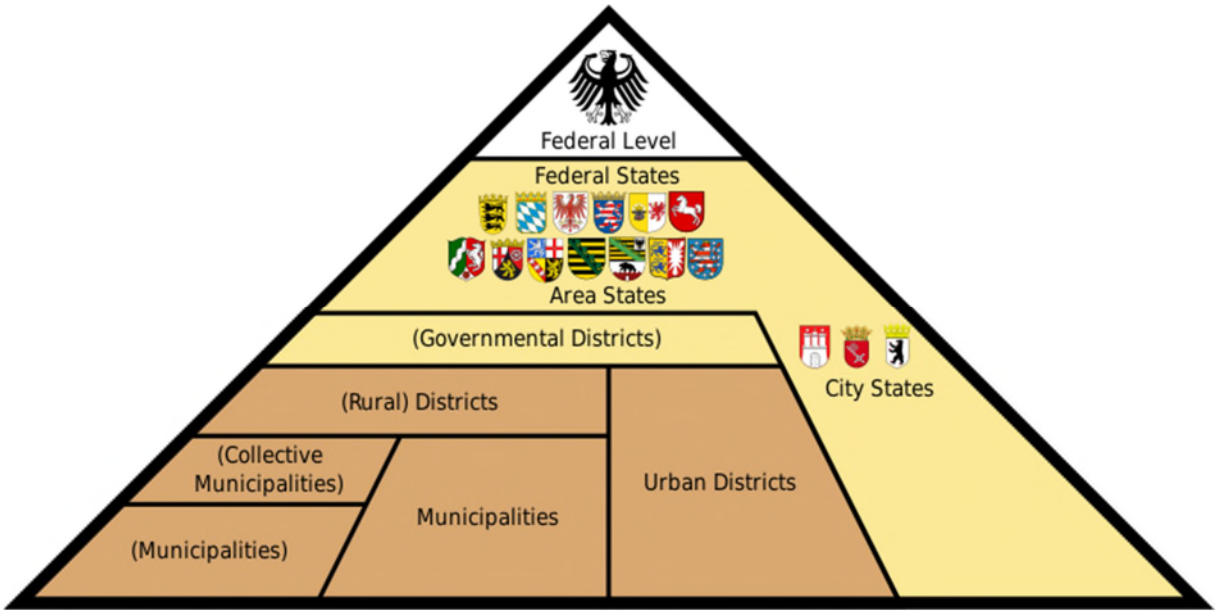

FIGURE 4: ADMINISTRATIVE DIVISION OF THE FEDERAL REPUBLIC OF GERMANY (WIKIMEDIA COMMONS, 2022)

Figure 4 shows the administrative division of the Federal Republic of Germany with the vertical (Federal) separation of powers across the federal government (White), the states (Yellow), and the municipalities (Brown).

The case study of *Rheinisches Revier* consists of different NUTS 3 regions. In applying the NUTS 3 structure of the EU, we gain comparable data that allows systematic comparison between the regions.

The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU and the UK for the purpose of:

- The collection, development and harmonisation of European regional statistics
- Socio-economic analyses of the regions

NUTS 1 classifies major socio-economic regions. In our case, this describes the federal state of North Rhine-Westphalia.

The level of NUTS 2 is used for basic regions for the application of regional policies. The region of *Rheinisches Revier* in our analysis is divided into the governmental districts (*Regierungsbezirke*) Düsseldorf and Cologne.

The NUTS 3 indicates "small regions for specific diagnoses". These are the districts of Düren, Euskirchen, Heinsberg, Rhein-Erft-Kreis, Rhein-Kreis Neuss, Städteregion Aachen and Mönchengladbach (Table 1) (eurostat, 2021).[1]

[1] Districts (German: Kreise) can be described as administrative districts, which are subareas of the federal states. Generally, a Kreis includes several towns or cities, however, the more important cities are not appendant to a Kreis, but have an equivalent status and functions to a Kreis, solely as the specific city (name: 'Kreisfreie Stadt', English: district-free city) (Heinrich-Böll-Stiftung e.V., 2018a; Heinrich-Böll-Stiftung e.V., 2018b). In *Rheinisches Revier,* Mönchengladbach is a district-free city. Städteregion Aachen, though, has the status of a district or of a district-free city, but is actually a municipal association, of which the city Aachen is the eponym (StädteRegion Aachen, no date-a).

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NUTS 3-Code	Name	Governmental district (NUTS 2)
DEA26	Kreis Düren	Cologne (DEA2)
DEA28	Kreis Euskirchen	Cologne
DEA29	Kreis Heinsberg	Cologne
DEA27	Rhein-Erft-Kreis	Cologne
DEA1D	Rhein-Kreis Neuss	Düsseldorf (DEA1)
DEA2D	Städteregion Aachen	Cologne
DEA15	Mönchengladbach	Düsseldorf

TABLE 1: NUTS 3-CODES AND NAMES OF RHEINISCHES REVIER (OWN PRESENTATION, BASED ON: EUROPEAN COMMISSION, 2022)

As the categorization above shows, the region as a whole is not politically represented. Its definition is based on the mining areas and therefore has a geological and economic meaning. This definition of the region is a construct that places function before identity or political entity.

Due to the fact that *Rheinisches Revier* is a region consisting of different municipalities and districts, the set of data for describing the region may vary in the course of this analysis. If possible, exact data about *Rheinisches Revier* will be used, but some aspects will be characterised and contextualised with data of NRW or Germany as well.

Looking at the district administrators and mayors in the region, party affiliations are divided between the traditional parties of Christian Democrats (CDU) and Social Democrats (SPD), the former making up the majority, while the local coalitions show that the Greens are involved in most districts (Table 2). The age span ranges from 33 years to 64 years of age (as of 2023), showing that the commissioners and mayors include both younger and older generations.

District Administrators and Mayors

Area	Mayor/ Administrator	Ruling coalition
Mönchengladbach	Mayor Felix Heinrichs, SPD (*1989)	SPD - Greens - FDP
Kreis Heinsberg	Commissioner Stephan Pusch, CDU (*1969)	CDU
Städteregion Aachen	City Councillor Dr. Tim Grüttemeier, CDU (*1980)	CDU - Greens
Kreis Düren	Commissioner Wolfgang Spelthahn, CDU (*1963)	CDU - Greens
Kreis Euskirchen	Commissioner Markus Ramers, SPD (*1986)	CDU - FDP - UWV
Rhein-Erft-Kreis	Commissioner Frank Rock, CDU (*1970)	CDU – Greens - FDP
Rhein-Kreis Neuss	Commissioner Hans-Jürgen Petrauschke, CDU (*1956)	SPD - Greens

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TABLE 2: CURRENT DISTRICT COMMISSIONERS AND MAYORS IN RHEINISCHES REVIER (HEINRICHS, NO DATE; RADIO 90,1, 2021; CDU-KREISTAGSFRAKTION HEINSBERG, 2021; MEDIENHAUS AACHEN GMBH, NO DATE; SCHMITZ ET AL., 2020; STÄDTEREGION AACHEN, NO DATE-B; BÜNDNIS 90/DIE GRÜNEN AND Kreisverband Düren, no date; Kreisverwaltung Düren, no date; Bühl, 2020; Kreis Euskirchen, no date; CDU-Kreisverband Rhein-Erft, no date; RHein-Erft-Kreis, no date; SPD Rhein-Kreis Neuss, no date; Rhein-Kreis Neuss, no date)

Political Landscape

The political landscape is rather homogeneous: The Christian Democratic Union (CDU) has a clear stronghold in the region. With the exception of the city of Aachen, where the Green Party (*BÜNDNIS 90/DIE GRÜNEN*) was the strongest, the CDU won the NRW state election 2022 in the whole of *Rheinisches Revier* (Figure 5). The Greens have, however, gained some strength in the region in the last years, while the party of the Social Democrats (SPD) has stagnated.

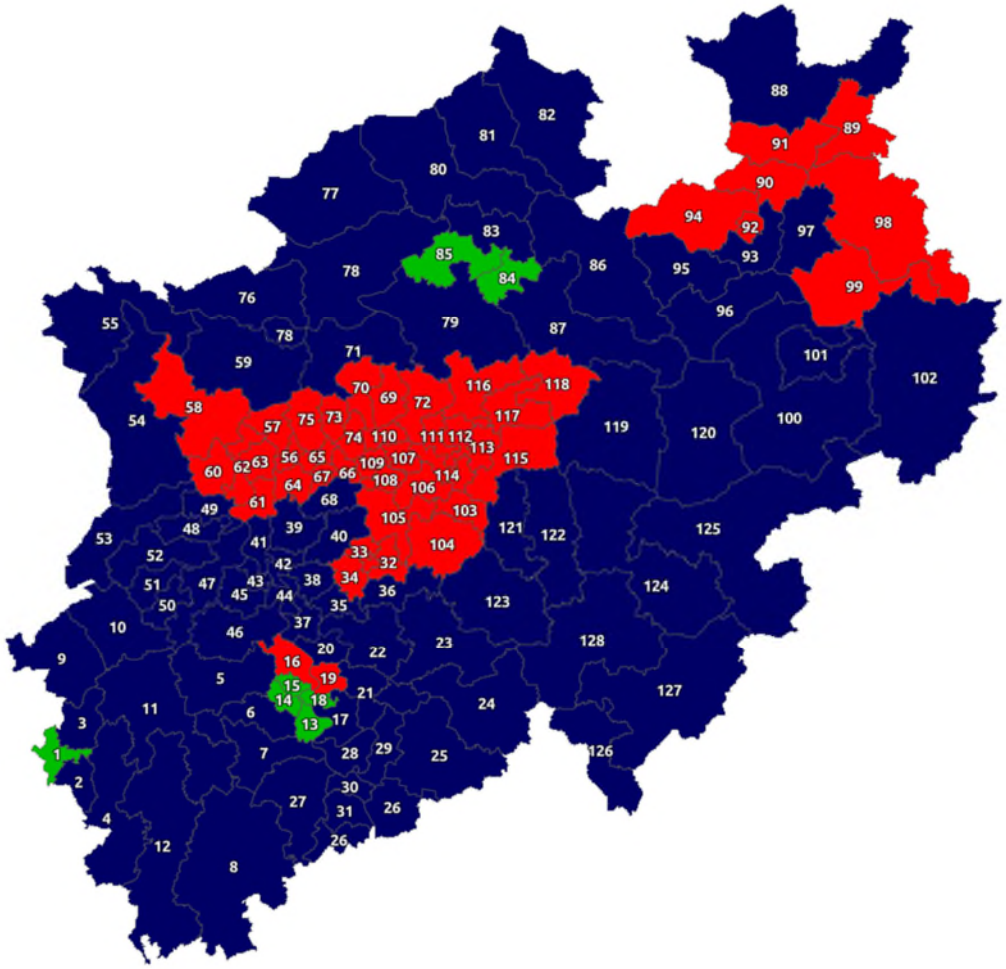

FIGURE 5: RESULTS OF STATE ELECTION 2022 IN NORTH RHINE-WESTPHALIA (BLUE: CDU MAJORITY, GREEN: GREENS MAJORITY, GREY CIRCLE MARKS RHEINISCHES REVIER) (MINISTERIUM DES INNERN, LANDESWAHLLEITER, 2022)

2.1.3 Population: Socio-demography

Around 2.5 million inhabitants live in *Rheinisches Revier* (as of May 2020; ZRR, 2022). Consisting of seven districts, the region has urban-rural transitory spaces and density clusters in Städteregion

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Aachen, Mönchengladbach and Rhein-Kreis Neuss. The inhabitants in the region range from circa 556,000 inhabitants in Städteregion Aachen to around 194,000 in Kreis Euskirchen (Statistisches Bundesamt (Destatis), 2022a), which can be characterised as a density from 780 inhabitants/km^2 to 155 inhabitants/km^2 (NRW: 525). The highest density of inhabitants is found in Mönchengladbach with 1,538 inhabitants/km^2 (IT.NRW, 2018a).

It is expected that the region will have a slow population growth by 2040. Some districts are expected to decrease slightly such as Kreis Düren (0.2 %) and Kreis Euskirchen (0.4 %), whilst the majority will gain marginally (Table 3). According to forecasts, the districts will age more than the independent cities without districts (Statistische Ämter des Bundes und der Länder, 2022). The median age is at 43.3 years in urban regions like Städteregion Aachen and goes up to 45.2 years in rural areas like Kreis Euskirchen, whilst NRW has a median age of 44.3 years (Statistische Ämter des Bundes und der Länder, 2022).

	2040 (change in % compared with 2018)	**2040 - under 19 y.**	**2040 - 19-65 y.**	**2040 - 65+ y.**	**Median age (2020)**
Mönchengladbach	+1.0 % (264,709)	+0.3 %	-8.9 %	+30.9 %	44.2
Kreis Heinsberg	+1.0 % (255,568)	-5.6 %	-13.5 %	+49.8 %	44.8
Städteregion Aachen	+2.7 % (568,883)	+1.8 %	-6.4 %	+31.8 %	43.3
Kreis Düren	-0.2 % (262,392)	-2.8 %	-13.0 %	+39.0 %	44.6
Kreis Euskirchen	-0.4 % (191,432)	-3.7 %	-16.1 %	+47.2 %	45.2
Rhein-Erft-Kreis	+5.7 % (494,028)	+6.1 %	-5.3 %	+36.9 %	44.6
Rhein-Kreis Neuss	+5.7 % (474,886)	+6.3 %	-5.0 %	+34.5 %	45.0
NRW	+0.9 % (18,080,562)	-	-9.8 %	+33.4 %	44.3

TABLE 3: POPULATION DEVELOPMENT FORECASTS IN RHEINISCHES REVIER (IT.NRW, 2018B, P. 174-178; STATISTISCHE ÄMTER DES BUNDES UND DER LÄNDER, 2022)

If one considers the age distribution, *Rheinisches Revier* is in line with the German age distribution, which is evenly distributed (Figure 6). Regarding the sex distribution (IT.NRW, no date-a), it is similarly in line with the German data, whereby the sex distribution is balanced (IT.NRW, no date-a; Statistisches Bundesamt (Destatis), no date-a).

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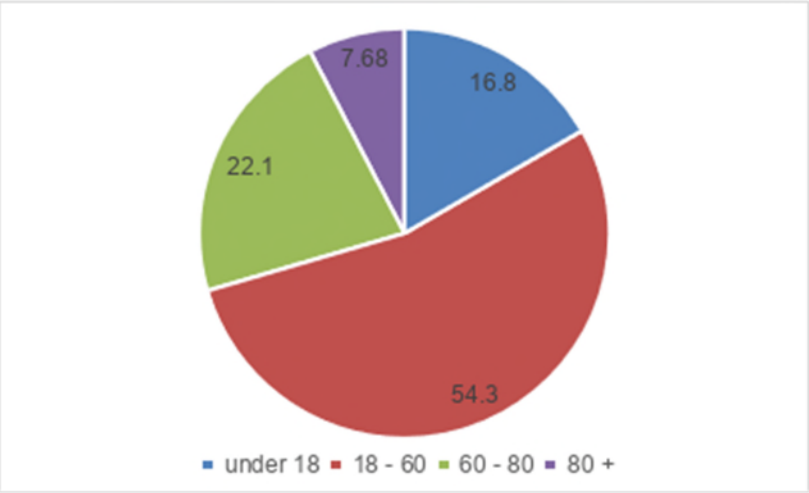

FIGURE 6: AGE DISTRIBUTION IN RHEINISCHES REVIER IN 2020 (IT.NRW, NO DATE-A; OWN PRESENTATION)

With regard to the number of household members, the average household in North Rhine-Westphalia consists of 2.05 members (Statistisches Bundesamt (Destatis), no date-b), whilst the German and EU average is 2.02 members (Statistisches Bundesamt (Destatis), no date-b; eurostat, 2022a). It is also very common to live in a single household as shown in the chart below (Table 4). In 2018, the home ownership rate was at 46.8 % in Germany and 43.7 % in North Rhine-Westphalia (Statistisches Bundesamt (Destatis), no date-c).

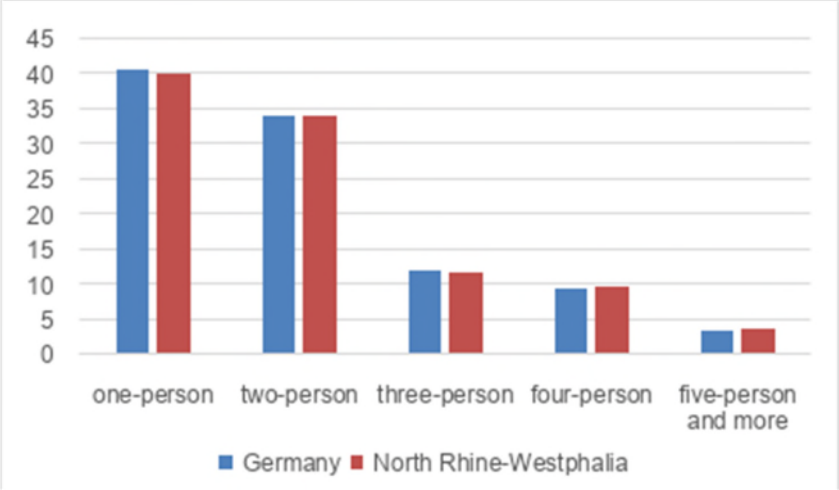

FIGURE 7: DISTRIBUTION OF HOUSEHOLDS FOR GERMANY AND NRW IN 2021 IN PERCENT (STATISTISCHES BUNDESAMT (DESTATIS), NO DATE-B)

Considering another indicator for the socio-demographic conditions, the migration, one can state that the western part of Germany in general and NRW especially are regions with a higher migration background than in other parts of Germany, where the data drops to under 10 % in some areas (BAMF, 2021, p. 10). On average, the migration background is at 27.2 % in Germany (Statistisches Bundesamt (Destatis), 2022b), while in North Rhine-Westphalia, the background varies between 28.9 % in Westphalia-Lippe and 31.2 % in the Rhineland (Figure 7). In Figure 7 it also becomes apparent that the percentages vary from district to district in accordance with their population density. This leads to lower percentages in the rural core of *Rheinisches Revier*.

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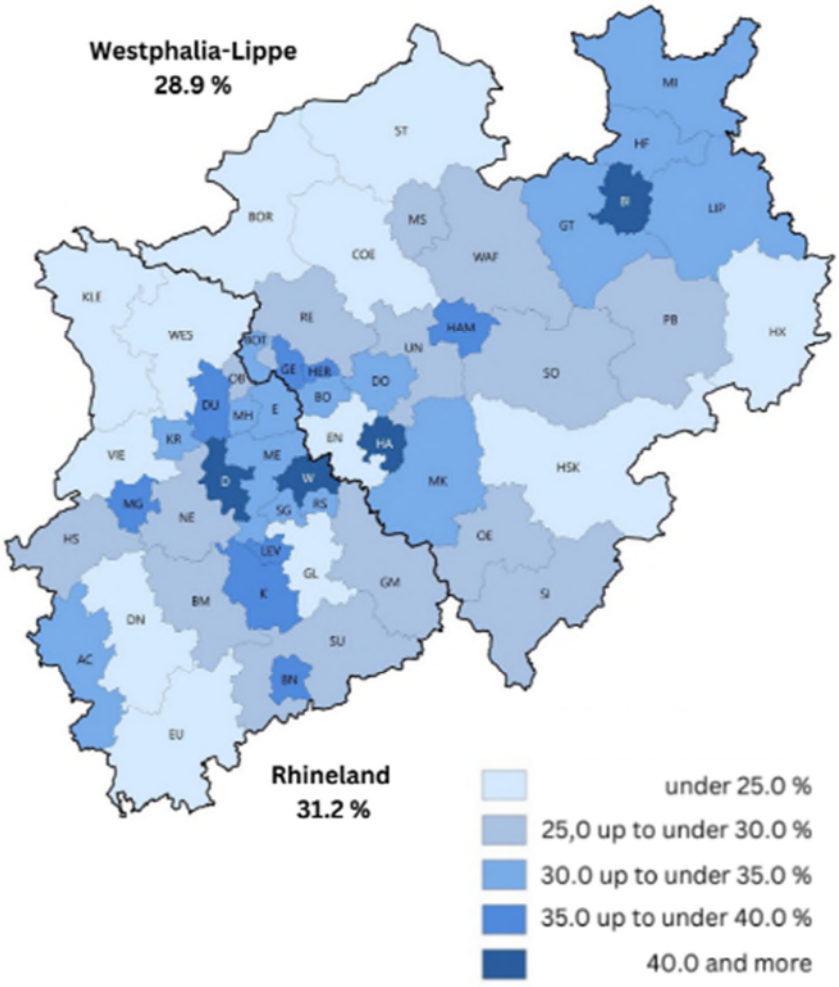

FIGURE 8: MIGRATION BACKGROUND IN NRW (LANDSCHAFTSVERBAND WESTFALEN-LIPPE, 2021)

According to the Eurobarometer survey of the European Commission, in 2018, one fourth of all Germans considered themselves as catholic and another fourth as protestant. Around 27 % can be described as non-religious, agnostic or atheist. The last fourth consists of different religious beliefs, whereof other Christian religions make up 7.6 %, the Islam adds up to 2.5 % and Orthodox Christians sum up to 2.2 % (Bundeszentrale für politische Bildung, 2020).

Regarding the level of education, the International Standard Classification of Education (ISCED)[2] is a commonly used classification which classifies national education programmes and its corresponding qualifications in order to compare them internationally. Concerning the level of education in NRW among workforce between 25 and 64 years, 17.8 % are considered below secondary education (ISCED 0-2), which is almost 4 % higher than the German share but 3.1 % below the mean of the countries of the Organisation for Economic Co-operation and Development (OECD).[3] Secondary education and post-secondary non-tertiary education (ISCED 344, 35, 3 and 4) make up 53.8 % in NRW, 54.9 % in Germany, whereas the OECD-mean is 42.6 %. Finally, in NRW 28.4 % are considered part of tertiary

[2] The exact categories of ISCED according to the level of education can be found in brackets at the relevant passages.

[3] The mean of the OECD is an unweighted mean of the values of all countries of the OECD (Blaeschke, Freitag and Reinhard, 2021, p. 8).

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education (ISCED 5, 6, 7 and 8), of which 1.4 % are ISCED 8 'Doctoral or equivalent level'. In Germany, tertiary education sums up to 31.3 % (1.6 % ISCED 8), while the mean of the OECD-countries is at 38.6 % (1.3 % ISCED 8) (Blaeschke, Freitag and Reinhard, 2021, p. 17).

On closer examination of the vocational status, it can be determined that the employment rate in 2021 was at 52.5 % in Germany (Statistisches Bundesamt (Destatis), no date-d), while North Rhine-Westphalia was at 57.0 % (IT.NRW, no date-b). The unemployment rate was 3.3 % in Germany (Statistisches Bundesamt (Destatis), no date-d) and 4.0 % in NRW (IT.NRW, no date-b). This implies a labour force participation rate of 55.8 % in Germany (Statistisches Bundesamt (Destatis), no date-d) and 59.4 % in NRW (IT.NRW, no date-b). The employment rate in NRW can be further broken down to occupational status: The biggest group, which accounts for 70.8 %, are employees and are followed by workers with 11.4 %. Around 8.1 % are self-employed including assisting relatives, 5.6 % are officials and apprentices make up 4.1 % (IT.NRW, no date-b).

2.1.4 History / Identity

Lignite was first discovered in Lucherberg (near Inden) in the year 1819, with extraction beginning in 1826. With the increasing demand for primary energy sources with high energy density during the beginning of industrialization as well as technical innovations regarding the mining of lignite, the extraction of lignite in the region began to be profitable. After an initial small-scale experiment in 1892, the first electricity plant was built in Frechen in 1899, supplying 1 MW to an energy-intensive sugar factory. RWE (*Rheinisch-Westfälisches Elektrizitätswerk AG*) took over the plant in 1906, marking the starting point of the companies' close ties to the region. Lignite was a winner of the First World War, making up for the shortage of bituminous coal. In the 1920s, 60 % of lignite was already being used to produce electricity – vastly more than in Lusatia, for example (Gehlen, 2020, p. 329). The autarchy policy of the NSDAP, which was elected into power in 1933, gave lignite from *Rheinisches Revier* national importance. After the Second World War, takeovers solidified RWE's strong position in the region. The production of briquettes reached its zenith in the 1950s, as demand for them declined with the emergence of other forms of building heating. However, this was offset by increased demand for electricity. Between 1950 and 2020, 6.74 billion tons of lignite were mined in the area (BUND NRW, no date). For every hard coal unit (HCU[4]) burned, lignite emits 3.25 metric tons of carbon dioxide[5].

After the Second World War, the use of bucket-wheel excavators gained in importance. At the same time as the technical improvements of lignite mining, the extraction area simultaneously expanded into increasingly difficult zones. The strip mines spread from north to west and villages had to be resettled. The Inde River had to be diverted and the groundwater level lowered. The encroachment on nature and the human environment took on ever greater proportions and a lot was invested in lignite mining. Extraction peaked in the 1980s and decreased until 2020 and then increased again slightly. In 2018, a 130-year-old church was demolished in Immerath near Erkelenz. The village was to make way for open-pit lignite mining.

Since the end of the 19th century, *Rheinisches Revier* has been characterised by lignite mining, briquette production and coal-fired power generation. This not only has economic implications, but also has identificatory potential. *Rheinisches Revier* was seen as the "powerhouse" of the increasingly industrialised Rhineland region. However, this does not mean that lignite is at the centre of a

[4] 1 kg HCU = 7000 kcal = 29,3 MJ = 8,14 kWh.

[5] By comparison, natural gas emits 1.5 metric tons of carbon dioxide.

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monolithic narrative unifying the region. Rather, open pit mining is linked to disputes of opposing positions. This is not just about ecological communication, but also about the fault line between labour and capital, as well as about structures in villages that have to make way for open-cast mining. Here, there is a striking difference to the nearby Ruhr area, whose interventions for the extraction of primary energy sources have literally remained below the surface.

Preliminary Conclusions:

The region consists of density clusters (Aachen, Mönchengladbach, Rhein-Kreis Neuss) and rural areas that are located in the centre of the region. A slight population growth is predicted for most districts. The rural districts are expected to age more and shrink slightly in number of inhabitants compared to the independent cities. In accordance with the demographic change in Germany, the population is expected to age in the next decades. But generally, the urban areas are spaces with less ageing and more growth, which opens up opportunities for a potentially strong workforce. The majority of inhabitants in NRW are decently educated as they completed an apprenticeship (ISCED 3 and 4) and are now mostly employees. This creates a possible future opportunity to establish a subject-specific workforce, as new generations succeed. With Mönchengladbach being the most densely populated district, it also can be a profitable factor for establishing a *hub for circularity*, because Mönchengladbach is almost neighbouring the Rhine and Rhineland, where the majority of the chemical industry is located.

With regard to the population of NRW, it can generally be stated that it reflects the German distribution in terms of sex and age distribution. One third to one fourth of the population has a migration background and the majority lives in a single- or two-person-household. The average North Rhine-Westphalian is of Christian faith.

Political power relations in the region seem to have a high stability and are hardly fragmented. The far-right parties play only a marginal role, while the CDU dominates the landscape and the Greens have gained popularity. No major shifts in the political constellations have occurred, which makes the political landscape rather reliable.

The physical surface of the region has been altered considerably by open-pit mining. As the remaining space is limited and there are many different types of land-use which are essential for this region, e.g. agriculture, when talking about new facilities in the area, e.g. the expansion of a production site, existing industrial sites should be used as far as possible according to an interviewee from IN4climate.NRW, a think tank for climate-neutral industry in NRW. This makes the Rhine region all the more important to take into account as well because the necessary infrastructure is already in place (Interview B, 2022).

Numerous interview partners have challenged the selection of *Rheinisches Revier* as a research area, pointing towards the Rhineland/ Rhine axis as a relevant region to be considered for the specific case in order to include major industry players.

The region's definition has a functional character instead of a political entity. In some respects, the data needed is only available for the level of the federal state (North Rhine-Westphalia) and will be marked accordingly. The report will therefore broaden the view towards the Rhine area and the level of NRW, where sensible.

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2.2 Regional Readiness for Introducing Hubs for Circularity

2.2.1 State of Regional Transformation

The energy company RWE holds a strong position in the region and is Germany's largest power producer. Their electricity plants and energy-intensive industries that are closely connected to the area are still major employers. In October 2022, together with the German government and the NRW Ministry of Economy, RWE announced it is "bringing forward its coal phase-out by eight years and is ready to end lignite-based electricity generation in 2030" (Steitz, Carrel and Eckert, 2022). Now, a deep regional transformation is taking place with the aim to convert the area from the coal "powerhouse" to a sustainable region, entailing massive economic, cultural and social challenges.

Since 2019, the regional government of North Rhine-Westphalia has set out for the development of a model region for a guaranteed energy supply and security of resources in *Rheinisches Revier*. Combining different investment projects, the government focuses their energy on the *Zukunftsagentur Rheinisches Revier* (ZRR, "future agency Rhenish region), which has become a hub of operation and coordination for the structural change in the region (MWIKE.NRW, 2019).

2.2.1.1 Transformation Paths

Groundwork

In 2018, the German government set up a **Commission** with the title **"Growth, Structural Change and Employment"** (KWSB, *Kommission "Wachstum, Strukturwandel und Beschäftigung"*). It consisted of very different players from politics, business, environmental associations, trade unions, and affected states and regions with the goal to find a balance between the different interests. It aimed at establishing a broad social consensus on the design of the coal phase-out and the resulting structural change in Germany. By handing over its final report to the German government in January 2019, the commission concluded its work by recommending the end of coal-fired power generation in Germany by 2038 at the latest. It also made indications about how economic structural change in the affected regions can succeed (BMWK, no date-a).

The ***Strukturstärkungsgesetz*** ("Structural Strengthening Act") was passed in 2020 to implement the structural policy recommendations made by the commission that allows for funding through the ***Investitionsgesetz Kohleregionen*** ("Coal Regions Investment Act", InvKG; for details on funding see chapter 3.1.2).

***Zukunftsagentur Rheinisches Revier* - ZRR**

Structural change in *Rheinisches Revier* region is managed in a three-level system between the federal government, the state and the region[6]. Key player to organise regional transformation is the ZRR. It functions as an intermediate agency between federal and state governments and local actors such as counties, municipalities and civil society. As a regional development agency with focus on structural change, it develops guiding principles, innovation strategies, and concepts for action, while supporting structural change by initiating and implementing projects. It works closely together with its partners

[6] https://www.wirtschaft.nrw/strukturwandel-im-rheinischen-revier

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from science, the economy, the politics and association within and outside the region (ZRR, no date-a).
The principles of cooperation between the state and the region are set out in a contract ("Reviervertrag", eng.: Transition Agreement), which was signed by the state government and key players in the region on 27 April 27 2021. The ZRR is being supported in the transformation process with EUR 8.9 million for personnel and financial equipment.

The ZRR has identified four so-called "**future fields**".

- "**Energy and Industry**": This future field aims at developing *Rheinisches Revier* into a modern and climate-neutral energy and industrial region of the future. It includes areas such as security and quality of supply, affordable and competitive energy prices, climate compatibility and energy efficiency. Industry-related issues are competitiveness and value creation, technology leadership at international level, investment incentives for private capital and climate neutrality and resource conservation (ZRR, no date-b).
- The future field of "**Innovation and Education**" intends to turn the region into an "Innovation Valley" by developing education and qualification concepts to ensure that innovations such as new, digital business models can also be implemented in the many small and medium-sized enterprises in the region. Moreover, it takes action in the fields of digitization, New Work, start-ups and growth as well as technical and social innovation potential for the region, health and life sciences, lifelong learning (ZRR, no date-c).
- "**Space and Infrastructure**" focusses on spatial development. Looking at topics such as settlement development, mobility, economy, agriculture, and nature and climate protection, suitable locations in the region are identified to develop new neighbourhoods with a high quality of life. Traffic routes, mobility and supply infrastructure are taken into account as well as the role of data centres and freight logistics to create market advantages (ZRR, no date-d).
- "**Resources and Agribusiness**": Implementing the resource transition is the core issue of the future field "Resources and Agribusiness". Central aim is the development of *Rheinisches Revier* into a future region for a resource transition with a focus on the concepts of bioeconomy and circular economy (ZRR, no date-e).

The International Building and Technology Exhibition (IBTA, *Internationale Bau- und Technologieausstellung*) is planned to showcase the future fields.

Spatial strategy

With the "Spatial Strategy Rheinisches Revier 2038+" (*Raumstrategie Rheinisches Revier 2038+*), the future field of "Space and Infrastructure" accompanies the spatial development of the region in the medium to long term. The aim is to develop an overall regional development strategy that addresses the challenges of structural change in the region and points the way to the future.

After an initial analysis phase, spatial models and development goals for *Rheinisches Revier* are worked out in different versions by three planning offices, put into concrete terms and brought together in the strategy paper of *Rheinisches Revier* 2038+. Public participation is understood as an integral part of the spatial strategy (ZRR, no date-d).

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WSP – Economic and Structural Programme

The regional transformation is guided by the Economic and Structural Programme (WSP, *Wirtschafts- und Strukturprogramm*) as a regional economic development plan that is constantly developed further. It simultaneously serves as a basis for funding, for the design of funding procedures and for the development of specific project selection criteria (ZRR, no date-f, p. 7). The current version 1.1 was resolved upon and publicly presented in 2021. It has been referred to as the "bible of structural change" by ZRR.

The ZRR has specified five lines of development for the region:
The region of *Rheinisches Revier* sees itself as a liveable region (1) because the district is both a high-performance region (2) and an innovative region (3). It also wants to become a climate-neutral region (4) and will further expand its profile as a networked region (5) in the process. (ibid. p. 1-2)
Concerning circular economy, the goal for the Rhineland mining area is to become a pioneer for initiating the resource transition in Germany. WSP 1.1 defines four fields of action:

- Protection of climate, environment and resources
- A sustainable economy based on organic approaches
- Sustainable agriculture, forestry and food management
- Resource efficiency and circular economy – also including chemical and construction industry, explicitly listing component and building material exchanges, and recycling of plastic waste from industry as examples (ibid. p. 4).

Vision & Narrative

The declared objective by ZRR is first and foremost to manage the structural change in a way that secures and creates jobs and boosts the regional economy. Additionally, the goal is to reach sustainability in all areas of life and to develop *Rheinisches Revier* into a European pilot region for sustainable energy production and resource management - without electricity prices rising significantly or jeopardising security of supply.

Kamlage et al. (2021) find that the structural change in the mining area is taking place under great time pressure. The aim by ZRR was to generate visible signals and a spirit of optimism in the region as quickly as possible and to start funding individual projects (ZRR, 2019, p. 19). This time pressure came at the expense of a well-thought-out funding concept and a long-term approach to participation (Kamlage et al., 2021, p. 253). A case study by the European Commission identifies challenges for the ZRR that include a weak mandate and inadequate funding in the beginning, summoning all relevant stakeholders on one platform, overcoming local thinking and individual interests, and transforming abstract visions into effective actions (European Commission, 2020, p. 1).

Conflicts

The transformation process that is in progress is creating opportunities as well as causing friction.
In the history of *Rheinisches Revier*, open-pit mining and the coal industry have already caused considerable social conflicts and protests.
Environmental groups, climate initiatives and local initiatives of citizens that fear losing home(s) as well as nature and recreation space have protested vehemently for ending lignite extraction. In contrast,

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proponents of a fossil growth path and organised interest groups advocate for using coal power generation longer as a bridging technology that secures growth and jobs (Kamlage et al., 2021, p. 245).

In *Rheinisches Revier*, almost 43,000 people have been resettled by RWE from more than 50 villages, districts, settlements and hamlets over the past 70 years (RWE, no date). Resettlement can be seen as a harsh intervention in people's everyday lives. Despite long planning periods and financial compensation, mining-related resettlement is often regarded as coercive and involuntary. When there are close emotional ties, the loss of home is coupled with the sense of being uprooted (Kabisch, 2018, p. 89, 93; Flor, 2018, p. 74).

In 2018, protests surrounding Hambach Forest close to abandoned old Morschenich and the Hambach mine reached nationwide media attention. The forest was occupied with about 22 treehouses and barricades to keep police vehicles from entering. The protests aimed at shutting down the mine and saving the remaining forest from being cut down (Democracy Now, 2017). The following clearance by police has been ruled as illegal by court. Fire protection regulations had only been used as a pretext while the action ultimately served to remove lignite opponents from Hambach Forest according to the Cologne Administrative Court (Süddeutsche Zeitung, 2021). The protests, at times 50,000 people strong, were successful: The decision was made to preserve the remaining forest.

During COP27 (United Nations Climate Change Conference 2022), around 2,000 people protested against the demolition of the village Lützerath. It has become a symbol for many other villages that have already been demolished for lignite mining. In January 2023, protests increased. In the course of the decision to bring forward the coal-phase out to 2030, it was concluded that five villages could be preserved, while Lützerath for reasons of security of supply and technical reasons could not (MWIKE.NRW 2022). Lignite opponents protested against the eviction of the village, stating that the lignite underneath it must remain in the ground, otherwise, the 1.5 degree target of the Paris climate protection agreement would not be achieved (WDR, 2023a). Representatives of the initiative behind the protests criticised the climate policy by the government and the federal state of NRW. The police estimated that 15,000 people participated in the demonstration on 14 January 14 2023, while the organisers indicated a number of 35,000 people. Clashes broke out between police and protesters, leaving many injured on both sides (WDR, 2023b). Directly following the eviction, the remains of Lützerath were completely demolished.

2.2.1.2 Projects / Funding

The ***Investitionsgesetz Kohleregionen*** (InvKG, "Coal Regions Investment Act") is the foundation for the funding of the German coal regions in Germany. It consists of two pillars:

- The first pillar finances particularly significant investments by states and municipalities; the federal states decide on projects.
- The second pillar supports federal government measures such as expanding research and funding programs, expanding transportation infrastructure projects, and locating federal facilities.

An important component of the second pillar is the STARK federal program, which was designed specifically for the situation of coal regions (BMWK, 2020). The **STARK Programme** – "Strengthening the Transformation Dynamics and Transition in the Mining Areas and at the Coal-fired Power Plant

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Sites" (loose translation) funds "projects that support the transformation process toward an ecologically, economically and socially sustainable economic structure in coal regions" (BAFA, no date).

The German federal government provides up to EUR 14.8 billion for a sustainable structural change within *Rheinisches Revier*. The call for projects **"REVIER-GESTALTEN"** (loose translation: "Shaping the region") initiated by the government of North Rhine-Westphalia, strives to strengthen the green economy and an effective circular economy, aims for steps for a climate adaptation and for a development of a sustainable agriculture and food industry (MUNV NRW, 2021).

An **immediate action programme** (*Sofortprogramm*) of EUR 88.8 million was issued for activities from 2019 to 2021 in the region.

In order to quickly set the first visible signs, the Zukunftsagentur *Rheinisches Revier* and the state government have drawn up a **"starter package for the core area"** (*Starterpaket Kernrevier*) together with the 20 municipalities that are particularly affected by opencast mining. The package has enabled the municipalities to make structurally significant investments in the short term, addressing future mobility, renewable energy production, AI or sustainable resource management such as bioeconomy (MWIKE.NRW, no date-a). Funded by this package are also around 50 positions for **structural change managers** that have started supporting the structural change developments in the 20 municipalities as of 2021. They serve as contact persons for all questions concerning the development and application of funding projects in *Rheinisches Revier*, working in close contact with each other to ensure the coordinated development of the region (MWIKE.NRW, 2021).

The **urban development programme** *Rheinisches Revier* (Stadtentwicklungsprogramm „Rheinisches Revier der Zukunft", STEP RR) by the Ministry of Regional Identity, Communities and Local Government, Building and Digitalization of the Land of North Rhine-Westphalia promotes sustainable urban development or infrastructure projects with a high impact on surface area. This includes projects on the topics of area and neighbourhood development, inner development, village renewal, developments in existing buildings, as well as the development of reuse of sites (ZRR, no date-g).

Unternehmen Revier is funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and supports projects by companies. The project aims to directly involve local stakeholders and their ideas in order to jointly shape structural change. Companies and initiatives from the region can participate in competitions with their proposals. The most convincing ideas will have the chance to receive funding of up to EUR 200,000 and cooperation projects can receive funding of up to EUR 800,000 (BMWK, no date-b).

Funding for SMEs in NRW is possible through the state-owned **"NRW.BANK"** in the founding phase, for the launch of products, for the cooperation with research institutes, for energy efficiency and electric mobility, and others (MWIKE.NRW, no date-b). With EUR 48 million annually, NRW.BANK invests more money than any other development bank in Germany (MWIKE.NRW, no date-c).

For SMEs in *Rheinisches Revier*, there is also the option for funding through so-called **"Vouchers for the Future"** (*Zukunftsgutscheine Rheinisches Revier*) by the EU Just Transition Fund that is intended to support them with the green and digital transformation. This includes the three measures "TransformConsult" (consultancy support for business model transformation), "Transformationsexpert:in" (recruitment of staff for transformation) and "TransformInvest" (investment subsidies for transformation) (MWIKE.NRW, no-date-f).

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Construction industry

The **Faktor X agency** is a separate division of Entwicklungsgesellschaft indeland GmbH and offers consulting services as part of LEADER funding (EU funding for rural areas) for builders, municipalities and construction professionals. Faktor X is an agency for climate- and resource-friendly construction whose goal is to increase the resource efficiency of a building by a factor x (e.g. by four times or factor 4, meaning that resource consumption is reduced to a quarter). It looks at the whole life cycle of a building including the production of raw materials, construction and use, as well as demolition and disposal. The agency has developed an online tool with which the factor x of a concrete building project can be determined (kurt.faktor-x.info). Its projects include the structural change projects ReBAU and ReNeReB, which are carried out together with the Zukunftsagentur *Rheinisches Revier* and RWTH Aachen, respectively (Faktor X Agentur, no date-a).

ReNeReB („Regionales Netzwerk Ressourceneffizientes Bauen“, translation: Regional Network Resource Efficient Building) is a cooperation project based on a digital best-practice network on resource-efficient and circular construction in *Rheinisches Revier*, complemented by three yearly events aimed at fostering cooperation and networking (Faktor X Agentur, no date-b).

ReBAU („Regionale Ressourcenwende in der Bauwirtschaft“, translation: Regional resource transition in the construction industry) is a so-called competence centre for circular and resource-efficient construction. The centre plans to develop an exchange platform (*Rohstoffbörse*) for raw materials in the construction industry based on geoinformation (ZRR, no date-h).

It is intended to serve various actors such as private and public construction managers, building material producers, demolition companies and processing plants to offer and obtain qualitatively and quantitatively assured secondary and primary raw materials. As an online information service, it is intended to record existing mineral raw materials with regard to georeferenced information on sources and sinks and expand the view of new potential deposits. This would make it possible to trade materials transparently and openly so that the usual project-based request for offers can be dispensed with (ZRR, no date-i).

Refrigerators

The funding measure “**ReziProK** - Resource-efficient Circular Economy - Innovative Product Cycles” by the Federal Ministry of Education and Research (BMBF) is part of the BMBF's research concept "Resource-efficient Circular Economy" and supports projects that develop business models, design concepts or digital technologies for closed product cycles (BMBF, 2019, p. 1).

One of these projects is **Circular by Design** (CbD) - Sustainable product design of consumer goods using the case study refrigerator/freezer. The consortium involves the Wuppertal Institute for Climate, Environment and Energy, the art school of Folkwang University of the Arts, Essen, the electronic recycling company BEC Becker Elektrorecycling Chemnitz GmbH, Chemnitz, and disposal services of EKM Entsorgungsdienste Kreis Mittelsachsen GmbH, Freiberg, with participation of the manufacturer Liebherr-Hausgeräte.

Its goal is to develop a recyclable product design for refrigerators/freezers that is both energy and resource efficient by running through various scenarios within a living lab design process during the project period (DECHEMA, no date).

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Preliminary Conclusions

The region is in a state of major transformation. This can be seen as an opportunity and a momentum that can be used for advancing circular economy: The necessity to transform the current linear economic strategies is obvious as the main economic factor of the region – lignite mining – is coming to an end. At the same time, a lot of funding options have become available and various structures are being installed for consulting and fostering funding for transformative projects.

However, there are many initiatives, strategies and efforts that are not always coordinated or cooperative. The conflicts surrounding the transformation process bring forth scepticism towards certain actors so that there seems to be a need for a common understanding and vision for the region.

Looking at the numerous initiatives in the construction sector, many of the projects are focused on new buildings, not so much on already existing structures or demolition/waste management issues. Also, they are often focused on bio-based materials such as wood etc. rather than, for example, conventional insulation panels. Plastics are not in the focus of these developments.

2.2.2 Culture of cooperation and innovation

Municipal cooperation

There are three major municipal unions between those municipalities directly neighbouring an open pit mine in *Rheinisches Revier*:

- *Zweckverband LandFolge Garzweiler:* Mönchengladbach, Erkelenz, Jüchen and Titz
- *Neuland Hambach GmbH:* Elsdorf, Jülich, Kerpen, Merzenich, Niederzier, Titz
- *Entwicklungsgesellschaft indeland GmbH:* Aldenhoven, Eschweiler, Inden, Jülich, Langerwehe, Linnich, Niederzier, Düren

The purpose of these municipal unions is to pursue a common coordinated regional development with regard to structural change and to exercise a joint public representation of interests.

Region Aachen Zweckverband is a municipal union not so much focused on the direct open pit environment but functions as a regional development association of the districts of Düren, Euskirchen and Heinsberg, the city of Aachen as well as the StädteRegion Aachen (Region Aachen Zweckverband, no date).

Industrial Covenant

In December 2022, the state government of NRW has concluded an industrial covenant ("Industriepakt") with 20 companies and 11 associations for climate neutrality and competitiveness. Its goal is to jointly develop a roadmap that sets out guidelines for the climate-neutral transformation of industry in North Rhine-Westphalia. The industrial covenant is designed as a process that is organised and supported by the state company NRW.Energy4Climate as part of the IN4climate.NRW initiative. The covenant can be seen as an alliance of change agents joining forces, its partners including Covestro and ZINQ (NRW.Energy4Climate GmbH, 2022).

Research and Development

The scientific institutes in North Rhine-Westphalia include 67 universities and universities of applied sciences (*Hochschulen*), 14 institutes of Fraunhofer Society, 12 Max Planck Institutes, and more than

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50 research institutes located at universities of applied sciences. They educate around 770.000 students and count circa 150.000 employees (MWIKE.NRW, no date-b).

Personnel in Research & Development

The share of total employment accounted for by R&D personnel in the governmental district of Düsseldorf accounted for 1.6 % in 2019. The share in the governmental district of Cologne was much higher with 3.1 %, the latter being above the EU average of 2.3 % (eurostat, 2022b).

Research & Development intensity

R&D intensity is defined as the ratio of gross domestic expenditure on R&D (GERD) relative to gross domestic product (GDP). In 2019, the governmental district of Düsseldorf had an R&D intensity of 1.98 %. The governmental district of Cologne was at 3 %, which is relatively high at EU level (average: 2.23 %) but not high within Germany, where the cities of Braunschweig and Stuttgart are above 7 % (eurostat, 2022c).

Innovation Scoreboard

The governmental districts of Cologne and Düsseldorf (NUTS 2 level, see 2.2) are described as "Innovation Leaders" in the Regional Innovation Scoreboard 2021 by the European Commission. This means that the innovation performance has increased over time: 5.8 % for Düsseldorf and 11.4 % for Cologne.

The Scoreboard for Cologne (Figure 8) shows that there are especially high expenditures in the public sector compared to both the EU and Germany. Relative to the EU level, the employment in innovative enterprises, product innovators, collaboration of innovative SMEs and public-private co-publications are particularly high, while lower in the area of life-long learning, R&D expenditures in the business sector and non-R&D innovation expenditures. In relation to the country's figures, it stands out that Cologne has a lower rate of business process innovators and R&D expenditures in the business sector as well as design applications. The score for international scientific co-publications is equally high when compared to EU and German figures.

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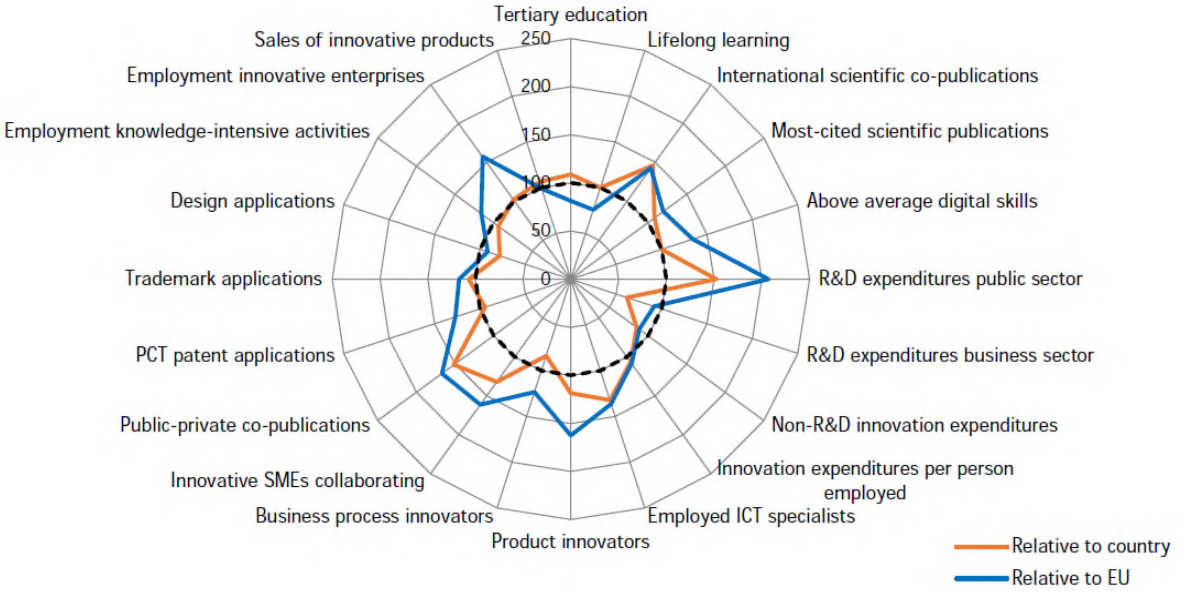

FIGURE 9: EU INNOVATION SCOREBOARD FOR COLOGNE (NUTS 2) (EUROPEAN COMMISSION, 2021, P. 25)

Looking at the Düsseldorf Scoreboard (Figure 9), employment in innovative enterprises, above average digital skills and business process innovators stand out when comparing them to EU numbers. In this regard, also public-private co-publications and applications in the areas of design, trademark, and PCT patents perform relatively well. Relative to Germany, trademark applications and public-private co-publications show a high performance. R&D expenditures in the public sector, collaboration of innovative SMEs and tertiary education score below both country and EU level.

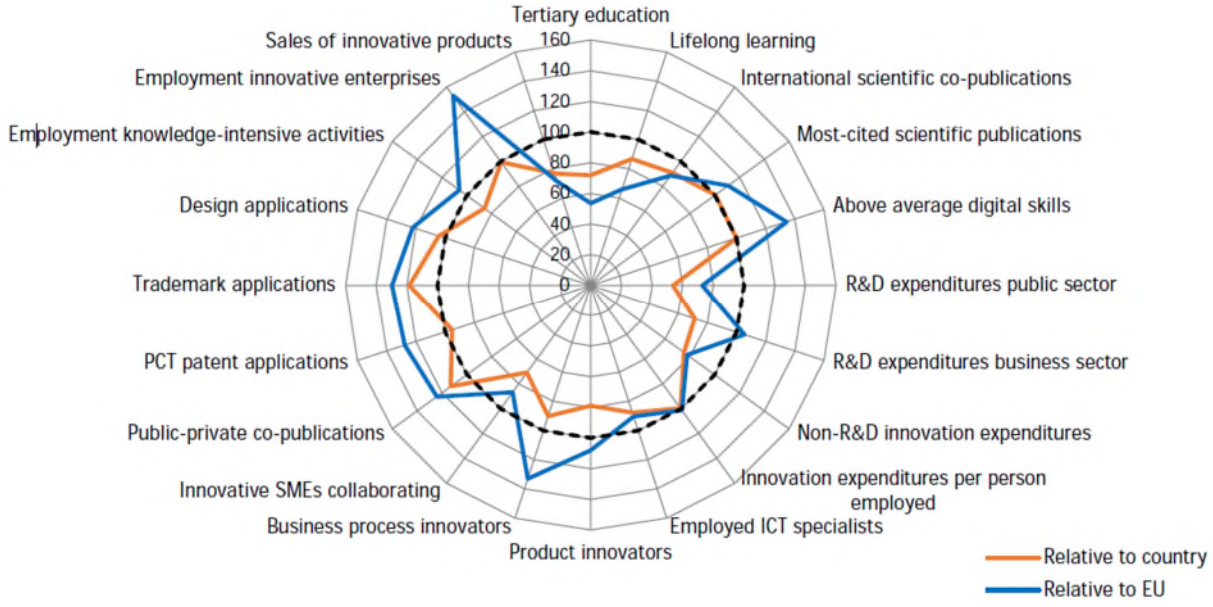

FIGURE 10: EU INNOVATION SCOREBOARD FOR DÜSSELDORF (NUTS 2) (EUROPEAN COMMISSION, 2021, P. 24)

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In comparison, employment in innovative enterprises is about equally as high in both districts, while there is a major contrast with regard to R&D expenditures in the public sector that are much lower in the district of Düsseldorf.

Start-ups

The German Start-up Monitor 2022 (DSM, *Deutscher Startup Monitor 2022*) identifies North Rhine-Westphalia as the federal state with the **most start-ups in Germany** with 19.8 % (Kollmann et al., 2022, p. 15). The DSM 2022 is based on survey data of a total of 1,976 start-ups. Located in the case study region, RWTH Aachen is the university at which the highest share of start-up founders (6.4 %) have obtained their highest degree (ibid., p. 25).

Looking at the latest available start-up monitor for NRW from 2020, which is based on data from 372 interviewees, the share of start-ups is highest in the region of Cologne/Bonn (29.8 %), followed by the Ruhr area (19.9 %), Düsseldorf (13.7 %) and Aachen (12.6 %), which is very high measured in terms of population share (Hirschfeld, Gilde and Walk, 2020, p. 13).

Concerning sector distribution, the largest share by far is accounted for by information and communication technology with 28.3 %. The two start-up hotspots Cologne and Düsseldorf have higher values for SaaS business models (29.7 % and 34.1 %), while Aachen is clearly a technology development location (47.4 %), which can be attributed to the influence of RWTH Aachen University (ibid., p. 21).

In NRW, 57.2 % of start-ups have already raised external capital. The average amount is just over EUR 1 million. A differentiated view, however, reveals that in NRW, capital up to EUR 150,000 clearly dominates. The financing used the most was government funding with 48.5 %, followed by Business Angels with 19.6 % and Venture Capital with 10.5 % (ibid., p. 31 f.).

Innovation spaces

Physical locations for innovation clusters within the region include, for example, the **RWTH Aachen Campus**. It serves as a centre that brings together companies and university institutes in one location. 433 companies are currently part of the centre, construction being one of the already realised research clusters. The affiliated Innovation Factory produces over 45 start-ups and spin-offs per year (RWTH Innovation Factory GmbH, no date).

The **Brainergy Park** by *Forschungszentrum Jülich* is an inter-municipal business park with a focus on innovation within the fields of new energy and energy transition. Simultaneously, it is intended to act as a simulation area and demonstration platform for the energy management of the future (BRAINERGY PARK JÜLICH GmbH, no date).

Serving as a place for innovation in the area of renewable energy, ***Innovationspark Erneuerbare Energien Jüchen*** ("Innovation Park Renewable Energies Jüchen") is a project funded by the NRW Ministry of Economy. At the centre of its plans are the areas of the *Garzweiler I* open-cast mining area that have been recultivated or are currently being recultivated. The project's goal, by means of five subprojects, is to create an integrated system in the newly emerging space after the end of active open-pit mining, in which energy production, storage and use go hand in hand (Zweckverband LANDFOLGE Garzweiler, no date).

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In the region and its wider surroundings, there are several **chemparks** of major industry players. Chempark Leverkusen, Chempark Dormagen and Chempark Krefeld-Uerdingen, all directly connected to the Rhine river, host, among others, production sites from the chemical companies Bayer, Covestro, and Lanxess. LyondellBasell Industries is one of the largest chemical companies in the world. Two of its production sites for polyolefins are in Wesseling and Hürth-Knapsack that belong to Rhein-Erft-Kreis. Shell Energy and Chemicals Park Rheinland is also located in Wesseling as well as in Cologne where it produces, among others, petrochemical products. It has put into operation a green hydrogen facility and is planning another plant with higher capacity.

In the chempark Hürth-Knapsack, the "ChemHub Knapsack'' is being established with the aim to promote and support start-ups and small and medium-sized enterprises in the fields of chemistry, power-to-X and industrial biotechnology (RWE, 2020, p. 99). The development of new technologies is needed to ensure the energy supply for the chempark with a view to the upcoming phase-out of the two nearby power plants (MWIKE.NRW, no date-d).

Initiatives and networks

The initiative **Circular Valley**, based in the city of Wuppertal in the greater Rhine-Ruhr metropolitan area, explicitly sees itself as an incubator and accelerator for circular start-ups (Wilts et al., 2022b, p. 71). Its website claims that „Circular Valley is for Circular Economy what Silicon Valley is for Digital", its activities involve a Circular Economy Accelerator Program, which is a 3-month program that takes place twice a year with 15 start-ups (Circular Valley Stiftung, no date). Among its focus industry areas, it lists "high impact intermediary products" such as chemicals.

The **Round Table Circular Economy NRW** (*Runder Tisch Zirkuläre Wertschöpfung NRW*) has been established by NRW ministry of environment. It is intended to pool activities in the region that concern circular economy and promote the exchange between actors from industry, research, politics, etc. Its goal is to support companies, educational institutions and municipalities in North Rhine-Westphalia in the development and implementation of circular economy concepts to contribute to the realisation of the European Green Deal (Bergischer Abfallwirtschaftsverband, no date).

Aachen Building Experts is a network and association of companies from the construction industry that brings together over 70 entrepreneurs from industry, architecture, engineering offices and trade as well as experts from RWTH Aachen University and FH Aachen University of Applied Sciences. Their goal is to establish the economic region of Aachen as a competence region for innovative construction (IHK Aachen, no date).

Innovation study by ZRR

The ZRR has published an innovation study regarding the region of *Rheinisches Revier* in 2021. It has identified ten fields of innovation.

Although the region is generally considered to be well-equipped with scientific and research institutions (e.g. RWTH Aachen University, Jülich Research Center, Aachen University of Applied Sciences and numerous non-university research institutes), in recent decades this has not been strongly reflected in regional economic growth. In key economic indicators, the region lags behind the state and national averages. However, the scientific landscape is expected to provide good conditions for an innovation-driven structural change and transformation process (ZRR, 2021, p. 10).

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Key findings

The innovation study has identified strengths and weaknesses of the region in three areas. Regarding **actors and structures in the innovation system**, its strengths include an excellent research landscape with international standing, R&D facilities of national and international large companies, a resilient, heterogeneous, and SME-driven industry structure and a variety of intermediaries and supporting institutions. However, deficits are seen within the fragmented constellations of players concerning the economic structure and intermediaries as well as in the uneven spatial distribution of companies with high affinity for transfer (with the highest density in Städteregion Aachen). The study also points out that there is a low absorptive capacity for new technologies from science by traditional, energy-intensive businesses in the region.

The strengths in the area of **networks between business, science, politics and society** mainly concern strong networks and relations between research institutes and general networks between science and industry on national and international level. On the other hand, there are deficits concerning demand-oriented networks between research and regional industry, sectoral networks outside of Aachen and high-technology sectors and a lack of transfer between science and regional industry on a regional level. Also, there is a lack of scaling potential for start-ups and the region faces the challenge to keep university graduates in the region (risk of "brain drain").

Looking at **political and structural conditions**, the region of *Rheinisches Revier* shows some strengths when it comes to regional self-organisation and access to funding policy instruments for the promotion of innovation. It also shows promising innovation projects in key technologies according to the study. Deficits include a lack of financing offers for start-ups for scaling up as well as bureaucracy, duplicate structures and non-transparency that hamper structural change. Further weaknesses identified are a lack of regional dynamics and the difficulty to define a regional identity, the lack of a common strategy and visibility and a poor cooperation culture, especially in small and medium-sized enterprises.

The **ten strongest fields of innovation** in *Rheinisches Revier* identified in the innovation study are shown in Table 5.

Field of innovation	Number of publications	Overall score	Scientific excellence	Exploitation potential
		Z score (weighted average)		
Alternative drive system technologies New drive system technologies that enable environmentally friendly mobility	1544	1.4	1.0	1.7
Aviation Innovations for a new mobility in the air	767	0.5	0.4	0.7
Bioeconomy Production, usage and protection of renewable, biobased resources	276	0.7	0.7	0.7
Digital medicine Transformation of medicine and the healthcare industry through digitalization	973	0.9	0.8	1.0

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Energy system of the future Technologies and systems that enable the transition to a sustainable energy supply	1327	1.4	0.3	**2.4**
Catalysis Acceleration of chemical and biological processes through the lowest possible activation energy	808	0.6	0.5	0.7
Nanoelectronics Electronic components on the nanometer scale	1115	0.6	0.5	0.7
New materials and substances New materials, substances and surface processing technologies that enable new applications in industry	1733	1.1	1.3	0.8
Quantum and supercomputing New forms of computing that enable highly demanding computational capabilities	2122	**1.5**	**3.1**	0.0
Future-proof industry Technologies that have the potential to digitise production processes	1386	0.8	0.6	1.0

TABLE 4: THE TOP TEN FIELDS OF INNOVATION IN RHEINISCHES REVIER WITH THE HIGHEST Z SCORES MARKED IN BOLD PRINT (ZRR, 2021, P. 31, OWN TRANSLATION AND PRESENTATION)

The highest overall score (Z score of 1.5[7]) is achieved by the field of quantum and supercomputing, which is primarily due to the strong scientific excellence in the field of quantum physics (3.1). However, the exploitation potential in this field of innovation is low (0.0) as the market maturity of quantum computer applications will still require several years (ibid., p. 31). The field of the energy system of the future, by contrast, shows a particularly high exploitation potential with a Z score of 2.4.

The innovation study also reports that many interviewees consider the **identity** of *Rheinisches Revier* as not very pronounced. Only the coal phase-out process produces a common identification basis that had not existed before. The experts see a chance to enhance cooperation through the common challenges in the region, while the structural change is at present not sufficiently anchored in the minds of citizens, entrepreneurs and mayors.

The low level of identity also entails that the **culture of cooperation** is not considered to be very good due to a lack of openness, acceptance and a common basis of trust. If regional identity is hardly perceptible to the local population, it is all the more difficult to develop external visibility. The region as a whole is apparently not being marketed as a whole to new companies and lacks the necessary

[7] The authors of the study have identified 16 indicators for measuring the scientific excellence and the exploitation potential of the 500 research fields with the most publications in the region of *Rheinisches Revier*. The raw data of all indicators were normalised by Z-transformation so that they can be included in a common score. All indicators were weighted equally and included in equal parts in the overall value as well as in the values for scientific excellence and exploitation potential. These values are Z-scores: If this value is 0, the research field has only an average performance; If it is 1, the value is one standard deviation above the average of all the fields evaluated (ZRR, 2021, pp. 25-26).

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structures so that potential investors mainly have to contact the individual marketers and business development agencies (ZRR, 2021, p. 90).

Resource Transition study by ZRR

The ZRR has commissioned the Wuppertal Institute for Climate, Environment, Energy gGmbH in cooperation with Prognos AG to develop a methodical concept of a **regional resource transition** for *Rheinisches Revier* (Wilts et al., 2022a). One of the examined aspects is the question of possible innovative resource strategies in the region.

The study has identified **four central subject areas** in this context:

- Agriculture, forestry and food industry
- Raw and basic material-related industry
- Construction and infrastructure
- Technologies & innovations for resource transition

With regard to the field of "technologies and innovations", the results of the study confirm the existing research landscape in *Rheinisches Revier* as a strength of the region. Further strengths include a good technological set-up as well as attractive urban centres in the region and political support for the transformation. Positive prerequisites are also regionally active SMEs and start-ups.

Risks include a "brain drain" as stated in the innovation study due to a lack of attractiveness of companies in the region for skilled workers. The uneven spatial distribution is also confirmed by the resource study: It is an inhomogeneous region with diverse economic areas with diverse focal points (ibid., p. 47 f.). The numerous players that are relevant in the field still need to be brought together. The study also identifies a need for social and participatory innovations, addressing top-down and bottom-up approaches in equal measure.

Report "NRW 2030: From the Fossil Past to the Circular Future"

The report "NRW 2030: From the Fossil Past to the Circular Future", commissioned by the Ministry of Economic Affairs, Industry, Climate Action and Energy of the State of North Rhine-Westphalia, analyses the status quo in NRW with regard to circular economy including weaknesses and strengths (Wilts et al., 2022b).

Weaknesses

The study found that there is **too little private investment** in circular products and business models (ibid., p. 71). NRW is characterised by a large number of SMEs with limited budgets for research and development. Other large companies are facing such fundamental structural challenges that they are not in a position to tackle a long-term transformation. At the same time, the classic, linear business models are still profitable enough that there is no urgent need for action for various companies.

Circular economy is furthermore often **perceived as a risk** for employment, not as a future opportunity (ibid., p. 70).

The study also shows that **NRW lacks risk capital** to support innovations and start-ups to bring them to the market, especially with regard to non-technological innovations. This is in line with the findings of the innovation study for *Rheinisches Revier.* According to the authors, the state of North-Rhine Westphalia has a highly specialised landscape of players in the credit and insurance sector but only

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few have addressed circular economy as a topic. This also applies to the funding programme NRW.Venture by the NRW-Bank that is mentioned as a possibility for start-up and innovation investments. The "Circular Valley" accelerator, however, is highlighted as a positive example as it sees itself explicitly as an incubator for circular start-ups, fostering their exchange of ideas with investors.

Furthermore, the **funding structure is highly fragmented** and often perceived as too bureaucratic. Time-consuming application processes and a lack of human resources within the public authorities result in long processing procedures with unclear duration.

In *Rheinisches Revier*, there are extremely **long delays** between the approval of structural change projects and the actual start of their funding due to a complex coordination process between the different funding levels (governmental/NRW level). Circular economy often does not fit into the funding programs and goals and has to be elaborately justified (ibid., p. 72).

As a circular economy is dependent on the cooperation of stakeholders, single companies have a **limited influence on value chains**. In North-Rhine Westphalia, being characterised by a strong SME landscape, these are dependent on their suppliers. However, the strategic decisions for or against circular innovations are often made at corporate headquarters outside NRW (ibid., p. 73).

Digitization is also a central issue: The transformation towards a circular economy requires real-time data concerning feedstock, waste streams etc.

Strengths

The study sees a central advantage in the **spatial concentration** of many key players in central value chains. Many value chains can already be covered completely due to the location of production sites and headquarters of central players in NRW. These actors are often personally acquainted and have established trustful, long-term cooperation that is crucial for a circular economy. The plastics value chains are pointed out as especially noteworthy in the study because in theory, all the players necessary for a completely circular system could be brought to the same table in less than an hour's travel time (ibid., p. 65). Also, the **high number of SME**s is considered as advantageous because they are often still family-owned and therefore tend to have a longer planning perspective and strategic foresight that are necessary for investments in circular solutions. According to the study, NRW shows many highly innovative companies and best practice examples for circular economy. Again, as in the aforementioned studies, the **excellent research landscape** from basic to application-oriented research is highlighted such as the Fraunhofer Institutes and RWTH Aachen. Concerning consulting and transfer institutions in the federal state, the *Effizienz-Agentur NRW* (EFA, "Efficiency Agency NRW") is particularly underlined for its activities for fostering a circular economy.

Preliminary conclusions

The numerous studies have shown that the region has an excellent research landscape with key innovation clusters as well as dense networks of actors in industry and in key branches. However, the population decrease in rural parts and the risk of "brain drain" are problems. Currently, the dominant narrative/vision is the concept of bioeconomy, not circular economy.

An interview partner from the ZRR future field "Resources and Agribusiness" has confirmed that there is a "bubble", a certain circle of people that are active and present at events in *Rheinisches Revier*. This

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is in line with the resource transition study by Wilts et al. (2022a) that sees the necessary "spirit" for transition only among isolated and always the same actors. According to the interview partner, the participation process for the structural change in the region needs improvement as civil society actors are partly frustrated with it. Better networks as well as cooperation are needed to reach beyond the aforementioned “bubble” to anchor the intended development into a sustainable region within the civil society as well. The newly appointed municipal structural change managers can play an important role for networking and cooperation between the municipalities (Interview E).

With regard to the culture of cooperation, interview partners from *IHK Aachen* (Chamber of Industry and Commerce, Aachen) have stated that there are many networks in different areas, e.g. medical technology and also the cultural sector, where companies join forces and start joint activities. Many companies are used to cooperation with research in consortia (Interview C). The innovations study, however, identifies a low level of identity and cooperation in the region of *Rheinisches Revier*. The experts see a chance to enhance cooperation through the coal phase-out process in the region. In part, the Resource Transition Study agrees that some of the relevant players still need to be connected to each other, but also indicates that the many SMEs in the region are well networked and have an interest in the regional economy. Looking at the larger level of North Rhine-Westphalia with regard to circular economy activities, the study commissioned by the NRW Ministry of Economy (Wilts et al., 2022b) also confirms that the high number of SMEs is considered advantageous and many key players along the value chains cultivate good relations and have a long-standing cooperation.

2.2.3 Regional Economy: Structure and Dynamics

The industrial cores are located at the edges of *Rheinisches Revier,* especially in proximity to the Rhine river and the city of Aachen. Strong and numerous small and medium enterprises are characteristic for the economic structure of the region. 690 so-called “**hidden champions**” can be identified in NRW, of which 54 are located in *Rheinisches Revier.* Hidden champions are businesses that can be characterised by their market leadership, turnover and degree of recognition. Most hidden champions in *Rheinisches Revier* can be found in Städteregion Aachen (24), followed by Mönchengladbach (8) and Rhein-Erft-Kreis (8). Kreis Euskirchen brings up the rear with one hidden champion (Block et al., 2021, p. 3-6, 66-67). Looking closer at the hidden champions of the region, different fields can be identified: Most businesses can be assigned to mechanical engineering and the production of metal products as they make up one third of the hidden champions of *Rheinisches Revier*. However, hidden champions can also be found in other sectors such as production of textiles, engineering and architectural offices, production of rubber and plasticware or production of chemical products and other fields (Block et al., 2021, p. 35-65).

2.2.3.1 Gross Domestic Product

When analysing the economy of a region, the Gross Domestic Product (GDP) is one of the central indicators for its general performance. With regard to the GDP, Germany is currently the biggest economy within the European Union, followed by France, Italy, Spain and the Netherlands, as it generated EUR 3,601.75 billion in 2021 (eurostat, no date-a). But on the other hand, considering the GDP per capita, Germany occupies the 19th position with EUR 43,290 in a ranking with all countries of the European Union, just behind Finland, Austria and Belgium (eurostat, no date-b).

Zooming into NRW, the GDP amounted to EUR 733,257 million in 2021 (IT.NRW, no date-c), whereas the GDP per capita came to EUR 38,756, which is below the German average (MAGS NRW, 2021).

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Rheinisches Revier itself generated an even lower GDP per capita, but the **GDP's of the different districts differ significantly**. The districts with the highest GDP per capita, Rhein-Kreis Neuss, Städteregion Aachen, Rhein-Erft-Kreis and Mönchengladbach, are also the regions with highest population densities (Table 6, own calculations, based on: MAGS NRW, 2021).

District	GDP per capita in EUR
NRW	38,756
Rheinisches Revier	32,886
Mönchengladbach	**34,007**
Heinsberg	26,066
Städteregion Aachen	**37,941**
Düren	30,641
Euskirchen	28,043
Rhein-Erft-Kreis	**34,977**
Rhein-Kreis Neuss	**38,527**

TABLE 5: GDP PER CAPITA IN RHEINISCHES REVIER AND NRW (MAGS NRW, 2021)

On closer examination of the **gross value added** of the districts of *Rheinisches Revier,* Rhein-Erft-Kreis, Rhein-Kreis Neuss and Städteregion Aachen stand out, as they cover the top 3 (Table 7).

District	Gross Value Added (2020) in €
Kreis Düren	7.35 billion
Kreis Euskirchen	4.93 billion
Kreis Heinsberg	6.04 billion
Rhein-Erft-Kreis	**14.89 billion**
Rhein-Kreis Neuss	**15.77 billion**
Städteregion Aachen	**19.14 billion**
Mönchengladbach	8.02 billion

TABLE 6: GROSS VALUE ADDED OF THE DISTRICT IN RHEINISCHES REVIER IN 2020 (IT.NRW, 2020)

In the following chapters, different economical causes for these figures will be analysed and discussed, as a closer inspection of the three economic sectors of *Rheinisches Revier* will be undertaken.

2.2.3.2 Sectors

The structural change of the region can be identified within the individual sectors of the economy of NRW with a detailed analysis. Being a **traditionally economically strong region**, it had to overcome a great transition from the mining and industry to a modern service industry (IT.NRW, 2021). In the past

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75 years, the service industry has become the most important employer in NRW (MWIKE.NRW, no date-b) as the share of the workforce in the service industry has more than doubled from 34 % to 74 % since 1946, whereas the production industry has shrunk from 50 % in 1946 to 25 % in 2019 (IT.NRW, 2021). Apart from the employment shift, the relations between the industry and the service sector have also intensified and intertwined more (MWIKE.NRW, no date-b).

Nowadays, the primary sector of agriculture, forestry and fishery accounts for 0.6 % of the gross value added, whereas the production industry generated 26.8 % as the secondary sector (Figure 10). The tertiary sector, which consists of the service industry, obtained 72.5 % of the gross value added from North Rhine-Westphalia (MWIKE.NRW, no date-e).

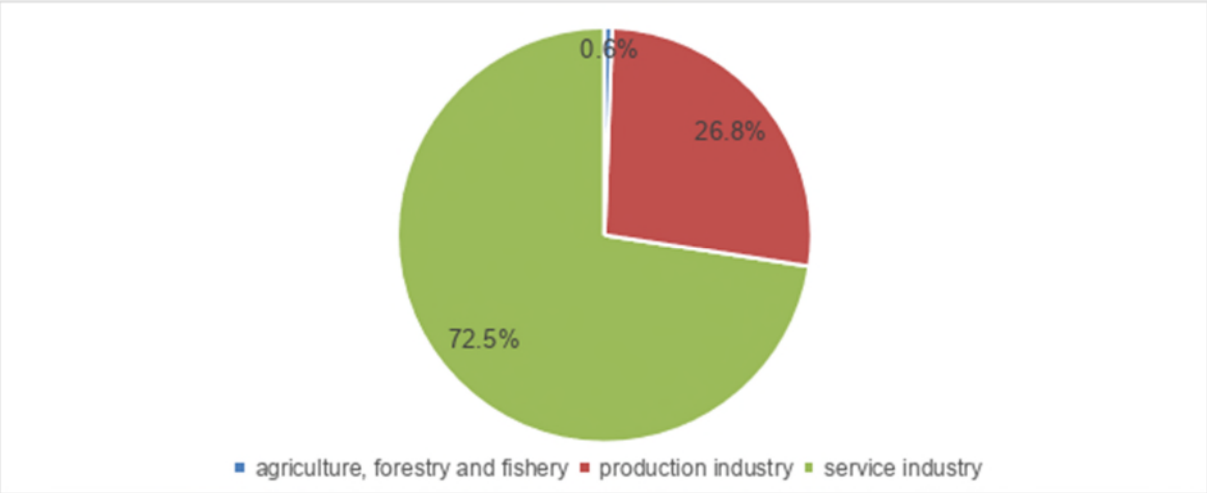

FIGURE 11: SHARE OF THE THREE ECONOMIC SECTORS IN NRW IN TOTAL (MWIKE.NRW, NO DATE-E)

Primary economic sector

The primary sector in NRW has experienced a **huge decrease** in its number of employees over the last 75 years: In 2019 less than one percent of all employees worked in the sector of agriculture, forestry and fishery, whereas almost 16 % of employees worked in the primary sector in 1946 (IT.NRW, 2021). The share of the primary sector on the German gross value added was at 0.9 % in 2021, while the EU-average was at 1.8 % (Eurostat, no date-c).

Secondary economic sector

The composition of the economy of NRW has not only changed regarding the primary sector over the last years: The employment share of the **manufacturing industry declined** from 24.0 % in 2008 to 20.4 % in 2018. Nationwide, the share decreased from 24.1 % to 21.3 % within the same time period (Koch et al., 2019, p. 13-14).

Considering the value-added shares of the manufacturing sector on the total economic output, the numbers fell statewide from 23.2 % in 2000 to 19.9 % in 2016, while the nationwide share was almost consistently high with a decrease of only 0.1 %. This indicates that the share of NRW on the German value added of the manufacturing sector decreased as well, which can be underpinned by the development of 22.3 % in 2000 to 18.4 % in 2016 (Koch et al., 2019, p. 13-14).

In 2020, the most important export goods in NRW as a whole were **chemical products** with a share of 16 % and Machinery, that made up 16 % of all exported goods, while metals had a share of 10 % and

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motor vehicles and motor vehicle parts made up 8 % (MWIKE.NRW, no date-e). The chemical industry in NRW is characterised by a **strong export orientation** (Wilts et al., 2022b, p. 47). The international supply links constitute a central basic condition for the transformation towards circular economy because this makes both the coordination of new models of circular value creation and access to raw materials at the end of the use phase of products significantly more complex (ibid.). Projects investigating the recycling of substances in the chemical industry are mainly (inter-)national projects that are not funded by individual states (Wilts et al., 2022b, p. 35).

The economic structure of **NRW** is defined by **nine economic regions**, which are Aachen, Bergisches Städtedreieck, Düsseldorf, Köln/ Bonn, Ruhrgebiet, Münsterland, Südwestfalen, and Ostwestfalen/ Lippe (Figure 11). Those regions are based on grown action areas and close economic interwoven relationships that the regional development and marketing agencies use as a spatial separation in their strategic consortium "regionen.NRW" (English: 'regions.NRW'). *Rheinisches Revier* is mainly distributed among Aachen and Niederrhein, while the Rhineland can be assigned to the region Köln/ Bonn (NRW.BANK, 2021, p. 2; regionen.NRW, no date).

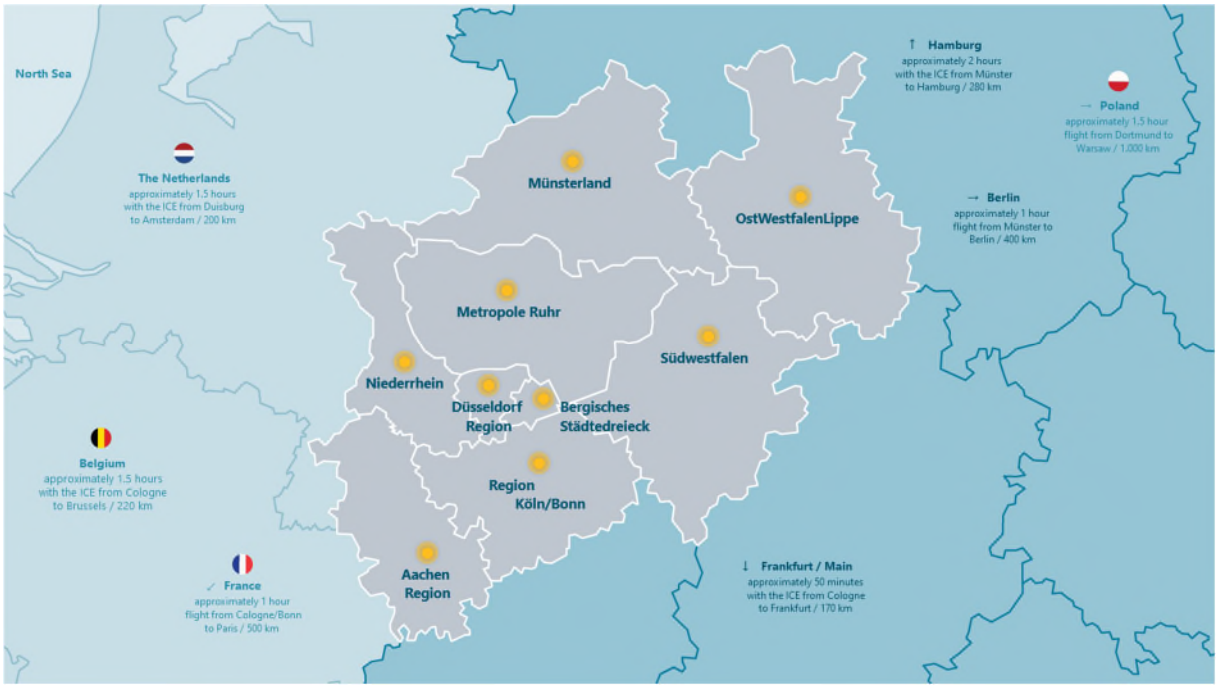

FIGURE 12: THE NINE ECONOMIC REGIONS IN NRW (NRW.GLOBAL BUSINESS, NO DATE)

The **economic region of Aachen** is located in the south-west of NRW and forms the border with Belgium and the Netherlands. This region is home to innovative industries, especially to automotive engineering and rail technology, life sciences, information and communications technology, modern material and production technology. It is also an **innovation location of technology and knowledge** due to the existence of numerous research institutes like the RWTH Aachen University, Forschungszentrum Jülich, FH Aachen University of Applied Sciences, multiple Fraunhofer institutes and numerous other research institutes. The economic region of Aachen is also an **attractive area for businesses** as they can profit from high potentials for transfer between industry and research (NRW.Global Business, no date).

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In the far west of NRW between the river Rhine and the Netherlands, the **economic region of Niederrhein** is located. It is **home to the chemical industry** and makes up one third of the regional industry´s revenue. Other economic emphases are wholesale, business-related service companies, energy production, electrical and mechanical engineering, logistics, tourism, the food industry/ agricultural business and the modern textile industry. International businesses value the **optimal infrastructure**. **Global Players** use the region as a hub for their European business dealings. Regarding its innovation and research, three universities of applied sciences, technology centres and scientific institutes can be found that offer good links for businesses between research and development (NRW.Global Business, no date).

The **economic region of Köln/Bonn** is located in the Rhineland in the centre of NRW and consists of three additional districts that are not part of *Rheinisches Revier*: Oberbergischer Kreis, Rheinisch-Bergischer Kreis and Rhein-Sieg Kreis. It accommodates major cities like **Cologne, Bonn and Leverkusen**. Its main economic emphasis lies on the automotive industry and mechanical engineering, the chemical industry, IT and telecommunications, logistics, media and biotechnology. A **dense network of research and science** can be found in this region: It is home to seven universities, eleven universities of applied sciences, numerous research institutes of Max Planck and Fraunhofer and the German Aerospace Center (NRW.Global Business, no date).

Looking at the gross investments of businesses in tangible assets within the districts in *Rheinisches Revier*, which can be an indicator on the regional economy's performance, the numbers vary between EUR 67,834 in Kreis Heinsberg and EUR 600,337 in Rhein-Erft-Kreis (Table 8). In general, businesses in *Rheinisches Revier* tend to invest more in tangible assets than businesses in NRW do as the share is 0.4 % higher.

District	Gross investments of businesses in tangible assets	Share of gross fixed capital formation on total turnover
Kreis Düren	158,946 €	4.1 %
Kreis Heinsberg[8]	67,834 €	2.1 %
Kreis Euskirchen	100,402 €	5.1 %
Städteregion Aachen	311,753 €	3.2 %
Rhein-Kreis Neuss	409,891 €	3.6 %
Rhein-Erft Kreis	600,337 €	5.1 %
Mönchengladbach	69,441 €	2.1 %
Rheinisches Revier	1,718,604 €	3.6 %
NRW	11,996,618 €	3.2 %

TABLE 7: REGIONAL ECONOMY - CORPORATE INVESTMENTS IN 2019 (IT.NRW, 2022H)

[8] The values for Kreis Heinsberg are based on 2020, because the values of 2019 are unknown or confidential. Other more recent observation dates were available for *Rheinisches Revier*, but 2019 is the observation date for which most districts have available values in order to compare them properly.

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Tertiary economic sector

The service sector alone is responsible for the **rising employment in the state**: Between 2008 and 2018, the number of employees increased by 1.05 million. This makes up nearly 96 % that can be traced back to the service sector (nationwide comparison: 87 %) and from that almost 40 % alone can be traced back to the industry-oriented services (nationwide 36 %). This turns it into the most important employment sector between the rivers Rhine and Ruhr. Nonetheless, the service sector cannot overcome the deficits of the industry sector (Koch et al., 2019, p. 13-14).

The **transition towards a service-oriented federal state** was accompanied by a general increase of numbers of employees. Since the end of the Second World War, the numbers of employees doubled from 4.4 million to 8.8 million in 73 years (IT.NRW, 2021). On closer inspection, the share of industry-oriented services on total industrial preliminary work makes up 18.1 % in NRW, in other German states 17.8 % and in other foreign countries 8.8 %. This indicates that the German industry is more dependent on **industry-oriented services** than other foreign industries on average (Koch et al., 2019, p. 14-15). Different economic sectors can be defined by the Classification of Economic Activities of the Federal Statistical Office Germany. Based on the shares of the industry on the total of preliminary work industry-oriented sectors are traffic and storage, provision of freelance, scientific and technological services, other economic services, provision of services of IT, information services, which represent categories of the Classification of Economic Activities (Koch et al., 2019, p. 14; Statistisches Bundesamt (Destatis), no date-e).

North Rhine-Westphalian providers (of industry-oriented services) are more dependent on value chains of other federal states and of foreign countries than on the value chains of their own federal state. 76 % of all businesses of the industry-oriented service sectors are part of the **first-tier industry**. This represents the services that are in direct contact with industry companies via more or less intense supply relationships. 12 % generate their revenue exclusively from the industry and 9 % of the service providers operate for the second-tier industry (Koch et al., 2019, pp. 15-16).

85 % of all industry-oriented providers in NRW are directly or indirectly as a supplier linked to the industry. Nonetheless, only 10 % of all industry-oriented providers are solely economically active within NRW. The majority operate beyond the North Rhine-Westphalian edges: 40 % are active in other German federal states, while 50 % operate internationally. 21 % of all providers are integrated in complex value chains and therefore have international procurement and sales markets (Koch et al., 2019, p. 16).

This shows some of the many linkages within the industry and that the industry-oriented service sector, situated in the Ruhr area and Rhineland, is less of a domestic industry supplier but more of a **global exporter of competitive service ranges**. But on the contrary, the revenue of the services in the manufacturing sector declined even though the range of services expanded. This can be due to competition-related reasons such as outsourcing, customer loyalty, non-realised returns with service innovations or rather unenforceable prices on the market. NRW displays the obstacles that Germany faces as well (Koch et al., 2019, p. 17).

The North Rhine-Westphalian industry lags behind regarding the supply of hybrid added values[9], whilst other German federal states are ahead. Especially in Westphalia, there is a disadvantageous

[9] Hybrid added values are defined as the joint offers of industrial goods and services of one or more businesses in cooperation (Kempermann and Lichtblau, 2012).

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environment and certain potentials are predominantly in the Ruhr area and Rhineland, which are neighbouring *Rheinisches Revier* (Koch et al., 2019, pp. 17). The industry in NRW also shows **deficiencies in hybrid value-added chains**, but there is, on the other hand, a **strong basis of industry-oriented service providers** that could strongly support regional producers with such offers. As a result, hybrid value-added chains can present potentials for new corporations for the regional network of industry and service, especially in the future field of digitalisation (Koch et al., 2019, p. 18).

2.2.3.3 Workforce

On closer examination of the workforce of the region's economy with regard to the regional transformation, it can be stated that around 8,000 people are directly affected by the lignite phase out. Another 15,000 people are indirectly affected, which are, for instance, supplier companies. In addition, around 50,000 people are employed in the **energy-intensive industry** (ZRR, 2022).

70 % of all employees in NRW of the economic sectors of lignite mining, provision of services for other mining and quarrying and electricity generation are employed in *Rheinisches Revier* (Roth, Kropp and Sujata, 2022, pp. 15), while the industrial corporation with the most employees is RWE with about 9,700 employees (DEBRIV, 2019, p. 55). This underlines the dimension of the coal phase-out´s impact on the workforce in the region and the **need for a transition** that takes the **creation of jobs** into account.

Taking a closer look at different business sectors of the region compared to NRW, it appears that especially in the sectors of the processing industry, construction, retail/ trade and transport/ logistics, a surpassing share of employees can be found. Especially the peripheral areas like Kreis Heinsberg, Rhein-Kreis Neuss and Rhein-Erft-Kreis seem to have a bigger focus on these business sectors. They rank the highest in comparison (Table 9) and the latter two are bordering the Rhine and the Rhineland, where major cities like Cologne, Bonn or Düsseldorf are situated.

Sector	% Employees: RR	% Employees: NRW	% Range in Districts (lowest to highest)
Processing Industry	16.7	18.3	13.7 (Mönchengladbach) - 19.0 (Kreis Heinsberg)
Construction	6.3	5.3	4.3 (Städteregion Aachen) - 8.6 (Kreis Heinsberg)
Retail / Trade	15.7	14.2	10.6 (Kreis Düren) - 19.5 (Rhein-Kreis Neuss)
Transport / Logistics	6.5	5.6	4.3 (Städteregion Aachen) - 8.1 (Rhein-Erft-Kreis)

TABLE 8: SHARES OF EMPLOYEES IN NRW AND RHEINISCHES REVIER IN DIFFERENT SECTORS (IT.NRW, 2023; BA, 2023A; BA, 2023B; BA, 2023C; BA, 2023D; BA, 2023E; BA, 2023F; BA, 2023G)

On further consideration of the relevant areas for the establishment of a *hub for circularity* for PU hard foam, the sectors chemical industry, construction industry and plastics industry are essential. Regarding the chemical industry, the basic chemicals industry is one of the most important economic

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sectors in NRW. Around 97,000 people are employed in 250 companies, which generated 28.6 % of the industry's sales in Germany in 2020 (Wilts et al., 2022b, p. 34).

In the construction industry, NRW ranks second behind Bavaria as the German state with the highest turnover with EUR 15 billion. 130,000 people are employed in NRW (Hauptverband der Deutschen Bauindustrie, 2021, as cited in Wilts et al., 2022b, p. 38).

With more than 134,000 employees and annual sales of around EUR 34 billion, North Rhine-Westphalia is the **most important plastics region** in Germany and Europe (kunststoffland NRW e.V., no date). The following Table 10 illustrates that with an excerpt of the most relevant sectors related to polyurethane and plastic production. In 2020, the number of NRW's businesses in the plastics industry made up 22.8 % of all German businesses in plastics and their employees accounted for 18.1 % of all employees in the German plastics industry (kunststoffland NRW e.V., 2021).

Economic sector: Manufacture of…	Number of Businesses	Number of Employees on 30 Sep 2021	Sales		
			total	domestic	non-domestic
			In EUR 1,000		
… plastics in primary forms	56	9,679	6,254,517	2,581,229	3,673,288
… man-made fibres	8	.	.	.	.
… plastic plates, sheets, tubes and profiles	147	16,645	4,798,411	2,530,552	2,267,859
… builders' ware of plastic	130	11,167	2,288,962	1,945,771	343,192
… other plastic products	338	33,033	5,185,164	3,395,734	1,798,430
… plastics and rubber machinery	65	9,053	2,563,444	620,263	1,943,181
Total	**744**	**70,524**	**21,090,498**	**8,492,320**	**10,025,950**

TABLE 9: BUSINESSES, EMPLOYEES AND SALES IN 2021 IN NRW BY SELECTED ECONOMIC, PLASTIC-RELATED SECTORS (OWN TRANSLATION AND PRESENTATION, BASED ON: KUNSTSTOFFLAND NRW E.V., 2021)

Considering the economy as a whole, there are some **long-term changes** within the range of economic professions as service occupations gained in importance in all sectors. The share of workers in a craft that produces specific physical products decreased in NRW but also nationwide. A decline of especially simple manual professions can be seen within the manufacturing industry as the numbers decreased by 7.5 % since the 1980s but the shares of simple and (highly) qualified service occupations increased simultaneously (simple: 11.5 % in 1980s and 14.5 % in 2016 and (highly) qualified: 11.4 % in 1980s to 15.6 % in 2016) (Koch et al., 2019, p. 17).

2.2.3.4 Infrastructure, accessibility and energy supply

The significance of the region becomes apparent in an international comparison of the economic output: North Rhine-Westphalia has greater figures than nations like Saudi-Arabia, Turkey, Switzerland, Poland, Sweden and Belgium. As an area with numerous commercial premises and real estate, highly-qualified academics, skilled employees and an innovative corporate landscape, it can be described as a lively location (MWIKE.NRW, no date-b).

On closer examination of *Rheinisches Revier* and its area by type of use (Figure 12), the **agricultural area** makes up the **majority** in every district of *Rheinisches Revier*. Especially the forest area and grove comprises a broad span of shares ranging between percentages of 9.3 % in Rhein-Kreis Neuss and 38.9 % in Kreis Euskirchen.

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Whilst Mönchengladbach has a comparatively high percentage of area that is used for residential building, industry and commercial space, it is also the municipality with the lowest share of agricultural area and the second lowest share of forest area and groves. By contrast, the landscape of Kreis Euskirchen consists mainly of agricultural area, forest area and groves, making up around 84.3 %.

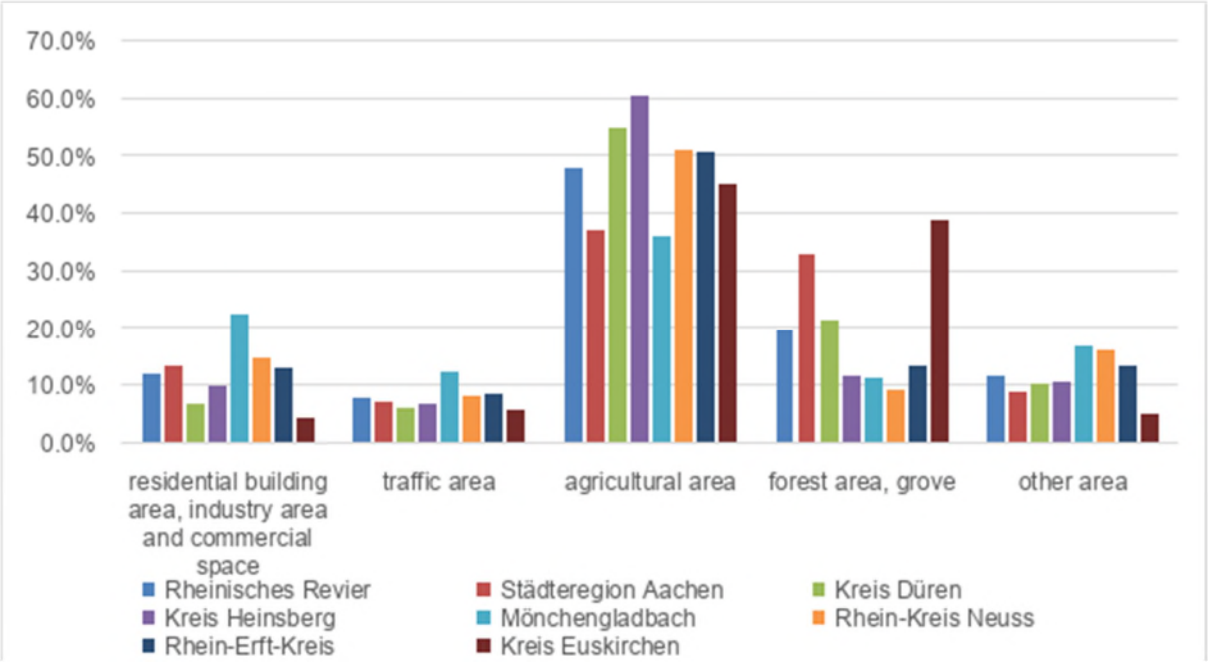

FIGURE 13: AREAS ACCORDING TO THEIR TYPE OF USE IN 2021 (OWN CALCULATIONS, BASED ON: IT.NRW, 2022A, P. 3; IT.NRW, 2022B, P. 3; IT.NRW, 2022C, P. 3; IT.NRW, 2022D, P. 3; IT.NRW, 2022E, P. 3; IT.NRW, 2022F, P. 3; IT.NRW, 2022G, P. 3)

An important impact on the economic strength of the region is the **convenient geographic location** of the federal state in general. Being situated in the centre of Europe and surrounded by densely populated states, it is also located at an **important intersection** of the north-south and the west-east axis. Those traffic routes extend from south-west England in the north to Northern Italy in the south and from Rotterdam in the Netherlands as its westernmost point to eastern Europe (MWIKE.NRW, no date-b).

The main commuter flows of the region and its bordering areas are another indicator for its relevance. Having a dense cluster of different motorways, it is connected with the neighbouring NUTS-2 region Arnsberg, which consists of a large number of NUTS-3 regions and cities like Dortmund, Essen and Bochum. The broader region is connected to the major German cities and regions such as Hamburg, Berlin, Munich and Frankfurt (Figure 13). 17.1 % of the German motorway network is situated in North Rhine-Westphalia alone and the average daily traffic load is 22 % above the German average. In the federal state itself, 20 % of the total mileage in Germany is covered (Straßenbau Nordrhein-Westfalen, no date).

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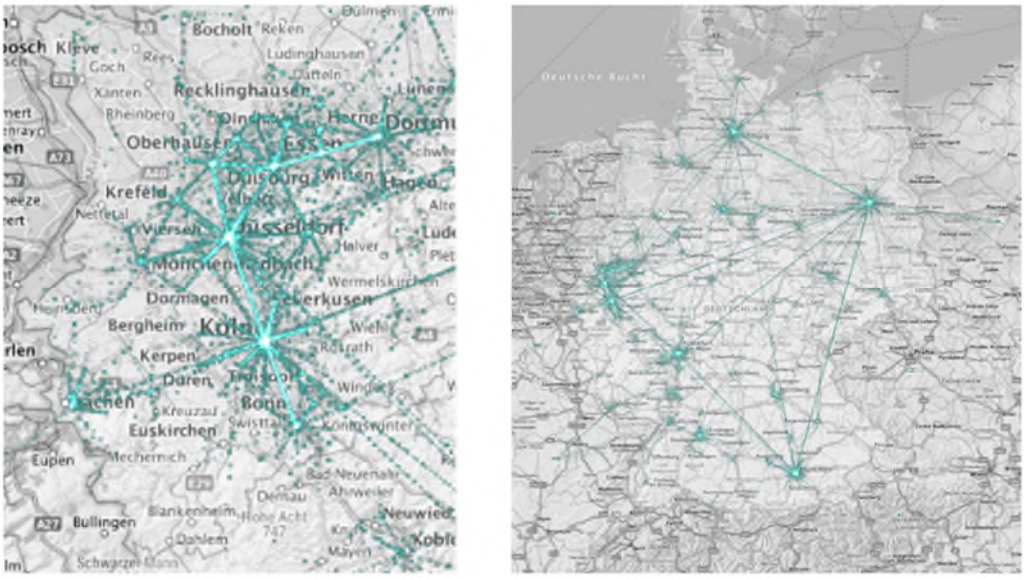

FIGURE 14: MAIN COMMUTER FLOWS IN RHEINISCHES REVIER AND NATIONWIDE IN 2021 (STATISTISCHE ÄMTER DES LANDES (HG.), 2022)

As an eponym for different districts and regions, **the Rhine** is an important transport route for *Rheinisches Revier* and also NRW. Different industry sites are dependent on this inland waterway transport route for the supply and delivery of goods (Covestro AG, no date). There are different waterways and canals situated in NRW itself but only the Rhine borders on *Rheinisches Revier*. Harbours in this area are Neuss, Düsseldorf and Cologne, the latter being the harbour with the largest freight transport in volume on national level (VM NRW, 2019, pp. 103). In 2016, 126.8 million tons of goods were shipped and received in NRW, of which the shipped goods accounted for 33.6 % of the total volume. 23.4 % of this freight transport was an exchange within Germany, whilst 75.8 % concerned a cross-bordering EU-transport. Only 0.7 % were of an international matter with countries outside of the European Union (VM NRW, 2019, p. 106).

In 2022, the transport of goods like coal and others was temporarily hampered due to low water levels of the river, which led to the need to spread cargo over more ships, a restricted production and higher transport costs for the industry along the river (Bertram, 2022).

The freight handling concerning the transport via railway summed up to 125,945 tons in 2016, which is a decline of 20.8 % compared with the year 2000. Around 76.1 % of the freight handling stayed within Germany and 23.9 % crossed German borders (VM NRW, 2019, p. 98). Regarding freight transport by truck, North Rhine-Westphalia is the federal state with the highest shares of quantities of goods concerning the receipt (20.8 % of German total) and dispatch (19.2 % of German total) (VM NRW, 2019, p. 122, 127). The air freight in North Rhine-Westphalia is handled at six different airports, which are Düsseldorf, Cologne/Bonn, Münster/Osnabrück, Paderborn/Lippstadt, Weeze and Dortmund. It accounted for 920,000 tons of freight in 2018, although only Düsseldorf and Cologne/Bonn handled any freight (VM NRW, 2019, p. 109).

The **energy profile of NRW** is characterised by an electricity feed of 18.2 % of renewable energy sources and 81.8 % of conventional energy sources (IT.NRW, no date-d). In 2019, the final energy

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consumption amounted to 2,129,886 terajoules. The biggest energy sources were gases with circa 30.0 % and mineral oils with a total of about 31.9 % (Figure 14).

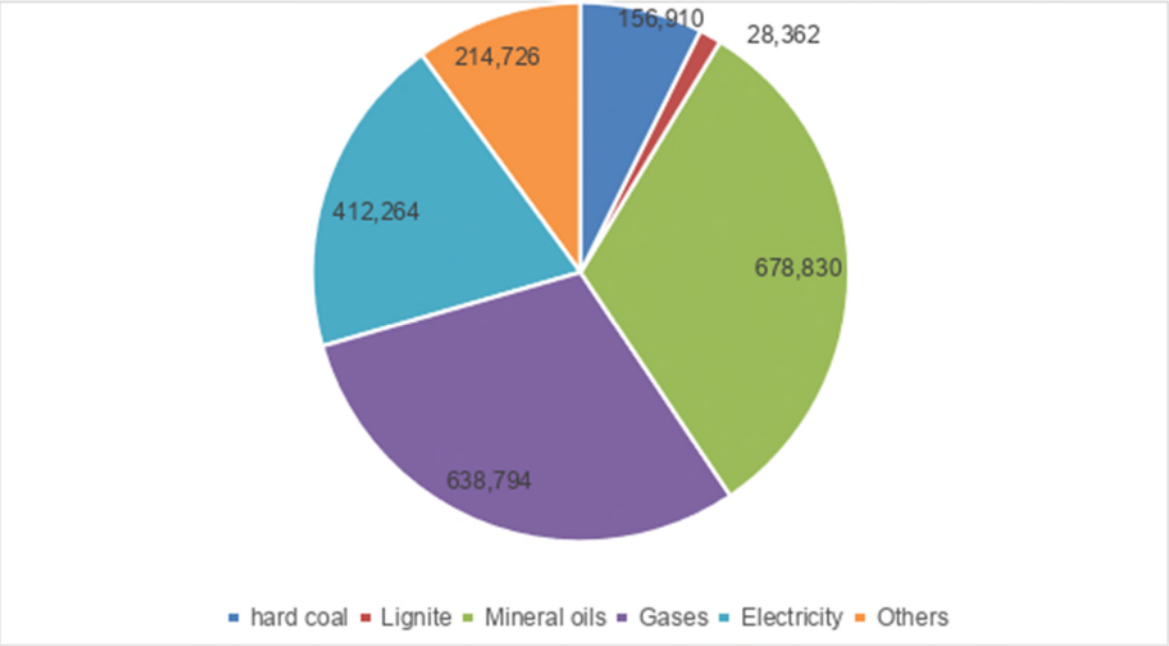

FIGURE 15: FINAL ENERGY CONSUMPTION IN NRW IN 2019, ACCORDING TO ITS ENERGY SOURCES IN TERAJOULES (IT.NRW, NO DATE-D)

The **industry's energy consumption** according to its economic sectors summed up to 1,314,245 terajoules in 2021, which is a reduction of 15.3 % (237,065 terajoules) since 2012[10]. Whilst the manufacturing sector is responsible for 98.1 %, the largest consumer of this sector is the production of chemical products with a share of 37.0 %, followed by metal production and processing with 35.2 %. The third biggest energy consumer of the manufacturing sector is the group "coke and refined petroleum products" with 7.0 % (IT.NRW, no date-e).

Looking into the future and different endeavours of the regional government, the funding programme "**Kommunales Strukturförderprogramm I"** (English: Municipal structural support programme) is intended to enable structurally important investments of the municipalities that are feasible on a short term. Furthermore, the "**Gewerbeflächenkonzept**" (English: "Regional industrial space concept") is a concept for industrial spaces with the aim to identify potential new spaces for a future industrial development in *Rheinisches Revier* (MWIKE.NRW, 2019). The regional government also supports and develops existing infrastructure with different activities and investments. One of the projects is to establish a legal base for the rail infrastructure project "**Westspange Köln**", in order to expand one of the most utilised intersections nationwide for the local and long-distance transport and the freight transport. Moreover, in 2022 it continues the funding for the rail transport of goods with EUR 12 million (EUR 5 million more than in 2021) in order to support logistics centres, industrial areas and industrial parks to shift their transport from road to rail (Landesregierung Nordrhein-Westfalen, 2021).

[10] The economic sectors in this source are defined by the Land Office "Information und Technik Nordrhein-Westfalen" and consist of the two sections B an C of the Classification of Economic Activities of the Federal Statistical Office Germany. The section B includes thereby the mining and quarrying, whereas section C covers the manufacturing sector with 24 subcategories (IT.NRW, no date-e).

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The regional government supports the mobility of the future with around EUR 40 million. Furthermore, new forms of mobility are already being explored and developed such as nine on-demand shuttles as an addition for bus and rail transport and the research on autonomous rail transport between Jülich and Aachen with the "Brain Train" (Landesregierung Nordrhein-Westfalen, 2021).

Preliminary conclusions

Summarising the economic situation of *Rheinisches Revier,* it can be stated that it is a traditionally economically strong region. Regarding economic key figures, some districts stand out as especially Rhein-Kreis Neuss and Städteregion Aachen are in the top 3 in terms of the highest GDP per capita and gross value added. Whilst the service industry increased and became the most important employer, it could not overcome the deficits of the industry sector. The composition of the primary, secondary and tertiary sector changed significantly over the last decades as the primary sector is employer to less than one percent of employees nowadays. The secondary sector decreased as well but *Rheinisches Revier* can be characterised as an innovative region as it is home to several research institutes.

The relations between the industry and service sectors have become more intertwined and intensified. The tertiary sector alone is responsible for a rising employment in the region making up almost three fourths of the gross value added in NRW. But the sector is dependent on national and international value chains as most suppliers in NRW are first-tier companies. NRW lags behind regarding the supply of hybrid value-added chains, which stresses the fact that the region needs to manage its ongoing transition in order to stay attractive in an international competition.

A strong workforce can be found in the area. NRW is the most important plastics region in Germany and has both a strong chemical and construction industry. However, though the plastics industry is a major player, PU hard foam is not in the focus. The economic regions of *Rheinisches Revier* show different emphases regarding their industry and established connections to relevant workforce and companies. While the economic region of Aachen can be described as home to innovative industries such as modern material and production technology and others, the economic region of Niederrhein has a focus on chemical industry, business-related companies, energy production and others and is known for its optimal infrastructure and global players. The economic region of Cologne/ Bonn is also home to the chemical industry, logistics, IT and telecommunications and others.

An interview partner from *Effizienz-Agentur NRW (EFA)* has given the assessment that NRW has the relevant industry and the possibility to close the material loops, but also the necessity: Raw material supply problems make it all the more necessary for companies to close the material cycles themselves (Interview F, 2022). In another interview with the NRW Ministry of the Environment, the stakeholder landscape in NRW was attested ideal conditions since all relevant players are there – when there is a business model, the stakeholders will likely participate. However, the interviewees see the risk that if a circular economy is supposed to replace fossil jobs in a region, high tech firms will likely bring their employees from outside the region (Interview A, 2022).

Concerning its accessibility, *Rheinisches Revier* is in a convenient geographic location in the centre of Europe at the intersection of the north-south axis and west-east axis. It is surrounded by densely populated states and has a very good transport infrastructure, with the river Rhine playing an important role.

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2.2.4 Zooming In: Waste Management

Counties and municipalities function as waste disposal authorities in Germany. They have the duty to organise waste management locally – for collecting, dismantling, sorting, recycling or depositing. They can organise it by setting up public waste management companies or by contracting with private businesses. Private companies are most active in collecting and treating industrial and commercial waste (for details see Stakeholder Report).

An obstacle to outline the exact circumstances concerning the current waste collection and treatment is the availability of exact data for *Rheinisches Revier* as a whole. Data concerning PU insulation boards was approached via waste at construction sites and data regarding cooling devices was approached via electrical and electronic devices. That being said, some waste businesses and their reports also considered refrigerators as bulky waste within their cosmos of collecting and sorting waste, which leaves a blind spot regarding an exact and fully extensive set of data.

2.2.4.1 Overview

PU insulation material

Polyurethane (PU) accounts for an **average market share of 3-8 % of insulation materials** in Germany, which is roughly as much as insulation materials made from renewable raw materials with about 4-7 % (co2online, 2018). In 2017, the amount of installed PU in the insulation sub-sector was estimated at 162,000 tons in Germany (Bendix et al., 2021, p. 40).

Currently, PU insulation is **disposed of by thermal treatment** in waste incineration plants. It is also possible to recycle the insulation material in pressed adhesive boards with insulating properties (Reinhardt et al., 2022, pp. 60, 86). However, only those PU insulation materials can be recycled that are delivered from the construction site as a mono fraction, unpolluted, and whose manufacturer is known, according to a study with a focus on the federal state of Baden-Wuerttemberg. It is assumed that these local conditions can be applied to other German states.

Cooling Devices

In Germany in 2021, **3.85 million cooling devices were sold** in total (statista, 2022). In the same year, in the product category of heat exchangers that include cooling devices (also heat pumps, air-conditioning devices, boilers etc.), **120,477 tons were disposed of** in total on the German level (stiftung elektro-altgeräte register, 2021).

According to a consumer survey from 2022 by ZVEI e.V., when refrigerators are replaced, most old devices are either still used or properly disposed of. In comparison to mobile phones that are often kept in storage (27 %) and only 23 % are discarded, **more than half of the replaced refrigerators are discarded (54 %), while 36 % are kept in use** and only 3 % are kept in storage. When electric appliances are stored at home instead of disposed of, the raw materials they contain are not available for circular economy and cannot be recycled. Therefore, the results for refrigerators compared to other product groups are rather positive in terms of waste recovery. For large household appliances, the most frequently used option of disposal is the handover to the dealer upon delivery of the new appliance with one third of all appliances (ZVEI e.V., 2022).

Regional Waste Generation

NRW

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In 2019, 13.2 million tons of waste were produced in NRW, 29 % of which was household waste (incl. electronic devices), 29 % was commercial waste (incl. insulation boards and sandwich panels) and organic and garden waste/valuable waste made up 33.9 % (LANUV, 2022, p. 15). Regarding the waste disposal methods, 29 % of all municipal waste in NRW was mechanically treated, 28 % was thermally treated, 23 % was disposed in landfills, 13 % was composted and fermented, 6 % was stored or transhipped and 1 % was disposed of in other ways, such as at production facilities, soil treatment facilities or at chemical-physical treatment plants (LANUV.NRW, 2019, p. 109).

Rheinisches Revier

On closer examination of *Rheinisches Revier* itself and its waste distribution, the amount of residential waste summed up to 1,285,320 tons in 2019 (Table 11). Major shares were household and bulky waste with 36.3 %, organic and green waste/valuable waste with 47.4 % and commercial waste with 8.9 % (own calculations: LANUV.NRW, 2022, p. 16). The commercial waste concerns waste material similar to household waste of a commercial origin. Commercial waste solely from businesses is listed separately. This waste group is subdivided in three categories: waste material similar to household waste, building and demolition waste and other waste types of commercial origin, which consist of circa 120 different waste types.

		from that				
	Amount of residential waste	**Household and bulky waste (incl. Contaminated waste)**	**Organic and green waste / valuable waste, collected separately**	**Infrastructure waste**	**Commercial waste**	**Waste from waste treatment plants**
District	**t**	**t**	**t**	**t**	**t**	**t**
Rhein-Kreis Neuss	211,164	116,288	91,710	0	3,166	0
Administrative district of Düsseldorf	3,409,584	1,257,744	1,115,058	68,834	708,892	259,056
Städteregion Aachen	240,072	53,614	93,994	884	7158	84,422
Kreis Düren	129,206	50,951	75,161	121	2974	0
Rhein-Erft-Kreis	237,493	107,242	127,973	97	2182	0
Kreis Euskirchen	168,748	41,600	64,029	7	62,055	1,057
Kreis Heinsberg	163,350	42,224	85,545	2541	31,293	1,748
Administrative district of Cologne	3,131,272	978,754	1,158,808	22897	729,972	240,841
Mönchengladbach	135,287	54,026	70,163	5,617	5,480	0
Cumulated values of *Rheinisches Revier* in total	1,285,320	465,945	608,575	9,267	114,308	87,227

TABLE 10: STRUCTURE OF THE RESIDENTIAL WASTE IN RHEINISCHES REVIER (OWN CALCULATIONS, BASED ON: LANUV, 2022, P. 16)

With regard to the waste distribution of the households, there are **varying numbers of electrical and electronic equipment**. While this waste type made up 0.30 % in the municipality of Merzenich in the district Düren (10,1449 inhabitants in 2021), it is responsible for 1.38 % in the city of Heimbach (4,262

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inhabitants in 2021), which is also located in the district Düren (IT.NRW (Hg.), no date-f) (Figure 15 and 16).

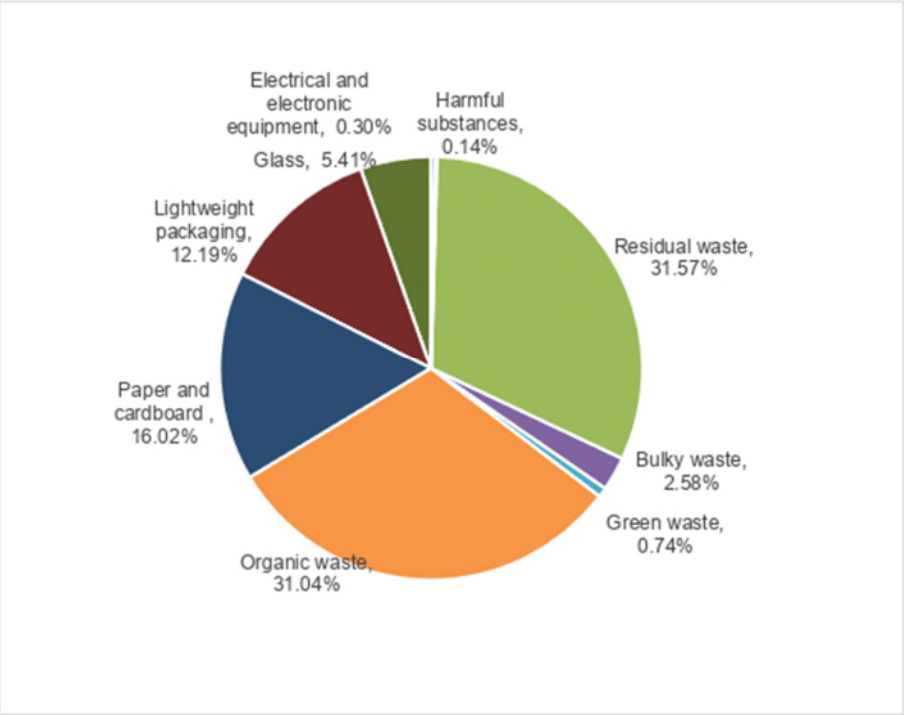

FIGURE 16: WASTE DISTRIBUTION IN MUNICIPALITY OF MERZENICH IN 2021 IN KREIS DÜREN (ZWECKVERBAND ENTSORGUNGSREGION WEST, NO DATE, P. 66)

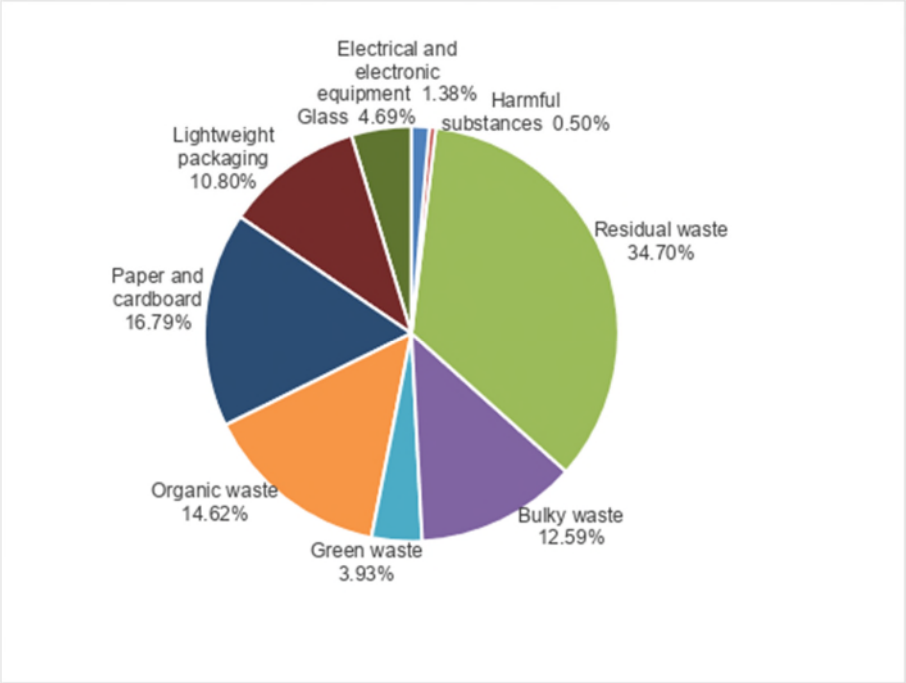

FIGURE 17: WASTE DISTRIBUTION IN HEIMBACH (KREIS DÜREN) IN 2021 (ZWECKVERBAND ENTSORGUNGSREGION WEST, NO DATE, P. 49)

According to the study of environmental economy, which was published by the Ministry of the Environment, Nature and Transport of the State of North Rhine-Westphalia, the environmental industry, of which the waste management is a part of, faces different obstacles even though its overall

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development can be described as positive: A better networking for the solution providers among themselves could lead to higher innovation potentials. Innovation processes should lead to cross-sectoral innovation ecosystems. Scientific research needs to connect itself better with the industry with accurate and purposeful exchange formats and continuous, working connections (Lühr et al., 2022, p. 84).

Financing

The responsibility of financing the waste management is divided between the state and the relevant municipality/district. The state determines the aims regarding environmental and political matters and supports the implementation with funding. The municipalities are responsible for financial organisation of the waste management, which can be realised with different financing models and private businesses (Bilitewski, Wagner and Reichenbach, 2018, p. 57).

Having an exemplary look at the district Düren, the budget can give more information about the financial distribution for waste management. According to its budget, which has a partial budget on waste management and monitoring, the district generated ordinary disbursals of EUR 384,601 for personnel in 2019. Adding other ordinary disbursals such as supplying disbursals or depreciations for reporting purposes the ordinary disbursals accounted for EUR 372,861.[11] The final budget had a shortfall of financial resources of EUR 343,337 in 2019. The planned budget for 2023 is a shortfall of financial resources of EUR 309,830 (Kreisverwaltung Düren, 2021, pp. 508-509).

Workforce waste management NRW

On closer examination of the workforce within the waste management, different aspects can be noted on a federal state level. Around **191,000 working persons** can be assigned to this field (Table 12). Especially the **subsector of circular and material-efficient production** processes has a **strong workforce** and generated the **biggest share** on the gross value added of EUR 6,857,000 in this field, which accentuates the regional focus on the future and upcoming transformation. Apart from this, NRW can be called **national innovation leader** regarding the subsector waste collection and transport, judged by its numbers of patent applications (Lühr et al., 2022, p. 19). The field in general could score a slight growth in almost every subsector with regard to the workforce and the gross value added.

Subsectors	**Workforce 2021**	growth 2010-2021 p.a.	**Gross value added 2020**	growth 2010-2021 p.a.
	total: 191.000		**EUR 15,114 million**	
Waste treatment and recycling ("Abfallverwertung")	35000	+ 0.7 %	4,056,000	+ 2.3 %
Waste collection and transport	25000	+ 2.4 %	3,060,000	+ 4.0 %
Circular and material-efficient production processes	115000	+ 0.7 %	6,857,000	+ 3.0 %
Renewable resources and environmentally friendly materials	5000	+ 2.2 %	341,000	+ 3.2 %

[11] No extraordinary disbursals were generated in 2019, except for disbursals from internal transactions, which added up to EUR 40,748.

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Technology for the waste management	11000	+- 0.0 %	830,000	+ 0.5 %

TABLE 11: WORKFORCE AND GROSS VALUE ADDED OF DIFFERENT SECTORS IN WASTE MANAGEMENT (LÜHR ET AL., 2022, P. 19)

Infrastructure for Waste Management

In Germany, there are seven large-scale plants for the professional recycling of cooling devices, one of which is in the region of *Rheinisches Revier*, namely NOEX in Grevenbroich. The main waste incineration plant in the region is MVA Weisweiler (for details see Stakeholder Report). For electronic waste collection, there are 24 collection sites in the region.

One major disposal centre is *Entsorgungszentrum Warden* by *AWA Entsorgung GmbH* in Eschweiler. In 2022, in the product category of heat exchangers that includes cooling devices, 110 tons were disposed of at the centre.

2.2.4.2 Chemical recycling in NRW

The study "NRW 2030: From fossil past to circular future" sums up that strong efforts have been made in recent years in the field of chemical recycling, giving hope to the establishment of a recycling route suitable for those plastics that are not amenable to mechanical recycling and for highly mixed or contaminated plastics. Numerous current research projects are examining whether and to what extent this can be achieved in an ecologically and economically sustainable manner. The authors of the study see a great need for action and research, but also a willingness to further develop a circular economy in the plastics industry. **Circular economy is receiving a lot of attention in the plastics sector** and there is a high incentive for an improved circular economy due to customer requirements, political developments and material shortages (Wilts et al., 2022, p. 44 f.).

Status quo of plastic waste recycling in NRW

In the federal state of NRW, a plastic waste volume of 2.4 million tons was available for recycling or disposal in 2017 (not including the plastic quantities from PET deposit systems [0.12 million tons] and internal recycling [0.08 million tons], as these go directly to material recycling due to their varietal purity) (Ramesohl et al., 2020, p. 33).

Of these 2.4 million, it is estimated that one million metric tons were directly recovered as energy in waste incineration plants. 1.4 million metric tons were subjected to pre-treatment, such as shredding, cleaning and sorting, while landfilling accounted for 20,000 tons. Of the 1.4 million tons, only 0.5 million tons were actually recycled. The remainder (just under 0.9 million metric tons) was also used for energy recovery, due to its greater homogeneity compared to mixed waste, mainly as substitute fuels (0.68 million tons).

Together with the plastic waste from the internal recycling of plastics processing and production and the waste from the beverage bottle deposit system (mainly PET), **around 0.7 million tons of plastic waste were available for material recycling** in NRW. A very small proportion (around 10,000 metric tons) of this 0.7 million metric tons was chemically recycled. The majority (0.69 million metric tons) was mechanically recycled (ibid., p. 33).

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One of the key messages of the discussion paper by Ramesohl et al. (2020) is that the **technical basis for plastics pyrolysis** is **available**, no fundamental exclusion criteria were identified. The decarbonisation of the energy system tends to improve the prospects for pyrolysis in terms of climate policy.

Also, the **feedstock for chemical recycling** is available in NRW: Significant quantities of mixed plastic waste are not currently used in mechanical or chemical recycling in NRW. The currently estimated volume flows of up to two million tons per year suggest that commercial plants of typical size can be used to capacity, even if the total volume and structure of plastic waste will change in the future. An expansion of the catchment area to neighbouring German states or Benelux would further secure the raw material base. However, the strategically relevant option of recycling mixed and contaminated waste by pyrolysis is **not yet commercially available**. There is a need for further development, especially at the stage of industrial development and demonstration (ibid., p. 38).

The project **NRW.Zirkulär** has produced a follow-up implementation study on circular plastics through pyrolysis processes in NRW including a technical analysis of pyrolysis processes, an economic and ecological evaluation of plastics pyrolysis, and an evaluation for the preparation of a pyrolysis pilot plant in NRW (IN4climate.NRW, 2022).

A **life cycle assessment** was conducted by *carbon minds*. Its results show that chemical recycling is more advantageous than energy recovery in all of the variants investigated. Compared to incineration, plastic pyrolysis can reduce greenhouse gas emissions by more than half and reduce the raw materials by 2.3 times. These ecological advantages are further reinforced by the decarbonization of the power sector and persist even with the use of alternative carbon sources from Biomass and CO_2/H_2 (ibid., p. 17).

Fraunhofer UMSICHT was responsible for the **technical evaluation**: Investment costs depend on the technology (milk of lime or caustic soda) and the use of the aromatics fraction. Furthermore, the investment costs depend on the plant capacity and whether the pyrolysis plant can be integrated into existing structures (lower out-of-battery costs). The pyrolysis technologies and investment costs are largely dependent on the composition and constant quality of the plastic waste. Therefore, it is technically feasible but further scale-up investigation is necessary to ensure the plastic waste quality and product quality (ibid., pp. 28 and 48).

The **economic efficiency** depends on many factors (such as fossil raw material prices, sorted plastic waste, operating costs, personnel costs etc.) according to *Wuppertal Institut*, which was responsible for the economic and infrastructural evaluation. Industrial plants can in principle be operated economically in the future (ibid., p. 48). Wuppertal Institut has also analysed the quantities of waste available for pyrolysis in NRW in the medium and long term. The base scenario describes the maximum amount of waste and continuation of the status quo (as of 2019) with a continuously high demand for plastics and without feedstock recycling. The recycling scenario also assumes a high demand but takes into account a rising share of recyclates in new products, fewer losses via residual waste, rising rates of mechanical recycling and feedstock recycling. In the circular scenario, the authors assume a minimal amount of waste and a lower demand of plastics, while expecting a higher share of recyclates and less losses as well as higher mechanical and chemical recycling rates than in the recycling scenario (ibid., p. 36).

Outlook

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In all scenarios, the demand for plastics as well as the amount of post-consumer waste is expected to continue to rise. In the circular scenario in the study, both will rise to a lesser extent. The study assumes that the rate of mechanical recycling can be increased even further. In the future, quantities that have so far been used for energy recovery will be available for chemical recycling, to a small extent in the 2020s, with increasing shares in the 2030s. Nonetheless, with increasing shares of mechanical and chemical recycling, relevant quantities of plastics will still be used for energy recovery (ibid., p. 47).

Preliminary conclusions

Within the waste sector, there is a well-established system of cooperation between public and private waste management companies. There are varying levels of regulation for different waste streams: The regulations for cooling devices are strict, while there is more intransparency concerning construction waste. The infrastructure for the current linear waste streams is in place: There is a dense network of waste collection sites, waste incineration plants and second-line treatment facilities for cooling devices in the region.

Pyrolysis technology is relevant for polymer recycling in NRW and research is already being conducted concerning material flows, availability, and the feasibility of pyrolysis plants. First commercial pyrolysis plants have been built in Germany and recently, construction plans for NRW have been published. However, there are reservations against chemical recycling. An interviewee from IN4climate.NRW, a think tank for climate-neutral industry in NRW coordinated by NRW.Energy4Climate, a state agency for energy and climate protection, has reported to have perceived scepticism or rejection in individual conversations with regards to chemical recycling. Especially from environmental NGOs, there are reservations towards the energy input which is higher than in mechanical recycling, but also in terms of products and residual materials concerning the end result and pollutants. However, assessments are changing, and it is increasingly recognized that chemical recycling is a complementary technology to mechanical recycling. Certain types of polymers, especially composite polymers, cannot be recycled mechanically. Also, the structure of polymers suffers during the process so that mechanical recycling is finite. Here, chemical recycling returns the raw materials to their original state in the sense of a "quality lift" and can make an important contribution towards reaching nearly unlimited circularity (Interview B, 2022; see also Stakeholder Report, p. 34).

The ZRR study by Wilts et al. (2022a), which looks into conditions for a resource transition in the region, also finds that with regard to the construction sector, there is scepticism towards recycled construction material. Fundamental differences in the application and quality of secondary raw materials compared to primary raw materials are identified as risks (Wilts et al., 2022a, p. 46).

Another interview partner has indicated that digitization makes it increasingly harder to recycle refrigerators due to electronic equipment built into the devices. The trend towards screens and smart home technology results in more wires within the casing of the devices and accordingly, the separation for recycling becomes more difficult (Interview F, 2022).

Intransparency poses another problem. In general, there is an obligation to disclose all building demolitions. However, as an interview partner from a municipal waste company has pointed out (Interview D, 2022), it is possible to disclose a demolition at a given point in time but to conduct the demolition not until, for example, a year later, which leads to a high monitoring effort. A disposal concept, according to the State Circular Economy Act, only becomes obligatory when the expected

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waste exceeds 500 m³ (e.g. bungalows or small warehouses). This means that there is a lack of data about the actual construction waste produced and discarded. Even though the regulations require that insulation materials must be collected separately, in practice, materials are often mixed at the demolition sites, e.g. in the case of fibre cement (Interview D, 2022). A study by Reinhardt et al. (2022) concerning material loops for insulation materials confirms that the success of recycling insulation materials depends on their degree of purity when supplied by the construction site. Even loose insulation materials are often not separated cleanly enough. As soon as the PU insulation material becomes part of mixed construction waste, the possibility of recycling is eliminated. Here, dismantling companies and the building trade are required to comply with the legal obligations to keep the materials separate in accordance with the Commercial Waste Ordinance (Reinhardt et al., 2022, pp. 4, 61).

Also, in the area of white goods, it was reported that a high level of discarded cooling devices is shipped to developing countries. An interview partner has estimated that around a third of all refrigerators are illegally shipped to Africa via international ports such as Antwerp (Interview D, 2022). This means that a high amount of material is permanently lost and the return rates are much lower than the actual number of devices no longer in use. This can be a limiting factor for the recovery of raw material and therefore recycling of PU hard foam.

2.2.4.3 Policy frames

Regulations / specific policies

As Work Package 3 will take a closer look at regulations and their implications for the Circular Foam project, this chapter will only shortly describe the regulatory framework for completeness and overview purposes.

Waste management regulations on European Union level

The years 2008 and 2018 were decisive years at the European level for the handling of waste. In 2008, the **Waste Framework Directive** 2008/98/EC set the basic concepts and definitions related to waste management, including definitions of waste, recycling and recovery. Article 29 stipulated that:

> "[t]he Member States [...] [should] encourage the use of recycled materials, such as waste paper, in line with the waste hierarchy and the objective of creating a recycling society, and [should] not support the landfilling or incineration of such recycled materials where possible."

Here the possibility arises that technical innovation can act as a driver of policy. The more and the faster waste can be turned into tradable materials through recycling, the more difficult it is to support disposal.

The **WEEE Directive** (Waste from Electrical and Electronic Equipment), passed in 2012, established the obligation to collect WEEE separately for sorting and recycling. It “sets a detailed framework for Extended Producer Responsibility and aims to provide incentives to improve the design of electrical and electronic equipment to facilitate recycling” (Municipal Waste Europe, 2020).

EU Circular Economy Action Plan 2.0: In March 2020, the European Commission adopted the Circular Economy Action Plan as one of the main building blocks of the European Green Deal, Components (amongst others):

- Sustainable Products Initiative (March 2022)

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- Consumer Transparency and Right to Repair
- Circular Electronics Initiative (upcoming)
- EU Strategy for Textiles
- Strategy for a Sustainably Built Environment (March 2022)
- EU-wide, harmonised model for the separate collection of waste and labelling
- EU KOM: GDP growth by 2030 of up to 0.5 % and 700,000 new jobs

National waste management regulations and specific policy initiatives on German level:

The **German Circular Economy Act** (KrWG, *Kreislaufwirtschaftsgesetz*) came into force on 1 June, 2012 and transposed the requirements of the EU Waste Framework Directive into national law (Umweltbundesamt, 2022; BMUV, 2022). The definition of recycling on the level of the Federal Republic of Germany follows the EU definition. This is what the Act states under § 3, Para. 25 (BMUV, 2012, p. 9):

"Recycling within the meaning of the present Act shall be any recovery operation by which waste is processed into products, materials or substances, whether for the original or other purposes; it shall include the processing of organic material, but shall not include recovery of energy and processing into materials that are to be used as fuel or for backfilling."

In 2015, the five-level Waste Management Hierarchy (previously: three-levels), the obligation to separate household waste and a Framework for Waste Avoidance were introduced.

In January 2023, a **Standardisation Roadmap for Circular Economy** in Germany was presented by the German Institute for Standardisation (DIN, *Deutsches Institut für Normung e.V.*), the German Commission for Electrical, Electronic & Information Technologies in DIN and VDE (DKE, *Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE*) and the Association of German Engineers (VDI, *Verein Deutscher Ingenieure*). It was funded by the Ministry of Environment and was developed by more than 550 experts (BMUV, 2023). The roadmap describes the challenges that industry faces in the area of circular economy and which norms and standards are needed to meet them. It focuses on seven key topics for which more than 200 standardisation needs were identified and which are based on the focus topics of the EU's Circular Economy Action Plan (DIN, no date). One of these focus topics is plastics. In this chapter, the recycling options and obstacles to the recycling of plastics are described and standardisation needs identified (DIN, 2023, p. 111 ff.).

The **Commercial Waste Ordinance** *(*GewAbfV, *Gewerbeabfallverordnung*), in its current version of 2017, requires the separation of waste material flows (unmixing) so that producers and owners of commercial waste and construction waste must collect the material flows separately. Priority is given to reuse and recycling purposes.

Amended in 2021, the **Electrical and Electronic Equipment Act** *(*ElektroG, *Elektro- und Elektronikgerätegesetz*) is intended to implement the product responsibility of producers of electrical and electronic equipment under waste legislation. This includes the duty of every manufacturer to register with the competent authority – the foundation *stiftung elektro-altgeräte register* (ear) - before bringing electrical or electronic equipment to the market (for details on the foundation see Stakeholder Report, p. 24). Consumers are obliged to separately discard their electronic equipment by handing it in at a collection point. Alternatively, some large appliances that are replaced by a new device by delivery can be handed over to the supplier if they are of comparable nature. They can also be registered for the local pickup of bulky waste. Small-scale devices can be returned free of charge to large retailers that sell electronic goods.

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The **German Resource Efficiency Programme** (ProgRess) was first adopted in 2012 to "determine targets, guiding principles and approaches to the conservation of natural resources". The German government is obligated to submit a report to the *Bundestag* (German parliament) on developments in resource efficiency in Germany every four years and to update the programme. The current version is the third update, ProgRess III, from 2020. The programme aims to decouple resource use from economic growth and strengthen the future viability and competitiveness of the German economy (BMUV, 2020).

Waste management regulations and policies in North Rhine-Westphalia:

The **State Waste Act of North Rhine-Westphalia** *(*LAbfG, *Landesabfallgesetz*) and its **Waste Management Plan** *(Abfallwirtschaftsplan* NRW) formulate requirements for local waste management concepts and reports and sets goals for waste management and sorting on the level of the federal state.

The **State Circular Economy Act** *(Landeskreislaufwirtschaftsgesetz NRW)* from February 2022 has not only amended but also renamed the former State Waste Act (*Landesabfallgesetz*) to underline the importance of circular economy. In addition to the implementation of the five-level waste management hierarchy in federal state law, it prioritises recycled material over primary raw material with a strong focus on the construction sector.

Circular economy

The report "NRW 2030: From the Fossil Past to the Circular Future" looks at strengths and weaknesses of the circular economy in North Rhine-Westphalia. Its results show that the circular economy is anchored in a large number of strategies, for example the sustainability strategy or the innovation strategy of the federal state of North Rhine-Westphalia. However, there is a strong focus on the topics of waste and waste disposal, while the much broader approach of a circular economy is still not sufficiently perceived (Wilts et al., 2022b, p.69). Concerning the establishment of a circular economy as a cross-sectoral issue, there are unclear responsibilities. For outsiders, it is often not clear which of the various ministries on the federal state level in NRW is responsible for which specific individual topic. The relevance of various state policy strategies related to circular economy also does not yet appear to have been conclusively clarified and thus prevents the realisation of actually possible synergies, for example in the coordination of individual funding strategies (ibid., p. 74).

Preliminary conclusions

In contrast to the Netherlands, Germany has so far put forth declarations of intent but no clear goals that are reflected in precise indicators. Interview partners have confirmed that NRW as the largest German federal state has a lot of potential, but so far only isolated solutions are being pursued. Currently, it is the EU that is identified as the main driver for circular economy solutions. According to an interview partner from *Effizienz-Agentur NRW* (EFA), a roadmap for Germany is needed first, which then needs to be broken down to the individual federal states (Interview F, 2022).

Another interview partner from IHK Aachen has pointed out that the energy crisis has pushed back the issue of circular economy, but nevertheless it is on companies' agenda and he expects it will get more attention soon (Interview C, 2022).

A Zero Waste Impulse Program 2050 is being compiled under the responsibility of the Ministry of Environment. Also, a new unit of the Ministry of Environment is being set up within the transformation

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department to develop a strategy for circular economy and to pool existing approaches. The lead responsibility within the government will be shared between the Ministry of Economics and the Ministry of Environment in a common steering group (Interview A, 2022).

2.2.4.4 Citizens' awareness and consumer attitudes

Awareness of Circular Economy in Germany

The forsa Institute for Social Research and Statistical Analysis has conducted a representative population survey on the topic of circular economy in 2021. 1,009 citizens aged 18 and over in Germany were interviewed.

Only a minority of respondents (13 %) say that they have heard or read about the term "circular economy". The situation is different for the German equivalent term "*Kreislaufwirtschaft*": A majority of respondents (61 %) say they have heard or read about this term. Men and people over 60 years of age in particular say they know the term (forsa, 2021, p. 6; see Table 13).

Have basic knowledge of	**"Kreislaufwirtschaft"**	**"Circular Economy"**
Total	61 %	13 %
18 – 29 years old	55 %	17 %
30 – 44 years old	60 %	8 %
45 – 59 years old	62 %	15 %
60 and older	65 %	13 %

TABLE 12: SURVEY DATA ON THE AWARENESS OF CIRCULAR ECONOMY IN GERMANY BY FORSA (FORSA 2021, OWN PRESENTATION)

Concerning the question who is primarily responsible for ensuring a reduction in the consumption of raw materials in the manufacture of products, the respondents most frequently name the manufacturers of the products (87 %). 62 % of the respondents see the responsibility primarily with politics, while 45 % think that consumers are primarily responsible. Only a few see trade (25 %) and the waste management industry (10 %) as primarily responsible (ibid., p. 12).

A study by DNV (2022, see Table 14) shows that the level of familiarity with the circular economy in Germany is significantly above the average data in the category of "extensive knowledge" and active participation in circular actions with 43 %. Compared to the survey mean, there is a slightly lower share of respondents who have only heard of the terms but are not familiar with the specifics. The share of respondents who have stated that they are a professional in the field (6 %) is also lower than the survey mean (9.7 %).

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Level of familiarity with circular economy	I am a professional in the field	I have extensive knowledge and I actively participate in circular actions	I have heard of the terms, but I am not familiar with the specifics
Germany	6 %	43 %	51 %
Survey mean	9.7 %	35.2%	55.1%

TABLE 13: DNV SURVEY DATA ON FAMILIARITY WITH CIRCULAR ECONOMY, PARTICIPATING COUNTRIES: USA, UK, FRANCE, GERMANY, ITALY, BELGIUM, NETHERLANDS, NORWAY, FINLAND (DNV, 2022, OWN PRESENTATION)

Compared to other European countries (UK, France, Italy, Netherlands, Belgium, Norway and Finland) Germans tend to prefer personal research (49 %) over other sources of information for circular economy. Only 48 % of Germans trust media (including social media) as a source on circular economy compared to 61 % (arithmetic mean of UK, France, Italy, Germany, Netherlands, Belgium, Norway and Finland) of other European countries (DNV 2022, p.11).

Importance of sustainability as purchase criterion

According to the Global Sustainability Study 2021 by the consultancy Simon-Kucher & Partners, sustainability is a slightly important to extremely important purchase criterion in the eyes of 58 % of the people surveyed in Germany. Those in Germany who are willing to pay a premium for more sustainable products would accept additional costs of 18 % on average (Simon-Kucher & Partners, 2021, pp. 21 and 26). The willingness to pay for goods with recycled content is also influenced by the recognisability of the recycled materials, the perceived quality of the products and by the image of the product as well as the image of the producing company (Polyportis, Mugge and Magnier, 2022, p. 5).

When asked who are the most important actors to realise positive changes, the German interviewees see consumers as most important actors (29 %), followed by for-profit companies (27 %) (ibid., p. 18). According to a survey from the DNV only 3 % of Germans say that they do not have a role in the circular economy and 86 % say that they have a role in the transition towards a circular economy (DNV, 2022 p.13).

Awareness of Chemical Recycling

The University of Surrey (UK) analysed the perception of chemical recycling processes (gasification) in the UK and in Germany. Participants were asked to state their self-claimed awareness for gasification and afterwards participated in a test to determine their objective knowledge. 77 % of the German participants stated that they either do not have any knowledge or do not know if they have any knowledge while the objective testing held 67 % total inaccurate answers. In the same study, Jones, Lee and Kaklamanou (2022) surveyed the attitudes towards chemical recycling methods before and after an infomercial explaining the process of gasification and came to the conclusion that the general positive attitude could further be improved with additional information.

Preliminary conclusions

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The general attitude towards Circular Actions is rather positive, considering that only about 60 % of Germans feel well informed about circular economy. Most citizens are willing to participate in a circular economy and a general awareness for the importance of recycling is established in Germany.

The studies of Jones, Lee and Kaklamanou (2022) and Polyportis, Mugge and Magnier (2022) show that the attitude towards circular economy efforts and especially chemical recycling is directly linked to the availability of trustworthy and understandable information, which could be a challenge for German regions as the general awareness of both topics is very low and therefore susceptible to negative framing. Reaching enough citizens might become a challenge for the acceptance of chemical recycling plants as according to DNV (2022), only 47 % of Germans receive their information through media and 48 % of Germans prefer to collect their own information, which creates another chance for negative framing.

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2.3 Conclusion

This report portrays the region of *Rheinisches Revier* and analyses which regional conditions need to be present in order to introduce *hubs for circularity.* Its purpose is to assess what degree of readiness this region possesses to become a suitable pilot region to introduce PU circular solutions. In the course of this analysis, the following advantageous and disadvantageous conditions concerning the research question have been identified.

Rheinisches Revier is a changing region undergoing a major transition. Originating from a traditional coal mining area, there is now a need for a new economic focus and future-oriented industry. This momentum can be used as an opportunity that also comes with various funding options. The ZRR as the main player to coordinate the change in the region can support this transition substantially. There is, however, the need for more coordination and wider participation in the region.

Furthermore, the general infrastructure of *Rheinisches Revier* conjoined with the Rhineland shows a high level of accessibility due to the river Rhine and the convenient location of motorways and railways along the north-south and the west-east axes. This creates an asset and good geographical preconditions for industrial symbioses.

The region has an excellent research landscape with key innovation clusters as it is home to different high-quality research institutes such as in Aachen, Jülich and Cologne, which is a clear beneficial factor for its innovative power. In addition, the topic of 'circular economy' has recently gained higher priority, which opens up opportunities to establish *hubs for circularity*. However, the focus is not on circular solutions for durable plastics or even polyurethane. Bioeconomy, as an example, has been positioned much more prominently in the regional discourse.

Currently, a rather competitive mindset can be observed among businesses. A cooperative mindset and culture could benefit the industry as a whole and is necessary for the cooperative network a hub of circularity can thrive in.

The currently prevailing, cross-sectoral shortage of skilled workers in Germany is another concern that needs to be taken into account as sufficient qualified personnel in the region is needed to drive the change. Despite its strong R&D sector and workforce in relevant sectors, the region is facing the risk of "brain drain".

Zooming into the waste management in the region, its prerequisites can be called favourable as the important processes and structures are in place for the current linear system. However, what is missing is the driving force and pilot leader to give an impulse for the establishment of a closed loop. This is also due to the fact that there is a lack of clear policy goals and precise indicators, while the main responsibility on governmental level is yet to be determined.

The region is a functional construct without a political representation as a whole. For the establishment of *hubs for circularity*, the view needs to be broadened towards the Rhineland. The Rhine axis needs to be included to adapt to the spatial conditions such as industry, infrastructure, workforce, waste management and generation, citizens and consumers. This results in the challenge that the administrative boundaries become blurred and the governance structure unclear.

Finally, the public understanding of recycling may affect the suitability of the pilot region as a *hub for circularity* for PU hard foam. Public awareness on polyurethane and chemical recycling is low. Citizens

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and consumers are not well-informed on the topic and there is a high potential for negative framing, especially with regard to chemical recycling.

Overall, *Rheinisches Revier* unites important preconditions for circularity, when regarded in conjunction with the broader Rhineland area, and provided that it can use the momentum of the current structural change dynamics to its benefit.

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3 Pilot Region B: Upper Silesia / GZM

3.1 Introducing the Region: Silesia Voivodeship and GZM Metropolis

The Silesian Voivodeship is the most industrialised region, located in the southern part of Poland. It contributes significantly to the country's national economy and is characterised by the highest degree of urbanisation and population density.

It is traditionally seen as the energy and heat base of the country, whose position has been built on rich deposits of natural resources such as coal, zinc, lead, methane and natural gas. For years a highly developed heavy industry has been the flywheel of the national economy and built the region's advantage.

The province is well organised in terms of infrastructure. It has the densest network of motorways and highways in the country. Pan-European transport corridors run through it. It is also one of the country's largest scientific and academic centres.

The region is undergoing continuous transformation, the effects of which can be seen at various levels. Although the area is still home to the largest mining company in Europe and the largest hard coal producer in the European Union - PGG (Polish Mining Group), the share of mining and metallurgy in the entire industry is declining. On the other hand, the importance of new industries such as automotive, medical devices, new technologies and IT is growing.

The Upper Silesia - like any region in the process of restructuring - has to face economic, technological and social challenges. It can be observed that the region’s economic and social attractiveness, as well as its competitiveness measured by the level of innovation, is gradually decreasing in relation to other regions in the country. The problem is recognised by the regional representatives and authorities, who have developed a couple of energy transition action plans for the region.

Part of the Silesian Voivodeship is a 41 cities and municipalities metropolitan association - Upper Silesian and Zagłębie Metropolis (GZM), which covers part of the historic areas of Upper Silesia and Zagłębie Dąbrowskie. The reason for the creation of the GZM Metropolis is the functional and spatial links between the cities within its area. The core of the GZM Metropolis is formed by 13 cities with district rights, which are highly urbanised and in fact form one super-city. In addition, the metropolitan zone includes 28 municipalities around the core.

3.1.1 Geography

Silesian Voivodeship is located in the southern part of Poland. The region neighbours four provinces: Opolskie, Łódzkie, Świętokrzyskie and Małopolskie, and borders with Czech and Slovak Republics from the South. Within a radius of 600 km from Katowice, the seat of the voivodeship, there are six European capitals: Warsaw, Prague, Bratislava, Vienna, Budapest and Berlin.

Silesia Voivodeship covers an area of 12,333.09 km² and is inhabited by 4,403 thousand people (according to national census conducted in 2021). It means the highest degree of urbanisation and population density in relation to the national statistics (366 persons/km², national average of 123 persons/km²).

Silesian Voivodeship (Figure 1a) is a local government unit and administrative division of Poland, located in the area of the Silesian Lowlands, the Silesian-Cracow Uplands, the Oświęcim Basin, the Western Beskids Foothills, and the Western Beskids. It covers the eastern part of Upper Silesia and the

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western part of western Lesser Poland, including the Zagłębie Dąbrowskie, Zagłębie Krakowskie, Żywiec and Częstochowa areas.

The GZM is located in the central part of the voivodeship. It comprises 41 cities and municipalities with a total area of 2.5 thousand square kilometres, 2.2 million inhabitants, 240 thousand companies and enterprises, generating approximately 8% of Poland's GDP. By convention, the towns and communes that make up the GZM have been divided into five sub-regions (Figure 1b)

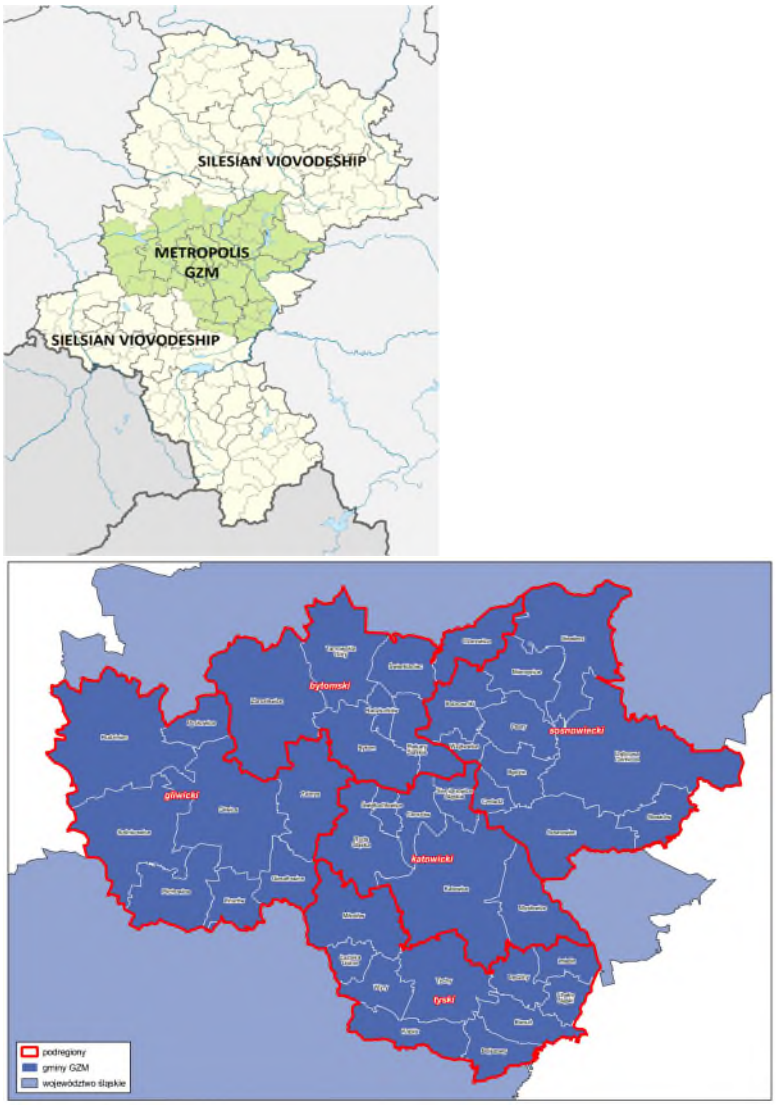

FIGURE 18: MAP FROM THE SILESIAN VOIVODESHIP (A) AND THE UPPER SILESIAN AND ZAGŁĘBIE METROPOLITAN AREA (B)

Source: https://infogzm.metropoliagzm.pl/mapy/Mapy.html

3.1.2 Policy

Poland is a parliamentary republic, a democratic state under the rule of law. Poland has a tripartite division of power into legislative, executive and judicial - these powers are exercised respectively by the Sejm and Senate, the Council of Ministers, the President and the ordinary courts. Poland is a unitary state, and the system of its local government is based on dualism, because in addition to the agencies

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of government administration, there is a local government, established by laws of the Sejm and Senate to carry out public tasks not reserved for other bodies of government. Its basic unit is the municipality.

Poland's territorial division underwent a major overhaul in 1999, when the number of provinces was reduced from 49 to 16 and districts were created, thus introducing three-tier self-government. The following are thus distinguished:

- municipal self-government;
- district self-government;
- provincial self-government

In 2017, in addition to the three-tier territorial division for the area of Upper Silesia and the Dąbrowa Basin, a Metropolitan Union was introduced, which can be placed in tiers between the country government and the provincial government. At the same time, only municipalities can be members of the Union.

Local government units (municipalities, counties and provinces) and the Metropolitan Union have legal personality and an assured share of public income.

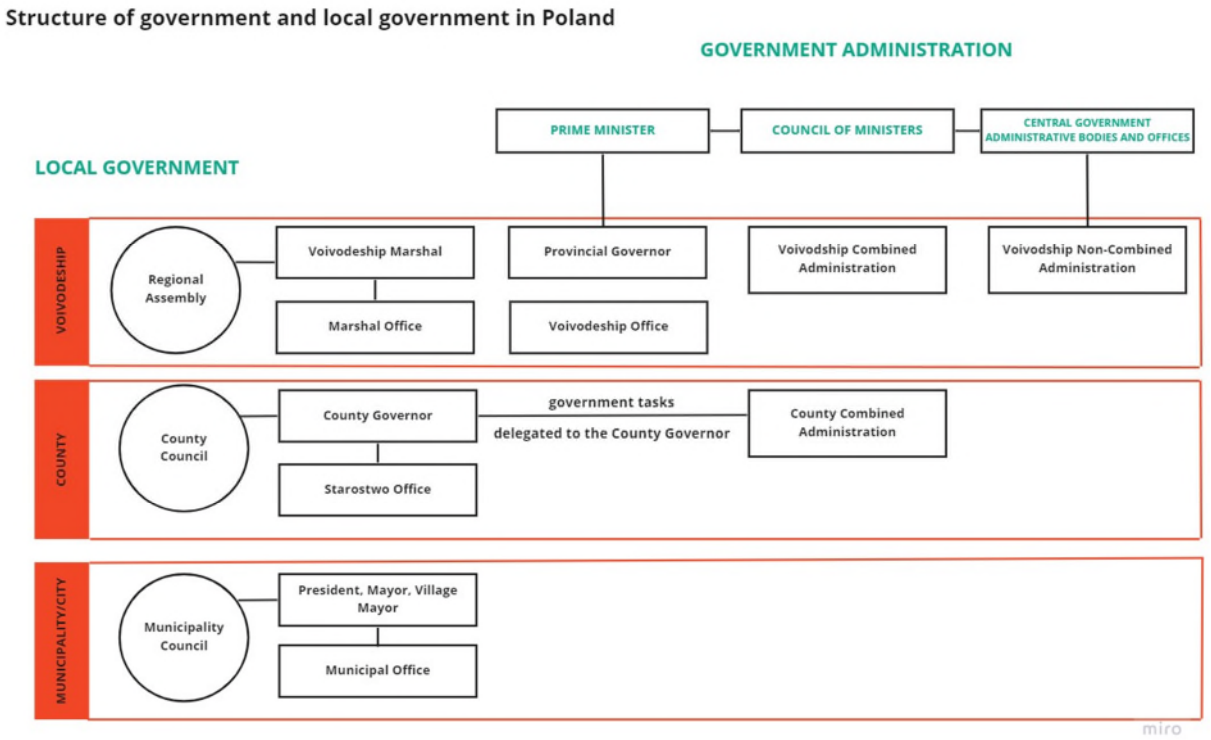

FIGURE 19: STRUCTURE OF GOVERNMENT AND LOCAL GOVERNMENT IN POLAND

Source: own elaboration

Silesian voivodeship is polycentric in character - administration, universities, cultural institutions, larger companies are mainly concentrated in the large cities of the agglomeration, such as Katowice, Sosnowiec, Bytom, Gliwice, Zabrze, Tychy and Chorzów (located in Metropolis GZM). The capitals of the subregions also play an important role: Rybnik, Bielsko-Biała and Częstochowa. It is the only voivodeship in Poland with more cities with powiat rights (19) than powiats (17). It is home to the largest metropolitan area in Poland – Metropolis GZM.

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According to the Polish statistical approach, as of 1 January 2021 (Eurostat, Local Administrative Units) (LAU), there are 97 units in Poland according to the NUTS classification (Nomenclature of territorial units for statistics): NUTS 1 - macro-regions (grouping provinces) - 7 units; NUTS 2 - regions (provinces or parts thereof) - 17 units; NUTS 3 - sub-regions (grouping counties) - 73 units. GZM is located as a part of: NUTS 1 - Southern Macroregion; NUTS 2 - Silesia Province. The GZM is composed of the following NUTS 3 parts: katowicki (in full); bytomski (in part); gliwicki (in part); sosnowiecki (in part); tyski (in part) (Figure 3).

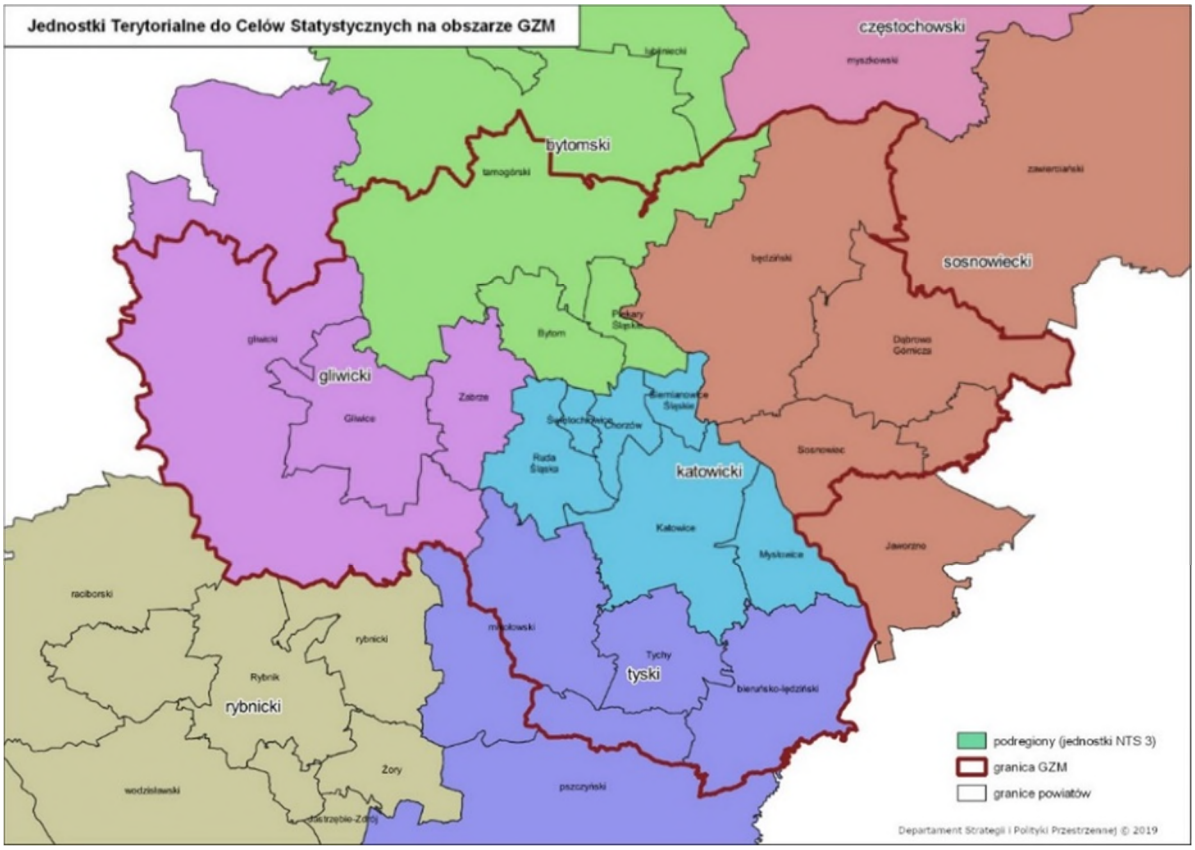

FIGURE 20: MAP WITH A DIVISION INTO TERRITORIAL UNITS IN THE GMU AREA

Source: https://infogzm.metropoliagzm.pl/mapy/Mapy.html

The voivodeship has legal personality, it also has legal and judicial capacity, so it can appear in civil proceedings as a party. On behalf of the voivodeship, the board of directors, as the executive body of the voivodeship, is authorised to carry out legal actions. In order for the self-government of the voivodeship to be able to fulfil its tasks and exercise its rights independently, it has been equipped with legal personality and its bodies are the voivodeship council and the voivodeship board. The basic tasks of the voivodeship self-government include matters relating to:

- public education, including higher education;
- health promotion and protection as well as social assistance and pro-family policy;
- culture and protection of its goods;
- modernisation of rural areas and environmental protection; water management, including flood protection;
- spatial planning;
- public transport and roads;
- physical culture and tourism;
- the protection of consumer rights;

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- public security and defence;
- counteracting unemployment and activating the local labour market.

The executive bodies of the Silesian Voivodeship self-government are:

- The Sejmik of the Silesian Voivodeship, composed of 44 councillors, directly elected. Its term of office lasts five years from the day of the election. Elections are held on the basis of the electoral regulations for commune councils, county councils and provincial assemblies. Elections to the Sejmik are held according to the proportional representation law.
- The Regional Assembly of the Voivodship consists of 5 members.

Metropolis GZM is a metropolitan association located in the Silesian Voivodeship, in the area of the Upper Silesian conurbation. Residents of Upper Silesia and the Dąbrowa Basin have long felt that they function in a single, cohesive urban organism, and that the boundaries between the cities are purely conventional. The creation of a metropolis in the center of the Silesian Voivodeship was only natural.

The metropolis was established on the basis of the Act of 9 March 2017 on the metropolitan association in the Silesian Voivodeship, and its name, seat and scope were defined by the Regulation of the Council of Ministers of 26 June 2017. The metropolitan association was established on 1 July 2017, with the implementation of its tasks commencing on 1 January 2018. The boundaries of the GZM Metropolis established in 2017 covered 41 municipalities, including 13 cities with county rights and 13 urban municipalities.

The most important **objective of the GZM** is to undertake activities that will improve the quality and comfort of life by introducing common solutions. The GZM wants to utilise the potential of the member municipalities, stimulate the creativity of the inhabitants and inspire changes that will enable the acceleration of economic and social processes, leading to the creation of a growth centre that can compete with other metropolitan areas.

The tasks of the GZM Metropolis are set out in the special law under which it was established. These include:

- public transport
- socio-economic development
- spatial order formation
- promotion

The organs of the GZM are the Assembly and the Board.

The rules and procedures of the management board are defined in the statutes of the metropolitan union. **Metropolis GZM has no legislative competence in the sense of creating laws and regulations related to the circular economy**. Municipalities have the possibility of entrusting some of their tasks to the GZM, which may perform public tasks belonging to the scope of activity of the municipality, county or voivodeship government or coordinate the implementation of those tasks on the basis of an agreement concluded with a local government unit or an association of local government units. In addition, in the event of such a will of the parties, the GZM may perform public tasks belonging to the scope of government administration on the basis of an agreement concluded with a government administration body.

The basic unit of local government is the **municipality**. The municipality's sphere of action includes all public matters of local importance not reserved by statute for other entities (such as: district, voivodeship or state administration).

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The public tasks performed by the municipality can be divided into own tasks and commissioned tasks. The municipality's own task is to satisfy the collective needs of its inhabitants, and in particular its own tasks e.g: spatial order, real estate management, environmental and nature protection and water management, water supply and water supply, sewerage, removal and treatment of municipal sewage, maintenance of cleanliness and order and sanitation, dumping grounds and disposal of municipal waste (the municipality's tasks include the entire management of municipal waste in its area), supply of electricity and heat and gas.

3.1.3 Population: Sociodemography

According to the final results of the National Population and Housing Census 2021, population of the region is decreasing. In 2021 there were 4.403,000 inhabitants, of which 51.8% were women and 48.2% men (Fig 4). The population was 4.9% smaller (nationally it decreased by 1.2%) compared to the 2011 census. At the same time, 1,815.7 thousand dwellings were located in the voivodeship,

6.9% more than in the 2011 census[12].

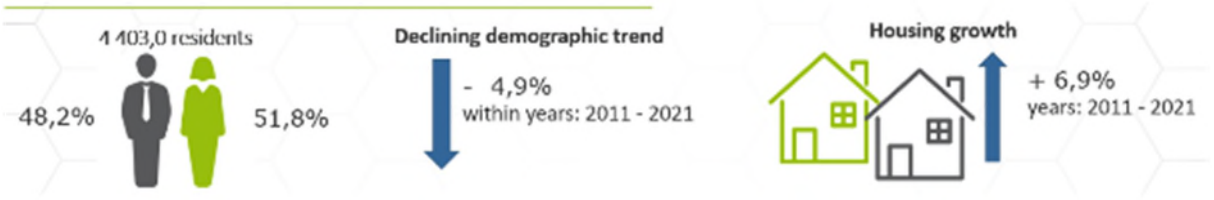

FIGURE 21: CHARACTERISTICS OF THE REGION – POPULATION AND HOUSING

Source: The Central Statistical Office, 2021. Stan i struktura demograficzna ludności oraz liczba budynków i mieszkań w województwie śląskim – wyniki ostateczne NSP 2021 [The state and demographic structure of the population and the number of buildings and flat in the Silesian province - final results of the national census 2021], https://katowice.stat.gov.pl/download/gfx/katowice/pl/defaultaktualnosci/1265/5/1/1/nsp_2021_-_wyniki_ostateczne.pdf

In terms of regional population size, a further decrease is expected. In 2050 the population of the Upper Silesia is estimated at 3,680,615. 59.1% of Silesian residents are of working age, 17.2% are of pre-working age and 23.7% of residents are of post-working age.

According to statistics, industry sector plays a significant role in the region's employment structure. In 2019 the average employment in the business sector in the Silesian Voivodeship was 793.3 thousand people (12.4% of the average number of employees in the country), which ranked the region 2nd in the country. At the same time a high share of those working in industry was still observed (in 2019, the share was 38.3% and was higher than the result for the whole country by 6.2 percentage points).

A significant problem of the regional labour market is the low economic activity of the population, including women (in 2019, the number of economically inactive people in the region amounted to 1,707 thousand people, which was the second position after the Mazowieckie Voivodeship - 1,726 thousand people) and the high territorial diversity of unemployment. The highest level of unemployment in February 2021 was recorded in Bytom (10.4%). Unemployment rates below 3% remain in the Bieruń-Lędziny county (2.9%), Bielsko-Biała (2.7%) and Katowice (1.8%). The long-term

[12] The Central Statistical Office, 2021. Stan i struktura demograficzna ludności oraz liczba budynków i mieszkań w województwie śląskim – wyniki ostateczne NSP 2021 [The state and demographic structure of the population and the number of buildings and flat in the Silesian province - final results of the national census 2021], https://katowice.stat.gov.pl/download/gfx/katowice/pl/defaultaktualnosci/1265/5/1/1/nsp_2021_-_wyniki_ostateczne.pdf

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unemployed at the end of February 2021 accounted for 42.7% of the total registered unemployed. The share of disabled unemployed among the total registered was 5.8%. At the end of February 2021. 23.9% of the registered unemployed were under 30 years of age, while 26.4% were over 50 years of age. The unemployed population of the Silesian Voivodeship is dominated by women, who accounted for 54.7% of the total registered in February 2021. Both the unsatisfactory dynamics of economic development and the lowest economic activity rate of the population in the country are significant obstacles to building a modern economy and accelerating the process of moving away from coal and achieving climate neutrality targets.

The negative migration balance and the related strong depopulation and population ageing processes can also be noted in the region. The outflow of human capital, especially mobile people (in terms of age and competence) and intellectual capital, in the form of innovative start-ups, investors and business concepts to other regions and countries, has been a phenomenon observed for a long time. According to forecasts of the Central Statistical Office, by 2050 the population of the Silesian Voivodeship will decrease by 18.8%, i.e. by more than 850,000 people, compared to 2018. This figure analysed in absolute terms is the highest in the country. The changing age structure of the region's population is associated with the need to provide adequate social service infrastructure necessary to take care of dependent persons. This will require special support for the social assistance system, due to the problem of the decreasing number of family/informal carers able to undertake caring responsibilities. Matching the social policies in place to the needs of all residents of the transition area is particularly important to increase the social and professional activity of the residents of the transition area. In the coming years, the demand for a workforce doing simple, repetitive jobs will be significantly reduced and occupations requiring higher, more specialised skills and characterised by a high degree of creativity will become very important. New skills will be sought to provide human resources for, among others, Industry 4.0, ICT, medicine, energy, circular economy industries or aerospace, which are replacing traditional industries. It is therefore necessary to increase the share of resources allocated to innovation and R&D activities in the region and to develop automation in industry while supporting workers to adapt to new labour market requirements.

The GZM, as of 31.12.20, has a population of 2.2 million, i.e. 49.6% in the Silesian Voivodeship and 5.8% in the country. The population density is 865 persons per 1 km², the highest in the country. The natural increase is minus 7.55 per 1,000 population and the migration balance is minus 1.41 per 1,000 population.

LEVEL OF EDUCATION

There are 30 higher education institutions in the Silesian region (Figure 5), including universities, technical schools, economic schools, pedagogical schools, among others. Among the best-known universities are: Silesian University in Katowice, University of Economics in Katowice, Silesian University of Technology in Gliwice, Silesian Medical University in Katowice, Academy of Fine Arts in Katowice and Karol Szymanowski Academy of Music in Katowice, Częstochowa University of Technology, Technical and Humanities Academy in Bielsko-Biała.

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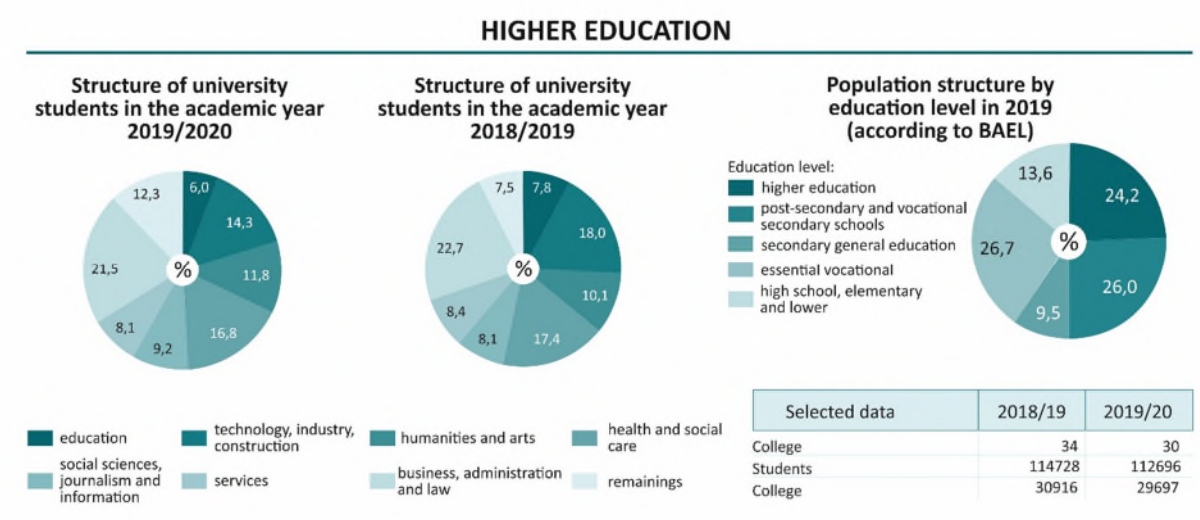

FIGURE 22: STRUCTURE OF EDUCATION INSTITUTIONS IN THE SILESIAN REGION

Source: The Central Statistical Office, 2020. Vademecum Slaskie. Portret Województwa [Vademecum Slaskie, A portrait of a region] https://katowice.stat.gov.pl/vademecum/vademecum_slaskie/portret_wojewodztwa/wojewodztwo_slaskie.pdf

The structure of post-secondary schools in Silesia indicates the largest share of general secondary schools (34.5%), technical schools (22.0%) and post-secondary schools (21.5%). On the other hand, analysis of the percentage of students (Figure 6) by school type distinguishes two main categories: high schools (37.6% of students) and technical schools (35.3%). In relation to the national average, the Silesian Voivodeship has a higher share of technical schools (about 1.5 percentage points), post-secondary schools and general art schools giving vocational qualifications (about 1 percentage point).

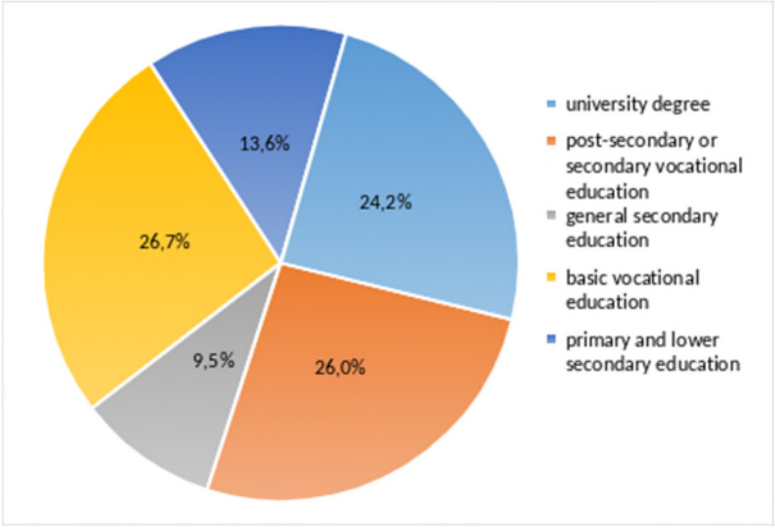

FIGURE 23: POPULATION STRUCTURE BY EDUCATION LEVEL IN 2019

Source: Potentials and development challenges of the Silesian Voivodeship in the context of just transition. Differentiation of the area of mining sub-regions. Annex no. 2 to the draft Territorial Plan of Just Transition of the Silesian Voivodeship 2030 [Katowice, 2022] https://transformacja.slaskie.pl/images/Dokumenty/1646921120_za_C5_82.-2-potencja-c5-82y-i-wyzwania-rozwojowe.pdf

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3.1.4 History and Identity

Since ancient times, ore mining, including silver and lead (Bytom, Tarnowskie Góry, Toszek) and iron ore mining (the region of the Liswarta, Mała Panew, Stoła, Bierawka, Ruda river valleys and the ore-bearing range Wieluń - Zawiercie) developed on the territory of the present Silesian province. Forest forging survived until the 14th century, later developing into workshop and riverside forges. The Cistercians, who arrived in Silesia in the 13th century, were also involved in mining and metallurgy, owning forges in Trachy (Sośnicowice commune) and Stanica (Pilchowice commune). Through the Cistercians, glassmaking also developed.

In the mid-18th century, the development of industry in Europe brought significant socio-economic changes to Upper Silesia. An important stage in the development of industry was the establishment of the Higher Mining Authority, based in Breslau, headed by Wilhelm Friedrich von Reden in 1779. Thanks to him, new technologies, machinery and qualified personnel were brought to Upper Silesia. The development of industry led to the activation of local feudal lords, who saw in it an opportunity to multiply their estates. Industrial tycoons included magnate families, including the Donnersmarcks, Ballestrems, Schaffgotschs, Hochbergs and Hohenlohe. Larger industrialists had stakes only in the zinc industry, e.g. Godula, Winckler. Raw material-rich areas were covered with mine shafts, heaps and smelting furnaces, and new towns were built. In parts of Austrian Silesia, the symbol of industrialization was Bielsko, where mostly textile factories were established. The development of industry necessitated the expansion of infrastructure to meet the needs of the growing transportation of raw materials and finished products. New routes and railroad stations were built. Throughout the 20th century, metallurgy in Silesia was at the forefront of European technological development. During the same period, mining, integrally connected with metallurgy, underwent significant transformations, including as a result of the development of coal mining technology (Syska, Wozniakowska, 2019).

The Silesian Voivodeship as a region has a history of more than 100 years. The Silesian province was first established in the interwar period within the borders of the Second Polish Republic. Following the Nazi aggression against Poland on October 8, 1939, the Silesian Province (Gau Schlesien) was established, with its headquarters in Wroclaw, which included the lands of the described region. In 1941, an administrative division of the Silesian Province (Provinz Schlesien) took place, resulting in the creation of the Upper Silesian Province (Provinz Oberschlesien). After the war, between 1945 and 1950, there was the Silesian Province (commonly referred to as the Silesian-Dabrowa Province), which covered the vast majority of the territory of today's Silesian Province (excluding the area around Częstochowa, Zywiec and Jaworzno) and the Opole Province (excluding Brzeg and Namysłow). In 1950, the Silesian-Dabrowa province was divided into the Opole and Katowice provinces. The latter had borders similar to those of today.

The current Silesian Voivodeship was created in 1999 from part of the territories of the previous administrative division of Katowice, Bielsko-Biala and Częstochowa provinces. Within the current borders of the province, about 48% of the area is historic Upper Silesia, 45% of the area is Lesser Poland and about 7% is Greater Poland.

Today, the region of Upper Silesia is seen by many as possessing a strong identity which combines historically inscribed national and ethnic minorities, as well as cultural diversity, which manifests itself in language, traditions which strongly emphasise the historical and contemporary regionalism of Upper Silesia. The Silesian Voivodeship is also the largest concentration of historic industrial buildings in Poland. The province's technical monuments are an integral part of its cultural heritage.

The contemporary identity of Upper Silesia is to be found both in the difficult and intricate historical memory of the region and in all activities aimed at the contemporary manifestation of Upper Silesian

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specificity in a cultural and social, but also economic and political context. Thus, we see efforts to preserve the cultural diversity stemming from the ethnic and national minorities living in the region, including efforts to formalise the regional speech as the Silesian language. In the context of regional identity, we must not forget the unique landscape of Upper Silesia with its red familocas and mine shafts, which are increasingly becoming symbols of shopping centres (Silesia City Center) or museums (Silesian Museum). An important aspect is Silesian religiosity, regional heroes and artists or traditional Silesian cuisine. But Upper Silesia is also a strong economic and business region in Poland, whose representatives are striving to achieve economic autonomy for the region within the borders of the present-day Republic of Poland. The identity of Upper Silesia therefore breaks through in many areas of life, creates a strong sense of the "we" community and a foundation which distinguishes Upper Silesia from other regions of Poland (Szczepański, Śliz, 2018). Thus ethnic and regional identity is often the dominant one. It can became so significant that Upper Silesian's habitants consider themselves as members of separate, Silesian nation (Kijonka, 2017).

HISTORY OF THE FORMATION OF THE GZM METROPOLIS

Residents of Upper Silesia and the Dąbrowa Basin have long felt that they function in a single, cohesive urban organism, and that the boundaries between the cities are purely conventional. The creation of a metropolis in the center of the Silesian Voivodeship was only natural.

In 2006, the Upper Silesian Metropolitan Union was established, which became the beginning of the future Upper Silesian and Zagłębie Metropolis (GZM). It included 14 of the largest cities in the Silesian conurbation.

The law establishing the metropolis in the Silesian Voivodeship was signed in Katowice on April 4, 2017 by the President of the Republic of Poland. On June 29, 2017, a decree of the Council of Ministers was issued on the establishment of a metropolitan union called the "Upper Silesian-Zagłębów Metropolis." Two days later - on July 1, 2017 - the Metropolis was established. The first Assembly was held on August 29, 2017, while the Metropolis Board was elected on September 12, 2017. Over the next few months, the structures of the MGA were built. As of January 1, 2018, the Metropolis began carrying out its statutory tasks.

SUMMARY

- As a result of economic and social changes a phenomenon of depopulation is visible in the Silesian Voivodeship. The population decline is very clearly noticeable in the area of the GZM (negative value of natural increase, outflow of population from cities to rural areas). It points to serious problem of an aging population.
- The Silesian Voivodship is characterized by low economic activity of the population - the professional activity rate has one of the lowest values in Poland last years. The voivodeship dominates in share of employment in the mining industry (almost 80% of those employed in mines in Poland and 43% of those employed in the EU) (Alves Dias et al., 2018).
- 8.5% of the total number of students in Poland study at 30 Silesian's Voivodship universities. The specificity of the region is well-developed vocational education
- Ethnic and regional identity is often the dominant one. It can become so significant that Upper Silesian's habitants consider themselves as members of separate, Silesian nation.
- The three-level administrative division of Poland, into voivodships, poviats and communes defines the competences of the public administration. These competencies are not always convergent - in consequence three-level administrative division hinders cooperation and may be a significant barrier to the implementation of a circular economy uniform system in the

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long term. In addition, Metropolis GZM has no legislative competence in the sense of creating laws and regulations related to the circular economy.

3.2 Regional Readiness for Introducing Hubs for Circularity

3.2.1 State of regional transformation

The Silesian Voivodeship is one of the most heavily urbanized and populated regions in Poland (urbanization level 76.1%, population density 366 persons/km2). This fact and the long-lasting processes associated with industrial development have led to environmental changes unparalleled anywhere else in Poland. The restructuring of the province's industry has resulted in the creation of large areas of post-industrial land in need of reclamation. This process has been going on for many years, leading to the creation of new areas, with new functions.

Upper Silesian Industrial District (GOP), which is the largest such area in Poland, is located in the northern part of the Upper Silesian Coal Basin, in the Silesian Voivodeship. It includes 14 large cities concentrated in the central part of the Silesian Voivodeship (Upper Silesian Conurbation): Będzin, Bytom, Chorzów, Czeladź, Dąbrowa Górnicza, Gliwice, Katowice, Mysłowice, Ruda Śląska, Siemianowice Śląskie, Sosnowiec, Świętochłowice, Tychy, Zabrze and surrounding industrialized areas. GOP covers area of about 3,200 square kilometers, where live about 3.5 million inhabitants (more than 1,000 people per square kilometer), of which about 2.8 million are urban.

The GOP is one of the regions with the highest environmental risk in Poland. Dust and gas emissions amount to about 21% of the air pollutants emitted in the country; 32% of the industrial and municipal wastewater generated in the GOP area is discharged into surface waters without treatment - is especially in terms of saline mine waters. There are also huge changes in the geographic environment of the region as a result of mining damage (extensive pits, dumps, sinkholes resulting from rock bursts). The GOP's rail network is the densest in Poland and is mainly used for freight transportation; passenger transport is mainly handled by public transportation. In the GOP also is a heavily developed railroad hub, with 12 rail lines branching out from it. There is also an important waterway -- the Gliwice Canal which connect the GOP with the Oder River.

After 1945, large housing estates were built on the periphery of the GOP (in Tychy, Pyskowice, Dąbrowa Górnicza, Piekary Śląskie, Bytom-Radzionków). The largest service, cultural and scientific center of the GOP is Katowice (Encyklopedia PWN). Former post-industrial sites have been partially turned into recreational areas, such as the Silesian Park on the border of Katowice and Chorzow, commercial facilities, such as the Silesia City Center complex on the sites of the former Kleofas mine, cultural facilities, such as the Silesian Museum in Katowice created on the sites of the former Katowice mine. Silesian Museum in Katowice created on the site of the former Katowice mine, or areas serving innovative entrepreneurs, e.g. the Euro-Center Science and Technology Park in Katowice (the site of a former chemical industry equipment factory) or Nowe Gliwice in Gliwice (the site of the former Gliwice mine). Post-industrial sites are also used to locate on them equipment that obtains energy from RES (e.g., a photovoltaic farm on the site of the former Jaworzno power plant ash dump). An interesting form of developing former post-industrial sites, while preserving their historical values, are the excavations of the Guido mine and Luiza shaft in Zabrze, which have been adapted for museum-tourist purposes, or the admits of the former silver mine in Tarnowskie Góry.

Since the Silesian Voivodeship is a heavily industrialized and highly urbanized region, it is normal to visit two or even three cities unnoticed during a walk in one park. For many years, traditional industry has driven the development not only of the region, but also of the whole country. Thinking "Silesia"

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one has the characteristic mine shafts and factory chimneys before one's eyes. At the same time, for the past 30 years the Silesian province has been undergoing a process of transformation, the results of which are:

- A gradual change in the economic structure,
- development of new sectors, including those based on new technologies,
- greater concern for the environment and the quality of life of residents.

Although the number of people directly involved in mining has declined from about 400,000 to about 72,500 over these 30 years, the Silesian Voivodeship still remains the largest mining region in the European Union, and the biggest EU-wide transformation challenge is still ahead of the province (Just transformation, no date).

It is worth noting that the Silesian Voivodeship is the largest mining region in the European Union, posing the biggest transformation challenge in the EU, and the transformation itself will involve some 1 million workers out of the region's 4.6 million inhabitants.

3.2.1.1 Vision & Narrative

SILESIA 2030

On October 19, 2020, with a resolution of the Silesian Voivodeship Assembly No. VI/24/1/2020, the councilors adopted the "Silesia 2030" Strategy for Development of the Silesian Voivodeship. The Development Strategy of the Silesian Voivodeship "Silesia 2030" is an update of the Development Strategy of the Silesia Voivodeship "Silesia 2020+", adopted by the Sejmik of the Silesian Voivodeship on July 1, 2013, and constitutes the fifth edition of this key document defining the objectives of the region's development and the instruments for their implementation in the 2030 perspective.

The presented vision of development is a continuation and detailing of the strategic thought already implemented since 2000 in successive editions of the Strategy. It increasingly consciously addresses the issues of transformation of the region taking into account respect for the environment - Green Silesia. The outlined issues and directions show the way and tools for significant economic changes leading to stimulation of the pace of economic development of the region based on the dynamically developing sector of innovative enterprises. The " Silesia 2030" strategy also responds to demographic challenges facing the Silesian region and those related to improving living conditions in the region, both for its current and future residents. Implementation of the strategic provisions that make up the aforementioned vision will require the involvement of numerous entities of the regional scene (Development Strategy…, 2020).

JUST TRANSITION TERRITORIAL PLAN FOR THE SILESIA VOIVODESHIP

According to the issuance of December 5, 2022. European Commission Executive Decision No. C(2022)9041, the Board of Directors of the Silesian Voivodeship adopted on December 15, 2022 Resolution No. 2267/382/VI/2022 adopting the program European Funds for Silesia 2021-2027 (European Funds…, no date).

According to Just Transition Territorial Plan of the Silesia Voivodeship 2030 (JTTP), the Silesian Voivodeship, in particular its seven mining sub-regions, make up the largest mining area in Europe, which faces a huge challenge in meeting the EU's climate challenges. According to the European Union's climate and energy policy, the ambitious goal is to achieve climate neutrality by 2050. This goal lies at the heart of the European Green Deal, a document that responds to climate and environmental problems affecting EU citizens. The document also aims to transform the Union into a just and

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prosperous society living in a modern, resource-efficient and competitive economy, with economic growth not coming at the expense of natural resource use.

The assumption of achieving climate neutrality by 2050 is also in line with the EU's commitment to global climate action under the Paris Agreement. In addition, in line with the European Commission's proposal, the European Council approved a binding EU target to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. In addition, the EU target of a 40% share of RES in gross final energy consumption was increased.

In order to establish a stable framework for a sustainable, economically efficient and equitable transition to a low-carbon economy in Poland, the National Energy and Climate Plan 2021-2030 (hereinafter: NERP) sets climate and energy targets to be achieved at the national level by 2030, viz:

- 7% reduction in greenhouse gas emissions in non-ETS sectors compared to 2005 levels;
- 21-23% share of RES in gross final energy consumption (the 23% target will be achievable if Poland is granted additional EU funds, including those earmarked for a just transition), taking into account:
- an annual increase in the share of RES in heating and cooling by 1.1 percentage points on average per year.
- a 23% increase in energy efficiency compared to PRIMES2007 projections;
- a reduction to 56-60% of coal's share of electricity generation.

At the same time, it should be borne in mind that due to the increase in climate targets at the EU level, the provisions of the NAPE, including those on climate and energy targets for the time being, are assessed as unambitious and need to be updated.

With the long-term goal of climate neutrality adopted by the EU by 2050, the Silesia Voivodeship faces a huge challenge to carry out a just transition, including energy transition, which will require changes at the social, economic and technological levels and a shift from carbon-intensive industries and energy sources to clean energy technologies. The transition to a climate-neutral economy is both an urgent and difficult challenge for the region's communities and an opportunity to build a better future based on the new economy. Given the scale of the challenge, the process of achieving climate neutrality will require phasing in the changes being made. The main area of activity in the Silesia Voivodeship related to the implementation of the provisions of the NAPE is energy transition and the associated reduction in the use of coal for electricity and heat production. In the province, this will translate into the gradual closure of mines due to the decline in demand for thermal coal in all sectors of the economy, as well as the restructuring of the conventional energy sector by extinguishing obsolete power units built in the 1970s and 1980s and replacing them with modern infrastructure that is friendly to the environment and residents. Complementary measures will be implemented aimed at developing new energy sources, improving energy efficiency and developing zero-emission transportation. Another stage of the transformation will be the reduction of emissions in non-ETS sectors.

It should be added that due to the scale of the challenges currently facing the region, the planned activities to achieve the EU climate goals go beyond the intervention planned under the Just Transition Fund. The development policy pursued by the Board of the Silesia Voivodeship is clearly defined and focused on the green economy. The Silesian Voivodeship is working intensively and taking a number of measures to achieve the set climate neutrality goals, resulting directly from the provisions of the Development Strategy of the Silesian Voivodeship "Śląskie 2030" - Green Silesia and the Policy of low-carbon economy for the Silesian Voivodeship. Regional Energy Policy until 2030, and related to, among other things, improving energy efficiency, reducing emissions (including carbon dioxide) and developing RES. In addition, since 2017, the Silesian Voivodeship has had an Anti-Smog Resolution

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(Resolution No. V/36/1/2017, 2017), the main objective of which is to improve air quality by replacing inefficient and emission-intensive heat sources in households. The Board of the Silesia Voivodeship is taking initiatives to tighten the provisions of the indicated Resolution.

The aforementioned scale of challenges and the need to stage the transformation process is due to the fact that the Silesia Voivodeship is the largest mining region in the EU, whose economy is largely based on fossil fuels and industries characterized by high intensity of greenhouse gas emissions. At the same time, the region ranks high in terms of both production and consumption of electricity in the country (3rd and 2nd, respectively, with respect to the other provinces), so actions taken in the transformation area are necessary to achieve the set targets at the national level. The transformation process will require a change in the generation structure and development of the energy sector, which will result in the need to implement, in the Plan area, the next stage of restructuring the mining sector.

It is assumed that, as part of the planned transformation process in the Silesia province, by 2030 the following mines will be closed down: the Ruda and Boleslaw Smialy, Sośnica Mines, as well as organizational changes at the RUDA MINE (merging the Bielszowice and Halemba Mines) and the Staszic-Wujek MINE (resulting from the merger of the Wujek and Murcki-Staszic Mines). The gradual shutdowns of the indicated mines will result in a decline in hard coal output by 7.1 million tons per year - from 30 million tons per year in 2021 to 23 million tons per year by 2030. The reduction in output will account for 62% of the national reduction in coal output planned under the NAPE by 2030 and will contribute to the NAPE's goal of reducing the share of coal in electricity generation. The indicated activities will also contribute to reducing methane emissions into the atmosphere. The analyzed mines currently emit methane at a level of 62.4 million m3/year[13]. In addition, it should be borne in mind that mines scheduled for decommissioning after 2030 will also see a gradual reduction in coal production, which will further contribute to a decrease in raw material production and methane emissions.

At the same time, it is estimated that due to the transformation of the region's power sector and the gradual closure of coal-fired units by 2030, there will be a decrease in the production of electricity from conventional units (whose decommissioning or significant reduction in production is planned by 2030) by nearly 80%, i.e. from 14,403.5 GWh in 2019 to 3,079 GWh. It should be emphasized, however, that in order to ensure energy security, the reduction in coal-fired power generation must be synchronized with the corresponding increase in available capacity, and the forecast of power generation depends on many factors (e.g., fuel prices, the amount of energy demand). It is also assumed that the planned reduction in coal-fired power generation will translate into a 62.1% reduction in CO2 emissions (from 13.2 million tons in 2019 to 5 million tons in 2030). The changes being implemented in the mining and energy sectors will result in a significant reduction in jobs and the need to develop new industries to reduce the negative effects of the transformation related to the labor market area. The JTTP provides support for the process of diversifying the region's economy and raising its level of innovation, including the development of the R&D sector in the area of regional smart and technological specializations.

The change in the energy system will result in the need to develop renewable energy sources. The JTTP provides support for this type of investment as an important element of diversification of generation sources in the regional energy mix. Implementation of the indicated measures will contribute to the achievement of climate targets for RES. It has been estimated that the planned intervention in this area will translate into an additional renewable electricity generation capacity of 265,074 MWh of energy per year. At the same time, the planned development of RES will further reduce CO2 emissions by 89,262.1 tons. In addition, in order to ensure energy security and avoid negative socio-economic

[13] Based on data obtained from the Polish Mining Group S.A.

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effects of the transformation of the electric power sector, it is planned to build new gas-fired (transitional fuel) power units in the location of existing utility power plants[14].

Process of equitable transformation of mining sub-regions of the Silesia Voivodeship, its scope will include an area characterized by one of the largest areas of built-up and urbanized land in the country (in 2018 - 12.8% of the area of the province). The area is also characterized by the highest use of land for residential purposes (in 2018 - 4.1% against the national average of 1.1%), and many buildings do not meet energy standards.

3.2.1.2 Transformation Paths

According to the Development Strategy of the Silesia Voivodeship "Silesia 2030" (Development Strategy…, 2020), the vision of the development of the Silesian Voivodeship will lead to the creation of a region with a new, positive image that will occupy an important position in the development processes of Europe. The Silesian Voivodeship will be a region:

- creating development opportunities for residents, providing a sense of public, economic, health and social security,
- with a strong cultural identity and a high degree of identification with the region,
- with an established, positive image of a modern and attractive region,
- effectively responding to emerging changes in the environment,
- in which a modern, innovative and diversified economy, medicine, culture and education ensure the maintenance of its position as one of several centers of civilization development in Poland and Europe,
- enabling the development of knowledge and competence in strong scientific and research units,
- constituting a territorially balanced area, basing its development on a system of: metropolises, agglomerations, cities and strong rural areas, balancing functions and maintaining regional cohesion,
- emphasizing cooperation and participation of local communities in subregions that are well organized and shaped in organizational, social and economic terms,
- shaping its economic, spatial and environmental policies responsibly,
- creating conditions for a healthy and active life in a high-quality environment and ensuring the preservation of the biodiversity of areas,
- with high natural, cultural and landscape values, as well as tourism and recreation,
- which is part of the most important infrastructural systems of Europe,
- open to national and international cooperation.

Building the future of the province is primarily about taking advantage of existing potentials and values that constitute the uniqueness of the region. These values include: respect for tradition, local and national culture, hardworking, strong intergenerational and family ties, social integration, hospitality and openness, and the ability to cooperate. Building the future also means creating new values such as creative and innovative attitudes, and the ability to act in networks.

In addition, the Report on the State of the Silesian Voivodeship for 2019 (State of the Province Report, 2019) diagnosed the challenges facing the Silesian province:

[14] Based on the draft Social Agreement on the transformation of the electricity sector and the lignite mining industry, including the spin-off of coal production and mining assets from state-owned companies.

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- the region is the most coal-dependent region in Poland. Mining continues to play an important role in the regional economy, although due to declining productivity and low profitability, a gradual decline in the mining industry's contribution to the region's Gross Value Added (GVA) is evident, from 9.8% in 2000 to 5.6% in 2016,
- the mining sector still employs about 72,500 people, accounting for about 4.9% of the region's total employment (2018 data). According to estimates, one job in mining generates 2 to 4 jobs in peri-mining sectors,
- mining activities are heavily concentrated in the central and western parts of the region, but the area of influence of the coal mining sector is much wider due to where people working in mining live. The high geographic concentration in a limited area means that these areas will bear most of the costs of coal phasing out,
- mining has a strong impact on the environment and space. The Silesia province has the highest percentage of degraded and devastated areas in the country and a relatively low rate of reclamation and development of these areas (65 hectares/year in 2018). Particularly challenging are mining areas, often located in the center of cities, and the so-called dumps, created as a result of coal mining and processing (as many as 138 dumps out of 153 nationwide are located in the Silesian province),
- in mining municipalities, the phenomenon of depopulation is particularly intensified (it is estimated that by 2030 the population decline in the Silesian province will be: -5.7%, including mining municipalities: -8.5%, non-mining: -2,7%),
- Among people employed in the mining industry are approximately 90% male. There is also an overrepresentation of middle-aged people in the employment structure compared to other sectors - about half of those employed in the mining sector are aged 30-44, compared to 43% in other sectors. Early retirement of people working e.g. in mining may create situation that people in their prime will leave the labor market,
- mining companies are responsible for an important share of tax revenues in many mining municipalities. Decommissioning of mines may reduce the investment capacity of municipalities, burdening them with a possible increase in expenditures on social security and elimination of the environmental effects of mining activities (Nie ma problemów…, 2020).

3.2.1.3 Projects / Funding

The costs of restructuring the mining sector will amount to an estimated PLN 200- 250 billion. This is the amount according to a study by the University of Economics in Katowice commissioned by the Mining Chamber of Industry and Commerce. Under the regional program "European Funds for Silesia 2021-2027" approved by the European Commission, the Silesian region is to receive €5.1 billion. This is the largest funding for a single region not only in Poland, but in the entire European Union. Depending on the EURexchange rate, it is 23 or 24 billion PLN. At the same time, the government's draft law on the Silesia Transformation Fund envisages 800 million zlotys over a period of 10 years from 2024 for the modernization of the "industrial heart of Poland".

The Territorial Fair Transformation Plan, as required by the EPiR 2021/1056, shall present an indicative list of operations and enterprises to be supported only if support is provided for productive investments in enterprises other than SMEs.

PARTNERSHIP AGREEMENT

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On June 30, 2022, the EU Commission adopted a partnership agreement with Poland, which sets out Poland's €76.5 billion cohesion policy investment strategy for 2021-2027. The cohesion policy funds will foster economic, social and territorial cohesion in the Polish regions and support the implementation of key EU priorities, such as green and digital transformation. The funds will also support the country's competitive, innovative and sustainable economic growth, and foster social inclusion and skills development for those struggling to integrate into the labor market.

Cohesion policy funds will support Poland's environmental transformation, according to the partnership agreement. EUR 17.9 billion will be invested in renewable energy sources and a closed-loop economy to reduce greenhouse gas emissions. The decarbonization of the transport sector, investments in railroads, clean public transport and zero-emission fuels, as well as the development of the Trans-European Transport Networks (TEN-T) will receive €20 billion in funds.

JUST TRANSITION TERRITORIAL PLAN

Just Transition Fund will provide €3.85 billion to the five regions hardest hit by the transition to a climate-neutral economy, namely Silesia, Greater Poland, Lower Silesia, Łódź and Lesser Poland. The measures will help restructure enterprises and implement the innovative ways they have adopted to transition to a low-carbon economy. They will also support employment in the enterprises concerned and improve the quality of formal and non-formal education to increase the skills of workers.

More than €3.5 billion will be invested to increase the involvement of local authorities in the implementation of cohesion policy. This will be done through bottom-up approaches and partnerships between local authorities and other involved parties in integrated territorial tools, such as community-led local development and integrated territorial investments.

The Partnership Agreement with Poland will enable investment from cohesion policy funds on the ground. It includes 8 national programs, 16 regional programs, 8 cross-border cooperation programs and 4 interregional cooperation programs. The agreement also specifies implementation and eligibility issues under the Equitable Transformation Fund and related equitable transformation plans in the five Polish regions most affected by the climate transition.

RECOVERY AND RESILIENCE PLAN

On June 1, 2022, the European Commission gave a positive assessment to Poland's Reconstruction and Resilience Plan (RRP), marking an important step toward the European Union's disbursement of €23.9 billion in grants and €11.5 billion in loans under the RRF. The funds will finance activities to implement key investments and reforms discussed in Poland's Reconstruction and Resilience Plan. They will enable Poland to strengthen after the COVID-19 pandemic and make progress in its environmental and digital transformation.

The RRF is a key NextGenerationEU tool. It will provide up to €800 billion (in current prices) to support investment and reform across the EU. Poland's NIP is part of an unprecedented and coordinated EU response undertaken to address the COVID-19 crisis, address common European challenges by advocating for green and digital transformation, and strengthen economic and social resilience, as well as the coherence of the single market.

The Commission assessed the Polish plan on the basis of the criteria given in the regulation establishing the RRF. In particular, it analyzed whether the investments and reforms included in it serve the green and digital transformation; contribute to effectively addressing the challenges identified in the European Semester; and strengthen growth potential, job creation and economic and social resilience.

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The Polish NIP identifies intermediate milestones related to important aspects of judicial independence that are particularly important for improving the investment climate. The plan also defines the conditions for its effective implementation. Before any disbursement under the Reconstruction and Resilience Facility can be made, Poland must demonstrate that these intermediate milestones have been achieved.

The Commission's assessment found that Poland's NIP allocates 42.7% of its total allocation to activities in support of climate goals. The implementation of the Polish NIP is expected to contribute significantly to the decarbonization of the Polish economy by increasing the share of renewable energy in Poland's energy mix, the energy efficiency of the economy and the independence of Poland's energy supply. This includes significant funding provided for offshore wind farms, as well as key changes to the regulatory framework to facilitate the construction of offshore and onshore wind farms. Implementation of the plan is expected to support the energy-efficient renovation of buildings, the modernization of railroads and bus transportation, road safety and the development of green hydrogen technology.

EUROPEAN FUNDS PROGRAM FOR INFRASTRUCTURE, CLIMATE, ENVIRONMENT 2021-2027

The European Funds for Infrastructure, Climate, Environment 2021-2027 (FEnIKS) program is a continuation of the two previous programs Infrastructure and Environment 2007-2013 and 2014-2020. More than EUR 24 million have been allocated for the program.

The main objective of the program is to improve the country's development conditions through the construction of technical and social infrastructure in line with sustainable development, including through:

- decarbonization of the economy transformation towards an environmentally friendly and closed-cycle economy,
- building an efficient and resilient transportation system with the lowest possible negative impact on the environment,
- completion of sections of the TEN-T core network by 2030,
- improving transportation safety, ensuring equal access to health care and improving the resilience of the health system,
- strengthening the role of culture in social and economic development.

In implementing the program, the energy efficiency of housing, public buildings and businesses is to be increased, as well as the share of green energy from renewable sources in final energy consumption. Investments in energy infrastructure are expected to improve the quality and operational security of electricity grids, as well as the development of smart gas grids and their increased importance in a modern, green energy system. Investments in the environment sector are expected to contribute to greater resilience to climate change (including droughts and floods) and protection of natural heritage (increased retention capacity and improved monitoring and emergency management systems).

The program should also enable:

- to improve the management of drinking water and municipal wastewater, as well as municipal waste, to strengthen the protection of biodiversity and natural ecosystems through the development of monitoring systems for natural resources, to reduce emissions in road transportation especially in cities,

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- to increase public transportation accessibility, and number of transportation modes (more environmentally friendly) in freight transport (seaports, inland waterways, intermodal transport).

In order to improve transport cohesion and reduce transport exclusion, the focus should be on the construction of new and modernization of existing railroads and national roads, including city bypasses. Investments are to be made in key areas of the health care system, which will contribute to an increase in patients' access to high-quality health services and greater efficiency.

In the cultural sector, measures are planned to protect monuments of global and national importance, both movable and immovable. At the same time, cultural institutions will be developed and their adaptation to new cultural and social functions will be supported.

POLISH DEVELOPMENT FUND

The Polish Development Fund (The Polish Development Fund, no date) is a group of financial and advisory institutions for entrepreneurs, local governments and individuals investing in sustainable social and economic development of the country. PFR's priorities are infrastructure investment, innovation, entrepreneurship development, export and foreign expansion of Polish enterprises, support for local governments, implementation of the Employee Capital Plans program and handling foreign investments.

NATIONAL CENTER FOR RESEARCH AND DEVELOPMENT

The National Center for Research and Development (NCBR) is an executive agency within the meaning of the Public Finance Act of August 27, 2009, which is supervised, as of August 1, 2022, by the Minister of Funds and Regional Policy. The Center conducts its activities on the basis of the provisions of the Act of April 30, 2010, on the National Center for Research and Development and the statute attached to the Ordinance of the Minister of Science and Higher Education of September 9, 2010, on the statute of the National Center for Research and Development. The functioning of the National Research and Development Center is further regulated by a number of executive acts and legal acts related to the implementation of programs financed by European funds.

RATIONAL WASTE MANAGEMENT

The National Fund for Environmental Protection and Water Management runs a priority program. 2.1 Rational Waste Management. The purpose of the program is to implement the principles of waste management, in particular the hierarchy of ways of dealing with waste, by creating and maintaining an integrated and sufficient network of waste management facilities in the country.

SUPPORT FOR THERMOMODERNIZATION AND RENOVATION

An investor implementing a thermomodernization or renovation project under the rules set forth in the Law of November 21, 2008 on Support for Thermomodernization and Renovation and Central Emission Register of Buildings (Journal of Laws of 2022, item 438) is entitled to financial support in the form of a so-called bonus. According to the law, the bonus is granted by Bank Gospodarstwa Krajowego from the funds of the Thermomodernization and Renovation Fund.

3.2.2 Culture of cooperation and innovation

CULTURE OF COOPERATION

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According to the update of the Regional Innovation Strategy of the Silesia Voivodeship 2030 (Regional Innovation Strategy…, 2021), the Silesian ecosystem for innovation has been consistently developed since 2002 by the Office of the Marshal of the Silesia Voivodeship and the partner institutions characterized below, such as: entities of higher education and science, Business Environment Institutions, clusters, Network of Regional Specialized Observatories, institutions financing the development of enterprises and creating other instruments of financial support, as well as local government units and their subsidiaries[15].

ENTITIES OF HIGHER EDUCATION AND SCIENCE

Research and development and cooperation with enterprises for innovation are an important part of the activities of selected higher education institutions. In the region these are: Bielsko-Biała University of Technology and Humanities, Częstochowa University of Technology, Silesian University of Technology, University of Silesia in Katowice, University of Economics in Katowice, WSB Academy, Silesian Medical University in Katowice. They participate in research and development projects, in the implementation of expertise and technical research, and in other activities to develop the competencies of current and future employees of enterprises, including those operating within the framework of smart specializations. It is worth mentioning that in 2019. Silesian University of Technology received, as one of 10 universities in Poland, the status of a research university. As a result, in 2020-2026 it will receive a 10% increased subsidy to strengthen its infrastructural potential to carry out R&D work in the following areas: computational oncology and personalized medicine, artificial intelligence and data processing, materials of the future, smart cities, mobility of the future, process automation and Industry 4.0, climate and environmental protection, modern energy.

Among the research institutes are: those supervised by the Minister of State Assets (Central Mining Institute, Institute of Energy and Fuel Processing Technology and KOMAG Institute of Mining Technology); those supervised by the Minister of Climate and Environment (Institute for Ecology of Industrial Areas) or a number of institutes of the Polish Academy of Sciences. Meanwhile, the Institute of Welding, the Institute of Ferrous Metallurgy, the Institute of Non-ferrous Metals, the Institute of Innovative Techniques EMAG, the Institute of Innovative Techniques, the Institute of Electrical Drives and Machines KOMEL, and the Institute of Medical Technology and Apparatus were in 2019 incorporated into the Łukasiewicz Research Network, which is the third largest research network in Europe. The institutes collaborate with each other within the Network in four technological areas. These are smart mobility, digital transformation, health, and sustainable economy and energy. In turn, at the regional level, they collaborate with business entities in their own networks and clusters.

In addition to conducting scientific research, the institutes offer their services as accredited research laboratories and certification bodies. The Silesia Voivodeship is the second region in the country with the largest number of accredited and active research laboratories, second only to the Mazovian Voivodeship in this ranking. More than half of the laboratories are thematically related to the "Green Economy" smart specialization, followed by those represented: "Emerging industries", "Energy", "Medicine" and to a small extent "Information and communication technologies" (Improving Research and Innovation…, 2020). The universities, in turn, provide education in bachelor's and master's degrees, but also in numerous postgraduate courses. Unfortunately, detailed analyses (Evaluation: Opportunities for…, 2019) show a decline in the number of students at technical universities, exceeding the national average, and the deepest nationwide decline in the percentage of those studying technical

[15] Regional Innovation Strategy of the Silesian Voivodeship 2030, Developed as part of the project "Network of Regional Specialized Observatories in the Entrepreneurial Discovery Process in the Silesian Voivodeship (SO RIS in PPO II)" co-financed by the European Regional Development Fund under the Regional Operational Program of the Silesian Voivodeship 2014-2020

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and natural sciences in the student body. The results of the analysis of research and innovation infrastructure in the Silesian Voivodeship, carried out in terms of smart specializations , indicate that the region is dominated by infrastructure present mainly in the area of "Green Economy" and "Emerging Industries." Other areas are "Energy" and "Medicine." The share of infrastructure associated with the specialization (Improving Research and Innovation…, 2020) "Information and Communication Technologies" is the smallest.

The vast majority of research infrastructure from the five smart specialization areas was located in research centers. The remainder was deployed in technology centers and a small number of competence centers. However, a number of barriers are associated with the use of research infrastructure. Some are external (legal conditions, competition) and others are internal. The authors of the analysis point to the following nature: institutional (concerning mainly issues related to the regulation of the way of using the possessed infrastructure), interpersonal (concerning both the competence of people managing a given infrastructure and attitudes towards conducting applied research in scientific-industrial consortia and the widely understood openness to cooperation with the business world), technical (covering issues of insufficient technical level of the possessed infrastructure and its low uniqueness).

BUSINESS ENVIRONMENT INSTITUTIONS

Technology parks and business incubators play an important role in the regional innovation system. The formation of the latter was primarily associated with the systemic and economic transformation of the 1990s. They played a major role in putting the local economy on a new track. Over time, their importance as centers providing infrastructure for doing business began to diminish and they turned into local counselling centers for people starting or already doing business. The operation of the incubators would not have been possible without the funding provided by local governments, and many of the projects that have been implemented with funding from the European Social Fund. On the other hand, greater thematic specialization and a more advanced consulting offer must be demonstrated by technology parks, created with a significant share of EU funding, available just after the Polish accession to the EU. In Katowice, Science and Technology Park “Euro-Centrum” is directing its offer, primarily to companies in the new energy and ICT sectors. Technopark Gliwice focuses on issues of digitization, particularly its industrial applications. The Sosnowiec Science and Technology Park operates in Sosnowiec, while the Bielski Aviation, Entrepreneurship and Innovation Technology Park Sp. z o.o. operates near Bielsko-Biała, at the airport in Kaniów. Selected services, specific to technology parks, are also provided by the Upper Silesian Agency for Entrepreneurship and Development Sp. z o.o., based in Gliwice (medicine, ICT) and those operating within its ecosystem: Śląskie Centrum Naukowo-Technologiczne Przemysłu Lotniczego Sp. z o.o. and Centrum Edukacji i Biznesu "Nowe Gliwice," also Bielski Aviation Technology Park, Entrepreneurship and Innovation Sp. z o.o., based in Kaniów (aviation), and Agencja Rozwoju Regionalnego SA, based in Bielsko-Biała (ICT, production management technologies). The offer of incubators and technology parks is complemented by the activities of university technology transfer centers, which operate at all public universities conducting research activities of importance to the economy. Their centers have: Silesian University of Technology, Częstochowa University of Technology, Silesian University in Katowice, Silesian Medical University in Katowice and the University of Economics in Katowice.

Most of the above-mentioned institutions are involved in animating processes that support the development of the specialties of the Silesia Voivodeship, including within the framework of SO RIS. They play an important role in promoting the idea of innovation and communicating the opportunities of the entrepreneurship and innovation support system. In this context, however, it should be emphasized that, at the moment, the leading entities animating the regional ecosystem for innovation

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are not formally included in the national network of accredited innovation centers (comprising technology parks, science parks, science and technology parks, industry and technology parks, technoparks; technology incubators; technology transfer centers; special purpose vehicles (as defined in Article 149, Law on Higher Education of July 20, 2018); innovation centers and digital innovation hubs).

Both qualified as consulting institutions. Previously, the Local Development Agency SA - Sosnowiec Science and Technology Park, the Lukasiewicz Research Network - Institute of Non-Ferrous Metals and the University of Silesia in Katowice were also accredited. Some organizations, such as the Upper Silesian Agency for Entrepreneurship and Development Sp. z o.o., have not renewed their accreditation due to their role as operators of the Development Services Base. Also in the evaluation report, on the technological development of the region (Evaluation: Possibilities of..., 2019), attention is drawn to the weakness of business environment institutions in supporting the innovative activities of Silesian companies - despite the significant support that has been given to them to expand their portfolio and improve the quality of their services. In this context, it should be noted that in recent years the policy of development of business environment institutions has been based on the assumption that there is no need to create new units, and the offer of existing ones should be strengthened. With this in mind, among other things, support was programmed within the framework of the ROP 2014-2020. The challenge of this kind of professionalization and specialization was taken up by only a certain group of entities, qualifying respectively for de minimis assistance under projects for this purpose. Rather, the others decided to focus on the implementation of soft projects with local impact, as well as (wherever possible) on activities related to the rental of premises.

CLUSTERS

Cluster initiatives are another entity, which in their objectives are supposed to dynamize technology transfer and create new opportunities for companies for market expansion. In recent years, cluster policy has not been consistently pursued throughout the country - from the heavy emphasis on cluster development at the end of the first decade of the 21st century, to the heavy negation of this approach, resulting from many failed ventures, to attempts to selectively support the most promising initiatives. As a result, numerous cluster initiatives emerged in the Silesia Voivodeship (as in many other regions), often ending their activities with the end of permanent external funding. Among the active cluster initiatives can be counted those that obtained the status of a National Key Cluster.

In the 1st round of the NCC competition (status granted until December 31, 2018) from the Silesia Voivodeship it was obtained by the Polish Aluminum Cluster - currently inactive. In Round II (status granted until October 31, 2019), the Silesian Aviation Cluster was included among the CCCs from the region. In Round IV (status granted until August 28, 2022), the KKK status was renewed for the Silesian Aerospace Cluster and the Silesia Automotive & Advanced Manufacturing cluster was granted status. MedSilesia was also granted key cluster status until 2023 in Round V.

The coordinator of the MedSilesia cluster is the Upper Silesia Agency for Entrepreneurship and Development Ltd. The main areas of specialization are: medical robotics, surgical and orthopedic instruments, diagnostic devices, rehabilitation, medical equipment, telemedicine. The cluster participates in numerous international projects that increase the internationalization opportunities of medical companies from the region, and is an important reference point for the activities of the Specialized Observatory in the area of Technologies for Medicine within the SO RIS.

The Silesian Aviation Cluster is represented by the Bielsko Federation of Aviation Companies. It focuses its activity mainly on projects providing internationalization of products and networking activities. The

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cluster's competencies relate to gliders, light and ultralight aircraft, drones, as well as modules for aircraft engines and composite structures.

The Silesia Automotive & Advanced Manufacturing cluster is an initiative of the Katowice Special Economic Zone SA, implemented for the benefit of companies operating in the automotive and advanced technology industries. The platform for exchange and cooperation between enterprises and educational and scientific institutions created within the cluster is built on two thematic pillars: innovation and cooperation and labor market and education. The cluster has also launched the "Digital Transformation - Evolutionary Industrial Modernization in the Era of Revolution 4.0" program, in which suppliers and integrators of Industry 4.0 solutions, affiliated with the cluster, disseminate experiences from the implementation of digital transformation processes in industrial enterprises.

Other clusters that communicate their activity in the media on an ongoing basis include two IT clusters: E-south Cluster and Silesian ICT Cluster, as well as Silesian IoT Cluster (Sinotaic) and Silesia Design Cluster and Silesia Nano Cluster. The E-South cluster is managed by the Association for the Development of Information Society and brings together local telecommunications companies looking to leverage their innovative potential and grow through modern services. The ICT Scientific and Industrial Center S.A. is the coordinator of the Silesian ICT Cluster, bringing together companies, universities, research institutes and other organizations working to implement projects in the ICT field.

In turn, the Silesia IoT Cluster (Sinotaic) aims to use the potential of entities operating in the province in the area of Internet of Things, with joint research work and implementation of innovative products on the Polish and international markets. The Silesian Design Cluster is made up of designers, innovative companies, research institutes, NGOs and universities, which help companies develop and implement new products and services, and local government units - in the design of public spaces. The Silesia Nano Cluster brings together representatives of industry, science and business environment institutions and local governments for joint research and implementation projects and the effective transfer and commercialization of their results in business activities. This cluster promotes the use of nanotechnology and organizes promotional or informational activities aimed at potential recipients of innovative solutions based on nanotechnology. The Foundation for the Support of Nanoscience and Nanotechnology NANONET, the coordinator of the cluster, is also involved in the Nano Observatory under SO RIS.

NETWORK OF REGIONAL SPECIALIZED OBSERVATORIES

Creating opportunities for cooperation between enterprises and scientific units within the framework of regional specializations designated in the Technology Development Program of the Silesian Voivodeship (2019-2030) is the subject of activities of the Network of Regional Specialized Observatories (SO RIS) conducted since 2013. SO RIS is now a partnership platform for managing the innovation ecosystem in the region and conducting the process of entrepreneurial discovery. The leader of the entire Network is the Marshal's Office, while the Observatories forming it currently include:

- SO RIS Medicine (leader: Górnośląska Agencja Przedsiębiorczości i Rozwoju Sp. z o.o.),
- SO RIS Energy (leader: Science and Technology Park "Euro-Centrum" Sp. z o.o.),
- SO RIS ICT (leader: Science and Technology Park "Technopark Gliwice" Sp. z o.o.),
- SO RIS Environment (leader: Central Mining Institute),
- SO RIS Materials (leader: Silesian University of Technology),
- SO RIS Machines (leader: Silesian Science and Technology Center of Aviation Industry Ltd.),
- SO RIS Nano (leader: University of Silesia in Katowice),
- SO RIS Transport (leader: Silesian University of Technology).

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FINANCING INSTITUTIONS FOR BUSINESS DEVELOPMENT AND OTHER INSTRUMENTS OF FINANCIAL SUPPORT

Fulfilling the provisions of the Regional Innovation Strategy 2013-2020, the regional government established the Silesian Development Fund. It is a financial institution whose goal is to build a sustainable, multi-year financing system for micro, small and medium-sized enterprises in the Silesian province. The target offer of the fund is to include, first of all, capital entries and innovative loans (for own contribution to grant programs), development loans, as well as guarantees in the field of: credits, leases, loans, defects. The instruments offered are to be repayable in order to ensure reinvestment of funds in the development of the economy in the region. Currently, the fund implements the component of investment inputs, providing its own financing in the range of PLN 0.5-3.0 million, allowing for the possibility of co-investments that increase the value of projects, implemented within the framework of a given investment round.

A similar investment mechanism is used by seed funds, which were created in the region before the creation of the Silesian Development Fund, mainly under Measure 3.1. of the Innovative Economy Operational Program 2007-2013 and (also co-financed by the European Union) the BRIdge Alpha program, run by the National Center for Research and Development. Under Measure 3.1, the operators of technology gas pedals became: Science and Technology Park "Euro-Centrum" Sp. z o.o., "Euro-Centrum" SA, Regional Development Agency SA, Bielski Aviation, Entrepreneurship and Innovation Technology Park Sp. z o.o. and Science and Technology Park "Technopark Gliwice" Sp. z o.o. In turn, the BRIdge Alpha funds located in the Silesian province are run by Akcelerator Technologiczny Gliwice Sp. z o.o. and Invento Capital Sp. z o.o.. However, it is worth mentioning that, unlike the Silesian Development Fund, these entities do not limit their activities to investing in companies originating from the region. By the same token, technology companies using seed financing (and financing at later stages) do not always choose funds located in the Silesian region. It is worth noting that the start-up ecosystem is still highly homogenized in the region. Most of the activities undertaken were of a project or pilot nature, none of them, except for single events of local scale, managed to turn into a large regional initiative.

Regional and local guarantee and loan funds have been active in the region for many years. Currently, active entities in this area are: Regional Development Agency SA in Bielsko-Biała, Local Development Agency SA in Sosnowiec, Silesian Regional Surety Fund Sp. z o.o., Bielskie Centrum Przedsiębiorczości Association, Górnośląski Fund SA, Górnośląska Agencja Przedsiębiorczości i Rozwoju Sp. z o.o. in Gliwice, and Rudzka Agencja Rozwoju "Inwestor" Sp. z o.o. However, most of the external financing of innovative and development projects in the economy, which is a regional responsibility, comes from the European Union. Under the Regional Operational Program of the Silesian Voivodeship 2014-2020, as of the beginning of November 2020.

INNOVATIONS

In the Regional Innovation Scoreboard 2021 (Figure 7), the Silesian Voivodeship is classified as an Emerging innovator.

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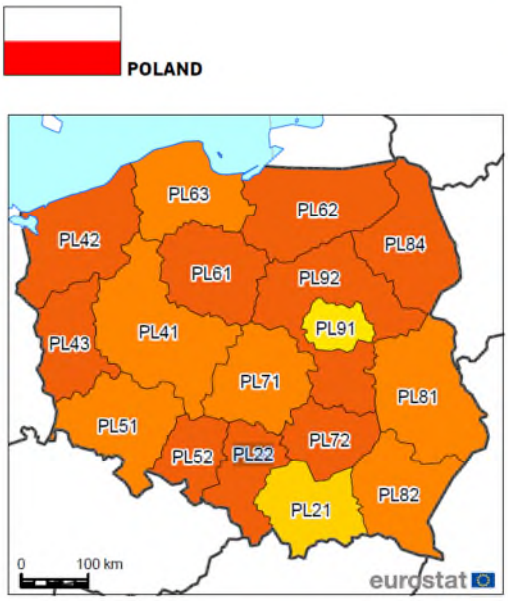

Map administrative boundaries: ©EuroGeographics ©UN-FAO ©Turkstat

NUTS	Region	RII	Rank	Group	Change
PL21	Malopolskie	71.1	170	Moderate -	25.2
PL22	Slaskie	50.5	210	Emerging	12.0
PL41	Wielkopolskie	52.3	208	Emerging +	16.1
PL42	Zachodniopomorskie	47.3	222	Emerging	11.1
PL43	Lubuskie	47.5	221	Emerging	11.8
PL51	Dolnoslaskie	64.5	182	Emerging +	22.1
PL52	Opolskie	48.4	217	Emerging	15.4
PL61	Kujawsko-Pomorskie	49.3	213	Emerging	16.7
PL62	Warminsko-Mazurskie	42.5	224	Emerging	12.0
PL63	Pomorskie	63.6	184	Emerging +	20.2
PL71	Lódzkie	52.8	207	Emerging +	15.2
PL72	Swietokrzyskie	40.7	225	Emerging	11.0
PL81	Lubelskie	53.0	205	Emerging +	19.3
PL82	Podkarpackie	57.0	196	Emerging +	14.4
PL84	Podlaskie	49.3	212	Emerging	13.4
PL91	**Warszawski stoleczny**	88.1	137	Moderate	29.9
PL92	Mazowiecki regionalny	36.3	227	Emerging	11.8

RII: performance in 2021 relative to that of the EU in 2021. Rank: rank performance in 2021 across all regions. Group: respective sub-group. Change: performance change calculated as the difference between the performance in 2021 and 2014 relative to that of the EU in 2014.

FIGURE 24: REGIONAL INNOVATION SCOREBOARD 2021

Source: European Union, 2021. Regional Innovation Scoreboard, https://ec.europa.eu/docsroom/documents/45958/attachments/1/translations/en/renditions/native

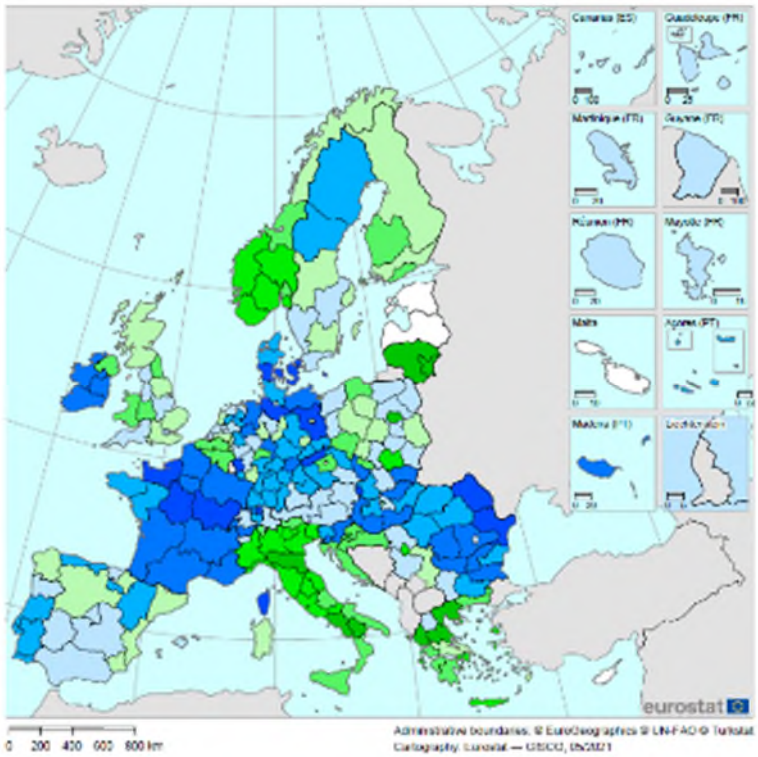

FIGURE 25: INNOVATION PERFORMANCE CHANGE 2014-2021

Source: European Union, 2021. Regional Innovation Scoreboard, https://ec.europa.eu/docsroom/documents/45958/attachments/1/translations/en/renditions/native

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Silesia (PL22) is an emerging innovator (Figure 8). Innovation scores have increased over time (12%). Table 1 shows the normalized scores for each indicator and relative performance compared to Poland and the EU. The table also shows the Regional Innovation Index (RII) in 2021 compared to Poland and the EU in 2021, the RII in 2021 compared to the EU in 2014, and the change scores over time between 2014 and 2021.

Indicators	Data	Normalised score	Relative to	
			PL	EU
Tertiary education	42.4	0.645	96	112
Lifelong learning	5.0	0.186	104	46
International scientific co-publications	379	0.316	86	56
Most-cited scientific publications	4.1	0.181	82	33
Above average digital skills	21.0	0.300	100	57
R&D expenditures public sector	0.20	0.124	47	26
R&D expenditures business sector	0.50	0.179	63	34
Non-R&D innovation expenditures	±	0.280	±	±
Innovation expenditures per person employed	±	0.297	±	±
Employed ICT specialists	2.7	0.327	85	65
Product innovators	±	0.250	±	±
Business process innovators	±	0.130	±	±
Innovative SMEs collaborating	±	0.181	±	±
Public-private co-publications	73.1	0.304	105	61
PCT patent applications	0.39	0.209	92	34
Trademark applications	2.93	0.214	68	47
Design applications	4.24	0.592	95	103
Employment knowledge-intensive activities	15.6	0.600	125	101
Employment innovative enterprises	±	0.117	±	±
Sales of innovative products	±	0.298	±	±
Air emissions by fine particulates	28.4	0.000	0	0
Average score	--	0.273	--	--
Country EIS-RIS correction f actor	--	0.995	--	--
Regional Innovation Index 2021	--	0.272	--	--
RII 2021 (same year)	--	--	88.5	50.5
RII 2021 (cf. to EU 2014)	--	--	--	58.0
Regional Innovation Index 2014	--	0.215	--	--
RII 2014 (same year)	--	--	93.7	46.0
RII - change between 2014 and 2021	--	12.0	--	--

TABLE 14: INNOVATION SCORES FOR SILESIA - SELECTED INDICATORS

± Relative-to-EU scores are not shown as these would allow recalculating confidential regional CIS data.

Source: European Union, 2021. Regional Innovation Scoreboard, https://ec.europa.eu/docsroom/documents/45958/attachments/1/translations/en/renditions/native

The radar chart (Figure 9) shows relative strengths compared to Poland (orange line) and the EU (blue line), showing relative strengths (e.g., higher education) and weaknesses (e.g., business process innovators).

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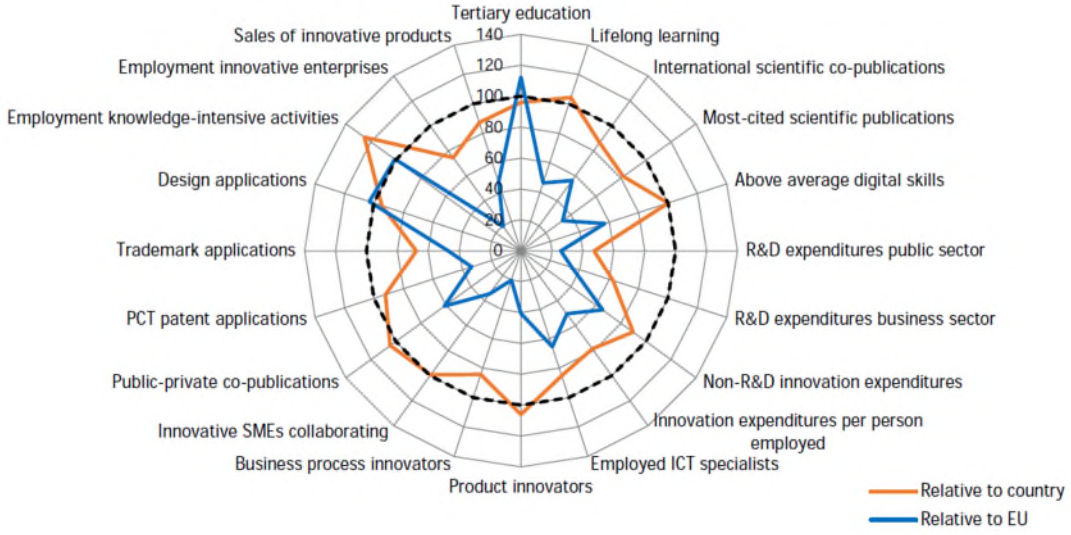

FIGURE 26: RELATIVE STRENGTHS AND WEAKNESSES FOR INNOVATIONS - COMPARED POLAND (ORANGE LINE) AND THE EU

Source: European Union, 2021. Regional Innovation Scoreboard, https://ec.europa.eu/docsroom/documents/45958/attachments/1/translations/en/renditions/native

Table 2 contains data highlighting possible structural differences, e.g.: population density (above average) and government employment (below average) .

Indicators	PL22	PL	EU
Share of employment in:			
Agriculture & Mining (A-B)	8.5	10.7	4.6
Manufacturing (C)	22.8	20.5	16.4
Utilities & Construction (D-F)	9.5	9.9	8.2
Services (G-N)	52.9	51.9	62.9
Public administration (O-U)	5.3	6.4	7.1
Average number of employed persons per enterprise	4.9	4.5	5.2
GDP per capita (PPS)	23,200	22,700	31,200
GDP per capita growth (PPS)	4.04	4.41	3.21
Population density	369	124	109
Urbanisation	88.4	69.5	75.3
Population size (000s)	4,480	37,960	446,450

TABLE 15: COMPARISON OF SELECTED STRUCTURAL INDICATORS FOR POLAND AND THE EU

Source: European Union, 2021, Regional Innovation Scoreboard, https://ec.europa.eu/docsroom/documents/45958/attachments/1/translations/en/renditions/native

BUSINESS COOPERATION

The Chamber of Crafts and Small and Medium Enterprises in Katowice (IR MSP Katowice)

The Polish Craft Association has 26 Chambers of Craft and Entrepreneurship (25 territorial and 1 sectoral). The chambers cover the area of a voivodeship or a part of a voivodeship and include craft guilds and craft cooperatives from the territory. The only exception is the National Optical Craft Chamber, which has been operating since 1996 and is a national organisation.

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The basic tasks of the chambers are to represent its affiliated organisations and members vis-à-vis the authorities, state and local government administration, to protect the interests of chamber members and to provide advisory and training assistance.

An important part of the activities of the chambers of crafts is vocational education. The chambers appoint examination commissions that conduct examinations for the title of master and journeyman. The examination boards of the chambers of crafts are supervised by the Polish Crafts Association. The qualification documents issued by the chambers - journeyman and master's certificates - have the weight of state documents.

The chambers of crafts organise and operate Advice, Education and Economic Promotion Centres, which offer advice, marketing and training services to craftsmen and entrepreneurs. In this way, the chambers support entrepreneurs in increasing the market competitiveness of their companies.

As a representative of the crafts community, the chambers establish and maintain cooperation with partner foreign crafts self-government organisations, implementing joint projects in the field of training and further training, exchange of masters and apprentices, organisation of exhibitions, conferences and seminars, promotion of regions and support of cooperation between entrepreneurs.

The Chamber of Crafts and Small and Medium Enterprises in Katowice is inscribed in the image of the region, it has been and is the second home of every craftsman for almost 100 years.

Accession to the European Union begins a completely new period. Within a few years, the Chamber will implement over 50 projects financed from EU funds. Several thousand people will be trained and will be given the opportunity to improve or change their qualifications in over 100 professions.

On the initiative of the organization, the first Regional Council for Corporate Social Responsibility in Poland will be established at the Marshal of the Silesian Voivodeship. The work of this Council, as it turns out, will have a great impact on the creation of a large family charter in Silesia. The Chamber will conduct its own labor market research, which will show that over 90% of graduates of craft apprenticeships have a job. Over 60% of people will stay with employers who taught the profession.

Regional Chamber of Commerce in Katowice

The Polish Chamber of Commerce has been supporting Polish entrepreneurs since 1989. It is an independent and the largest business organisation in Poland, bringing together nearly 160 regional, sectoral and bilateral chambers. It represents the interests of Polish business. It participates as experts in the process of creating laws concerning entrepreneurs. Helps companies to develop their exports - organises economic missions, trips to trade fairs, searches for business partners abroad. Organises events - meetings, conferences, congresses - which are a space for dialogue between people of business, politics, science, media. It engages in public debate on issues concerning the economy, innovation, the directions of Poland's development.

The Regional Chamber of Commerce in Katowice was established by 103 founders on February 13, 1990 and registered on March 21, 1990. It is an organization of economic self-government associating business entities conducting business activity. The Chamber has legal personality under the Act of 30 May 1989 on Chambers of Commerce (Journal of Laws 35/89 item 195) and its own Statute.

RIG is a continuator of the tradition of the Chamber of Commerce established in Katowice in 1922, and from 1927 of the Silesian Chamber of Commerce and Industry - operating until 1950.

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To become a Member of the Chamber, you must complete the membership declaration and the questionnaire. The amount of the contribution depends on the number of employees and is determined by the Council of the Chamber.

Silesian District Chamber of Civil Engineers

The Silesian District Chamber of Civil Engineers (SDCCE) is an organizational unit of the professional self-government operating pursuant to the Act of 15 December 2000 on professional self-governments of architects and construction engineers (original text: Journal of Laws of 2001, No. 5, item 42) (consolidated text: Journal of Laws of 2016, item 1725). SDCCE was established in 2001 and is one of the 16 regional chambers operating within the Polish Chamber of Civil Engineers. SDCCE unites engineers and technicians in nine industries:

- construction and construction, (BO) also covering the architectural specialty to a limited extent
- sanitary installations (IS)
- electrical installations (IE)
- and melioration (WM)
- road construction (BD)
- bridge construction (BM)
- railway construction (BK)
- telecommunications (BT)
- demolition (BW)

Pursuant to the Act on Professional Self-Governments of Architects, Civil Engineers and Urban Planners, the right to perform independent technical functions in the construction industry is granted only to persons entered on the list of members of the chamber of professional self-government competent for the place of permanent residence.

Members of the chamber are subject to civil liability insurance for damages that may arise in connection with the performance of independent technical functions in the construction industry.

The strategic goal of the activities of the Mining Chamber of Commerce and Industry is to support the sustainable development of coal mining.

Polish Mining Chamber of Industry and Commerce

One of the main tasks of the Chamber is to act to improve the situation of the mining industry and to strengthen the current and prospective role of Polish coal. It includes e.g. issuing opinions on draft legal acts, both Polish and EU. This activity is always preceded by the process of collecting comments and opinions of interested members of GIPH.

The Mining Chamber of Commerce and Industry actively works for hard coal and lignite on the European and global forum. For several years, the Chamber has been cooperating with the European Hard Coal and Lignite Association Euracoal, and since January 2016 it has been its member. The Chamber actively participated in the work of the Executive Committee, the Energy Committee, the Market Committee and the Environment Committee of the above-mentioned Association, e.g. in the field of information exchange and the development of positions on legal regulations related to mining and energy, prepared by the European Commission and the European Parliament. Representatives of the Chamber lobbied for coal-friendly solutions not only in the Euracoal Commissions, but also by participating in the work of the Committee for Social Dialogue in Mining Industries operating within the Directorate General for Employment of the European Commission.

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In connection with the continuing worrying trends that appear in the climate and energy policy of the European Union, GIPH puts a lot of effort into actions aimed at reversing these phenomena or at least limiting them. First of all, the Chamber tries to draw attention to the need to use indigenous resources of energy resources, especially hard coal and lignite.

The Chamber is a co-creator of the Katowice Declaration prepared during a seminar organized by Euracoal with the participation of all mining countries of the European Union, in which it calls on the Member States, the European Commission, the European Parliament, the Economic and Social Committee and the Energy Community to promote energy in the EU and climate policy for all.

The Mining Chamber of Commerce and Industry presented to the Provincial Council for Social Dialogue in Katowice a draft position on the problems of functioning of companies and institutions in the hard coal mining environment and the necessary actions aimed at improving the situation of this group of entrepreneurs. This position has been adopted both at the voivodeship and national level.

The Chamber strongly opposed the program assumptions of the Energy Union, whose main goal is to decarbonise the economy of the European Union. From the point of the programme, which was mentioned as one of the grounds for establishing the Energy Union - that is, the rehabilitation of coal - there was no trace left in the assumptions of the Energy Union's activity.

GIPH also opposed any actions aimed at reforming the ETS system aimed at creating a stabilization reserve in order to increase the prices of CO2 emission certificates.

Gliwice Chamber of Industry and Commerce

The tradition of chambers of commerce and industry in the Polish lands dates back to the 19th century. The trade councils established in 1809 in the Duchy of Warsaw can be considered the first organisations of this type. Their task was to inform the government on matters of trade, industry and crafts.

Chambers of industry and commerce in the Austrian and Prussian partitions were established much later - in the second half of the 19th century. In the Prussian partition, chambers were established on the basis of the Chamber of Commerce Act of 1848 and the Chamber of Industry Act of 1849. Chambers in the Prussian state dealt with issues of industry, commerce and vocational education. It was during this period, in 1859, that the Gliwice Chamber of Commerce was established, which covered the region of Gliwice, Bytom, Lubliniec and Pszczyna.

After Poland regained independence in 1919, the possibility of the existence of chambers of commerce was provided for by the Constitution of 17 March 1921. However, modern chambers of industry and commerce did not begin to operate in independent Poland until 1927, by virtue of a decree of the President of the Republic of Poland of 15 July of that year. The principles of their activities were based on French models. Membership of the chambers was compulsory. A member of a chamber was anyone who ran an industrial or commercial enterprise "by the mere fact of running this enterprise, without the need to declare his membership".

The chambers of industry and commerce reactivated their activities soon after the end of the Second World War. In fact, the role of the chambers during this period was severely limited. Apart from keeping records and files, they were mostly concerned with trade licensing and the distribution of raw materials to private enterprises.

The liquidation of the chambers of industry took place in Poland in 1950. A few months earlier, the Polish Chamber of Foreign Trade (PIHZ) had been established. The PIHZ was a public law institution and its activities were supervised by the Minister of Foreign Trade. The revival of self-government and chambers of commerce took place in 1989.

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On the wave of political and system changes, the Gliwice Chamber of Industry and Commerce was established on 19 June 1990, continuing the tradition of the first Gliwice Chamber established in 1859. However, the final character of today's Chamber was shaped five years later. Due to the interest of many entrepreneurs, on 22 June 1995 the General Assembly of Chamber members passed a change of name from Gliwice Chamber to Regional Chamber and a new statute, enabling the creation of local branches.

The share of funds allocated to innovation and R&D activities in the region is at a low level. In the Silesian Voivodeship in 2019, outlays on R&D activities per capita reached PLN 544.1 (6th place among regions), which is PLN 244.8 lower than the average for the country (PLN 788.9). It will be important, therefore, to strive to optimize financial flows in enterprises enabling a larger stream of funds to be directed to research and pro-innovation activities (Just Transition Territorial Plan…, 2021).

3.2.3 Regional Economy: Structure and Dynamic

The voivodeship is one of Poland's economically strongest regions. 13.1% of Gross Domestic Product (GDP) is generated here, giving it second place in the country (The Central Statistical Office, 2022). An expression of the transformations in the region's economy is the marked change in the structure of the gross added value (newly created value) generated here. Market and non-market services account for almost 60% and industry for 33%, giving it first place in the country[16]. The Silesian Voivodeship has numerous natural resources at its disposal, including hard coal, zinc and lead deposits, methane deposits, natural gas, marl, limestone, natural aggregate, and therapeutic, thermal and mineral waters. Based on the existing raw material base, the largest industrial district in the country was created here. Restructuring processes that have been taking place for several years are causing systematic changes in the structure of the economy of the voivodeship and the Upper Silesian and Zagłębie Metropolis (Figure 10). The share of mining and metallurgy, which until recently dominated the economy, is decreasing in the entire industry, while the position of electrical machinery, IT and energy industries is increasing, and the fastest growing are the automotive industry (the region is the largest producer of cars in the country) and the food industry.

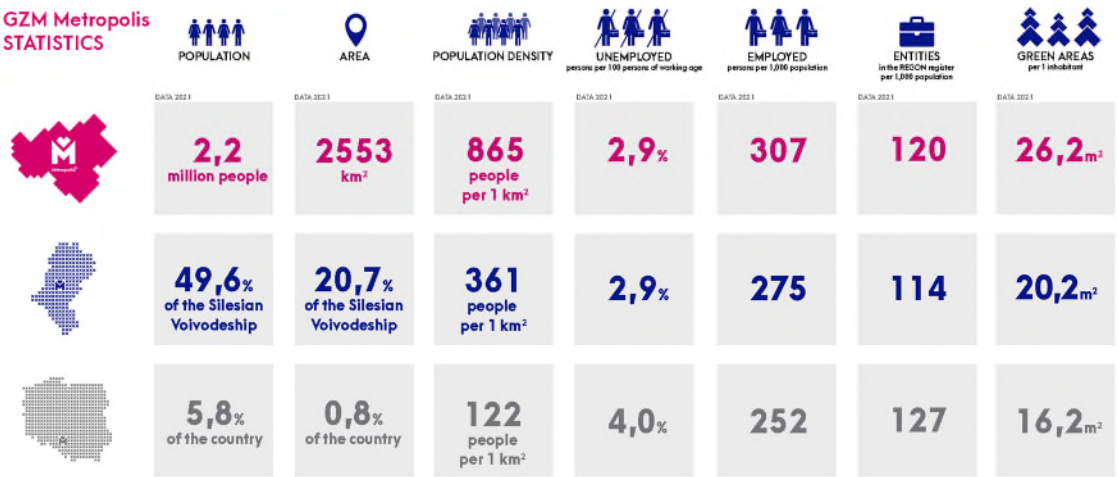

FIGURE 27: MAIN STATISTICS FOR GZM - COMPARISON WITH POLAND AND THE SILESIAN VOIVODESHIP

Source: https://infogzm.metropoliagzm.pl/mapy/Mapy.html *(20.01.2023)*

[16] Invest in Silesia, 2019 http://invest.slaskie.pl/index.php?page=gospodarka

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7.4% of the economically active inhabitants of the region work in the agricultural sector (agriculture, forestry, hunting and fishing), 37.6% in industry and construction, 21.6% in the service sector (trade, vehicle repair, transport, accommodation and catering, information and communication) and 3.2% work in the financial sector (financial and insurance activities, real estate service (Silesian voivodeship in numbers, no date).

The basis for the developing of the GOP was coal deposits, exploited on a larger scale since the 18th century; most mines are concentrated in the central part of the GOP (between Gliwice and Dabrowa Gornicza). Thanks to the rich coal deposits, fuel-intensive industries have developed, especially the iron smelting, power generation and coking industries. Ironworks in the GOP area supply about half of the country's pig iron and steel production; the largest are located in Dabrowa Gornicza (Katowice, Bankowa), Chorzow (Kosciuszko, Batory), Swietochlowice (Florian), Zawiercie (Zawiercie), Gliwice (Labedy), Sosnowiec (Cedler), Ruda Slaska (Pokój), Laziska Górne (Laziska), Katowice (Ferrum, Baildon). After 1945, several large power plants were built: Miechowice, Halemba, Lagisza, the Laziska power plant was expanded; GOP power plants produce about 15% of the country's electricity production. The coke and gas industry is developed in the western part of the GOP, where gas-coking coal is mined. There are deposits of lead-zinc ores in the Bytom, Tarnowskie Gory and Zawiercie areas, exploited in 3 mines; GOP zinc and lead smelters (main centers: Katowice and Miasteczko Śląskie) supply about 80% of domestic production; in the 19th century it was the most important zinc production district in the world.

Due to metallurgical production, the electrical machinery industry developed, producing mainly heavy castings, mining machinery and machinery for metallurgy, steel structures, transportation equipment, means of transport (cars, railroad and streetcar cars), electrotechnical and precision products; main centers: Katowice, Zabrze, Gliwice, Bytom, Sosnowiec, Tychy, Świętochłowice, Tarnowskie Góry, Dąbrowa Górnicza, Chorzów. Also of great importance are the building materials, food, chemical industries (mainly in Chorzow, Gliwice, Tarnowskie Gory, Tychy) and the textile industry (Sosnowiec). A slow process of restructuring GOP industry, especially coal mining, is underway; 1993 4 coal companies (concerns) were established in the GOP area: Nadwiślańska, grouping 8 mines (1999 - 7), Gliwicka - 8 (6), Rudzka - 8 (4), Bytomska - 12 (8), and Katowicki Holding Węglowy - 11 (9); less productive mines are being liquidated or merged, among others, by 1999 mining was terminated at mines: Saturn, Sosnowiec, Grodziec, Morcinek, Porąbka-Klimontów, Poręba (part of the Bielszowice mine), Jowisz, Siemianowice, Paris, Pstrowski; in liquidation are: Andaluzja, Powstańców Śląskich, Wawel (part of the Pokój mine), Niwka-Modrzejów and others; 1998-2002, the total liquidation was to include 15 mines, and partial liquidation - 9. In 2002, in place of the coal companies, a single concern was formed under the name Kompania Węglowa.

3.2.3.1 GDP

The Silesian Voivodeship is counted among the regions with the greatest economic potential, expressed in the high value of GDP. The traditional economic sectors are reducing the competitiveness of the region's economic structure. This is reflected in the decline of their share in the national GDP (from 13.7% in 2004 to 12.3% in 2018).

The strongest position in the region is held by the Katowice subregion, which is in the central part of the GZM while showing stable growth in GDP per capita. The subregion's position is determined by the fact that Katowice is the capital of the country's largest metropolitan area and, thus, is home to many companies, offering numerous jobs for the region's residents. As studies of commuting by residents of the Silesian region show, the largest number of people commute to Katowice for work every day, while at the same time, the reverse flows; for example, people leaving Katowice for work in other cities, are

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relatively small. In second place in terms of GDP per capita is the Tychy subregion, also located in the GZM. The growth rate there in 2011-2018 was the lowest in the voivodeship (12.5%), and the indicator in 2011-2014 declined by 6.3%. This fact can be linked to the crisis in the automotive industry, which has a dominant position in the industrial structure of the subregion.

The worst situation in GDP per capita was in the Bytom subregion (also the GZM area) - the lowest value of GDP per capita and relatively low growth of this value. The main problem of the Bytom subregion is the adverse effects of the coal industry restructuring processes in the area. The long-term domination of the mining industry has caused significant degradation of space, requiring comprehensive revitalization and reclamation, and the liquidation of plants in the sector requires support for developing the subregion's economic sector.

The Silesian Voivodeship is a region with one of the highest contributions to the generation of national Gross Value Added (GVA). In 2018, the region's share of GVA was 12.28% (only the Mazowieckie Voivodeship produced more - 22.52%). However, the region's share is steadily declining - compared to 2000, it is 1 pp lower. The region's GVA growth rate is lower than the national average. In the 10-year period between 2008 and 2018, there was a 55.34% increase in the region's GVA, which was only the 11th value among 16 provinces and was almost 10 pp lower than the national average (65.28%) (Potentials and development challenges…, 2022).

3.2.3.2 Sectors

The structure of gross value added in the Silesian province is dominated by the services sector, but nevertheless its share is significantly lower than in the country overall. In 2018, services accounted for 63.7% of national GVA, while the region's share of services was 57.0%. A strong position in the region's GVA structure is held by industry, whose share in the Silesian Voivodeship is the highest in the country (42.3%) and is higher than the national average by 8.6 percentage points (Figure 11)

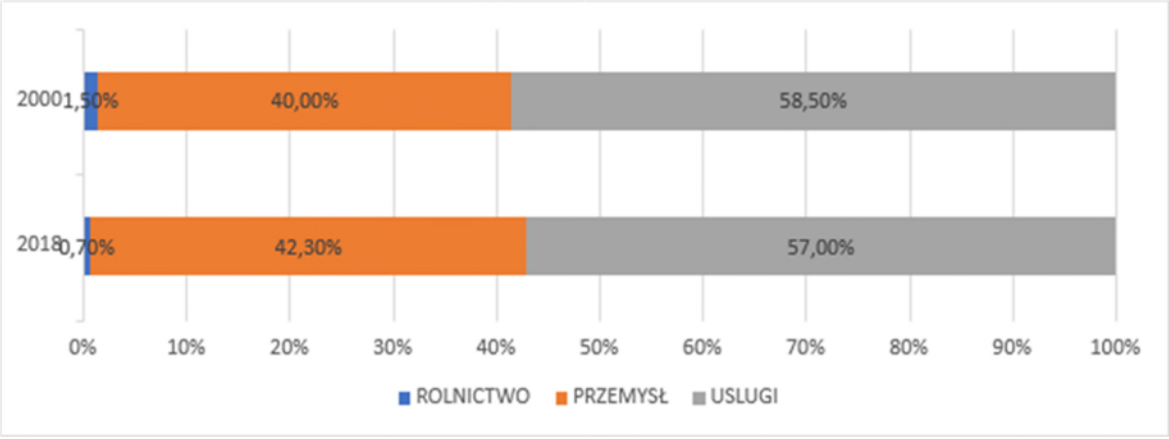

FIGURE 28: SECTORAL STRUCTURE OF GROSS VALUE ADDED IN THE SILESIAN PROVINCE IN 2000 AND 2018

Source: Just Transition Territorial Plan of the Silesia Voivodeship 2030 (Appendix 2) based on the CSO Local Data Bank.

The industrial structure of the region is changing. Compared to 2000, the share of section B of the PKD classification (mining and quarrying) in the creation of GVA has clearly decreased, which illustrates the gradual decline in the importance of the mining sector in the region's economy. The share of mining in the structure of industry in the Silesia Voivodeship has decreased since 2000 from 24.4% to 16.3%. At the same time, the share of manufacturing in the structure of GVA generated in the industrial sector increased significantly (from 46.0% to 56.2%) in 2018 (Figure 12)

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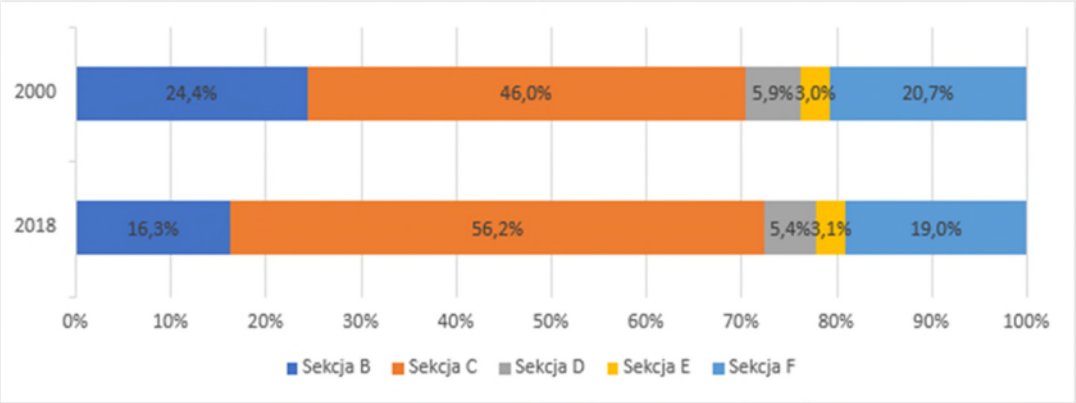

FIGURE 29: STRUCTURE OF THE INDUSTRIAL SECTOR IN SILESIA PROVINCE IN 2000 AND 2018

Sections: B - Mining and quarrying, C - Manufacturing, D - Electricity, gas, steam, hot water and air conditioning supply, E - Water supply; sewage and waste management and remediation activities, F - Construction.

Source: Just Transition Territorial Plan of the Silesia Voivodeship 2030 (Appendix 2) based on the CSO Local Data Bank.

The structure of Gross Value Added in industry in the Silesia Voivodeship varies by territory (Figure 13). The largest share of the industry sector is found in the subregions of Tychy (GZM) and Rybnik (outside the GZM). These are also the subregions in which the total share of sections B, D and E of the PKD classification is the largest - within this group of sections is included a section reflecting the importance of the mining industry (section B - mining and quarrying). The share of sections B, D and E is also relatively high in the Gliwice subregion.

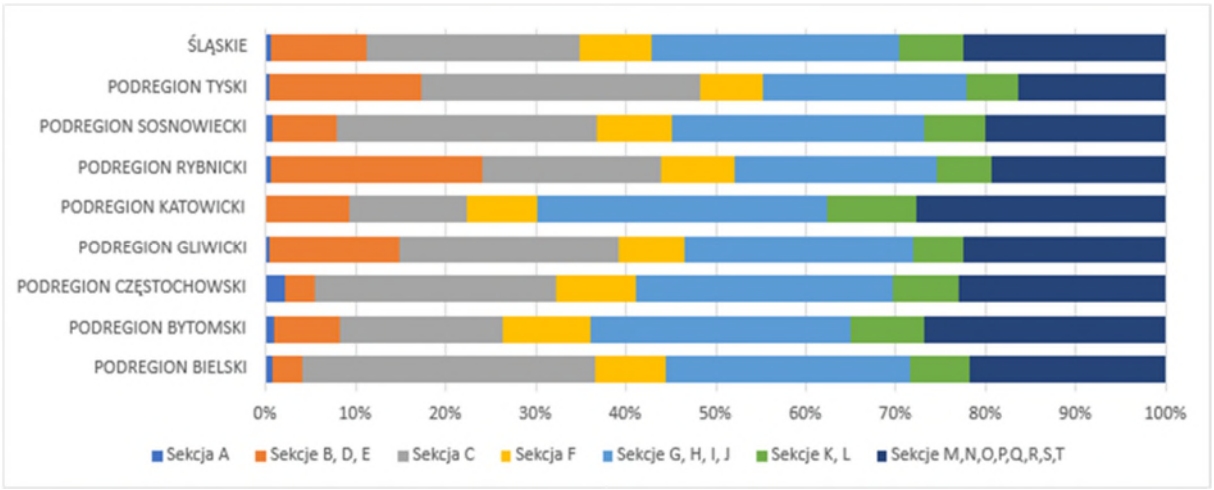

FIGURE 30: STRUCTURE OF THE INDUSTRY SECTOR BY TERRITORY

Sections: A - Agriculture, forestry, hunting and fishing, B - Mining and quarrying, C - Manufacturing, D - Electricity, gas, steam, hot water and air conditioning supply, E - Water supply; sewage and waste management and remediation activities, F - Construction, G - Wholesale and retail trade; repair of motor vehicles, including motorcycles, H - Transportation and storage, I - Accommodation and food service activities, J - Information and communication, K - Financial and insurance activities, L - Real estate activities, M - Professional, scientific and technical activities, N - Administrative and support service activities, O - Public administration and defence; compulsory social security, P - Education, Q - Health care and social assistance, R - Arts, entertainment and recreation, S - Other service activities, T - Households employing workers; households producing goods and services for own use.

Source: Just Transition Territorial Plan of the Silesia Voivodeship 2030 (Appendix 2) based on the CSO Local Data Bank.

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The restructuring processes that have been going on for years have not significantly changed the existing structure of the economy, which is still characterized by a significant share of the mining sector and a high dependence of local labour markets on traditional industries. The industrial heritage contributes to the declining competitiveness of the region's economic structure. Internationalization of the economy is still at a low level due to insufficient innovation of enterprises. The generic structure of international trade confirms the significant role of the automotive industry (28.83% of the value of exports I-IX 2020) and metallurgy and metallurgical industry (6.48% of the value of exports I-IX 2020).

In 2019, more than 57.2 thousand enterprises with the primary type of activity: construction (section F of the PKD classification) were registered in the Silesian province, which gave the fourth position in the country (9.8% of construction enterprises in the country). Within this group of companies, almost 15.7 thousand were entities for which the primary type of activity was construction work related to the erection of buildings, while more than 4.9 thousand were entities with a dominant activity in civil engineering works. The number of companies in the latter group was the highest in the country (the region's share was 13.5%). In contrast, the largest group among construction companies were those engaged specifically in specialized construction work (36.6 thousand companies; 4th in the country). The number of people working in the construction sector in the Silesian province in 2019 was 114.6 thousand (2nd in the country). Those employed in section F: construction accounted for 6.5% of the region's total workforce (the national average was slightly lower at 6.3%). In 2020, the Silesian province saw a significant recovery in the construction industry. Record indicators were recorded related to the number of new housing units (an increase of 30.7% from a year earlier), or the number of building permits issued, which was 17.9% higher than a year earlier.

In order to achieve the climate goals, the process of diversification of the economy, modernization of production processes and creation of new companies in the areas of technological specialization of the region, as well as raising its level of innovation will be crucial. The effects of measures taken in the process of equitable transformation of the region will be felt primarily in the mining sector (declining sector), where the changes taking place will result in employment reductions of 12,300 people by 2030 and 48,700 people by 2050. The transformation process will also be affected by industrial sectors characterized by highly carbon and energy-intensive production processes, such as energy, metallurgy, chemicals, minerals, machinery, transportation equipment, which employed 79.3 thousand people in 2019.

The industrial heritage of the Silesia Voivodeship and the need to intensify the region's economic transformation, resulting from the requirement to meet the goals of achieving climate neutrality, will result in the emergence of numerous large-scale challenges in the economic sphere soon. The labour force participation model of the region's residents, a significant number of whom are employed by large employers such as numerous industrial plants, particularly those in the mining, energy or steel industries, will have to be transformed. Overcoming the resistance of the mining community to a profound transformation of the sector will therefore be an important factor in facilitating a successful transition (Report on the state…, 2019).

Key areas for the green economy include renewable energy, clean technologies, energy-efficient (energy-saving) construction, public transportation, waste management and recycling, sustainable use of land, water, forests, and ecotourism. The green economy is about managing resources, using economic instruments conducive to environmental protection, providing support for innovative projects, pursuing more efficient water and waste management policies, and making efforts to develop sustainable consumption and production.

There is considerable potential for green economy activities in the Silesia Voivodeship, including, among other things, a large potential for the location of photovoltaic farms, which can provide a way

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to develop part of the post-mining areas, and the region is additionally one of the leaders in the production of components for PV modules in Poland.

3.2.3.3 Industry

The strong industrial nature of the Silesian economy makes the region the right place to develop and implement new material solutions related to the ease of recovery of materials at the end of the life cycle of the products in which they are used. Today, modern homogeneous materials and composite materials are machine parts, household, cosmetics, furniture and construction sectors. The use of ceramic plastics is very wide in the chemical, environmental protection, energy, machinery, household widely used in production processes. This emphasizes the extensive use of modern metallic, polymeric and ceramic materials. This includes technologies for energy generation and storage, electronic equipment, sensors and sensors, smart coatings and membranes, composites for aerospace, 3D printing or medical devices. Metallic plastics (steel, aluminium and copper) are the most widely used in the construction, automotive and energy sectors. The development of polymer plastics is linked to the growth of the packaging, medical, electronics and electrical engineering, transportation and communications, apparatus appliances, etc. industries.

The chemical industry is one of the largest, key sectors of all Polish industry. It currently produces products worth about 341.3 billion PLN, accounting for 16.9% of the value of sold Polish industrial production (Polish Chamber of Chemical Industry, 2022).

According to the classification of the Central Statistical Office, the chemical industry consists of:

- production of chemicals and chemical products,
- production of rubber and plastic products,
- production of pharmaceutical products, and
- refined petroleum products

Data for 2009-2021 show that the chemical segment is one of the fastest growing areas of the Polish economy. The average annual growth rate of the chemical segment's sold production from 2009 to 2021 was 4.92%, compared to 5.92% growth in industrial sold production over the same period.

Poland's chemical industry consists of four basic areas:

- Bulk chemistry, the so-called "big chemistry" - high-volume and mass-use products (excluding fuels);
- Chemical processing - manufacturing final products based on high-tonnage products;
- Fuels and refined petroleum products;
- Low-volume chemistry - high-margin products used in small quantities.

The value of sold production of industrial products of the chemical industry in Poland in the plastics segment amounted to 17.8 billion PLN and in the plastic products segment to 86.0 billion PLN.

Foreign trade plays a very important role in the chemical industry in Poland. A large proportion of raw materials and intermediates are imported for processing and consumption at home or export abroad. A favorable trade balance of chemical processing was recorded in 2021. It increased by 4.9 billion PLN compared to the previous year. The unfavourable trade balance of bulk chemicals also expanded at the same time - by PLN 18.7 billion. The unfavourable trade balance of low-volume chemistry also increased - by 3.5 billion PLN.

A detailed analysis shows that the flagship export product of the bulk chemistry and chemical processing areas is plastic products, whose surplus over imports in 2021 amounted to 14.9 billion PLN

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(an increase of 3.7 billion PLN over the previous year). In 2021, the main export area of Polish chemicals was EU countries (EU-27) - the total value of exports to the EU oscillated around nearly 31.5 billion EUR. The value of exports to non-EU countries was approximately 10.4 billion EUR. The total export value of the Polish chemical sector amounted to nearly 42 billion EUR, (nearly 191 billion PLN).

In 2021, the main import area for Polish chemicals was EU countries (EU-27) - the total value of imports from the EU oscillated around nearly 40 billion EUR. The value of imports from non-EU countries was approximately 12.5 billion EUR. The total import value of the Polish chemical sector amounted to more than 52 billion EUR, which translates into nearly 239 billion PLN.

In 2021, the main partners in the export of Polish chemicals were: Germany (export value of over 1 billion EUR 1), the Czech Republic (nearly 3 billion EUR) and France (over 2.3 billion EUR).

The main partners in the import of Polish chemicals in 2021 were: Germany (import value of 14.7 billion EUR), Belgium (4.1 billion EUR) and the Netherlands (slightly over 4 billion EUR).

From 2012 to 2021, capital expenditures in the Polish chemical industry recorded a steady increase, reaching 13.14 billion PLN. Capital expenditures in the difficult, pandemic year 2020 in the Polish chemical industry also increased, reaching 15.4 billion PLN. According to the available partial data for 2021, the upward trend, albeit insignificant, will continue - capital expenditures will reach 15.9 billion PLN.

The chemical industry also implements numerous investments in environmental protection. The key direction of investments by the chemical sector are activities related to air protection, where almost 65% of funds are allocated. The area of protection of soils and underground and surface waters is also important, where more than 20% of funds are allocated. In addition, the outlays of the chemical industry on fixed assets for environmental protection account for over 55% of all outlays in domestic industrial processing.

CHEMICAL INDUSTRY IN SILESIA

In the Catalogue of companies, places and facilities in the Silesian Voivodeship (Chemical industry, 2023), in the "chemical industry" section, 197 companies are registered. It includes both companies producing technological lines, machinery and equipment for the chemical industry, manufacturers of chemical products as well as chemical stores and chemical product distribution sites.

3.2.3.4 Workforce

As of March 31, 2022, the amount of the unemployment rate in Silesia was 4.2% (the country 5.4%). Silesia is second on the list of provinces with the lowest value of this indicator, behind Greater Poland (3.1%). Invariably, there is a wide variation in the intensity of unemployment in the region. At the end of March 2022, the height of the unemployment rate in Bieruń-Ledziny district was 1.8%. On the opposite position was Bytom, where the amount of this indicator reached 8.5%. The districts with the highest and lowest unemployment rates were separated by a difference of 6.7 percentage points in March this year. As for subregions, during the period in question, the lowest unemployment rate was recorded in the Tychy subregion (GZM) (2.7%), followed by the subregions of Katowice (GZM) (2.8%), Bielsko-Biala (3.8%), Gliwice (GZM) (3.9%), Rybnik (4.4%), Częstochowa (5.4%) and Sosnowiec (GZM) (5.5%). The highest unemployment rate was in the Bytom (GZM) subregion (6.7%).

The most numerous occupational groups among the employed was professionals (21.9%), while the least numerous occupational groups were farmers, gardeners, foresters and fishermen (1.7%). Women outnumbered men in such occupational groups as service and sales workers (68.0%), employees

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performing simple work (66.1%), specialists (61.1%) and office workers (60.7%). Men were in the majority in occupational groups such as industrial workers and craftsmen (87.3%) and operators and assemblers of machinery and equipment (87.1%).

As of April 2022, there were 2,750 unemployed foreigners in the registers, which accounted for 3.6% of the total registered. On a monthly basis, the number of registered from this category increased by as many as 1,014 people, and the share in the total number of unemployed increased by 1.4 percentage points.

This increase was due to the acquisition of special rights and the possibility of registering Ukrainian citizens in labour offices in accordance with the provisions of the Law of March 12, 2022, on assistance to citizens of Ukraine in connection with armed conflict on the territory of the state (Journal of Laws, item 583). At the end of April this year, there were 2,598 registered unemployed citizens of Ukraine in the Silesian province, including 2,442 women.

3.2.4 Zooming In: Waste Management

In Poland, waste is classified according to the source of its generation. There are three main categories of waste: industrial, municipal and agricultural waste. Industrial waste is waste that is generated as a result of economic activity in industrial or manufacturing production processes. Municipal waste is mainly waste generated in households. Municipal waste also includes hazardous waste, such as used batteries, fluorescent lamps, thermometers, used electrical and electronic equipment. Agricultural waste includes both natural (organic and inorganic) and unnatural (i.e., of industrial origin) by-products of agricultural activities.

Due to the strong industrialization of the Silesian province, a considerable challenge remains the management of a large number of industrial wastes and the need to minimize their generation. Industry in the region, due to its high resource and material intensity, negatively affects both the competitiveness of the economy and the environment, including causing overexploitation of limited resources. In addition, low public awareness of the principles of sustainable consumption and waste management, as well as the paucity of waste processing infrastructure, results in the lack of comprehensive handling and proper management of generated municipal waste. It is reasonable to implement innovative solutions that take advantage of the region's potential in the use of waste.

In 2020, 13,116,900 Mg of municipal waste (MW) were generated in Poland, which corresponded to 342 kg per capita (a 2.9% increase as compared to 2019 figures of 332 kg per capita). The European average is higher, as it amounts to 502 kg per capita. The domestic sector in Poland was responsible for as much as 86.1% of all collected municipal waste [also referred to as MW] (11.3 million Mg) (Statistics Poland, Environmental Protection, 2020; Eurostat, Municipal waste statistics, no date). The overview of the amount of MW generated per capita in EU is shown in figure 14.

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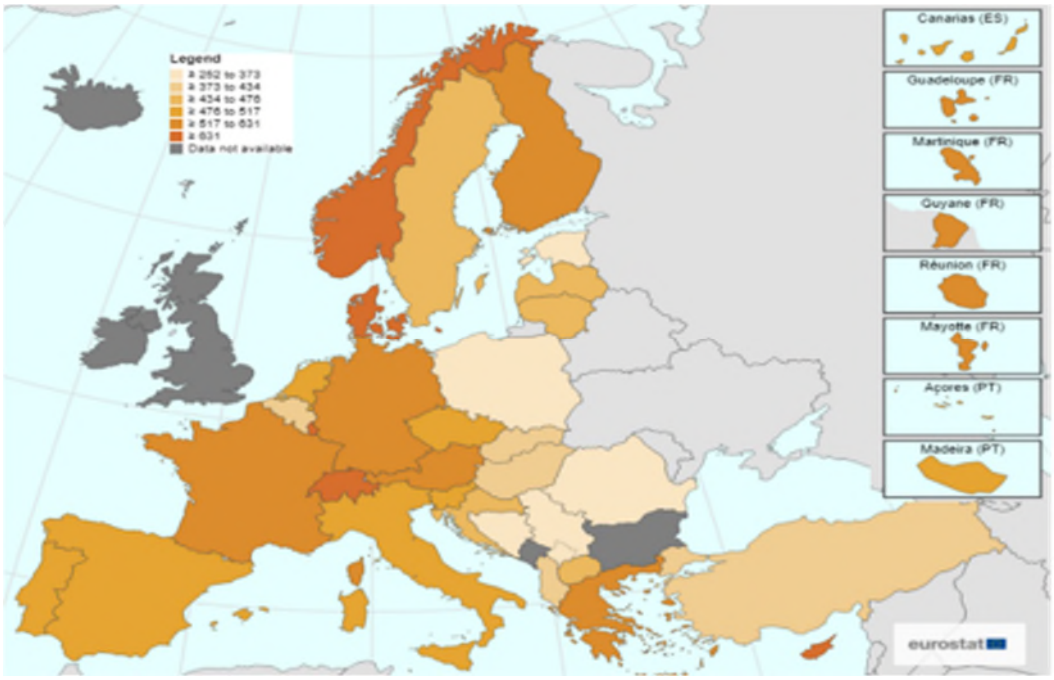

FIGURE 31: GENERATION OF MUNICIPAL WASTE PER CAPITA IN EU IN 2019

Source: Eurostat, Municipal waste by management operation, https://ec.europa.eu/eurostat/databrowser/view/env_wasmun/default/map?lang=en

Among Polish administrative regions, i.e. provinces, the Lower Silesian and Silesian provinces generated the most municipal waste in Poland per capita in 2020, 400 and 395 kg, respectively(Figure 11). A total of 1,780,470 Mg MW was generated in the Silesian province in 2020. The amount of municipal waste generated per capita in Poland's provinces is shown in figure 15.

FIGURE 32: GENERATION OF MUNICIPAL SOLID WASTE PER CAPITA IN POLISH VOIVODESHIPS IN 2020 (THE SITUATION OF SILESIAN VOIVODESHIP ON POLISH MAP IS MARKED)

Source: The Central Statistical Office, Local Data Bank, https://bdl.stat.gov.pl/BDL/dane/podgrup/tablica, (20.01.2023)

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The main methods applied to the MW stream in Poland in 2020 were as follows:

- recycling – 26.7% (3,498,629 Mg)
- biological processing (composting and fermentation) – 12% (1,577,934 Mg)
- thermal processing with energy recovery – 20.3% (1,577,934 Mg)
- thermal processing without energy recovery – 1.3% (166,400 Mg)
- landfilling – 39.7% (5,217,720 Mg)

In Silesia, the share of applied waste management methods in 2020 was the following:

- recycling – 30.3% (538,978.7 Mg)
- biological processing (composting and fermentation) – 12.9% (229,084.5 Mg)
- thermal processing with energy recovery – 10.5% (187,564.1 Mg)
- thermal processing without energy recovery – 0.1% (2,319.8 Mg)
- landfilling – 46.2% (822,523 Mg)

According to the Act on the maintenance of the Cleanliness and Order in Municipalities (ACOM), respective municipalities are responsible for collection of municipal waste, as well as their further processing and utilization. Separate collection of waste also falls within their responsibilities, obliging municipalities to minimize the amount of waste deposited in landfills.

As defined in the Waste Framework Directive (EU WFD, 2018/851), the recycling levels of municipal waste should meet the following: 55% by 2025, 60% by 2030 and 65% by 2035. What is more, from 2035 onwards no more than 10% of waste can be deposited in landfills, and from the end of 2023 the collection of biowaste will be mandatory with simultaneous reduction of biowaste landfilling and incineration. From 2027, only selectively collected biowaste will be eligible for inclusion in the overall amount of recycled waste (MBT - Mechanical Biological Treatment of Municipal Solid Waste will no longer be included in recycled biowaste calculation).

MUNICIPAL WASTE MORPHOLOGY

The morphology of municipal waste collected in Poland in large (>50 thousand inhabitants) and small (<50 thousands of inhabitants) cities as well as in rural areas is shown in figure 16.

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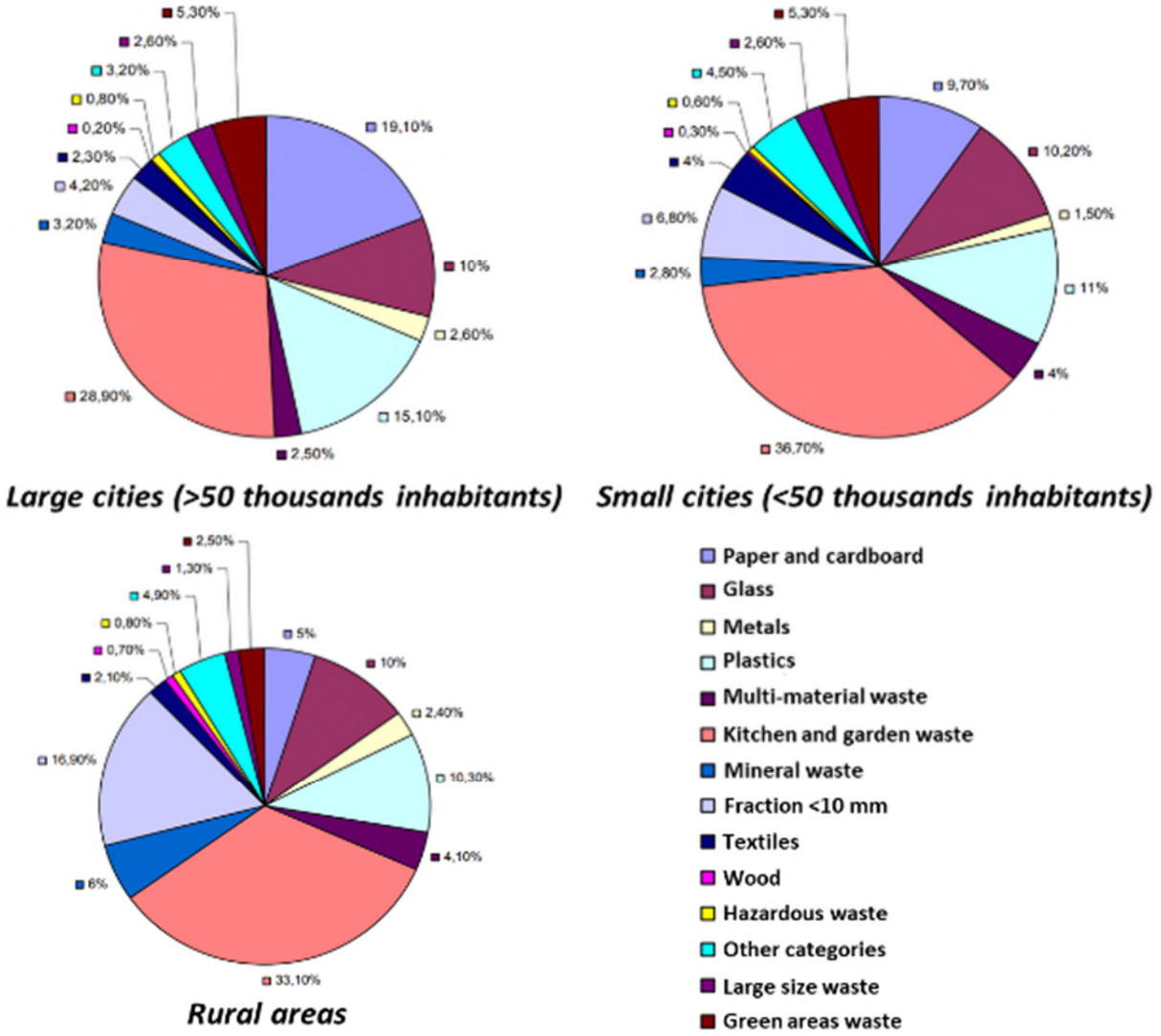

FIGURE 33: THE MORPHOLOGY OF MUNICIPAL WASTE COLLECTED IN POLAND

Source: Guidance for separate collection of municipal waste collection, 2020, Separate collection of biowaste, Chapter 4, April

In 2020 in Poland, 37.9% of municipal waste (4,974,563 Mg) was collected separately any by far the largest share (92,5%; 4,603,366 Mg) was collected from households.

According to the Silesian Plan for Waste Management for the period 2016-2022 (Silesian Plan for Waste Management, 2017), the situation in Silesia and GZM is similar to the rest of the country. The morphology of municipal waste collected in Silesia is presented in figure 17.

In 2020 in Silesia approx. 44.2% (786,312.9 Mg) of all municipal waste was separately collected.

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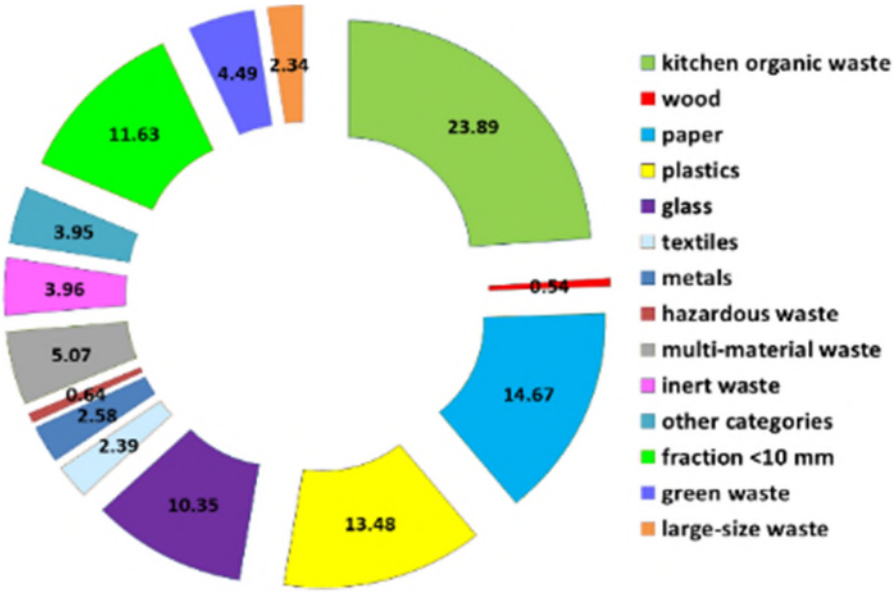

FIGURE 34: MORPHOLOGY OF MUNICIPAL WASTE COLLECTED IN SILESIA

Source: Silesian Plan for Waste Management for the period 2016-2022, https://www.slaskie.pl/content/gospodarka-odpadami , (20.01.2023)

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (INCLUDING REFRIGERATORS)

The table below, based on data from the Central Statistical Office, summarizes the amount of waste electrical and electronic equipment collected in Poland, Silesia Province and the GZM, respectively (no GZM data for 2017 due to the fact that it began operations in 2018) (Table 3)

Administrative division	Waste electrical and electronical divices					Including hazarodus waste				
	total					total				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
	[Mg]	[Mg]	[Mg]	[Mg]	[Mg]	[Mg]	[Mg]	[Mg]	[Mg]	[Mg]
Poland	41757,24	36595,50	40619,21	43506,08	44616,29	18672,53	12643,20	14223,56	16981,73	17561,41
Silesian Voivodeship	5421,07	3937,66	5004,53	5710,15	5795,88	2521,87	1532,66	2002,80	2500,73	2067,03
GZM	-	581,90	875,70	1469,56	1663,06	-	252,08	304,14	438,75	514,92

TABLE 16: AMOUNT OF WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT COLLECTED IN POLAND, SILESIA PROVINCE AND THE GZM FROM 2018 TO 2021

Source: Central Statistics Office, (20.01.2023)

Waste from construction, repair and dismantling of buildings and road infrastructure.

Table 4 based on data from the Central Statistical Office, summarizes the amount of construction and renovation waste collected in Poland, the Silesian Voivodeship and the GZM in 2020 and 2021, respectively.

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Administrative division	Collected construction and demolition waste (municipal waste)	
	2020	2021
	[Mg]	[Mg]
Poland	750 091,6	820 868,9
Silesian Voivodeship	152 512,4	161 030,5
GZM	95 475,8	100 399,3

TABLE 17: TABLE AMOUNT OF CONSTRUCTION AND RENOVATION WASTE COLLECTED IN POLAND, THE SILESIAN VOIVODESHIP AND THE GZM IN 2020 AND 2021

Source: Central Statistics Office, (20.01.2023)

The source of generation of this group of waste should be considered at the site of construction, renovation, demolition of a building. The above-mentioned waste is also generated in households during the renovation of apartments and family buildings, and the stream of this waste goes into mixed municipal waste. Recent years have seen the development and application of construction waste processing technologies, resulting in an increase in the degree of waste management.

Business operators and municipal waste collectors are required to record and report in the Database of Products and Packaging and Waste Management (BDO). BDO is an information system that allows for comprehensive collection and management of information on waste management and ensures fully electronic implementation of obligations related to the possession and disposal of waste. The obligation to enter the BDO Register applies to entrepreneurs who: produce waste and keep records of such waste, introduce packaged products, tires, lubricating oils, vehicles, batteries or accumulators, electrical and electronic equipment into the country, produce or import packaging or purchase it in intra-Community transactions.

Municipal waste management in Poland has undergone significant changes in past years. The 2012 amendment to the Law on Maintaining Cleanliness and Order in Municipalities introduced a new municipal waste management system and made local governments responsible not only for organizing the collection of municipal waste from property owners, but also for most aspects of waste management, including organizational processes. Municipalities are obliged to ensure conditions for achieving appropriate levels of recycling, preparation for reuse and recovery by other methods, reduction of the mass of biodegradable municipal waste sent to landfill.

Important waste streams from the point of view of the project are industrial and municipal waste, both categories generate waste containing polyurethane foams, i.e. waste electrical and electronic equipment, and renovation and construction waste. On the territory of the GZM, collection of electrical waste that constitutes municipal waste is carried out:

- through municipal separate collection points;
- by stores during the purchase of new electronic equipment;
- through mobile collection of waste directly from properties where residents reside.

On the other hand, collection of renovation and construction waste is carried out on the basis of individually concluded contracts between service providers and customers in this regard, or through municipal selective collection points.

With regard to renovation and construction waste, it should be noted that this type of waste from households represents only a certain portion of the total stream of such waste. Entities collecting

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renovation and construction waste from residents should have an entry in the Register of Regulated Activity (Register of Entrepreneurs Collecting Municipal Waste from Property Owners), while entities providing renovation and construction services to households should have appropriate transport permits.

In the field of collection of renovation and construction waste, the problem is that the requirements to be met in order to obtain the above-mentioned entry mainly concern the conditions to be met in order to collect typical municipal waste, i.e. waste generated daily in households. As a result, most companies transport waste from renovation and construction sites only on the basis of a waste transport permit.

According to the Database on Products and Packaging and Waste Management (BDO), in the Silesian province in the field of collection and transportation of renovation and construction waste, 67 entities have an entry in the register of regulated activity in the field of waste collection, a waste transportation permit has been issued for 2605 companies (due to the extensive scope of data, the list of these entities is available at https://rejestr-bdo.mos.gov.pl).

In addition, in accordance with the amendment to the provisions of the Waste Law effective January 1, 2022, construction and demolition waste was excluded from the definition of municipal waste. However, this does not mean that municipalities will no longer deal with this type of waste. Each municipality must still provide for the collection of this type of waste at a selective municipal waste collection point (PSZOK).

On January 1, 2023, regulations aimed at bringing Polish law in line with EU standards related to environmental protection were to come into force. According to the new provision (Article 101a) of the Waste Law: Construction and demolition waste shall be collected and picked up selectively, divided at least into: wood, metals, glass, plastics, gypsum, mineral waste, including concrete, brick, tiles and ceramic materials, and stones.

This meant that construction waste would no longer be put into one bag or container, but segregated on site. The same would apply to renovation waste. Significantly, the change was not to include the collection of construction and demolition waste from households - here the rules remain as before. The obligation to segregate into a minimum of six fractions was to apply only to companies implementing investments. However, due to the adoption of the Law on Special Protection of Certain Recipients of Gaseous Fuels in 2023 (this forces changes in the Law on Amendments to the Law on Waste), the effective date of the regulations on the collection of construction waste was postponed by two years, i.e. until December 31, 2024.

As a result, separating this fraction from construction and demolition waste is difficult. An important incentive for separate collection of this type of waste would be to collect it free of charge, as construction companies have to pay fees for collection and management of construction waste.

According to detailed reports from member municipalities, 925,223 Mg of municipal waste was collected in the GZM in 2020. This represents about 52% of all waste collected in the Silesian province (about 415 kg of waste per capita). 788,522 Mg of municipal waste came from households while 136,700.66 Mg came from other sources. The waste stream of interest from the project's point of view was estimated at 726.00 Mg per year (average of 2018 - 2020). These wastes, in accordance with the Decree of the Minister of Climate of January 3, 2020 (Journal of Laws of 2020, item 10), include the following codes (classifications) of municipal waste:

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- 20 01 23 "Equipment containing CFCs", the average annual quantity of which in the area of GZM oscillated at 152.60 Mg, and it is estimated, assuming the weight of a single equipment, that in this mass 25% is PU foam, i.e. 38.00 Mg;
- 20 01 35 "Waste electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components", the average annual quantity of which in the GZM area oscillated at the level of 396.52 Mg (this stream will gain in importance due to the change of cooling factors in equipment). It is estimated, assuming the structure of this group of waste and the weight of a single piece of equipment, that in this mass about 8% is PU foam, i.e. 32.00 Mg;
- 17 06 04 "Insulation materials other than those listed in 17 06 01 and 17 06 03", the average annual quantity of which in the GZM area oscillated at 152.60 Mg and it is estimated that up to 80% is PU foam i.e. 122.00 Mg;
- 17 01 07 "Mixed waste from concrete, brick rubble, waste ceramic materials and equipment other than those mentioned in 17 01 06", the average annual quantity of which in the GZM area oscillated at 53,489 Mg and it is estimated that about 1% is PU foam i.e. 534.00 Mg;

In order to achieve the objectives of the report, questionnaire surveys were carried out in commune offices to assess waste management policies implemented in communes belonging to the GZM. These studies show that:

- The degree of waste segregation relative to the total weight of waste depends on the size of GZM communes measured by the number of their inhabitants. In the largest communes, about 30-40% of waste is segregated relative to its total mass. Smaller communes are characterized by a higher degree of segregation, usually at a level exceeding 60%.
- Statistical data collected by Statistics Poland do not allow to determine the share of used refrigerators in all electrical and electronic devices collected in municipalities. A frequent problem is also the lack of data for the indicators for the selective collection of used electrical and electronic equipment (this group of waste includes refrigerators insulated with PUR foam) and for waste recovered from the total waste generated during the year in the communes.
- The amount of electrical and electronic waste equipment collected in the analyzed municipalities varies widely, from 246.2 tons to just 0.46 tons. In 95% of cases, used equipment comes from the household. The share of recycled waste in the amount generated during the year is very diverse, in addition to not being reported in 61% of municipalities. The highest rate is 90.2%, but in most cases, it is between 0.3% and 10%. These data indicate a low level of waste recovery. A large part of the waste generated in the municipality is transferred to other recipients. In 17 of the analyzed units, the volume of waste transferred outside the municipality ranges from 80% to 100%.
- A separate category of waste collected in municipalities is bulky waste, which may include waste containing PUR foams. Most of this waste was collected in the largest municipalities of the GZM, and the smaller ones gathered the least. There is a visible correlation between the number of inhabitants and the amount of collected bulky waste. The vast majority of bulky waste collected comes from households - the lowest value of the indicator is 80%. This is a consequence of the more significant accumulation of municipal services, trade, small businesses, offices and institutions in these municipalities, which also generate this waste category.

Comparing the availability of information on the countries in the project consortium, it should be noted that the situation in Poland differs from that of foreign partners. This conclusion should either result

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in carrying out research to fill the gap in available information or encourage the relevant institutions to expand the data set.

To sum up, it should be emphasized that the available statistical data do not allow a precise estimate of the volume of the PUR foam waste stream that can be processed by the method developed in the project. The task is not facilitated by the fact that part of the PUR foam waste ends up outside the GZM area. Only some GZM communes process this waste on their territory.

A huge weakness of the project's ability to estimate the actual waste stream is the imperfect reporting of municipal waste management and the different classification of the same waste in different municipalities. It is estimated that the waste stream that can be utilized in the project is at least 2-3 times larger than can be inferred from official statistics.

What needs to be emphasized is that currently 100% of PU waste from electrical and electronic equipment is managed through energy recovery, it does not currently go for recycling, while PU waste contained in renovation and construction waste is deposited in landfills operating in the GZM.

In 2020, almost half of the municipal waste collected was landfilled after treatment processes in the GZM. There is a similar problem throughout the province.

Summarizing the consideration of aspects of municipal waste management in the GZM and the Silesian province, it should be noted that:

- there is significant potential to improve the efficiency rates of waste collection (the current model is not very effective and the recycling levels of municipal as well as industrial waste is relatively low to EU standards and plans defined in the Waste Framework Directive 2018/851),
- high degree of urbanization and good road infrastructure are conducive to the development of infrastructure for the management of waste generated not only in the region,
- it is necessary to intensify environmental education among residents and entrepreneurs,
- introduction of closed-loop economy solutions for municipal waste is not treated comprehensively and there is a lack of consistent action as well as legal regulations in this regard.
- the formation of the GZM Metropolis provides an opportunity to improve the system of municipal waste management in the Silesia Voivodeship through the development of a coherent and fully integrated waste management infrastructure and appropriate managerial solutions.

In addition, a new WPGO plan is currently being developed, and the partners involved in the project will be taking steps to ensure that it places a strong emphasis on the closed-loop economy.

3.2.5 Infrastructure, accessibility and energy supply

In the GZM area there are:

- 9 municipal waste processing facilities, called municipal facilities according to the nomenclature of the Waste Act,
- 48 stationary municipal selective waste collection points,
- 18 municipal waste collectors from municipalities,
- 8 active municipal waste landfills,
- 1 installation managing waste thermally (co-incineration of waste in a multi-fuel unit with admixture of coal or biomass - Fortum CHP Plant in Zabrze) ,

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- 1 installation managing waste thermally as part of cement and clinker production processes (Rudniki Cement Plant).

Situation and structures of collection and recycling of construction waste and electronic waste.

In the GZM area, the collection of:

a. renovation and construction waste is collected:
b. on the basis of individually concluded contracts between service providers and customers in this regard,
c. through municipal selective waste collection points;
d. electronic waste takes place:
e. through municipal separate collection points for municipal waste;
f. through stores during the purchase of new electronic equipment;
g. through mobile collection of waste directly from properties where residents reside.

In addition, there are:

- 87 enterprises engaged in the collection of waste electrical and electronic equipment and electronic equipment,
- 6 waste electrical and electronic equipment processing plants.

There is no plant managing insulation materials from construction waste in the GZM. In addition, a significant amount of waste in the form of electrical and electronic equipment is transferred for management from the GZM area to plants located in other provinces.

The spatial arrangement of the distribution of plants in the GZM area is illustrated by the map shown in figure 18.

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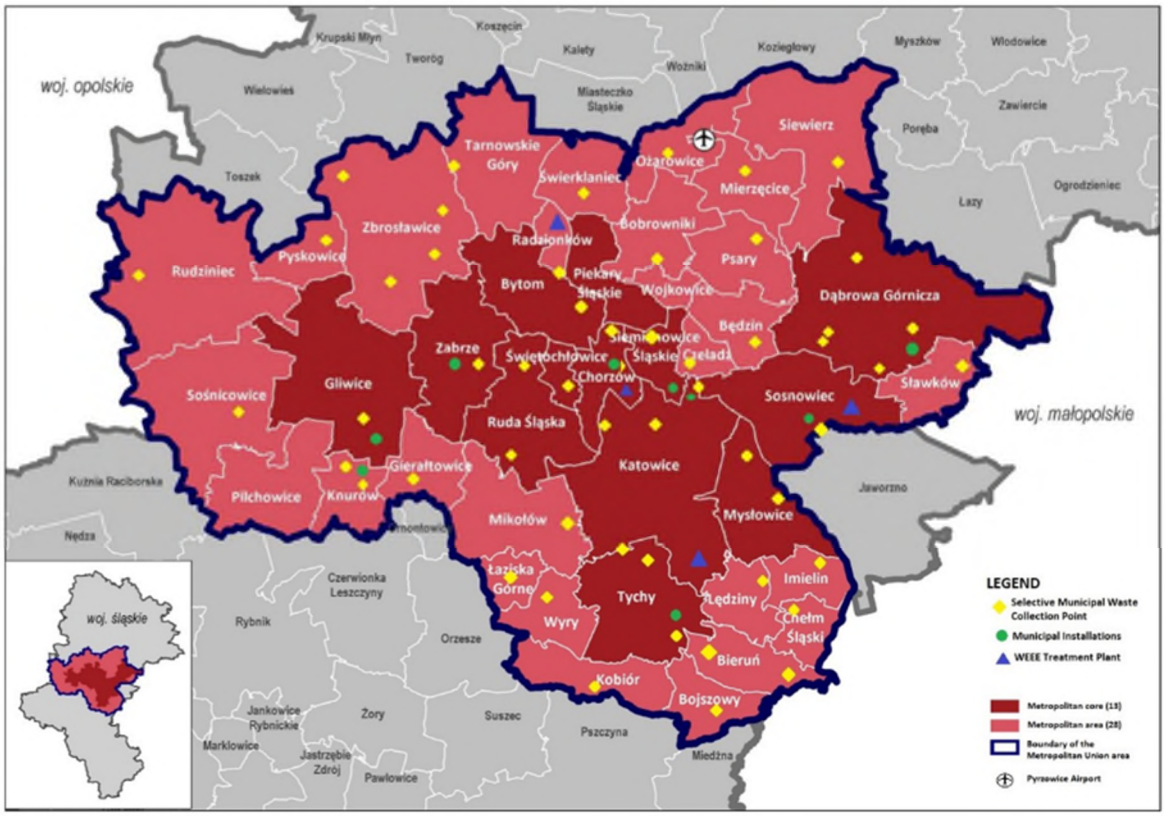

FIGURE 35: MAP OF THE SPATIAL ARRANGEMENT OF THE DISTRIBUTION OF PLANTS IN THE GZM AREA

Source: https://infogzm.metropoliagzm.pl/mapy/Mapy.html

3.2.6 Policy frames and regulations

The fundamental law regulating the subject of waste in Poland is the Waste Act of December 14, 2012 (Journal of Laws 2022, item 699). However, the law on waste, among other things, due to Poland's presence in the European Union and the economic development of our country, has been expanded quite significantly. There are about nine primary directives in force in the EU, especially interesting from the perspective of the project's research are. Most of these regulations relate to waste management (considering various types of waste) and landfill waste. Essential are those directives associated with electronic and electric equipment waste, the disposal (removal) of polychlorinated biphenyls and polychlorinated triphenyls, and the management of waste from extractive industries. In Poland, from the project's perspective, there are three of the most important legal acts regulating the so-called waste issues:

Law on Waste Electrical and Electronic Equipment - a law dedicated to electrical waste including refrigerators and other household appliances containing PU. The law regulates the rights and obligations of businesses that bring equipment to market, collect, transport and process waste electrical and electronic equipment.

The Law on Waste - a general (framework) law on the organization of waste management in Poland, regulates the operation of the Waste Database, where information is collected on the amount of waste produced, entities that produce and manage waste, and how waste is managed. Based on the provisions of the Act, regulations are issued containing: detailed requirements for waste management entrepreneurs; a waste catalogue for waste classification is also issued based on the Act.

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Law on Maintaining Cleanliness and Order in Municipalities - is dedicated to municipal waste, including electrical and electronic waste included in the municipal waste stream; regulates the organization and operation of municipal waste management systems, including the rights and obligations of entrepreneurs collecting municipal waste and operating selective collection points for municipal waste.

LEGAL REGULATIONS ON REFRIGERATORS

Law of September 15, 2015 on waste electrical and electronic equipment (Journal of Laws of 2020, item 1893, as amended) - key from the point of view of the project[17]:

With regard to electrical and electronic equipment, the extended producer responsibility system applies. Such waste is not disposed of with other municipal waste. Therefore, at the time of purchase of new large equipment, such as a refrigerator or washing machine, the store is obliged to accept from the consumer free of charge old equipment of the same type and function (Journal of Laws, No. 180, item 1495, 205, art. 37 par 1). It is the producers - under the extended liability system - that indirectly finance the above. A number of obligations are imposed on businesses involved in the introduction of equipment and management of waste electronic equipment.

The most important obligations of equipment introducers are, among others:

a. registration with BDO (Journal of Laws, No. 180, item 1495, 205, art. 84)[18], and posting the BDO registration number (Waste Database) on invoices and other documents (Journal of Laws, No. 180, item 1495, 205, art.12, par. 1),
b. informing households about the prohibition of placing waste equipment with other waste (Journal of Laws, No. 180, item 1495, 205, art.13, par. 1) and about the system of collection, return (Journal of Laws, No. 180, item 1495, 205, art.13, par. 2), reuse and processing of waste equipment (Journal of Laws, No. 180, item 1495, 205, art.18, par. 1 and art. 19)
c. to organize and finance collection from collectors of waste equipment and processing of waste equipment,
d. to achieve minimum annual levels of waste equipment collection, which is from January 1, 2021. - not less than 65% of the average annual weight of equipment placed on the market or 85% of the weight of waste equipment generated in the territory of the country (Journal of Laws, No. 180, item 1495, 205, art. 20, par. 1, 2), and payment of a product fee in case of failure to meet the obligation (Journal of Laws, No. 180, item 1495, 205, art.72, par. 1).

There are also obligations on businesses other than equipment introducers, such as:

a. compliance with the prohibition of placing used equipment together with other waste (Journal of Laws, No. 180, item 1495, 205, art. 34) and the prohibition of collecting incomplete used equipment (Journal of Laws, No. 180, item 1495, 205, art. 35, par. 1),
b. the holder of used equipment from households is obliged to hand it over to the collector of used equipment (Journal of Laws, No. 180, item 1495, 205, art. 36),

[17] Compiled from the document PARP, 2021, Gospodarka o obiegu zamkniętym w przedsiębiorstwie. Przewodnik dla małych i średnich przedsiębiorstw [Closed-loop economy in the enterprise. A guide for small and medium-sized enterprises], Warszawa.

[18] More specifically: the obligation to register in BDO must be performed by an entrepreneur who is: 1) an equipment introducer, 2) an authorized representative,

3)collector of waste equipment, 4) operator of a processing plant, 5) recycling operator, 6) operator of other other than recycling recovery processes, or 7) electrical and electronic equipment recovery organization

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c. a distributor, delivering equipment intended for households to a purchaser, shall be obliged to take back used equipment from households free of charge at the place of delivery of such equipment (or at the point of sale), provided that the used equipment is of the same type and performed the same functions as the delivered equipment. A distributor operating a retail unit with a sales area of at least 400 square meters dedicated to the sale of household equipment shall be obliged to accept, free of charge, at this unit or in its immediate vicinity, used household equipment, none of the external dimensions of which exceed 25 cm, without having to purchase new household equipment (Journal of Laws, No. 180, item 1495, 205, art. 37, par. 1-3),
d. the operator of a service point shall be obliged to accept waste equipment free of charge if the repair of the equipment accepted at the service point is impossible for technical reasons or if the owner of the equipment considers it uneconomical for him to repair the equipment (Journal of Laws, No. 180, item 1495, 205, art. 40, par. 1),
e. the collector of waste equipment is obliged to accept waste equipment transferred to it, including at least free acceptance of waste equipment from households (Journal of Laws, No. 180, item 1495, 205, art. 42, par. 1).

BUILDING MATERIALS AND PANELS[19]

As of January 1, 2023, Article 101a. will enter the Waste Law, according to which (Journal of Laws, No. 180, item 1495, 205, art. 101a, par. 1-3):

a. Construction and demolition waste shall be collected and picked up selectively, divided at least into: wood, metals, glass, plastics, gypsum, mineral waste, including concrete, brick, tiles and ceramic materials, and stones.
b. The obligation referred to in paragraph (1) shall not apply to households, points of separate collection of municipal waste, or construction and demolition waste, for which there is no obligation to keep records of waste specified in the regulations issued pursuant to Article 66 paragraph (5).
c. Construction and demolition waste, which has not been collected and collected selectively, shall be sorted at least into: wood, metals, glass, plastics, gypsum, mineral waste, including concrete, brick, tiles and ceramic materials, and stones.

In addition, as of January 1, 2022, construction and demolition waste was excluded from the concept of municipal waste, however, this waste is still of interest to each municipality, which must provide for its collection at a separate municipal waste collection point (PSZOK).

However, according to the Law on Maintaining Cleanliness and Order in Municipalities, "the regulations on handling construction and demolition waste from households are applied to the handling of municipal waste," so despite the fact that construction and demolition waste is not municipal waste it is still treated as municipal waste (such a Polish peculiarity). This waste is still accepted by the PSZOK , with the possibility of a quantitative limitation in this regard, and will have to be included in the report submitted by the PSZOK operator . However, construction and demolition waste was excluded from the scope of the report submitted by the entity collecting municipal waste from property owners .

[19] Compiled on the basis of Karciarz, M., Jerzmanowski, Z. 2022. Odpady budowlane i rozbiórkowe nie są już odpadami komunalnymi [Construction and demolition waste is no longer municipal waste], Serwis administracyjno-samorządowy, no. 1

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The above-mentioned exclusion of construction and demolition waste from the scope of municipal waste means, at the same time, that it is impossible (unfortunately) for municipalities to include this waste in the necessary levels of preparation for reuse and recycling of municipal waste.

Municipalities are obliged to local legislation (the Municipality must operate a PSZOK).

According to the Waste Act, generators of construction and demolition waste from construction work carried out by individuals who are not entrepreneurs are not required to keep waste records . This does not apply to entrepreneurs. Collectors of waste from construction or renovation have such obligations.

In the context of building a Closed Circuit Economy, it is also worth mentioning the document "National Environmental Policy 2030" adopted by the Council of Ministers in August 2019, which is a strategy for building an innovative economy with sustainable development. One of the specific goals of this strategy is "waste management towards a closed-loop economy."

The adopted changes in Polish legislation on waste management are driven by the need to achieve the above-mentioned goal, as closed-loop economy is a concept aimed at rational use of resources and reducing the negative environmental impact of manufactured products. Materials and raw materials should remain in the economy as long as possible, while reducing waste generation and increasing recycling.

These challenges are reflected in the document "Roadmap for Transformation Towards a Closed-Circuit Economy" developed by the Polish government administration as one of the strategic projects of the "Strategy for Responsible Development."

3.2.7 Citizens' awareness and stakeholders' attitudes

The conclusions on stakeholders' attitudes related to implementation of closed-loop economy system in GZM area have been developed based on regional survey in form of several interviews with waste management experts (waste collectors, environmental organizations, scientists, municipal offices).

ATTITUDES OF WASTE COLLECTORS, ENVIRONMENTAL ORGANIZATIONS, SCIENTISTS

1. Interactions between entrepreneurs are business-like, where the price and quality of the waste and the potential for further management play a key role. The waste collection and treatment system is considered to be developed. Recycling of metals, plastics, organic bio-waste is evident. Construction waste is recycled to a negligible extent, but the vast majority is recovered.
2. A lack of experience in plastics recycling is prevalent among stakeholders, but some are considering investing in this area mainly due to the lack of a sufficient number of recyclers in the market. A prerequisite, however, is the availability of preferential external funding. They see the potential for PU recycling mainly in refrigerators. Here, the PU recovery process is automated and not time-consuming. In the case of bulky waste, PU recovery is time-consuming and economically unjustifiable.
3. Experts indicate that GOZ is related to efficient recycling, the longest possible use of raw materials and the design of products that allow this. The state of transformation towards a closed loop economy is in its infancy - some steps have already been taken, but they are not sufficient or the pace of implementation is too slow and they are a reaction to top-down legal regulations (EU and then governmental). Education and information campaigns and new legal regulations are noticeable, but there are not enough of them and more action is needed in this direction. The influence of the GOZ concept on the packaging sector, the energy sector (heating) and the construction industry is noticeable, while the municipal economy and the electrical engineering

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industry have been identified as areas with potential to implement GOZ. However, experts believe that it is not possible to implement a full GOZ due to high costs and the unavailability of suitable technology.

4. Stakeholders perceive the potential of the Region as a possible PU recycling centre in the future, pointing out, among other things, its convenient geographical location, transport accessibility, the high level of industrialisation in the Region and the potential of waste management and recycling operators. The idea of such a Centre is also seen as an opportunity to attract funding to support the environmental policy and promotion of the Region. Unfortunately, according to stakeholders, there are currently no suitable cooperation structures on which to base the PU recycling system in the Region. Among the most important barriers to the development of such cooperation are those of an organisational, legal, economic and logistical nature. The scale of the necessary actions and the lack of presence, according to the experts, of factors conducive to the development of cooperation causes that stakeholders do not expect a radical change in the process of establishing a closed loop economy for PU in the region.

3.3 Conclusion

1. Poland is in the early stages of transformation from linear to circular economy (we have mastered sorting)
2. Waste is a problem, not a resource
3. Poland is in the early stages of recycling - lobbying for regulations and funding for recycling needed
4. As a result of economic and social changes a phenomenon of depopulation is visible in the Silesian Voivodeship. The population decline is very clearly noticeable in the area of the GZM (negative value of natural increase, outflow of population from cities to rural areas). It points to serious problem of an aging population.
5. Silesian Voivodship is characterized by low economic activity of the population - the professional activity rate has one of the lowest values in Poland last years. The model of professional activity based on employment in relatively large enterprises. The voivodeship dominates in share of employment in the mining industry (almost 80% of those employed in mines in Poland and 43% of those employed in the EU)(Alves Dias et al.,2018).
6. 8.5% of the total number of students in Poland study at 30 Silesian's Voivodship universities . The specificity of the region is well-developed vocational education
7. Ethnic and regional identity is often the dominant one. It can became so significant that Upper Silesian's habitants consider themselves as members of separate, Silesian nation.
8. The formation of the GZM Metropolis provides an opportunity to improve the system of municipal waste management in the Silesia Voivodeship through the development of a coherent and fully integrated waste management infrastructure and appropriate menagerial solutions .
9. The three-level administrative division of Poland, into voivodships, poviats and communes defines the competences of the public administration. These competencies are not always convergent - in consequence three-level administrative division hinders cooperation and may be a significant barrier to the implementation of a circular economy uniform system in the long term. In addition Metropolis GZM has no legislative competence in the sense of creating laws and regulations related to the circular economy.

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10. The Silesian Voivodeship is one of Poland's economically strongest regions, ranking second in Poland. It is also in first place in the country in the market, and non-market services and industry (60% and 33%, respectively). But on the other hand, Silesian Voivodeship still remains the largest mining region in the European Union, and the biggest EU-wide transformation challenge is still ahead of the province.
11. The region has the greatest economic potential, expressed in the high GDP value. The Silesian Voivodeship is a region with one of the highest contributions to the generation of national Gross Value Added (GVA). In 2018, the region's share of GVA was 12.28%. The region's GVA growth rate is lower than the national average. From 2008 to 2018, there was a 55.34% increase in the region's GVA; however, it was only the 11th among 16 provinces and almost 10 pp lower than the national average (65.28%). Silesia has also high potential in workforce, high qualified labour workers with the second on the list of provinces with the lowest value of unemployment rate in Poland.
12. The strong industrial character of the Silesian Voivodeship makes the region stand out the right place to develop and implement new material solutions, related to the ease of recovering materials at the end of the life cycle of the products in which have been used.
13. It is worth adding that GZM is transitioning from a black to a green economy; the region's industrial structure is changing. Compared to 2000, nowadays, mining and quarrying in the creation of GVA have decreased, which illustrates the gradual decline in the importance of the mining sector in the region's economy from 24.4% to 16.3%.
14. There is considerable potential for green economy activities in the Silesia Voivodeship (green economy in the Silesian Voivodeship is over 51 thousand entities (as at the end of June 2020) and more half of thematically related accredited and active research laboratories) (Potencjały i wyzwania rozwojowe…, 2022, p. 18), especially for the location of photovoltaic farms. They can develop part of the post-mining areas, and the region is also one of the leaders in producing components for PV modules in Poland.
15. With the long-term goal of climate neutrality adopted by the EU by 2050 and national and regional legislation, the Silesia Voivodeship faces a huge challenge including energy transition, which will require changes at the social, economic and technological levels and a shift from carbon-intensive industries and energy sources to clean energy technologies. The scale of challenges and the need to stage the transformation process is due to the fact that the Silesia Voivodeship is the largest mining region in the EU, whose economy is largely based on fossil fuels and industries characterized by high intensity of greenhouse gas emissions.
16. Under the regional program "European Funds for Silesia 2021-2027" approved by the European Commission, the Silesian region is to receive €5.1 billion for restructuring the mining sector. This is the largest funding for a single region not only in Poland, but in the entire European Union.
17. In the Regional Innovation Scoreboard 2021, the Silesian Voivodeship is classified as an Emerging innovator. According to the Regional Innovation Strategy of the Silesia Voivodeship 2030 (Regional Innovation Strategy, 2021), the Silesian ecosystem for innovation has been consistently developed since 2002 by the Office of the Marshal of the Silesia Voivodeship and the partner institutions as: entities of higher education and science, Business Environment Institutions, clusters, Network of Regional Specialized Observatories, institutions financing the development of enterprises and creating other instruments of financial support, as well as local government units and their subsidiaries. The share of funds allocated to innovation and R&D activities in the region is at a low level (6th place among Polish regions). But on the other hand, Technology Development Program of the Silesian Voivodeship (2019-2030) indicates technological areas, the development of which will contribute to the best use of the potential

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of entities operating in the region and the achievement synergistic effects due to cooperation between them. These areas include technologies for environmental protection.

18. The collection, segregation and treatment of waste is carry out by both public and private sector companies. In the market structure of waste management companies, there are public operators, corporations and private operators from the SME sector.
19. There is significant potential to improve the efficiency rates of waste collection (the current model is not very effective and the recycling levels of municipal as well as industrial waste is relatively low to EU standards and plans defined in the Waste Framework Directive 2018/851).
20. High degree of urbanization and good road infrastructure are conducive to the development of infrastructure for the management of waste generated not only in the region.
21. It is necessary to intensify environmental education among residents and entrepreneurs.
22. Introduction of closed-loop economy solutions for municipal waste is not treated comprehensively and there is a lack of consistent action as well as legal regulations in this regard.

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4 Pilot Region C: Amsterdam Metropolitan Area (AMA)

4.1 Introducing the Amsterdam Metropolitan Area (AMA)

The Amsterdam Metropolitan Area (Dutch: *Metropoolregio Amsterdam* (MRA)) is located in the northwest of Netherlands. It is at the north of the Randstad region of the country, which is the main economic powerhouse region of the country, made of the region including Amsterdam, Utrecht, Rotterdam and The Hague.

The Amsterdam Metropolitan Area is a major centre for banking, financial services, hi-tech, and tourism. It is a major transportation hub for air, rail, river and sea/ocean transport. It also holds significant historical significance, with the centre of Amsterdam holding UNESCO designation as a World Heritage Site.

4.1.1 Geography

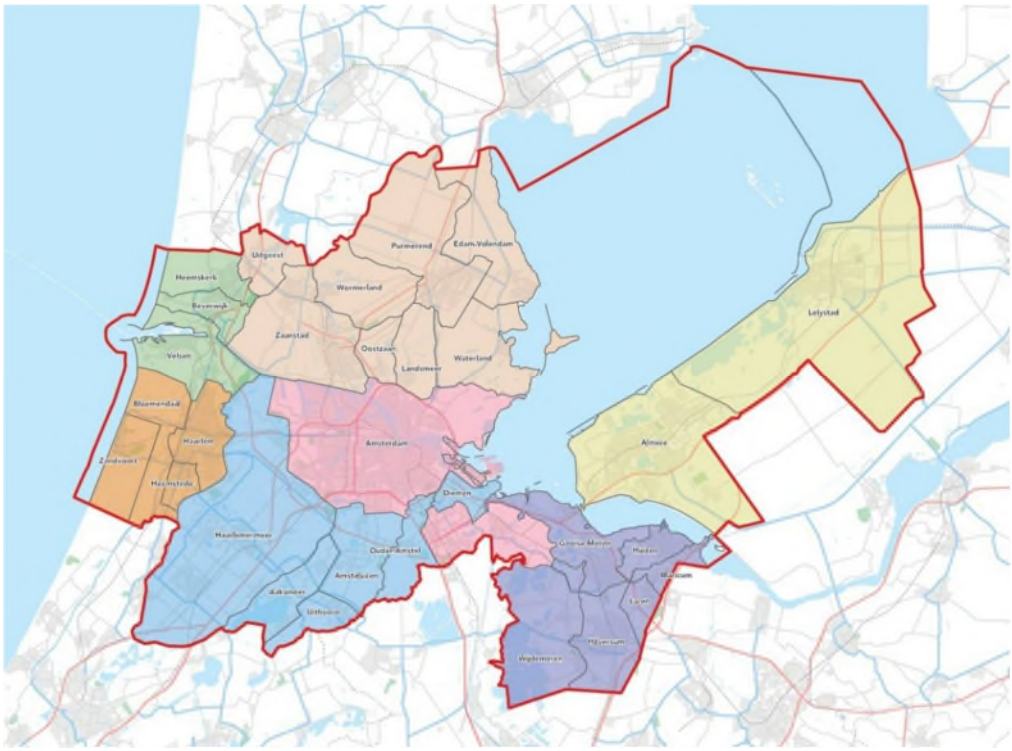

FIGURE 36: MAP OF AMSTERDAM METROPOLITAN AREA (AMA)

The Amsterdam Metropolitan Area (AMA) is comprised of two provinces (North Holland and Flevoland), and within this 30 municipalities, and the Transport Authority Amsterdam. The region functions as a single city / administrative body. The AMA is known in Dutch as *Metropoolregio Amsterdam (MRA)*.

The AMA is in the north-west of the Netherlands, with direct access on the west to the North Sea. To the south of the city are the major cities of Utrecht, Den Haag, and Rotterdam. To the north of the AMA is the Ijsselmere and Waddenzee, and the east of the AMA is the Dutch province of Gelderland. To the south-east, the AMA has direct access via canal systems and the Rhine to the interior of Europe.

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Much of the Amsterdam region is close to, or below sea level. This has a significant impact on land use, governance and public policy. Following is a summary of land use in the Amsterdam Metropolitan Area:

- Surface area: 650,424 hectares
- Transportation: 1,427 hectares
- Built Up: 9,190 hectares
- Semi Built Up: 6,490 hectares
- Recreation: 6,268 hectares
- Agriculture: 2,377 hectares
- Woodland: 29,992 hectares
- Inland Water: 174,478 hectares
- Tidal Water: 68,301 hectares

4.1.2 Polity

4.1.2.1 National Level

The Kingdom of the Netherlands was established in 1815 as a constitutional monarchy, and since 1848 as a parliamentary democracy. The parliament consists of two cambers: The Lower House, which is elected every four years in national elections, and the Senate, who's members are elected by the provincial parliaments. The Lower House can initiate legislation and controls budgets. The Senate approves or rejects legislation.

Within the national structure the monarch holds no real power, but by signing approved legislation the monarch makes the legislation into law. The monarch also nominates mayors of the cities within the country.

There are currently twenty parliamentary parties in Netherlands, of which ten are considered long-term, well-established political parties. Netherlands is currently led by a coalition government, with the Prime Minister, Mark Rutte, coming from the VVD (People's Party for Freedom and Democracy) party. The coalition consists of the VVD together with the D66 (Democrats 66), CDA (Christian Democratic Appeal), and CU (Christian Union) parties. This coalition is considered centre-right in philosophy and policy. Each of these parties has a strong environmental platform that supports the environment, and global initiatives such as the Paris Accords. Refer to Stakeholder Report Deliverable 1.1 for further detail on the political parties and the national Coalition Agreement of the governing parties.

4.1.2.2 Provincial Level

The AMA makes up part of two provinces of Netherlands: North Holland and Flevoland. The AMA makes up a large part of each of these two provinces. While the provinces control their own budgets and administrations, within the administrative area of the AMA, budgets, administration, and planning are managed by the AMA. Thus, the AMA is the dominant body for the areas within the AMA.

North Holland is governed by a coalition government, consisting of Groenlinks, PvDA, D66 and VVD parties.

Flevoland is governed by a coalition consisting of PvDA, VVD, Groenlinks, and FVD (Forum for Democracy).

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4.1.2.3 Regional / Civic Level

The AMA consists of 33 different authorities divided over **seven** sub-regions:

- City of Amsterdam
- Amstelland-Meerlanden
- Zaanstreek-Waterland
- Almere-Lelystad
- Zuid-Kennemerland
- Gooi en Vechtstreek
- IJmond

The Amsterdam Metropolitan Area, though comprised of 33 authorities with different financial resources and separate local administrations, acts as a single policy body for overall planning and administration.

Amsterdam Metropolitan Area summary / key figures:

- **33 authorities** comprised of:
- **2 provinces**:
- North Holland
- Flevoland
- **30 municipalities**:
- Aalsmeer
- Almere
- Amstelveen
- Amsterdam
- Beemster
- Beverwijk
- Blaricum
- Bloemendaal
- Diemen
- Edam-Volendam
- Gooise Meren
- Haarlem
- Haarlemmermeer
- Heemskerk
- Heemstede
- Hilversum
- Huizen
- Landsmeer
- Laren
- Lelystad
- Oostzaan
- Ouder-Amstel
- Purmerend
- Uitgeest
- Uithoorn
- Velsen

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- Waterland
- Weesp
- Wijdermeren
- Wormerland
- Zaanstad
- Zandvoort

- **Transport Authority Amsterdam (TAA)**
- 7 sub-regions
- 2.5 million inhabitants, or approximately 14% of the population of Netherlands
- 300,000 business
- 1.5 million jobs

Alignment with EU Regions:

- EU Classification NUTS 2: Noord Holland: NL32
- EU Classification NUTS 3: Groot-Amsterdam: NL329

The government of Amsterdam Metropolitan Area consists of several territorial and functional forms of local and regional government.

The dominant body within the AMA is the municipality of Amsterdam, which is led by an appointed mayor and an elected council. The municipality's territory covers the city of Amsterdam as well as a number of small towns, as detailed earlier.

The **City of Amsterdam** is also part of several functional bodies that are part of the regional government. These include:

- Waterschap (water board) of Amstel
- Gooi en Vecht, which is responsible for water management
- Stadsregio (City Region) of Amsterdam, which has responsibilities in the areas of spatial planning and public transport.

The municipal council has 45 seats, and its members are elected through city-wide elections. There are twelve political parties represented in the makeup of the city council. The political philosophy of the main parties within the city council is considered to be centre-left to left, with a strong support of green and environmental initiatives.

The current civic political administration is a coalition structure, set up under the *Amsterdam Agreement 2022-2026 (2022)*. This agreement sets out a framework amongst the main governing political parties in Amsterdam (PvdA, GroenLinks, D66) for the main initiatives, including commitments to sustainability and green spaces.

The governing coalition parties individually advocate the following environmental platforms:

- PvdA believes that achieving the EU's climate and environmental goals requires a new policy based on circular economy. This includes giving control of waste collection to the districts and establishing a regional resource cooperative for recycled materials (PvDA, no date).
- Groenlinks advocates for solving environmental problems, especially climate change, by stimulating durable and sustainable alternatives. (Groenlinks, no date).

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- D66 has a strong commitment to the environment and sustainability. Their goals include for the Netherlands to become the largest producer of wind energy in Europe and become a net exporter of electricity, to decrease the use of natural resources by 30% by 2025, and exceed the agreed climate goals of the Netherlands. (D66, no date).

The AMA is a leader in Netherlands in the drive to circular economy. It is also one of the 30 European cities and regions selected by the European Commission in the Circular Cities and Regions Initiatives (CCRI) (Circular Cities and Regions Initiative, no date).

4.1.2 Population: Socio-demography – Basic Statistics

Population:

- Netherlands: 17,590,672 (2022)
- Amsterdam Metropolitan Area: 2.5 million (14% of NL)

Population Density (2022):

- Netherlands: 523 inhabitants/km^2
- Amsterdam Metropolitan Area: 5296 inhabitants/km^2

Projected population growth, 2021-2030: 4.45%

City product per capita (2021): €66,550.00

Internet penetration (2021): 97.1%

5G availability: yes

Number of universities: 5

- University of Amsterdam
- Hogeschool van Amsterdam (AUAS)
- VU University Amsterdam
- Tilbergen Instititute
- Amsterdam University College

Research Institutes: numerous, both within the university structures, and independent

Mean years of schooling: 12.9 years

Percentage of individuals with higher education: 45.4% (Iamexpat, no date.)

Language Proficiency: 80% of the AMA workforce speaks English, and 90% are fluent in at least 2 languages. (Iamexpat, no date.)

Age	**Under 20**	**20 > 40**	**40 > 65**	**65 > 80**	**80 and over**
2022	21.2	25.5	33.2	15.2	4.9
2020	21.7	25.2	33.7	14.8	4.7
2015	22.7	24.5	35.1	13.4	4.3

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2010	23.7	25.3	35.7	11.4	3.9
2005	20.5	27.4	34.1	10.5	3.5
2000	20.4	30.0	32.0	10.4	3.2

TABLE 18: POPULATION BY AGE (NL), BY PERCENTAGE (%) (CBS STATLINE, EMPLOYMENT, 2022)

	Total population	Males	Females
2022	17,590,672	8,745,468	8,845,204
2020	17,407,585	8,648,031	8,759,554
2015	16,900,726	8,372,858	8,527,868
2010	16,574,989	8,203,476	8,371,513
2005	16,305,526	8,065,979	8,239,547
2000	15,863,950	7,846,317	8,017,633

TABLE 19: POPULATION BY GENDER (CBS STATLINE, EMPLOYMENT, 2022)

	Total population	Males	Females
2022	42.4	41.6	43.2
2020	42.2	41.3	43.0
2015	41.3	40.4	42.1
2010	40.1	39.1	41.1
2005	39.0	37.9	40.0
2000	38.3	37.0	39.4

TABLE 20: AVERAGE AGE BY GENDER IN NETHERLANDS (BY YEAR) (CBS STATLINE, EMPLOYMENT, 2022)

	Dutch Background	Migration Background
2022	74.8	25.2
2020	76.8	24.2
2015	78.3	21.7
2010	79.7	20.3
2005	80.8	19.2
2000	82.5	17.5

TABLE 21: POPULATION WITH IMMIGRATION BACKGROUND IN NETHERLANDS (%) (CBS STATLINE, EMPLOYMENT, 2022)

	Dutch Background	Foreign Background
2020	49.5	50.5

TABLE 22: POPULATION OF AMSTERDAM REGION BY ORIGIN (%) (CBS STATLINE, EMPLOYMENT, 2022)

	Unemployed Rate
2022	3.7

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2020	4.8
2015	7.9
2010	6.1
2005	7.0

TABLE 23: UNEMPLOYMENT RATE IN NETHERLANDS (%) (CBS STATLINE, EMPLOYMENT, 2022)

Type of Employment	Number
Employees	8,075,000
Self-Employed	1,684,000
Total	9,759,000

TABLE 24: EMPLOYMENT, BY TYPE IN NETHERLANDS IN 2021 (NUMBER) (CBS STATLINE, EMPLOYMENT, 2022)

	Total	1-person	2-person	3-person	4-person	5-person	Average per household
NL	8,138,591	3,172,564	2,661,105	942,346	956,266	406,310	2.13

TABLE 25: DISTRIBUTION OF HOUSEHOLDS IN 2021 (NL) (CBS STATLINE, HOUSEHOLDS, 2022)

As of 2021, the population of Netherlands identifies as (Netherlands Religions, 2022):

- 23.6% Roman Catholic
- 14.9% Protestant (Protestant, Dutch Reformed, Calvinists)
- 5.1% Muslim
- 5.6% Other religions
- 50.7% Do not identify with any religion

While there are areas of the country where religion is dominant in everyday life, in the Amsterdam region and other large cities in Netherlands the society is secular, and religion plays little to no influence on day-to-day activities.

As the demonstrated in these statistics, the population of the Netherlands provides educated, multilingual, and international workforce. Overall, over 44% of the workforce has higher education, over 50% have international backgrounds, and 90% are fluent in at least two languages. Combined with the strong economic conditions in the country, this creates a high demand for labour. The demand for labour has remained high in recent years, resulting in a low unemployment rate of 3.7% in 2022, and high competition for skilled workers, especially in the AMA. The population is young, with the majority of the population between 20 and 65 years of age. This provides employers with a very skilled, educated, and international workforce.

4.1.3 History / Identity

The origins of Amsterdam begin in the 12th century when it was a fishing village at the conjunction of the Amstel River and the Ij River, which was a saltwater inlet at the time. The Amstel river served as a port, and the construction of a dam and locks on the Amstel river protected the village from floods. The village became a trading hub for the region.

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By the 14th and 15th centuries, the town had grown and had become a trading hub for grain and timber, as well as other commercial goods. The growth of the town into a city continued and the growth of Amsterdam as a trading centre continued into the 17th century, which is known as the "Golden Age", considered to be between the years 1585 – 1672. During this period Amsterdam was a major trading and financial centre, and was the basis for a world-wide trading network to North and South America, Africa, and Asia. In 1602, the Dutch East India Company was founded, and was the first multi-national corporation to offer stocks in order to finance the business. During this period, Amsterdam was the most important point for the trans-shipment of goods in Europe, and it was the main financial center of the world. By 1660 the population of Amsterdam reached 200,000.

During the Golden Age, entrepreneurs were encouraged to set up shops and factories in the city, and immigration was encouraged in order to expand the growth and wealth of the city. The wealth of the city was based on trade and commerce, and the growth of factories and contributed to the further growth of the city and its wealth.

In the 17th and 18th centuries the city continued to grow and immigration continued to the city from other areas of Europe. By the 18th century the majority of the population of Amsterdam was made up of immigrants, including Lutheran and Protestants from the German regions, Huguenots from France, Portuguese and Spanish Jews, and Armenians who were skilled traders with knowledge and connections to the middle-eastern regions.

The late 18th and early 19th centuries brought a decline to Amsterdam due to wars between the Dutch Republic and countries such as England and France. The Kingdom of the Netherlands was established in 1815, which reversed the decline that had occurred in the previous decades. This reestablishment of stability preceded the start of the Industrial Revolution in the second half of the 19th century. The late 19th century also saw the digging of the Amsterdam-Rijn Kanaal and the Noordzee Kanaal, which provided Amsterdam with a direct connection to the North Sea, and to the Rhine river. This helped to re-establish Amsterdam as a major port in north-western Europe. The Industrial Revolution also saw rapid growth of manufacturing industries which resulted in large numbers of individuals from other regions of Netherland and large numbers of immigrants settling in Amsterdam.

Economic and population growth continued in Amsterdam in the early 20th century. While Netherlands remained neutral in World War I, the city and country suffered greatly during World War II when the country was occupied by Germany. During the war years, the city saw the deportation of over 100,000 from the Jewish community, and shortages of most basic goods. Following the war years, the city continued to see large number of immigrants from countries such as Turkey, Suriname, and Morocco. By the 1970s Amsterdam had shifted from a manufacturing and industrial economy to more of a service-based economy with major growth in the financial services and banking sectors. At the same time, the city went through a period of turmoil and conflict, particularly during the years 1966-1986. During this period, large numbers of youth and unemployed fought back against the city government, based on a push for more freedom and anarchy from the youth against the establishment and established gentry. Due to a loss of public support and sympathy, this movement died out in the mid-1980's.

Following this, the city was able to establish security and stability in the city centre, and make improvements to the municipal infrastructure such as new roadways, public transportation and a metro-system. This has helped to attract new residents to the city centre and has lead to significant growth in surrounding communities. The city has also become a tourism hub, attracting approximately 20 million visitors a year.

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Throughout its history, the Netherlands, and Amsterdam has at times endorsed certain religions, and been tolerant of many religions. Through the periods of the Golden Age and since, Amsterdam has attracted large number of immigrants who were valued for their commercial skills and trades. The result is that Netherlands is a religiously tolerant society, and is a secular country.

4.2 Regional Readiness for Introducing PU Hubs for Circularity

The Amsterdam region is considered the economic centre for Netherlands, and is recognized as a banking and financial centre globally. It is also seen as a centre for innovation and hi-tech. Additionally, the Amsterdam region is a growing centre for circularity, with support from the national and civic administrations.

The OECD has presented the Amsterdam Metropolitan Area as a leader in moving toward a Circular Economy (Elkins, et.al. 2019, p70), highlighting the planning, strategies, infrastructure, and innovation of the region towards a Circular Economy.

4.2.1 Regional Economy

The Amsterdam region has been a financial centre since the Golden Era, and this has continued to the present time. Amsterdam is a major global centre for banking, financial services, and business services. It is also a center for manufacturing and industry, as well as for tourism.

In 2021 the GDP of Netherlands was €940.89 billion (Statista Netherlands GDP, no date). The Amsterdam Metropolitan Area contributed €188.18 billion towards the national total. While the AMA makes up only 14% of the national population, it contributed approximately 20% of the national GDP total. The current unemployment rate (December, 2022) is 3.7%. Overall, the economy of Netherlands is strong, as is the economy of the Amsterdam Metropolitan Area.

The strength of financial, business and IT services is evident when we look at the key sectors of the Amsterdam economy; both in the number of jobs and in the financial contribution to the economy.

Sector	Jobs	Value (x million €)
Services (financial, business, IT)	469,000	56,000
Tourism	150,000	19,000
Industry / Manufacturing	180,000	15,000
Consumer Goods	70,000	10,000
Construction	NA	3,000

TABLE 26: KEY SECTORS OF THE AMSTERDAM ECONOMY

The industry / manufacturing sector presents a range of industries including agri-business, chemicals, petroleum, petroleum-based products (plastics, fertilizers, paints, solvents), steel, machines and appliances.

The strength of the economy and the business environment in Amsterdam and Netherlands is recognized globally. In the 2022 report by PwC, *Doing Business in the Netherlands*, they provide a

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summary of rankings of Netherlands on a global basis for a number of topic areas completed by other organizations. These include:

- Government:
- 6th in Government Effectiveness (World Bank, 2021)
- People and Talent:
- 6th in Global Talent Competitiveness Index 2021 (INSEAD, 2021)
- 1st in EF English Proficiency Index 2021 (OECD, 2021)
- 2nd in Knowledge Absorption (World Intellectual Property Organization 2021)
- Digital Infrastructure:
- 4th in IT infrastructure (World Intellectual Property Organization 2021)
- 1st in Global Connectedness (DHL Global Connectedness Index, 2020)
- 1st in the EU for e-digital intensity and digital infrastructure index (European Investment Bank, 2021)
- Innovation:
- 6th on the Global Innovation Index 2021 (World Intellectual Property Organization 2021)
- 3rd in Innovation Outputs (World Intellectual Property Organization 2021)
- 6th in Knowledge Creation (World Intellectual Property Organization 2021)

This sample of rankings demonstrates that Netherlands, and Amsterdam provide an environment where the business environment, the labour supply, the technology structures, and the outlook is one geared toward growth, innovation, and progress.

4.2.2 The Approach to Circular Economy in Netherlands and Amsterdam

The concept of moving towards a circular economy is one that is being approached around the world at the realization sets in that resources are limited, and the linear economic approach of **Take > Make > Dispose** is not sustainable.

In a circular economy, we keep resources, materials and products as long as possible in the cycle, we use renewable energy sources and safeguard the resilience of natural systems. By doing so, we minimise environmental pollution and optimise the use of valuable resources, materials and products, while at the same time ensuring the security of supply, creating new, sustainable businesses and jobs and generating new knowledge and innovation (Kaza, S. 2020).

While this concept is new in many places in the world, it is not new in Netherlands. In 1979 the government of Netherlands introduced environmental policies that began to promote a Waste Hierarchy of “reduce, reuse, recycle, energy recovery, incineration and landfill.” As much of the country is at or below sea level, the ability to create landfills for waste was costly, and lead to environmental issues relating to soil degradation and water pollution. Thus, in the early 1980’s the government banned most landfills for waste and moved to recycling and of incineration of non-recyclable wastes. This led to a strategy whereby 30 resources streams, such as batteries, tires, and packaging were managed according to the Waste Hierarchy.

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In the 1990's, Netherlands introduced Extended Producer Responsibility (EPR) for specific products and materials. Producer responsibility applies to producers or importers who put a product on the Dutch market. They have to set up a logistic waste management system, as well as organise its financing. This is a matter of chain responsibility: other links in the chain, for instance municipalities and retailers, have their own responsibilities in this process. This now applies to five main categories of products or materials:

- Electrical and electronic equipment
- Batteries and accumulators
- Scrap vehicles and associated parts
- Car tires
- Packaging

Through the 1980's and 1990's various waste management policies were developed. This led to the development, in 2002, of an integrated National Waste Management Plan. While developed at the national level, it's development and management was coordinated at national, provincial, and civic levels. This integrated approach led to the following major achievements with waste between 1985 and 2016 (Elements of Dutch Waste Management, no date):

- amount of land-filled reduced to 2.1%
- establishment of waste incineration plants nationally
- 77% of waste is recycled, with the remaining waste used for energy production
- recovery (waste-to-energy) rose to 93%

The approach to how waste was minimized and recycling encouraged used the following:

- Enforcement of legislation
- Financial instruments
- Separate collection
- Effective communication

The Waste Management Plan was expanded in 2007 to include and overall plan for waste management and the eco-design of products.

In 2016 the Netherlands, through the Ministry of Infrastructure and Water, developed a Circular Economy Programme, with the ultimate goal of making the Dutch Economy completely circular by 2050, which is in alignment now with the Paris Agreement on climate, and the 2030 Sustainable Development Goals.

Through the period from the 1970's to the present day, the principles and concepts of a circular economy have been present in the various waste management plans at the national and civic levels of governments in Netherlands, and the various targets that were set through the 1990's and early 2000's were achieved. While the term "circular economy" may not have been used initially, the principles of the approach were being initiated, established and followed.

4.2.3 Policy Frameworks

As a member of the EU, the Netherlands supports the EU policies on waste management and the move to Circular Economy. At the regional level, the Amsterdam Metropolitan Area also supports the

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EU policies and initiatives and has put in place strategies and structures to support the move to circularity and a Circular Economy.

4.2.3.1 European Union Regulations / specific policies

There are a number of key initiatives led by the European Union that are also drivers for legislation and initiatives in the Netherlands. First and foremost is the Waste from Electrical and Electronic Equipment (WEEE): Waste Framework Directive which sets the basic concepts and definitions related to waste management, including definitions of waste, recycling and recovery.

The EU Circular Economy Action Plan, adopted in March 2020, is one of the main building blocks of the European Green Deal, with is made up of a number of additional components. These include:

- Sustainable Products Initiative (March 2022)
- Consumer Transparency and Right to Repair
- Circular Electronics Initiative (upcoming)
- EU Strategy for Textiles
- Strategy for a Sustainably Built Environment (March 2022)
- EU-wide, harmonised model for the separate collection of waste and labelling

Finally, of note is the Circular Cities and Regions Initiative (CCRI): The CCRI is funded by Horizon 2020 and Horizon Europe. The CCRI works with designated cities and regions to combine knowledge sharing technical and financial support towards achieving the EU Circular Economy Action Plan 2020. The Amsterdam Metropolitan Area is one of the 30 model cities/regions that are identified in the CCRI.

4.2.3.2 Netherlands Regulations / specific policies

The environmental and Circular Economy initiatives by the EU form the basis for regulations in the Netherlands, and in the Amsterdam Metropolitan Area. In many cases, the national and regional initiatives in the Netherlands incorporate the directives of the EU, and go beyond them in the drive to fully circular economy.

- The Netherlands Circular in 2050:
- This program, lead by the Ministry of infrastructure and Water, lays out the plan for development and realization of the goal of Netherlands being completely circular by 2050 (Netherlands Circular in 2050, no date)
- Raw Materials Agreement (2017):
- This agreement lays out an initiative to run the Dutch economy on reusable raw materials. The agreement is between the national government and 180 other organizations representing the business community, trade unions, and environmental organizations. (Grondstoffenakkoord, 2017)
- Circular Economy Implementation Program (2019-2023):
- This national initiative outlines concrete actions and projects for the period 2019-2023 regarding five transition agendas to meet the overall Netherlands Circular 2050 goal. (Uitvoeringsprogramma Circulaire Economie 2021-2023, no date)
- National Waste Management Plan 2017-2029 Draft Second Amendment:
- This lays out the revised waste management framework directive for the country. (Landelijk afvalbeheerplan 2017-2029, 2020)
- Regeerakkord (Coalition Agreement):

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- The Regeerakkord is the coalition agreement for the current national government of the Netherlands. The governing parties of the national coalition have outlined their overall plan, including initiatives on climate, the environment and circularity. (Coalitieakkoord 2021 – 2025. 2021) In this agreement, the ruling parties agree to:
- prepare the Netherlands for the future – climate-neutral, fossil-free and circular – with a clean energy supply and green industrial policy
- be at the forefront of the transition to a green industry with a green industrial policy agreed to between governments, the business community and society
- ensure that the Dutch industry in Europe and worldwide sets the sustainable standard
- renew the National Housing and Building Agenda, including agreements on the number of homes to be built and the preconditions for construction, such as capacity for permits and sufficient construction personnel, and encouraging circular construction.
- support innovative start-ups and scale-ups and focus on the three major transitions: climate and energy, digitization and key technologies, and the circular economy.

4.2.3.3 Amsterdam Metropolitan Area/ Region Regulations / specific policies

- The Amsterdam Metropolitan Area has been selected by the European Commission to participate in the Circular Cities and Regions Initiative (CCRI) (Circular Cities and Regions Initiative, no date). The CCRI was established as part of the EU Action Plan for the Circular Economy and aims to strengthen the circular transition in European cities and regions. The CCRI supports 30 selected cities and regions, including the AMA, in their leading position in the field of circular economy.
- Amsterdam Agreement 2022-2026 (Amsterdams Akkoord 2022-2026, 2022):
- The elected coalition parties ruling Amsterdam have published an agreement that sets out the plans agreed upon by the coalition for the next 4 years. This includes actions on safety, the environment, housing, and responsible growth.
- Circular Inkopen & Opdrachtgeverschap (Roadmap Circular Procurement & Commissioning, no date):
- The region has set up and administers the Roadmap Circular Procurement and Commission, intended for the governments within the AMA, which provides a step-by-step plan to design the implementation process and select actions needed to ensure that circular procurement and commissioning is firmly established within the organization.
- Amsterdam Circular 2020-2025 (Amsterdam Circulair 2020-2025 Strategie, no date):
- This policy sets concrete goals for making Amsterdam city circular, including meeting the goals of by 2030, using 50 percent fewer new raw materials in Amsterdam, and by 2050 having Amsterdam being 100 percent circular.
- Innovation and Action Programme Amsterdam Circular 2020-2021 (Amsterdam Circulair 2020-2025 Innovatie- en Uitvoerings- programma 2020-2021, no date):
- This initiative describes and monitors over 200 circular economy projects that are being carried out in the city.
- Port of Amsterdam (Port of Amsterdam Strategy 2021-2025, no date):
- The Port of Amsterdam is a major hub in the region for circularity, and currently hosts 30 major circular enterprises. The aim of the Port of Amsterdam is to become the major hub for Circular Economy in Europe. Currently the Port of Amsterdam supports the drive to a Circular Economy by providing R&D facilities for biobased and circular innovation, as well as the ability to allocate space for enterprises involved in circular projects. The port also has a strategy to become carbon-neutral by 2025. (Port of Amsterdam Strategy 2021-2025 Taking the Lead, 2021)

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4.2.4 Zooming In: Waste Management in the Greater Amsterdam Region

Waste management in the Amsterdam Metropolitan Area is managed with an overall plan, but with each municipality being allowed to manage waste collection in their own jurisdiction. Following the national plan, landfill is not an option for disposal, leaving the options of recycling and incineration. In the Netherlands there are 12 incineration plants (AVI's) for waste, and in Amsterdam there is the AEB facility for waste incineration which is used for power generation. The AVI's in Netherlands are of large capacity, and cannot be run economically if they are not running at full capacity, so waste is imported to the Netherlands to ensure the plants maintain full capacity, including for the AEB facility in Amsterdam.

For domestic waste, the waste is collected in approximately 11,000 local containers, with separate containers for general waste, paper/cardboard, and glass. In some areas of the city containers are not used, but rather the waste is left curbside by the residents or businesses on designated collection days. Trucks from the municipality or private collection companies empty the containers or collect the curbside bags, and transport the waste to waste sorting facilities or recycling facilities.

Commercial waste is normally collected on a contract basis between the enterprise and a commercial waste collection company. Similarly, demolition waste and construction waste is removed by commercial waste collection companies on a contract basis.

Large residential waste can be disposed of in a number of ways. For items where a replacement is being delivered, the similar item being disposed of may be taken for disposal or recycling by the delivery agent of the retailer, or returned to the retailer. Items can also be disposed of by contacting the municipality and arranging for the item to be picked up. Or the item can be taken directly to the recycler or to the local waste processing centre.

The report *Uitvoeringsprogramma afval en grondstoffen 2020-2025* (2020) by the City of Amsterdam provides details on waste management in the city. The goal of the municipality is to reduce the amount of waste, and by 2050 to have zero waste. The amount of primary waste generated in Amsterdam (municipal and commercial waste) is decreased over the period 2016 to 2019:

- In 2016, 2,040 kilotons of waste was produced
- In 2019, 1,760 kilotons of waste was produced; a decrease of 14%

In Amsterdam, construction / demolition waste and overall municipal waste also decreased between 2016 and 2019, with a 17% and 12% decrease respectively. In 2019 volumes were:

- construction and demolition waste, 1,160 kilotons, or 69% or total wastes
- overall municipal waste, 390 kilotons, or 22% of total wastes

The decrease in the total amount of waste generated cannot be attributed to a specific type of waste.

For residential and light commercial business waste, 69% was general mixed waste, with the remainder being wastes that are separated for recycling. In the area of large commercial waste, 85% is from the construction and demolition areas, with the vast majority of that being soil, bricks and concrete.

Waste is collected by the municipality or commercial waste collectors by trucks. It is estimated that approximately 145 trucks are used on a daily basis to collect waste, and the waste collection trucks

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drive approximately 2.5 million kilometers in the city per year, generating approximately 80 ktons per year of CO_2, and 86 ktons of NOx. (Remments, L. no date)

Waste is pre-sorted by residents to separate recyclables (e.g., paper, glass), or by commercial collection companies based on the type of waste. Waste that then goes to the AEB is further sorted as part of their process stream to identify and mechanically remove seven more categories of recyclables (e.g., plastics).

With respect to polyurethane hard foam found in refrigerators and as insulation in laminate flooring and other construction materials, the following are extrapolated amounts for the Amsterdam region based on population from national figures:

- Refrigeration units collected and available for recycling per year (2019): 147,000 units
- Construction materials (2020):
- Laminate flooring: 117 Tonnes
- Insulation materials*: 136 Tonnes

*Note: category is for all types of insulation materials

4.2.4.1 Current situation white goods and insulation panels in the Netherlands

The European Union (EU) has legislated Waste Electrical and Electronic Equipment (WEEE) management since 2002. The WEEE Directive describes two methods for calculating the collection rate in the EU Member States. The "WEEE Generated method" is calculated by the mass of WEEE collected divided by the mass of WEEE Generated in the same year. The collection rate in Netherlands increased from 40% in 2014 to 54% in 2021 using this method. The increases are mainly driven by the significant increases in the WEEE collection compared to the WEEE Generation. The second method is the "EEE POM method", calculated as the mass of WEEE collected divided by the average amount of EEE put on the market (POM) in the three preceding years.

The Netherlands is actually amongst the European countries with lowest recycling rates of e-waste. Using the EEE POM method, collection rates increased from 39% to 50% from 2013 to 2016. From 2016 to 2020, the collection rate dropped to 44%. Despite the significant increases in WEEE collection, the decrease in the collection rate is caused by even larger increases in the EEE POM, causing the collection rate to decrease using this method. The Netherlands scored 55% using the WEEE-generation approach and 33% using the EEE POM. (WEEE Flows 2, 2021)

Undocumented Flows

One of the obstacles in reaching collection targets is that considerable amounts of WEEE are diverted to other undocumented WEEE flows. Unwanted WEEE flows need to be reduced and steered into the formal WEEE management regime. The exports for reuse and illegal exports are hardly monitored in most countries due to the lack of trade codes for used-EEE.

Hoarded Items and Consumer Behaviour

There is some untapped potential in WEEE through circular economy strategies. The 10 Mt hoarded items could be repaired or brought back into use. This could substitute for new electronic and electrical equipment placed on the market and lower consumption, lowering environmental impact in mining and production phases and preventing future WEEE generation. Additionally, through extending product lifespans, otherwise discarded items are not discarded and prevent the generation of WEEE in the same year. If lifespan extension is not possible, the broken hoarded items can be

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handed over to formal recyclers to turn them into secondary raw materials, thereby increasing collection rates and mitigating the environmental impact in mining and production.

For the Metropool Regio Amsterdam (MRA), extensive research has been done into 'urban mining' of residual streams in e-waste. The main conclusion of the 2018 report (Circulaire Business Cases in de MR, no date) is that there is a lot of value stored in the region and that much becomes available each year. For e-waste, that value is about €144 million.

Currently about 50% is 'lost', for example because e-waste ends up in processing methods that are considered 'low-value' because they reduce the value of the waste and value of the material. In addition, some of the e-waste does not reach certified processors due to leakage flows: e-waste disappears to non-certified parties at home and abroad, or in household waste, residual waste or construction and demolition waste.

The main conclusions of the e-waste substreams analysis are:

- In the first phase of the study, in cooperation with knowledge partners, a database was created that identifies the material streams in e-waste in the MRA. Sub-streams that are major contenders for life extension and high-quality reuse were identified. These are the residual streams of small household and IT, batteries, printed circuit boards and lighting and fixtures. The analysis revealed that currently only 56% of the total e-waste produced by consumers is collected. The leakage rate of 44%, represents nearly half of the estimated economic value of all e-waste.
- The value of e-waste that is not properly collected is approximately €52 million per year. This phase of the study shows that separate collection and high-quality reuse or recycling of promising residual streams within e-waste will greatly increase.

In a 2022 study conducted by the Hogeschool van Amsterdam (HvA), stakeholders involved in recycling of E-waste indicated that they would like to increase the supply of E-waste available to them. In the current situation the supply of E-waste is the bottleneck of the process. The percentage of E-waste that market leader Coolrec receives is around 50%. The other 50% does not end up in the circular circuit but goes to a grey circuit (23%), where E-waste ends up on a scrap heap (bulky waste) or with non-certified waste processors (27%) where consumers hand in their waste at local metal/iron recyclers, who process waste in a non-certified way. To increase Coolrec's e-waste supply, consumer return behaviour will have to change. To be more specific: E-waste must be prevented from ending up in the grey circuit and/or at non-certified waste processing companies. To prevent E-waste from ending up in these groups, the research recommends taking three actions.

- Adjust the design strategy: In order to minimize E-waste ending up in the grey circuit, it is advised to cooperate with manufacturers to see how their products can be adapted. The goal is to find ways to design products in such a way that they can be recycled more easily (design for recycling). Consumers often throw household appliances away in the bulk trash because they assume they are not E-waste and are largely made up of plastic. When components can be easily dismantled, it is more possible for consumers to separate components. And they are more inclined to dispose of it in the right places if there is the possibility to do so. Therefore, more bins should be placed where consumers can dispose of their materials. This can be done through cooperation with the OPEN Foundation.
- Product identification: Another method that takes the E-waste out of the grey circuit is the application of stickers or markings on household appliances. Here, the main goal is to inform consumers. Stickers or markings with a short quote such as "this product must be handed in

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at an environmental recycler" can help make consumers aware of their hand-in behaviour and the options where it can be disposed of. It also recommends placing a QR code on the sticker after which consumers have more information about further separation of the product. Applying this method of disseminating information is very effective and is also very financially attractive. For the consumer, the sticker is not annoying because the sticker is only visible when the product is thrown away. For example, on the bottom of a coffee maker that is not normally seen.

- Media campaign on importance and possibilities of separation: The previous advice mainly focused on preventing E-waste from ending up in the grey circuit. Still, 27% of the E-waste that is not handed in ends up at uncertified processing sites. To prevent this, an advertising campaign is advised on the importance of recycling and the impact of proper separation of E-waste. The emphasis here is that waste should not be handed in to old iron recyclers who are not certified (CENELEC) because of the negative impact on the environment.

For the Amsterdam Metropolitan Area (AMA), extensive research into 'urban mining' of residual streams in construction and demolition has been done. The main conclusion is that there is a lot of value stored in the region and that much more becomes available each year. For construction and demolition, that value of the industry is approximately €688 million annually. At this level currently about 50% of this is "lost," as it ends up in processing methods that are considered low-value because they do not maximize the value of the material.

In the first phase of an AMA-study, a database was created in collaboration with knowledge partners to map the material flows in the construction and demolition sector in the AMA. Promising sub-streams with substantial size and high potential value were then further investigated. These are the material streams wood, insulation material, gypsum board and bitumen.

The technology to recycle or reuse insulation material is available in the Netherlands. However, an important condition for high-quality reuse is better collection (separate separation) of insulation material. This is the first step. There are many different material streams and each of them has a separate logistics and treatment process. This needs to be recognized before processing solutions can be effectively deployed.

Insulation materials are currently not widely reused or recycled due to perverse price incentives. Although there is potential in the case study due to the growing demand for insulation material, and the technology needed is available in Netherlands, high-quality reuse of insulation material is often uneconomic at present.

The report, Circulaire Business Cases in de MRA, Bouw en Stoopaval (no date) presents a number of recommendations to improve the recovery of valuable contruction and demolition wastes. These include:

- Regulation and incentives: Real estate companies and government should create, with regulations, the right price incentives so that reuse of insulation material becomes more attractive.
- Commit to circular design and demountable construction: this enables selective demolition and separate collection of valuable residual streams at a later stage. Many of the chain parties we spoke to see opportunities here, and by, certainly in Amsterdam where the municipality has a strong land position, incorporating such building designs in the land allocation and tendering, rewarding such building designs, these circular frontrunners on impact can be rewarded.

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- Map existing construction: Unlock and manage data regarding construction and demolition actively from the AMA, at the project level, and thus create more insight into the material streams stored in the built environment, and thus demolition, on the one hand, and the demand for building materials for new construction on the other. Data at the project level is essential to make more materials available for reuse or recycling. Supply and demand must be matched at specific locations (where demolition or construction is taking place) and times (when demolition or construction takes place) must be brought together.
- New construction mapping: Gather detailed information about the urban mine of the future: by mapping now for all new construction projects in the metropolitan region, the preparation of a materials passport is made mandatory. For new construction, the opportunities for demountable construction and increasing the residual value of buildings are many times greater than existing construction, which is not designed for this. It is important to realize now through good design but also to determine in detail where materials and economic value will be located in the future.
- Explore the possibility of establishing a building depot/marketplace where secondary materials can be temporarily stored so that supply and demand can be matched. This would mean that materials can be stored so that supply and demand in these released materials are better brought together. This will help collect large, consistent fractions and create scale. Some market parties have indicated that existing locations and infrastructure of suppliers may also be able to be utilized for this purpose.
- Invest in circular 'demolition': Here too, not only the business community can take its responsibility but this can be started when issuing demolition permits and thus actively managed by the AMA municipalities.
- Ensure sufficient knowledge about the functional properties of secondary materials and building elements: This is important for materials with, for example, fire-resistant properties, but applies equally well to for example, the insulation value of materials. For materials derived from recycling, this is easier to do than with materials from direct reuse, because the treatment and production process in recycling is ultimately controlled, whereas with direct reuse an estimate must be made of the influence that the life cycle of an element has had on its properties at the end of its life cycle.

4.2.4.2 Planning for the Future in the Amsterdam Region

The location of current and future recycling and circularity hubs in the Amsterdam region has been defined in the regional plan. The current site of the AEB facility will provide the anchor point, with land around the facility and in the Port of Amsterdam being made available to support the move to a Circular Economy.

The document, Metropoolregio Amsterdam Grondstoffen Atlas (2018), lays out the plans for and the location of future development supporting circular enterprises for the Amsterdam Metropolitan Region. The graphic below illustrates the areas designated for circular enterprises. These are indicated on the graphic in the areas set to yellow. In terms of access, these areas have direct water, rail and road access for transportation.

In addition to the space allocated in the Port of Amsterdam or large recyclers, commercial circular enterprises and circular economy research, one area has been set aside as the Zero Waste Lab. This is a neighbourhood and community lab for social and circular innovation. Consumers can separate and return waste, and in exchange for the waste the consumer will receive tokens that can be used at vendors who upscale recycled goods, or for items such as fresh fruit, vegetables, or even coffee. The

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aim of this facility is to encourage innovation in small-scale entrepreneurs, and to encourage consumers to return waste goods of any type to the facility.

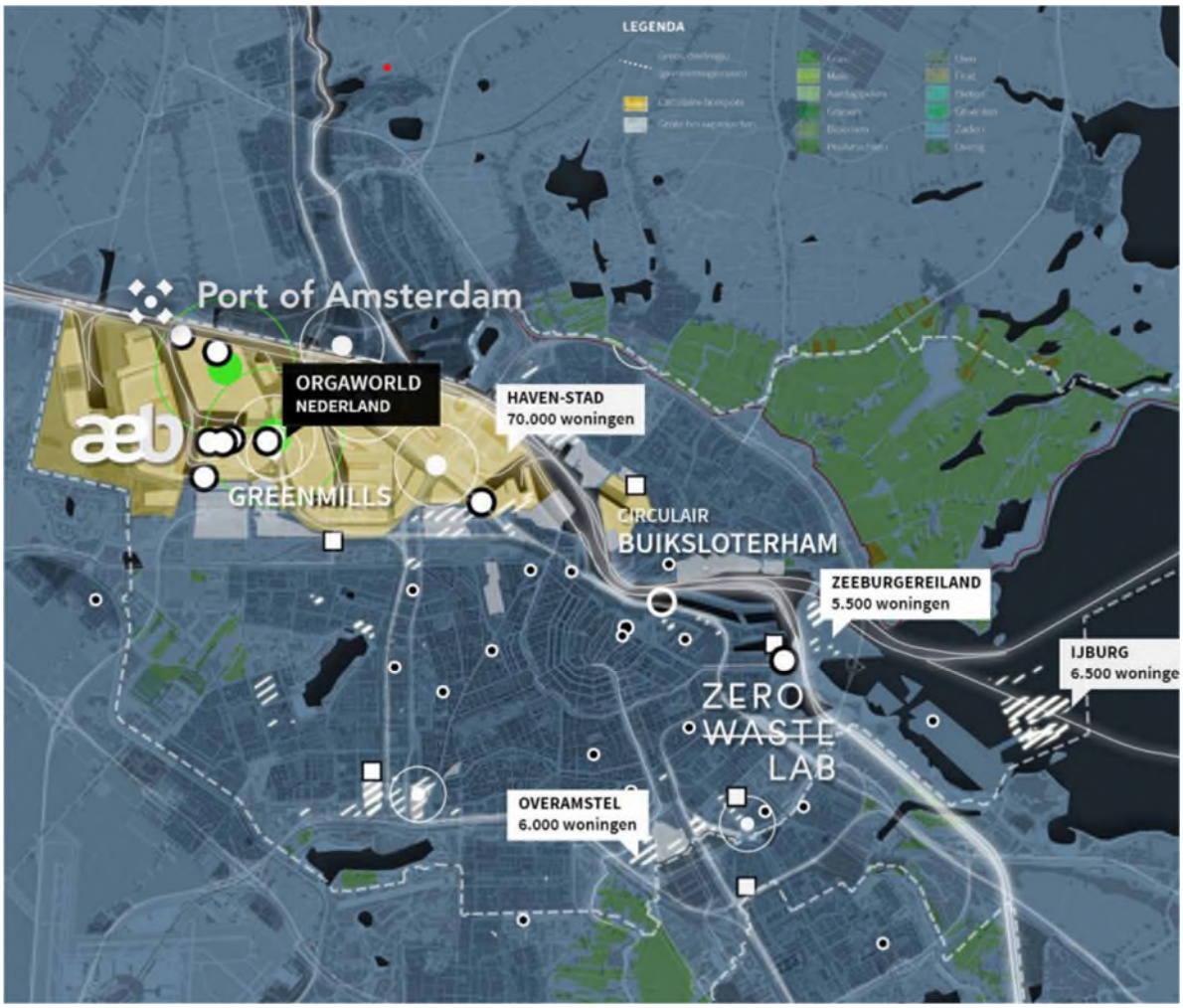

FIGURE 37: MAP OF AREAS DESIGNATED FOR CIRCULAR ENTERPRISES IN THE PORT OF AMSTERDAM

4.3 Key Findings

The Amsterdam Metropolitan Area (AMA) is a stable economic powerhouse of the Dutch economy. While making up approximately 14% of the population of the country, it contributes over 20% of the national GDP. With low unemployment, and projected to grow by approximately 600,000-750,000 inhabitants by 2040, the region provides opportunities to become one of the key hubs for Circular Economy in Europe by 2050.

Geography, economic and social conditions:

Strengths:

- The AMA is geographically situated with direct access to the North Sea, to the interior of Europe via canal and river systems for water-based transportation, and is a major air, rail and road hub in Europe

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- The Netherlands has a long history of social cooperation, innovation and entrepreneurialism. Where value can realized from goods of any type, over the course of Dutch history, entrepreneurs have demonstrated the ability to create value in those goods.
- The Netherlands, and the AMA have strong economies, with high levels of productivity, innovation, low unemployment, and a highly skilled workforce

Weaknesses:

- The AMA sits close to, or below sea level, requiring major water management, and making it susceptible to climate change and changes in sea level
- The current strong economy and low unemployment may limit growth in new industries due to competing demands for labour

Political and structural conditions:

Strengths:

- National and civic administrations are aligned on the need to embed Circular Economy in order to achieve the target of zero waste and be circular by 2050
- National and civic governments have put legislative, policy and administrative structures in place to support circularization
- AMA, through it's land use policy, has designated large areas of the Port of Amsterdam for enterprises involved in achieving the goal of Circular Economy
- The Port of Amsterdam organization fully supports the goal of Circular Economy, and it assisting enterprises by allocating land, assisting with sourcing of funding, and setting up networks of enterprises involved in circularization

Weaknesses:

- Coalition governments rely on stability within the coalition for continuation
- National and Civic governments may change based on election cycles, which may shift priorities and focus

Regional Readiness for Introducing Hubs for Circularity:

Strengths:

- The Amsterdam Metropolitan Area has been selected by the European Commission to participate in the Circular Cities and Regions Initiative (CCRI) as one of 30 designated example cities/regions
- The regional administration has made Circular Economy one of its main goals, and currently supports over 200 circular initiatives that are underway in the AMA
- Regional goals for waste reduction and eventual elimination by 2050 can only be achieved by making the AMA fully circular
- Concepts of Reuse and Recycle have been present in Dutch society since the 1980's so the underlying concept of Circular Economy concept known

Weaknesses:

- The goal of achieving zero waste and to be completely circular by 2050 may lend itself to many completing projects and initiatives, resulting in competition for waste materials

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- Funding and financial support for circular initiatives may be limited as the pool of competing enterprises grows
- The national, regional and civic governments assist with linking enterprises with potential sources of funding support, but provide very limited direct funding, if any

Waste Management:

Strengths:

- Long-established citizen awareness and behaviours supporting recycling
- Legislation and policies in place supporting recycling, recycling and circularity enterprises
- Structures and systems in place currently supporting recycling behaviours through separate public collection bins for designated items, support from retailers for return of used items such as batteries, appliances, and white goods
- Use of Artificial Intelligence (AI) and mechanical means to separate recyclables at the main waste processing facility and AEB incinerator
- Current trends demonstrate reduction in the volumes of consumer and commercial wastes
- Land use planning has designated significant space in the Port of Amsterdam for further development of enterprises involved in recycling and the Circular Economy
- Established recycling flows for other goods in the region allow research into best practices for setting up and establishing circular flows for polyurethane foams

Weaknesses:

- Dependence on large numbers of trucks to collect waste in the city on a daily basis, contributing significant amounts of CO_2 and NO_x gases for the collection of wastes
- The current dominance of the AEB incinerator for power generation creates an ongoing demand for waste materials. A solution to the question of potential loss of local waste materials to feed the plant will be required with the move to a complete Circular Economy.

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5 Joint Conclusion

This report analysed basic regional conditions for the introduction of *hubs for circularity* in three different regions (*Amsterdam Metropolitan Area (AMA)* in the Netherlands, *Rheinisches Revier* in Germany and *Upper Silesia / GZM* in Poland) by making use of a new concept of regional readiness. It focuses on non-technological dimensions in transition processes analysing societal, political and economic dimensions in each region. We translated this concept into an analytical framework consisting of six key aspects that helped us assess factors that foster or hamper cooperation towards the goal of establishing PU hard foam *hubs for circularity.*

1. *State of regional transition*

We see a stark difference between the three regions when it comes to their current state of transition towards a sustainable economy. The *Amsterdam Metropolitan Area* is a buzzing international commercial centre with a highly developed public infrastructure, education and innovation system. Sustainability as a concept is deeply ingrained in society. Especially the concepts of reuse and recycle have been present in the Netherlands since the 1980s, the concept of a circular economy is well-known and supported by clear policy goals. In contrast, the former mining regions *Rheinisches Revier* and *Upper Silesia /GZM* find themselves in the middle of a dynamic and deep transition from a black economy (shaped by coal mining and traditional energy-intensive industries) to a green economy (driven by renewable energy production and sustainable business models). In *Rheinisches Revier,* this transition towards finding a new economic focus is well under way - supported with substantial financial contributions by the German federal government and the state of North Rhine-Westphalia as well as a binding regional development plan and a unique transition agency, *Zukunftsagentur Rheinisches Revier*, that coordinates the implementation of various regional projects. Among them is a path for a sustainable resource transition in the region (*Ressourcenwende*). *Upper Silesia / GZM* is also at an even earlier stage of transition from a linear to a circular economy. As one interviewee put it: "*Waste is still seen as a problem, not a resource.*"

2. *Policy Frameworks*

Based on the assessment of the state of transition that the three regions are currently experiencing, we can also see major differences in policy frameworks that are in place to set clear goals for the transition towards a sustainable and circular economy. In the Netherlands, ambitious policy frameworks are already in place. Guided by the goal of becoming net-zero, by a concrete circular economy implementation program and an ambitious national waste management plan, the Netherlands are set to go fully circular by 2050. This goal is strongly facilitated on the regional level - with an ambitious Amsterdam Agreement for AMA and specific policy initiatives such as *Amsterdam Circulair 2020-2025 Strategie*. A highly supporting factor also seems to be the high level of alignment in politics, science, business and society - pushed by a broad set of stakeholders who act as important drivers of change (see also: Stakeholder Report). In the *Rheinisches Revier* area, there is also broad political support for the introduction of circular economy solutions. Various stakeholders in Germany, in NRW and in the region engage in conceptualising, discussing and shaping the debate on introducing circular economy solutions. However, on the national and state government level, there are so far only statements of intent on adopting binding circular economy action plans. They have not yet been put to work. In Poland as well as in *Upper Silesia/ GZM,* we also identified a lack of clear policy goals and leadership of key political leaders that are currently hesitant to move the transition towards a circular

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economy forward with ambition. Stakeholders in government and industry seem to mostly pursue a wait-and-see approach on the future plan to establish *hubs for circularity*. An additional hampering factor in the region is the fragmented administrative system driven by a complex multi-level governance with three levels of administration in the region: voivodships, poviats and municipalities.

3. *Regional Economy*

We analysed the economic set-up of all three regions - including a closer look at the characteristics of the local waste management system. The *Amsterdam Metropolitan Area* can be described as a stable economic powerhouse for the Netherlands - with a high level of productivity, market leading international companies, low unemployment and a skilled workforce. The region is characterised by a high degree of accessibility through its well developed transportation infrastructure. The same is true for its modern collection and sorting systems for waste which not only has a high local density of collection points but also uses (digitised) technologies to constantly improve its sorting and recycling abilities for various material flows. However, the very low level of unemployment and fast moving transition towards sustainability could also lead to limits in growth for new industries due to competing demands for funding, public awareness and skilled labour.

In *Rheinisches Revier,* we see a regional economy with a strong base in industry and manufacturing mostly located in the urban centres on the western (*Städteregion Aachen*) and eastern (Rhineland) edges of the region - paired with a skilled workforce and a high level of accessibility of the area due to a well-established transportation infrastructure. *Rheinisches Revier* and its neighbouring chemparks in the Rhineland area seem to be well suited to set up a dense industrial symbiosis for joint and sustainable usage of resources. There also is a well-developed waste management infrastructure in place with modern public and private companies engaging in collecting, dismantling and recycling in the wider region. *Upper Silesia / GZM* also has a good economic base and is one of the strongest economic regions in Poland, having the second highest regional GDP in Poland. The high level of urbanisation also seems to be a fostering factor for introducing *hubs for circularity* as well as the modernised transportation infrastructure and a dense network of scientific and research institutions. However, the region is being afflicted not only by a slow and challenging conversion of its industries towards a green economy but also by depopulation tendencies that could result in losing skilled workers and talents. The density of public and private companies in waste management is high, but also very fragmented (see Stakeholder Report). The region is thus characterised by a lack of consistent action and comprehensive planning in waste management and recycling.

4. *Culture of cooperation & innovation*

All three regions have a long history of business and social cooperation that can be helpful in setting up *hubs for circularity* since they are fundamentally based on a high degree of stakeholder collaboration. The Netherlands, and especially the *Amsterdam Metropolitan Area,* are well-known for their unique model of cooperation labelled *polder model* - starting with common land reclamation projects as early as in the 16th century and having been translated into the 21st century as a way to engage and align relevant stakeholder groups as early as possible in transition processes. In the region of *Rheinisches Revier,* though many companies are used to cooperating with science in consortia and many SMEs in the region are considered well networked, several studies still see a lack of cooperation among key players and a low level of regional identity. However, the transition process in the region is seen as a chance to enhance cooperation and serve as a common base for identification with the

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region. In *Upper Silesia / GZM,* the opportunities of a cooperative culture are also paired with the challenges of a rather polarised debate on the direction of regional progress.

The level of innovation that the three regions have developed for creating new technologies, business models and startup companies differ strikingly. Most international rankings show the Netherlands to be one of the most innovative countries - ranking in the top ten worldwide. The basic conditions for translating innovative ideas into business opportunities seem to be supportive - especially in the field of circular economic solutions. A dense network of innovators exists in the *Amsterdam Metropolitan Area* - supported by the government which is consciously making use of planning space for further development. A key area and nucleus for circular innovation is the Port of Amsterdam where a nearby *Polymer Science Park* as well as a *Zero Waste Lab* were created to provide physical space for new enterprises in the circular economy business. *Rheinisches Revier* as well as *Upper Silesia / GZM* also provide innovation spaces clustered around research institutions and science parks. Both regions also have a local strategy that is supposed to lead innovation activities. However, the focus of innovations currently lies on other sectors - mostly in renewable energy and not so much in circular economic solutions. Striking is the low level of funding for innovation and R&D in *Upper Silesia / GZM* compared to other regions in Poland as well as the European Union.

5. *Societal Awareness and Acceptance*

In all three analysed regions we see a broad public support for recycling and for moving into the direction of a circular economy. In the Netherlands, we can measure the highest degree of public awareness for a sustainable use of resources. The public debate on making progress on circular economic solutions is very lively and diverse - pushed by a diverse set of stakeholders, amongst them very targeted NGOs such as *Stichting Open Wecycle* or *Cirkelstad*. It translates into the political realm with all major political parties strongly supporting the goal of becoming fully circular on the national and regional level by 2050. In Germany, the concept of *Kreislaufwirtschaft* is well known and based on broad public support. This is, for example, indicated by a comparably high level of participation of citizens in the waste separation system. However, a low level of knowledge can be observed regarding the much wider concept of a circular economy, its technologies, systemic costs and benefits. It will also be important in Germany to closely analyse how the debate on the advantages and perceived risks of different chemical recycling technologies will develop with environmental groups leading the way by advocating binding zero-waste strategies or the substitution of plastic with bio-based products instead. In *Upper Silesia / GZM,* we can also observe a low level of public awareness and pressure on introducing new circular economic solutions. We also see a lack of public education on the relevance, urgency and opportunities of becoming circular.

Conclusively, Figure 38 visualises how well the three different regions that we have analysed in this report are positioned to introduce PU hard foam *hubs for circularity.* It becomes clear that the *Amsterdam Metropolitan Area* is best suited to move forward on the establishment of circular economic solutions in the near future. *Rheinisches Revier* finds itself in the middle of a fundamental transition towards a green and sustainable economy supported by a basic positive regional set-up that can potentially lead to functioning collaboration schemes and industrial symbiosis in the region - including the chemparks along the Rhineland. The *Upper Silesia / GZM* region is instead in a very early stage of a green transition with only soft policy goals and low public awareness. The path towards the introduction of circular economic solutions seems promising but not tangible enough - although it is supported by a mentality of change in the region and a culture of industrial cooperation.

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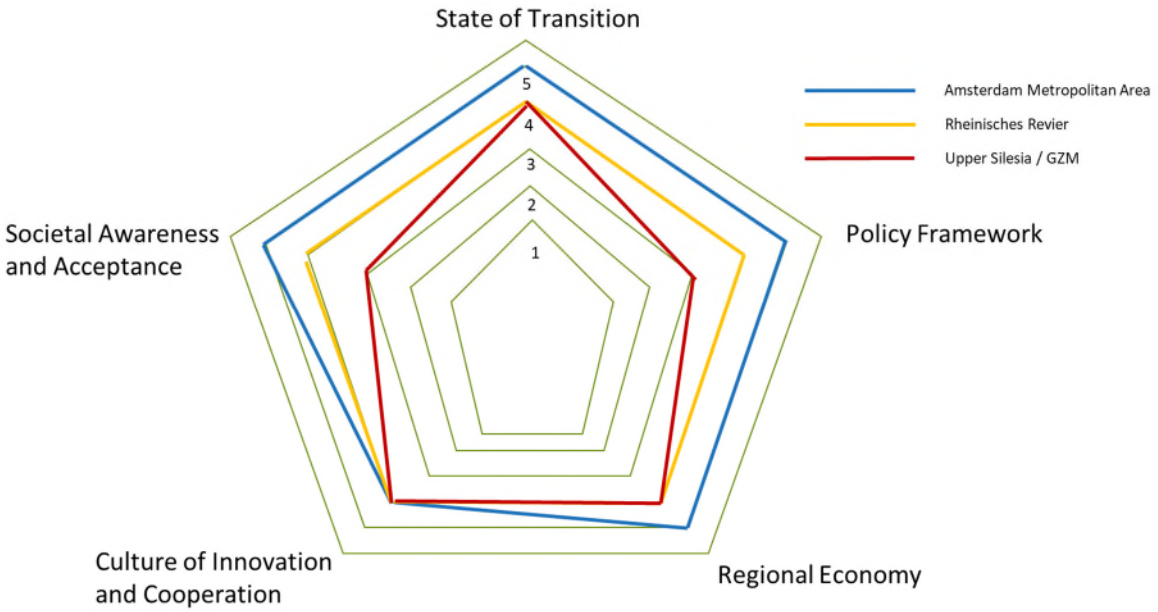

FIGURE 38: SPIDER WEB VISUALISING THE POSITIONING OF THE REGIONS IN KEY AREAS FOR INTRODUCING HUBS FOR CIRCULARITY (OWN PRESENTATION)

The most important factor for a successful establishment of *hubs for circularity* is, however, the forming of a definite stakeholder alliance (as *agents of change*) which is capable of pushing the transition forward in a coordinated and forceful way. Only if such a regional coalition for change exists, we will avoid a *hen and egg* problem of stakeholders waiting on each other to make the first move - as currently seen in other transition projects that have broad public and political support but lack the momentum of realisation. Unfortunately, we currently do not see such alliances in the case of PU hard foam or even on recycling of durable plastics in all three regions. PU seems to be a too specific material flow which is - to be blunt - not on stakeholders' minds at the moment. But, if it is seen and **understood as a pilot project** on the exemplary introduction of a circular economy in each region, it can have the potential to gain more attention and awareness - from politics, administration, business, NGOs and citizens alike.

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Interview B: Dr. Iris Rieth-Menze, team leader project management for industry and production, NRW.Energy4Climate/ IN4climate.NRW, 1 November 2022.

Interview C: Markus Wolff and Thomas Wendland, Chamber of Industry and Commerce Aachen (*IHK Aachen*), 15 November an 2022.

Interview D: Anette Harings, project coordinator for the department of structural change (*Stabsstelle Strukturwandel*), City of Mönchengladbach / Anna Engelpracht, leader of environmental management at the municipal waste services of Mönchengladbach, *mags - Mönchengladbacher Abfall-, Grün- und Straßenbetriebe*, 14 November 2022.

Interview E: Dr. Ruth Hausmann and Nicole Krüttgen, project managers at *Zukunftsagentur Rheinisches Revier*, department for “Resources and Agribusiness”, 16 November 2022.

Interview F: Stefan Alscher, resource efficiency consultant, *Effizienz-Agentur NRW* (EFA), 6 October 2022.

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