Specification of regional challenges / typology of high-carbon industry regions

Working Paper by:

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How to read this report

This working paper has a twofold purpose: First, it is intended as a theoretical basis for the EIT Climate-KIC Re-Industrialise Flagship and Program. It is conceptual in nature and primarily designed to fulfil specific functions for the Re-Industrialise Flagship: It sheds light on three major challenges for high-carbon industry regions that constitute barriers for low-carbon transitions. It supports the design and focus of the Re-Industrialise solutions hub by identifying challenges that can and need to be tackled and by describing them in more detail. It also supports the selection of new projects under the roof of the EIT Climate-KIC Re-Industrialise Program. And, last but definitively not least, this working paper is an internal document for the Re-Industrialise Flagship consortium. Due to the inter- and transdisciplinary character of the consortium, it was necessary and required many discussions to reach common ground on the meaning and purpose of different terms and concepts.

Second, we would like to ask readers to understand this compilation of regional challenges as a basis for future research. This is why we will treat this working paper as a living document over the course of the Flagship's work by adding and adapting challenges whenever needed. Moreover, we aim to cross-link the identified challenges and sub-challenges with particular characteristics of high-carbon industry regions in order to create a solid typology of high-carbon industry regions at a later stage. One crucial condition for developing regional strategies for low-carbon development in a timely manner will be to understand how and when we can transfer learnings in one particular region to another region.

As a result, this working paper on challenges in high-carbon industry regions explains basic assumptions and develops guiding hypothesis for the Flagship based on a mix of scientific results, direct experiences of the consortium members with regional stakeholders and reasoned arguments. Based on literature reviews, experiences from previous research and implementation projects in coal and industry regions, as well as on interactions with stakeholders in the two focus regions of Re-Industrialise, Silesia in Poland and North-Rhine Westphalia in Germany, we – the researchers and practitioners involved in the project – compiled a list of regional challenges that we determine to play a significant role in the transition of high-carbon industry regions to low-carbon industry regions. Thus, the working paper adds more pieces to this puzzle of low-carbon development in currently high-carbon industry regions. We do not expect each challenge or problem to be equally relevant in all regions nor do we expect this list of challenges to be exclusive. We focus on three different but intertwined challenges that we perceive to be of importance in high-carbon industry regions:

- low levels of low-carbon oriented innovation activities in high-carbon industries,
- low capacities of high-carbon industry regions to drive low-carbon transitions, and
- lack of political will to drive low-carbon transitions.

1 Introduction

„1.5°C-consistent pathways are characterized by a rapid phase out of CO2 emissions and deep emissions reductions in other GHGs and climate forcers (...). This is achieved by broad transformations in the energy; industry; transport; buildings; and agriculture, forestry and other land-use (AFOLU) sectors" (Rogelj et al., 2018, p. 112)

Just a few weeks prior to the 24th COP in Katowice, the Intergovernmental Panel on Climate Change (IPCC) published a special report focusing on the goal to limit global warming to 1.5°C above pre-industrial levels. Bottom line: Greenhouse gas (GHG) emissions need to be cut in half by 2030 and equal net zero by 2050. Otherwise, there will be significant climate impacts (IPCC, 2018).[1] The report puts special emphasis on the role of (heavy) industries as major contributors to global GHG emissions and argues that a low-carbon transition in industry is not only indispensable for any 1.5°C-pathway but even for limiting global warming to 2°C above pre-industrial levels. Moreover, only a couple of days before the COP, the European Commission published a communication on its *strategic long-term vision for a climate neutral economy* aiming at a "net-zero greenhouse gas emissions by 2050 through a socially-fair transition in a cost efficient manner" (European Commission, 2018, p. 3). This policy framework stresses the importance of clear and long-term signals for investment and finance and a research and innovation agenda putting special emphasis on zero-carbon challenges. Most importantly, it recognises the uneven distribution of positive and negative impacts the low-carbon transition will have in Europe; which was also the starting point of the Re-Industrialise flagship:

"Whereas the number of jobs increases in construction, farming and forestry and renewable energy sectors, for a number of sectors the transition can be difficult" (European Commission, 2018, p. 19)

The transformation of high-carbon industries (e.g. exploration of fossil fuels and the energy intensive industries like steel, cement and chemical as well as car manufacturing) is a particularly complex process involving fundamental and concurrent changes on many dimensions. In order to help us to think about this complex process, we have developed

1 Levin (2018), writing on the WRI Blog INSIGHTS, explains the most important results of the 2018 Special Report by the IPCC.

three basic categories of low-carbon economy transitions for high-carbon industries (see chapter 2.1 and Figure 2 for a visualisation):

1. reducing the carbon-intensity of products by changing the industrial production **processes** (e.g. chemical industry),
2. phasing-out high-carbon **products** in favour of low-carbon products in the same industry (e.g. automotive industry),
3. and phasing-out carbon-intensive industries that are not compatible with low-carbon development (e.g. fossil-based power).

These transitions are never solely technical processes, in which a technology A is substituted by a technology B while everything else remains the same. Instead we need to understand that these transitions will require system change; they will involve regime-change[2], encompass far more than slight adjustments to the established technical and technological infrastructures and will have lasting effects on the socio-economic structure.

1.1 The Re-Industrialise approach

In Europe, carbon-intensive (=energy-intensive) industries often cluster in certain regions. An analysis of GHG emissions by NUTS-3 regions[3] in Europe for 2017 shows a range of annual GHG emissions between only 2 tCO_2e in Primorsko-goranska županija (north-west of Croatia) and 38,298,554 tCO_2e in Piotrkowski (in the centre of Poland). The European Union consists of almost 2000 of these NUTS-3 regions spread across all Member States. In 2017, only 20 of them emitted about 25 % of all emission recorded in the EU ETS (see Table 1 on page 9). Therefore, the EIT Climate-KIC Flagship "Re-Industrialise" is looking at high-carbon industry regions. By that we mean economic areas in which the production and/or heavy use of fossil fuels constitute a) an important source of economic prosperity and an important share of value added in the region and b) result in a high level of direct or indirect GHG emissions.[4]

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[2] We use the term "regime" in alignment with its use in transitions theory: A socio-technical regime is the complex interaction of mutually reinforcing and highly institutionalised processes that perpetuate existing systems. In this perspective, not only actors and institutions in power, but also the prevailing processes of knowledge generation and diffusion, the established technical and technological infrastructures and institutions, the economies of scale and markets of incumbent systems including their social effects as well as the everyday practices and lifestyles of people constitute a socio-technical regime (STRN, 2010).

[3] According to the EU regulation on the common classification of territorial units for statistics, the NUTS-3 level is based on an administrative unit within a Member State that has in-between 150.000 and 800.000 inhabitants (European Union, 2017).

[4] The definition deliberatively designed to encompass regions that are economically dependent on exporting fossil fuels. These regions do not usually show high levels of direct GHG, but any transition towards low-carbon economies compromises their regional economic model.

“Re-Industrialise is borne out of a recognition that Europe’s overall shift to a net-zero-carbon 2050 will not affect its regions equally. Because some of its most carbon-intensive regions are economically dependent on the assets and processes that climate science tells us we need to stop, there is a risk of deep economic and social damage in some regions. This risk presents not just a social challenge for these regions, but a barrier toward the overall 2-degree climate target" (EIT Climate-KIC, 2018, p. 2).

Box 1 Our terminology explained: High-carbon industry regions

We define **“high-carbon industry regions”** as economic areas in which the production and/or heavy use of fossil fuels constitute an important source of economic prosperity and an important share of value added of the region. These are either regions with high intensity of heavy, industrial activities that produce a high level of direct greenhouse gas (GHG) emissions or regions that are indirectly responsible for high levels of GHG emissions as they export fossil fuels.

The 1.5°C limit to global warming and the corresponding emission reduction requirements challenge the economic model of high-carbon industry regions. In theory, this could be positive and lead to new creativity and innovation. But in reality, regime actors often find it difficult to overcome path dependencies and lock-ins (Avelino & Wittmayer, 2016; Fischer & Newig, 2016; Rock, Murphy, Rasiah, van Seters, & Managi, 2009; Smith, Stirling, & Berkhout, 2005; Wittmayer, Avelino, van Steenbergen, & Loorbach, 2017). This might in part be due to the fact that the pressure for change does not come from within the system but in form of normative political decisions from the larger *landscape*[5]. Moreover, it is to be expected that any kind of industry transition will upset the economic structure of a region that is economically dependent on high-carbon industries.

This is where the Re-Industrialise Flagship comes in; Re-Industrialise is all about how to minimise negative economic impacts and maximise economic, environmental and social opportunities for high-carbon industry regions. Apart from supporting local solutions, which might entail the application of new technologies, the Flagship will address questions of governance as well as participation and ownership. One of the core assumptions of the Flagship is that it is not only the actual risks and challenges that slow down the necessary transition processes, but the *perception of risks and challenges*. This is why Re-Industrialise, on the one hand, will look at specific challenges that high-carbon industries face with regard

[5] Landscape, in the transition theory, is the exogenous context to the socio-technical system under investigation. As Re-Industrialise looks at the regional socio-economic system of a certain high-carbon industry region, any political decision or global economic developments that influence this system, would be part of the landscape (STRN, 2010).

to low-carbon transitions. On the other hand, it will also look at good practices of low-carbon transitions in order to provide positive examples for regions in or pre transition.

1.2 The diversity of high-carbon industry regions

At its core, the Re-Industrialise Flagship project is built around the assumption that we can only fully understand transition processes if we take account of their socio-spatial conditions. These conditions are affected by global changes, but they are also subject to local and regional dynamics. Therefore, we seek to identify characteristic with which we can describe different types of high-carbon industry regions. The willingness as well as the capacity for sustainability transitions may differ significantly between different regions, we assume. Furthermore, we presuppose that this is dependent on a multitude of interacting factors that can be described as characteristics of a region.[6]

For example, Table 1 shows that clusters of high-carbon industries can be found in predominantly urban and intermediate regions, but also in predominantly rural areas. Although all regions share an economic structure that includes high-carbon industries, they might be very different in terms of economic structure and social opportunities for people living in these regions:

"Urban areas are often characterised by their high concentrations of population, economic activity, employment and wealth with the daily flow of commuters into many of Europe's largest cities suggesting that opportunities abound in these hubs of innovation, distribution and consumption, many of which act as focal points within their national economies and in some cases within Europe or even globally" (Koceva et al., 2016, p. 34)

Let us consider two examples from Germany, both part of the infamous Top20-emitting regions as presented in Table 1: the districts of Görlitz and Aachen. They have one important feature in common: Both regions produced almost the same amount of GHG emissions in 2017. One could assume that these regions are quite similar and, indeed, the emissions are mostly due to the presence of a lignite-fired power station in both regions. However, the fact that both regions encompass parts of the Rhenish lignite mining area and the Lusatian lignite mining area, respectively, seems the most important shared characteristic. One could argue that the proximity to German's east and west border, respectively, is another shared characteristic. However, by looking at the location of both regions in Europe (see Figure 1) it becomes obvious that these two regions are very different in terms of their settlement

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[6] This basic assumption corresponds with a trend in research regarding sustainability transitions. Transition research is working on establishing a *geography of sustainability transitions* that accounts for "the role of transnational relationships, global forces, and sub-national processes and actors in shaping the evolution of socio-technical systems" (Truffer, Murphy, & Raven, 2015, p. 64).

structures: The district of Aachen is not only a predominantly urban area itself, but it is also in close proximity to other important predominantly urban areas in Germany, Belgium, France and the Netherlands. The district of Görlitz, in comparison, is located close to the border to Poland and the Czech Republic. It can be described as intermediate region in terms of settlement structures and the next bigger city is Dresden (about 100 km). However, instead of being located in the midst of a cluster of urban agglomerations, it is surrounded by other intermediate regions. According to Dijkstra & Poleman "(a)ccess to a city is an indicator of access to a wide range of services and opportunities. For example, cities with over 50 000 people are more likely to offer diverse employment opportunities, higher education, specialised health care, a sizeable local market, shops and services such as banking" (2008, p. 3). With regard to Re-Industrialise and the structural change that high-carbon industry regions face, we can assume that a region – like the district of Aachen – embedded in urban agglomerations offers more access than a region where travel distance to these services and opportunities is longer – like the district of Görlitz.

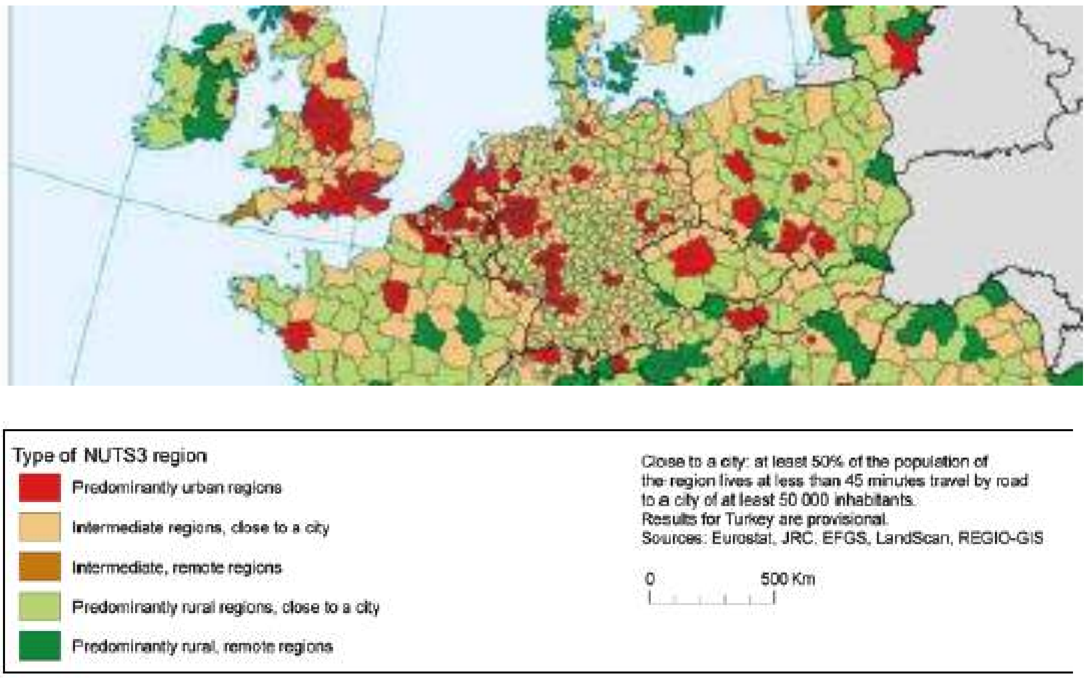

Figure 1 **NUTS-3 regions in Germany distinguished in terms of the EU urban-rural-remoteness typology**
Source: **European Commission (2011)**

Table 1 Top20 GHG-emitting regions in Europe in 2017

	NUTS-3 Region	Country	tCO2e (2017)*	Settlement structure**
1	Piotrkowski	Poland	38.298.554	Predominantly rural region, close to a city
2	Rhein-Erft-Kreis	Germany	36.469.304	Predominantly urban
3	Rhein-Kreis Neuss	Germany	35.986.273	Predominantly urban region
4	Spree-Neiße	Germany	35.185.508	Intermediate region, close to a city
5	Duisburg, Kreisfreie Stadt	Germany	32.603.270	Predominantly urban region
6	Groot-Rijnmond	Netherlands	27.235.876	Predominantly urban region
7	Ústecký kraj	Czech Republic	24.589.158	Intermediate region, close to a city
8	Стара Загора (Stara Zagora)	Bulgaria	20.893.637	Intermediate region, close to a city
9	Asturias	Spain	20.194.737	Intermediate region, close to a city
10	Bouches-du-Rhône	France	19.549.985	Predominantly urban region
11	Sosnowiecki	Poland	19.356.196	Predominantly urban region
12	Aachen (district)	Germany	19.289.981	Predominantly urban region
13	Görlitz (district)	Germany	19.200.722	Intermediate region, close to a city
14	Nord	France	18.465.156	Predominantly urban region
15	Γρεβενά, Κοζάνη (Grevena, K)	Greece	15.338.861	Predominantly rural, remote region
16	Arr. Antwerpen	Belgium	14.858.519	Predominantly urban region
17	North and North East Lincolnshire	United Kingdom	13.972.044	Intermediate region, close to a city
18	Kirde-Eesti	Estonia	13.653.673	Intermediate region, close to a city
19	Leipzig (district)	Germany	12.918.820	Predominantly urban region
20	A Coruña	Spain	12.846.344	Intermediate region, close to a city

*Data compiled by UNIBO, data set based on EU ETS (see Mura, Longo, Toschi, Boccali, & Zanni, 2018a).

**Attribution based on the urban-rural typology including remoteness used by the EU. Remoteness refers to the relative proximity of these region to urban centres with >= 50,000 inhabitants (Dijkstra & Poelman, 2008).

Let us consider two additional examples, the British county of North Yorkshire and the Stara Zagora province in Bulgaria: While the former reduced its emissions by 77 % between 2013 and 2017 (as a result the region was not part of the infamous Top20 in 2017 anymore)[7], the latter increased the emissions by 19.9 % over the same period (see Mura et al., 2018a, Table 1). Without going into detail with regard to the measures and investments that led to these contrasting pathways, the mere fact that one of the top emitting regions has already moved to drastically cut emissions while another has increased it emissions significantly, indicates that these regions are radically different from each other. Moreover, these two different development pathways might imply that there are already structural economic changes on-going in both regions, albeit very different ones.

We expect similar differences to arise when we look at the socio-economic structures of high-carbon regions (see Mura, Longo, Toschi, Boccali, & Zanni, 2018b), where some regions might already have a comparatively diversified economic structure, a high level of education, a low level of unemployment as well as a well-developed digital infrastructure. Other regions may be less fortunate with regard to these prerequisites of transition (see Table 2 on page 25).

1.3 Different regions face different challenges

This working paper aims at understanding the diversity of high-carbon industry regions in terms of their challenges to foster low-carbon economies. We look at challenges of and in a particular region and not so much at challenges of and in particular industrial sectors. For example, we are not so much interested in understanding which specific technological solution will help a certain industrial sector to improve the carbon footprint of production processes. Nor are we interested in analysing the markets regarding their needs for alternative, low-carbon products. Instead, we would like to get a better understanding of the regional conditions that lead to these kinds of innovations – or not. In addition to that, we recognise the social and economic risks involved in low-carbon transitions, especially when it comes to the phase-out of a complete industry. These are challenges for regional development that can act as barriers to transition.

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7 North Yorkshire is home to the largest power generation plant in the UK, Drax Power Station, which used to be the countries single largest emitter of GHG-emissions until 2016. By a combination of different measures, like the re-blading of steam turbines and the co-firing of biomass, the plant reduced its emission drastically by 2016.

Box 2 Our terminology explained: barriers, challenges, drivers and problems

Challenges, as we use the term, refer to **barriers for low-carbon development** in high-carbon industry regions. This does not mean, that these challenges are per se negative. For example, mining jobs in Europe are generally paid above average, with high social benefits and the share of miners in workers unions is also above average. From a social or employees perspective this is a good thing. However, it means that workers unions are not interested in swapping miners jobs against less well-paid jobs, for example in renewable energy production with lower rates of union membership. Therefore this fact becomes a challenge in a low-carbon transition.

In contrast, many high-carbon industry regions face obvious **problems**. One frequent problem is that of air pollution and subsequent health risks. This problem is obviously negative for the region. However it is generally not a barrier, but a **driver for a low-carbon transitions**: Here the reduction of fossil fuel burning offers a win-win opportunity for improving local health and CO_2 emissions reduction.

Some high-carbon industry regions have to deal with interlinked **problems** that are functioning as **barriers in low-carbon transitions**, thereby constituting challenges to low-carbon development. Such a problem might be poorly developed infrastructure for digitisation, a high level of unemployment coupled with a low level of education, or the lack of financial capital to invest in (low-carbon) regional development.

There have been various attempts to develop a typology of regions. For example, Tödtling & Trippl (2005) differentiate between peripheral regions, old-industrial regions and fragmented metropolitan regions in terms of their innovation capacities and problems. By analysing and connecting different research results from different regions and disciplines, they determine that

1. peripheral regions, which are often characterised by a dominance of SME, have a rather low level of research and development (R&D) and innovation activities are often implemented in form of incremental and process innovations;
2. old-industrial regions, which are likely dominated by larger businesses and specialised in mature industries, often face an innovation lock-in coupled with only incremental and process innovations;
3. fragmented metropolitan regions, which are often home to technology companies and R&D-departments, are much more active in terms of product innovations.

While a typology of regions that reflects different degrees of innovation activity as well as different problems for innovativeness is helpful for understanding the dynamics or the stagnation of low-carbon transitions in high-carbon industry regions (and will be looked at in more detail in chapter 2.1), it will always remain only one part of a complicated puzzle.

Thus, the following chapter attempts to add more pieces to this puzzle of low-carbon development in currently high-carbon industry regions. It is important to repeat, that we do not expect each challenge or problem to be equally relevant in all regions nor do we expect this list of challenges to be exclusive. Moreover, some challenges listed below are well documented in the literature (and we will give sources whenever available), others stem from our empirical and practical experience in working with regions. Some challenges might even be more hypothetical at our current knowledge, but we include them in this selection in order to find more evidence for (or against) them in subsequent steps of the Re-Industrialise Flagship.

In this paper, our focus is on three different but intertwined challenges that we perceive to be of importance in high-carbon industry regions:

1. low levels of low-carbon oriented innovation activities in high-carbon industries,
2. low capacities of high-carbon industry regions to drive low-carbon transitions, and
3. lack of political will to drive low-carbon transitions.

2 Transition challenges in high-carbon industry regions

High-carbon industry regions need to develop low-carbon economies; that is one take-away from the latest IPCC report. However, what does it mean to transition a regional economy from high-carbon industries to low-carbon industries? More precisely, what does it take? Innovation and investments, that is a given. But it will also take the socio-economic restructuring of these regions as well as the political will to do so.

Economic structural change is something that can happen to regions, as many historical examples show: In the Ruhr area, the former coal and steel region of Germany, coal mining became increasingly unprofitable due to globalised markets. Silesia experienced massive mine closures after the collapse of the Soviet Union and Poland's accession to the European Union. But even long before, the industrialisation of different sectors (e.g. textile industries, agriculture) can be understood as processes of structural change. In all these historic transitions, shocks to the landscape – either in form of radical innovations or globalised markets – triggered the transition process. In many cases, the signs were ignored as long as possible. By the time, the economic re-structuring was widely accepted as happening, political and economic actors were only able to react – usually trying to prevent the worst. Structural policy instruments often included infrastructure measures and funding or tax cuts for certain sectors and branches. Policy instrument to counter the negative effects of radical structural change were sometimes even designed to slow down the phase-out of unviable economic sectors via extensive public subsidies in order to prevent strong socio-economic ruptures.

Climate change can also be understood as such a pressure on the landscape; one that was translated and still is translated into climate policy on various governmental levels. These policies function as drivers for the energy transition. And they currently increase the pressure on the transport and industry sectors. But similar to the previous transitions described above, it took a while for climate change to be accepted as a fact. As a result, climate policy needs to be that more ambitious now. Some cases seem to be comparatively 'easy' low-carbon transitions, for example if measures have economic benefits in the short run (e.g. incremental energy efficiency measure in energy-intensive industries). But in many (industry) cases, low-carbon transitions equal system change and require huge investments. These are the 'hard ones'[8] that we would like to get the conversation started on – by talking about and eventually tackling the challenges regions might face in driving low-carbon transitions.

2.1 Challenge: Low level of low-carbon oriented innovation in high-carbon industry regions

Industrial production processes in high-carbon industries are often already on a very high level of (energy) efficiency. Energy-intensive industries constantly work on incremental[9] innovations for their production processes (the first of our three categories of industry transitions, see Figure 2), as energy efficiency (including the use of renewable energies) is cost-effective in the short run (e.g. production of steel). As a result, the potential for emissions reduction by increased energy efficiency is comparatively low (Wehnert, Mölter, Vallentin, & Best, 2017). However, Lechtenböhmer et al. (2016) describe several other decarbonisation options in transitioning industrial processes, which might have a significant impact on carbon emissions: indirect electrification based on electrolysis, hydrogen, and other synthetic fuels (e.g. producing steel by using hydrogen in a direct reduction process instead of using a blast furnace) including *power to chemicals*, as well as carbon capture and use technologies.

At the same time, high investments and long investment cycles, which often exceed 50 years, as well as significant sunk costs lead to highly concentrated markets dominated by only a few large corporations. Within this context, the establishment of niche-innovations is virtually impossible and radical (possibly disruptive) innovations are highly unlikely to occur. But they are needed in order to achieve the necessary emissions reduction for a 1.5˚C limit to global warming. Thus, instead of a high-carbon industry that only focuses on optimising carbon- and energy-intensive production processes, climate change requires industries to produce low-carbon alternatives to the old high-carbon products (the second of our three categories of industry transition, see Figure 2) and to leave existing pathways. This could be, for example, the development of lightweight steel that reduces the emissions in the subsequent value chains; or the development of bio-based industrial products and bio-refinery systems. The third category of industry transition is certainly the most disruptive process: the conversion of a complete industry, e.g. in the case the of the coal sector. For other sectors, cross-

[8] The „Mission Possible" report of the Energy Transition Commission (2018) defines harder-to-abate sectors as "(e)conomic sectors with relatively higher abatement costs than the rest of the economy. These include heavy industry sectors (cement, steel, chemistry) and heavy-duty-transport (heavy-duty road transport, shipping, aviation). They currently emit 10.3Gt of CO2 out of 34.3Gt CO2 from the energy and industrial system" (Energy Transition Commission, 2018, p. 11). The report outlines the technical, economical, political and social feasibility of reaching net-zero emissions by mid-century.

[9] Incremental innovations make up for the major part of innovations (95 %) compared to radical innovations when taking into account the scope of shift that results from an innovation (Lefenda & Pöchhacker-Tröscher, 2014).

industrial synergies are expected to have a big potential for low-carbon transitions. This applies for the use of residual material or by-products across industrial sectors (e.g. using the gases from the blast furnaces in the chemical sector).

In general, the more radical and disruptive an innovation, the bigger are the uncertainties involved for the respective industry. This often causes hesitation to implement innovations. A reaction that can be observed in general when it comes to innovation processes; irrespective of a low-carbon orientation of the innovation. In sum, we can conclude the following: Industries in high-carbon regions are often dominated by well-established incumbents as coal-mining or steel companies which tend not to implement (low-carbon) innovations that might lead to a risk for their business models. As a consequence, these regions often lack powerful actors who foster low-carbon innovations.

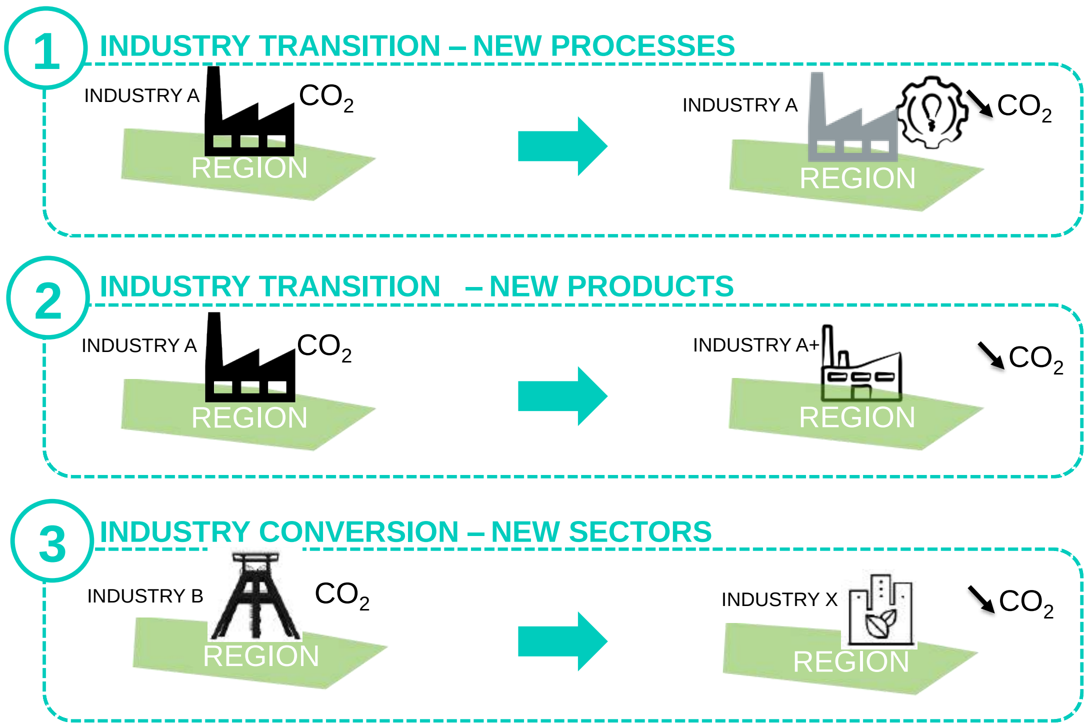

Figure 2 **Three categories of industrial low-carbon transition processes**
Source: **Own illustration.**

Moreover, based on case studies in North-Rhine Westphalia, which is one of the two focus regions in Re-Industrialise, Wehnert et al. (2017, p. 13) identify two main barriers of radical low-carbon innovations with regard to the high-carbon industry:

1 | A volatile legal framework that is slowing down the development of new products: Against the background of high investments and long investment cycles in high-carbon industries, corporations look for predictability and stability when investing in (low-carbon) innovations. According to industry representatives, innovation does not fail

due to technological limitations anymore, but because of a certain risk aversion in the sector (see chapter2.3 on the role of political will).

2 | **The characteristics of a highly centralised market dominated by conservative actors:** Well-established businesses have a low incentive to disrupt their own markets. This is the so-called "innovator's dilemma" (Christensen, 1997). Instead, they focus on incremental innovations that preserve their own market position. Although, there are various cases in which companies have supported innovation labs that develop radical innovations, Wehnert et al. (2017) were not able to find such labs for high-carbon industries that focus on low-carbon product innovation.

Conclusion:
Most innovations in high-carbon industries are incremental and aim at optimising mature technologies. However, a timely decarbonisation also requires fundamental and disruptive innovations.

However, case studies show some evidence that the following three factors are in support of radical industry innovations, even in high-carbon industries (Wehnert et al., 2017, p. 15ff.):

1 | **Access to external funding for R&D and demonstration projects:** External funding directed at industry innovations was crucial in all cases examined, but even large corporations require support in identifying and applying for the best funding schemes (see chapter 2.2.2 on the role of economic capital in high-carbon industry regions).

2 | **Support by consulting-, energy-, business-development agencies (so-called intermediaries):** Intermediaries can be crucial in supporting industry innovation, but their performance depends on various factors (see chapter 2.1.2 on the role of intermediaries).

3 | **Established and dynamic regional innovation systems:** Innovations studies can show that regional proximity of research, industry and suppliers can lead to a locational advantage and function as a basis for innovation (see for an overview Doloreux & Parto, 2005).

These three factors are not exclusively important for creating the necessary conditions for low-carbon innovation, but all of them are relevant on a regional level and depend on regional circumstances. In the following sub-chapters, we will see that intermediaries have an important function in building bridges and trust between different stakeholders – a role that is best fulfilled on a local or regional level. And we will look closer into the conditions and barriers for dynamic regional innovation systems.

2.1.1 Developing dynamic regional innovation systems (RIS)

Regional innovation systems, as defined by Tödtling & Trippl (2005, p. 1205ff.) on the basis of (Autio, 1998), comprise of two connected subsystems:

1. The **knowledge application** and exploitation subsystem includes all companies and their clients, the suppliers, competitors, as well as industrial cooperation partners (e.g. the sum of industrial clusters).
2. The **knowledge generation and diffusion** subsystem consists of public research institutions, technology mediating organisations as well as education institutions (universities, technical colleges, vocational training institutions, etc.), and workforce mediating institutions (e.g. unions, etc.).

What is important to understand is that RIS approaches recognize the interaction and exchange between different actors within or in-between clusters and networks as one crucial factor influencing innovativeness in a particular region. Tödtling and Trippl add to that a certain policy awareness: They argue that "(p)olicy actors at this level can play a powerful role in shaping regional innovation processes" (Tödtling & Trippl, 2005, p. 1206) if they "shift (their attention) from the traditional firm oriented perspective towards a more system-centred approach of innovation policy" (ibid. 2005, p. 1211).

Box 3 Terminology explained: clusters and networks

"Clusters and networks are different yet linked phenomena. Clusters are agglomerations of interconnected companies and associated institutions. Firms in a cluster produce similar or related goods or services and are supported by a range of dedicated institutions located in spatial proximity, such as business associations or training and technical assistance providers. Vibrant clusters are home of innovation oriented firms that reap the benefits of an integrated support system and dynamic business networks.
Networks are alliances of firms that work together towards an economic goal. They can be established between firms within clusters but also exist outside clusters. Networks can be horizontal and vertical.
Horizontal networks are built between firms that compete for the same market, such as a group of producers establishing a joint retail shop.
Vertical networks, particularly supplier development schemes, are alliances between firms belonging to different levels of the same value chain, such as a buyer assisting its suppliers for upgrading." (UNIDO, n.d.)

Moreover, Tödtling and Trippl associate different deficiencies with regard to innovativeness to different kinds of regions: They differentiate between peripheral regions that often lack an organisational and institutional set-up to successfully foster product innovation, old industrial regions that are often too specialised on mature industries and stick to incremental innovation (innovation lock-in) and metropolitan regions where a lack of coordination of a multitude of activities lead to fragmentation. For the purpose of Re-Industrialise, the typology developed is only indirectly helpful. Our description of high-carbon intensive regions in chapter 1.2 shows that we find high-carbon industry regions in rural, intermediate as well as urban areas. Moreover, these regions are not necessarily old-industrial regions with an economic structure build solely around certain conservative high-carbon industries. Instead, some of our regions might have a diversified, industrial economic structure. Nevertheless, we take the three problem areas developed by Tödtling & Trippl (2005, p. 1207ff.) as our starting point to explain deficiencies of high-carbon based regional economies:

The role of industry clusters

Functioning regional industry clusters that form alongside the value chains of certain industrial products are important for (low-carbon) innovations. As Malmberg & Maskell (2002, p. 433) put it: "In such an environment, chances are greater that an individual firm will get in touch with actors that have developed or been early adopters of new technology. The flow of industry-related information and knowledge is generally more abundant, to the advantage of all firms involved. A local culture with specific norms, values, and institutions (formal and informal) makes it possible to transfer tacit forms of knowledge from one actor to another."

This quote is an expression of empirical findings described in many studies and supports the antithesis, that regions exhibiting underdeveloped clusters, or a complete lack thereof, will have significant disadvantages in terms of their innovative capacities in general and in terms of compliance with climate mitigation targets in particular. However, even if there are highly developed clusters, they do not necessarily support (radical low-carbon) innovation: First, industrial clusters might be focused on improving high-carbon products instead of inventing new, low-carbon alternatives. Second, there might be too many different and highly specialised clusters that are not linked and coordinated. The latter often leads to a lack of knowledge sharing that undermines the function clusters should have for innovativeness (Tödtling & Trippl, 2005, p. 1211).

Hypothesis:
If a high-carbon industry region is not characterised by dynamic industry clusters, it may lack the innovative capacity to drive low-carbon transitions.

The role of knowledge generation and diffusion

Some major companies have the resources to establish their own departments for research & development (R&D), most companies will not. Moreover, in the context of Re-Industrialise, these major companies are representatives of rather conservative industries with regard to innovation. Thus, their incentives to foster and support disruptive innovations for a low-carbon transition are low and the exchange between independent research organisations and industry companies is of crucial importance.[10] However, this exchange does not necessarily happen automatically: (High-carbon industry) Regions sometimes have few or low-profile universities and research organisations to begin with. As our stakeholder analysis has shown, this is neither the case for our focus region of NRW nor is it the case in Silesia.

[10] Information and communication technologies (ICT) do offer new ways of communicating that render geographic locations less important. However, research has shown that local and regional proximity is still highly important with regard to knowledge diffusion (see for example Anselin, Varga, & Acs, 1997; Benneworth & Hospers, 2007; Bottazzi & Peri, 2003; Doloreux & Parto, 2005; Malmberg & Maskell, 2002).

Instead, (high-carbon industry) regions are sometimes home to a multitude of high-quality research organisations – as in the cases of NRW and Silesia alike (see Adisorn et al., 2018). However, even the existence of a multitude of high-quality research organisations does not automatically guarantee the exchange of knowledge between these research organisations and the industry. On the one hand, the links between industry and academia might be poorly developed and coordinated, which inhibits knowledge transfer. On the other hand, these knowledge transfer structures – even if well established and coordinated – can be thwarted by technological or political lock-in. Most importantly, these structures are not necessarily directed towards generating radical low-carbon innovations.

Hypothesis:

If there are no established and well-coordinated networks that include R&D institutions as well as industry clusters, a high-carbon industry region may lack the innovative capacity to drive low-carbon transitions.

Box 4 Example: IN4climate & SCI4climate.NRW

IN4climate.NRW and SCI4climate.NRW

One very recent example for an initiative tackling the typical challenges of RIS is the formation of the IN4climate.NRW initiative and its corresponding SCI4climate.NRW knowledge hub. Initiated by the state government, this new cooperation-platform is designed "to develop strategies to enable the North Rhine-Westphalian industries to maintain their high level of competitiveness, generate additional growth and contribute to achieving the Paris climate protection targets" (MWIDE NRW, 2018). The core idea is to facilitate a collaborative, innovative network by experts from the North Rhine-Westphalian industry, science and the state government. More specifically, the partners will work in so-called innovation teams focusing on the following questions: How can production processes and value chains be rendered climate-neutral in the long term? How can the industry contribute to the development of climate-friendly products?

The corresponding knowledge hub SCI4climate.NRW will conduct the necessary studies by looking at the technological, economical, ecological, institutional and infrastructural system challenges that arise for North Rhine-Westfalia in a transition towards a climate-neutral industry in 2050. Carrying out studies and developing conceptual approaches as the design of competitively neutral incentive schemes will comprise the activities of the knowledge hub. Besides that, specialists from the state government will work on shaping framework conditions that are conducive to innovation and climate change.

More information: https://www.in4climate.nrw/en/index/

2.1.2 Designing intermediary actors that can drive the low-carbon transition

As we have seen, one of the central factors for dynamic RIS is the vertical and horizontal exchange between different stakeholders within a region as well as with external actors. According to Cohen & Levinthal (1990, p. 128) "(t)he ability to exploit external knowledge is (…) a critical component of innovative capabilities". This holds true for absorptive capacities of specific firms as well as of regional industry clusters and networks, that need to be able to import ideas from other stakeholders as well as from outside of the region (Tödtling & Trippl, 2005, p. 1214).

This assumption can be reduced to a simple formula: Communication and cooperation is key to innovativeness, but only if these exchange processes are managed and neither insufficient nor overwhelming. Therefore, many different kinds of intermediary actors were established that function as a connection between different stakeholders and are often tasked with managing the processes of information and knowledge diffusion as well as network and cluster development. These are, for example, traditional business development agencies or actors designed for a more specific purpose, e.g. to support a specific sector or a specific industrial park. Moreover, we have seen the establishment of many intermediary actors with a rather different normative goal over the last decades: Intermediaries that are tasked with supporting climate action or resource efficiency in trade and industry. These are, for example, energy or resource efficiency agencies that often work on a regional level targeting either the 1st or 2nd category of industry transition (see Figure 2) – or both.

With regard to the role intermediaries can play in industry transitions, we need to look at empirical cases. For several German cases, Wehnert et al. (2017) were able to find that most intermediaries focus on cross-sectional technologies that are rather easy to scale-up (diffusion of knowledge). Only few intermediaries specialise in supporting the development of low-carbon breakthrough technologies or processes (production of knowledge).

Regardless of the function they are designed to fulfil, intermediaries face several challenges when engaging with different regional stakeholders themselves. These challenges should be taken into consideration when designing new intermediary actors in and for high-carbon industry regions where they might not yet exist (Wehnert et al., 2017, p. 34):

1. Intermediaries need either established connections to the industries or they need to create intelligent points of reference for these industries.
2. Intermediaries need to offer continuity with regard to staff and offers.
3. Intermediaries need to establish direct contacts in order to create trust, which means they need to work from inside the region.
4. Intermediaries need to know the workings of their target industries (and industrial processes).

We would like to emphasise that local or regional proximity is key to success for intermediaries as trust is an important currency in the innovation business. Moreover, the regional roots of an intermediary function as catalysts for regional driven innovations in general (whether focusing on climate actions or not). Additionally, the specific configuration of regional intermediaries will probably be at least equally important: Especially in the case of high-carbon industries, which we already described as rather conservative actors, it is of uttermost importance that these 'regime' actors are to some degree part of either the configuration process or the institution itself. This relates to the concept of ownership, which has proven to be an important factor for the success of transitions.

Hypothesis:

If there are no low-carbon oriented intermediaries active in a high-carbon industry region or if these intermediaries are not carefully designed, the region might lack the innovative capacity to drive low-carbon transitions.

Box 5 Example: Zukunftsagentur Rheinisches Revier

Zukunftsagentur Rheinisches Revier

As an example of the importance that intermediary actors can have for structural development and innovation activities in Regional Innovation Systems, we take a closer look at the *Zukunftsagentur Rheinisches Revier* (= Future agency of the Rhenish lignite mining area). This actor does not have any legal or executive power, but it functions as an important connector of regional stakeholders. It was established in 2010[11] as an initiative for preventive structural change by the affected municipalities and districts, the regional chambers of business and trade and the regional branch of the *Industrial trade union mining, chemistry, energy* (IG BCE). Since 2014, the agency operates as a project development actor developing ideas, visions, strategies, action plans and concrete implementation projects for the structural development of the region (Vallentin, Wehnert, Schüle, & Mölter, 2016, p. 9f.).

The agency acts as a "key player with regard to decarbonisation" (Adisorn et al., 2018). For example, in 2018 it published a paper on the cornerstones of an economic and structural development program for the region (IRR, 2018). Most importantly though, the agency functions as a connector for regional stakeholders from science, business, politics and civil society – for one thing it organises a yearly *Revierkonferenz* bringing together all these stakeholders

2.2 Challenge: Low capacity for low-carbon transitions in high-carbon industry regions

Climate change driven low-carbon transitions aiming at decarbonisation do not just happen, they need to be desired, planned and implemented, not least because low-carbon transitions require deep structural changes in our societies and economies. And we know – from historic experiences with similarly fundamental changes – that structural change can mean crumbling industries and job losses, strains on public and corporate budgets, huge efforts going into the attraction of new markets and, ultimately, job creation as well as in re-structuring vocational trainings. Amongst recent historic examples we can find structural change processes that resulted from the downturn of Europe's hard coal mining industries due to globalised markets as well as the maturation of new energy technologies or the crises of the automotive

[11] The *Zukunftsagentur* was initially called „*Innovationsregion*".

industry in the US-American *rust belt* since the 1960s. Another example, with an even earlier onset, is the relocation of production sites (and jobs) in the textile industry since the 1950s to low-income countries in order to withstand price battles. These historic examples occurred in different regions at different times and affected workers of different industries, but in the grand scheme they had similar effects: The flow of huge investments and subsidiaries into certain regions as a political response and the seemingly unavoidable (and at least temporary) socio-economic downturn of these regions – regardless of political efforts.

From an analytical perspective, we need to differentiate between the socio-economic prerequisites for low-carbon transitions (e.g. skillsets and funding) and the socio-economic impacts of structural change (e.g. job losses and budget strains). In reality though, these are two sides of the same coin that can never be looked at in isolation: Whether a region already meets certain prerequisites or not will have a significant effect on the impacts of structural change.

Conclusion:
High-carbon industry regions are not all the same with regard to their socio-economic settings, leading to different capacities to drive low-carbon transitions.

2.2.1 Substituting jobs and addressing education and training

"To the extent that it can be predicted, it does not appear that the transition towards green growth is likely to imply rates of labour reallocation or rates of change in job skill demands that are outside of historical experience. However, that conclusion may say more about how difficult it is to predict the labour market consequences of decoupling economic growth from harmful environmental impacts than how easily green growth driven structural change can be managed" (OECD, 2012, p. 10).

While radical low-carbon transitions require radical innovations, they also pose a socio-economic challenge for high-carbon industry regions. The actual effects of low-carbon transitions in high-carbon industry regions are hard to predict, as they will be dependent on a variety of factors. Acknowledging that a low-carbon transition to the necessary extent is unprecedented, the OECD opted for historic analogies: Taking the revolutionary effects of the information and communication technologies (ICT), they argued that

a | the negative effects on job markets will be strongly concentrated on particular 'brown' sectors (e.g. power generation based on fossils, transport via land, air and water, the industrial production of basic metals, other mineral products and chemicals as well as agriculture and mining).

b | the degree to which jobs are dependent on these brown sectors varies significantly between countries (e.g. 10.7 % in Denmark and Germany, 26.7 % in Poland) and the Central and Eastern Europe member states to the EU will most likely be affected harder.

c | the sectoral concentration of negative effects on the job markets will translate into spatial disparities where some regions will experience "prolonged decline" (OECD, 2012, p. 14).

In other words: Some of Europe's regional economies are constructed around extracting fossil fuels and/or around energy intensive industries for economic prosperity and jobs – others are not or to a lesser extent (see Figure 3). In these regions, crumbling energy-intensive industries would have substantial effects on the socio-economic structure. With regards to job security, the impact will likely be unevenly distributed within these regions as well:

- Low-skilled workers "are more than twice as likely as workers with a university level degree to work in the most polluting industries" (OECD, 2012, p. 49) and will be hit harder by an industry phase-out than high-skilled workers.
- Similarly, older workers tend to be overrepresented in 'brown' jobs and will be hit harder than younger workers (OECD, 2012, p. 49).

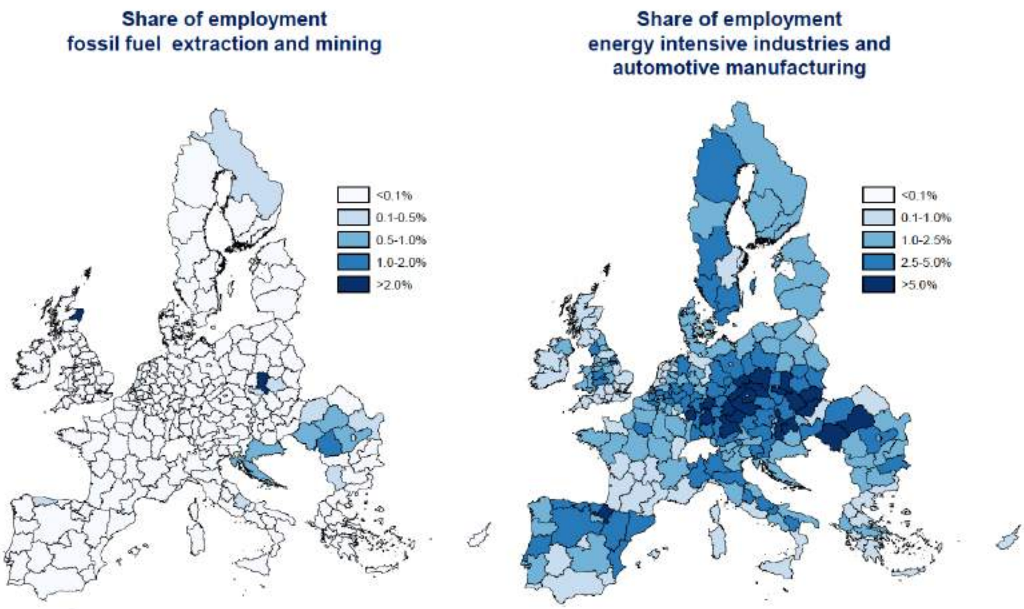

Figure 3 Geographic distribution of jobs in high-carbon industries (NUTS-2)
Source: European Commission (2018, p. 20)

However, the socio-economic impacts of a low-carbon transition of fossil-fuel dependent or carbon-intensive regional economies are highly debated. In Germany, for example, the economic importance of lignite-based electricity production is a very controversial issue on the political agenda, at the very latest since a federal Commission on Growth, Structural Change and Employment, recommended a gradual phase-out of coal by 2038 (Kommission 'Wachstum, Strukturwandel und Beschäftigung', 2019). This debate is particularly strong with regards to the actual impacts a low-carbon transition will have on the economic performance, the labour market and the overall prosperity of regions that evolved around either the extraction of coal (lignite) or the heavy use of a constant supply of cheap energy produced by burning coal. While the studies differ with regards to assessing the actual regional number or share of jobs that are dependent on lignite mining or energy-intensive industries, they all agree that it is important to take into account not only the initial effects of these industries but also indirect and induced effects on economic performance and the job market (see for example Bothe & Bräuninger, 2018; Oei et al., 2019; RWI, 2018). These quantitative analyses are mirrored in the concerns of stakeholders in our two Re-Industrialise focus regions. Stakeholders in Silesia in particular, confronted the Flagship consortium with corresponding questions: What happens to 'older' people employed in the mining sector? What kind of new businesses can be attracted? How can younger people be educated and trained to find work in these new businesses? How can the region deal with rising unemployment rates and the subsequent strain they put on public budgets? How can the region prevent increasing poverty rates? The actual impact of low-carbon transition in high-carbon industry will certainly depend on a variety of factors, e.g. the type of transition the region is facing and its dependence on the industry in transition. But the age structure as well as the educational level of those workers whose jobs directly or indirectly depend on a contracting industry will also play a significant role.

In the case of industry conversion, it will be crucial to either hold companies and respective jobs related to this industry (e.g. energy-intensive industries in coal regions) or attract new sectors and work opportunities. This creates an atmosphere of uncertainty for people living and working in high-carbon industry regions and induces fears that are not only related to unemployment. It means that workers most likely will need to be trained to work in new industrial processes or sectors that might be highly digitalised and require a different skill-set. It means that education and vocational training need to be adapted and the brain drain that some old-industrial regions complain about must be contained. But this also means that there can be no guarantee that the new jobs will be equally well paid or offer the same general conditions as the old jobs. Moreover, it means that significant investments will be necessary to prepare high-carbon industry regions for this transition; the extent of investments needed being dependent on the initial situation of these regions.

Indeed, it is important to note here that high-carbon industry regions show very different socio-economic settings and will have very different capacities to deal with economic transition. Table 2 shows the socio-economic performance of high-carbon industry regions in Europe as determined by Mura et al. (2018a, 2018b). As the table shows, the 20 regions that emitted the most GHG between 2013 and 2017 differ significantly in terms of their economic performance, their level of education and digitalisation. All three indices are considered as proxies for the regional's capacity to cope with structural change.

Hypothesis:

If a high-carbon industry region is already structurally weak, it has less access to the human and social capital needed to drive a low-carbon transition.

Table 2 Socio-economic performance of high-carbon industry regions

NUTS-3 Region	Country	tCO2e (2013–2017)*	Wealth**	Edu-cation***	Digital Develop ment****
Piotrkowski	Poland	187,018,817	0.12	0.25	0.50
Rhein-Erft-Kreis	Germany	183,128,786	0.25	0.33	0.83
Rhein-Kreis Neuss	Germany	192,206,961	0.24	0.31	0.83
Spree-Neiße	Germany	179,864,700	0.18	0.26	0.61
Duisburg, Kreisfreie Stadt	Germany	166,326,282	0.24	0.31	0.83
Groot-Rijnmond	Netherlands	133,173,270	0.24	0.25	0.96
Ústecký kraj	Czech Republic	114,741,152	0.13	0.02	0.49
Стара Загора (Stara Zagora)	Bulgaria	98,088,605	0.08	0.07	0.14
Asturias	Spain	95,195,963	0.13	0.22	0.54
Bouches-du-Rhône	France	93,887,120	0.18	0.25	0.69
Sosnowiecki	Poland	92,795,598	0.13	0.18	0.46
Aachen (district)	Germany	93,133,052	0.25	0.33	0.83
Görlitz (district)	Germany	95,365,843	0.19	0.34	0.68
Nord	France	82,906,479	0.15	0.23	0.54
Γρεβενά, Κοζάνη (Grevena, K)	Greece	97,848,880	0.03	0.11	0.24
Arr. Antwerpen	Belgium	72,792,291	0.25	0.19	0.73
North and North East Lincolnshire	United Kingdom	68,898,789	0.17	0.24	0.84
Taranto	Italy	68,156,894	0.09	0.08	0.31
North Yorkshire CC	United Kingdom	90,377,712	0.19	0.29	0.84

*Data compiled by UNIBO, data set based on EU ETS (see Mura et al., 2018a);
**The Wealth Index was complied based on data regarding the region's GDP and unemployment; ***The Education Index was compiled based on data regarding tertiary education of people living in the region; ****The Digital Development Index was compiled based on data regarding computer and internet use as well as on broadband access (see Mura et al., 2018b for methodology and methods)

2.2.2 Finding the capital to invest in innovation

Low-carbon transitions involve investments and high-carbon industries – conservative actors they are – hesitate to make significant investments in innovation as long as there is no stable political framework. Thus, acquiring external funding for research and development as well as demonstrator projects can help these industries and their respective regional homes to bypass these obstacles. But, regional and industrial stakeholders often claim that access to funding is insufficient due to various reasons.

As a matter of fact, access to finance is probably the most widely named barrier for a regional transition by the respective local stakeholders. Even though – looking at the plain numbers – it seems there is abundant EU funding available for a low-carbon development (e.g. for Silesia it adds up to 791 Million EUR; 291 Million EUR for North-Rhine Westphalia from 2014-2020[12]), it still represents a challenge to access this funding successfully and use it then in a transformative way (Bukowski, Śniegocki, & Wetmańska, 2018).

This ambiguity shows that the debate is complex and requires an increased effort in terms of identifying the true factors behind this challenge. Based on exchanges with stakeholders and insights from the discourse on climate finance in international development, we identified the following problems with regard to acquiring necessary funding:

1. building adequate and innovative consortia and bridging the gaps between different stakeholders,
2. getting the necessary information on available funds and meeting the formal requirements,
3. mixing different financial tools in order to rely not only on public funding.

Building the consortia

First of all, obstacles lie within the nature of the kind of transitions that are needed in order to achieve climate mitigation goals in high-carbon industries: Singular activities by individual stakeholders (e.g. for energy efficiency measures) are relatively easy to access and to finance. However, to accelerate the dynamics and speed of low-carbon transitions, cross-sectoral activities are required that ideally connect governmental regulations with financial investments. This entails a joint effort of stakeholders with diverse backgrounds – coming from academia, enterprises and public authorities. The fact that those stakeholders do not always have close working relationships represents a major barrier. Access to finance is thereby conditional on a set of factors that are more fluid: the trust between the applicants

12 An overview of the EU's structural funding activities can be found here: https://cohesiondata.ec.europa.eu/overview#achievements .

in the consortia, the perception of the visibility by firms, the crowding out of productive investments by public expenses financing or non-productive activities (GIZ International Services & Eurecna CNA Veneto International Services, 2016).

Moreover, there is a significant difference between large, multinational companies (e.g. Bayer, Covestro, Thyssen Krupp) and small and medium-sized enterprises when it comes to acquiring and handling external funds. Large corporations usually have their own R&D-departments and are more experienced with external funding. SMEs often do not have the capacity to include substantial R&D activities (let alone stand-alone R&D departments) into their business model. They often lack the resources to invest in elaborate funding proposals, especially when grant approvals are particularly uncertain. This signifies a key barrier in the access to funding for SMEs. In addition, they often cannot fall back on a rich network with relevant stakeholders in the region – be it universities or regional authorities – to build consortia with a sufficient level of trust among the parties. In particular, the link between SMEs (and even bigger enterprises) and the city officials or the regional government is often underdeveloped.

Public funding can act as an attractive incentive to bring stakeholders with different backgrounds together, as the example of Carbon2Chem shows. In this project, Thyssen Krupp teamed up with the Max Planck Institute (a well renowned German research institute), as well as other companies and universities. Key success factors for building this particular consortium were close personal relationships and regional proximity (Mölter, Kobiela, Vallentin, & Wehnert, 2017).

Governments and regional authorities could ideally act as the convenor of such consortia. However, they often lack the right information and need support in analysing models such as market-based approaches, financial incentives and technical assistance in terms of efficiency and effectiveness. Intermediaries – as laid out in chapter 2.1.2 – could play a significant role in bringing stakeholders with diverse backgrounds together and form projects that tackle a systemic challenge.

Requirements for funding

When talking to SMEs, it is stressed that information on available funds is insufficiently disseminated, notably as regards the terms and conditions attached to the facilities. The mapping of detailed information already requires substantial efforts. In particular when it comes to financial institutions (e.g. the larger public investment banks – such as the European Investment Bank), they do not want to commit on terms that may vary from one borrower to another; and often consider detailed data confidential as it reflects the strategy. On a positive note, more advisory services are now available to support in the first steps, e.g.

the EIB advisory hub, or regional public support[13]. These offers do, however, not specialise in low-carbon development. For one thing, investing in low-carbon development has the benefit that additional resources can be tapped; in particular in view of a 25 % climate mainstreaming in the upcoming EU budget and creating specified funds based on the ETS revenues. However, proving (and even quantifying) that a project will have a positive effect on the climate represents yet another challenge to the applicants.

Mixing financial tools

When in looking at Poland, there has been a strong focus on public funds (namely EU structural funds) to foster the regional transition. However, public funds will likely not be enough to cover the costs for a low carbon modernisation of the regions. To succeed in an effective mobilisation of funds requires combining various financial tools at regional, national as well as EU level that leverage private investments as well (Bukowski et al., 2018). The status quo is that companies are still hesitant to invest their own money, due to the high-perceived risk in the new technology. Currently, the incentives for investors to incur the risks and additional organisational efforts are not sufficient. Specialised companies, which are more experienced in new low-carbon technologies, could step in and support both with knowledge and investment services. However, this is often not the case due to limited knowledge.

Hypothesis:
Structurally weak region’s oftentimes lack the resources and capacities to access funding at the required scale and use it in a systemic way.

[13] E.g. for Hessian in Germany: https://www.rkw-hessen.de/beratungsfoerderung/innovationsfoerderung.html; https://www.een-hessen.de/innovation.

2.3 Challenge: Lack of political will to drive low-carbon transition

In the previous two sub-chapters we already touched upon various political requirements that are important for creating a framework for low-carbon transitions: Innovation activities of high-carbon industries need a reliable political framework for investing into (radical) low-carbon innovations. Regional innovation systems benefit from new forms of governance, in which intermediary actors can play the role of network coordinators, communicators, and overall facilitators. Most importantly, high-carbon industry regions need support from higher political levels in preparing for and dealing with the structural change inherent in the low-carbon transitions of their economies. They will need this support in terms of funding and assistance to acquire additional funds, but they will also need this support in terms of an adequate political framework that enables high-carbon industry regions to move forward and to foster low-carbon economies.

This need for political commitments becomes even more obvious if we consider the nature of low-carbon transitions. In contrast to other system changing processes, e.g. the first industrialisation and the digitalisation, the development of low-carbon economies is not primarily driven by technological innovations that revolutionise societies and economies. The development of low-carbon economies is also not primarily driven by an economic decline of particular sectors that is triggered by developments on globalised markets (Popp, Pous, & Reitzenstein, 2018, p. 36ff.). Instead, the development of low-carbon economies needs to be driven by normative, political decisions that in turn trigger and/or require social and technological innovations. Climate change mitigation is by nature a proactive endeavour, which requires long-term thinking and decision-making as well as investments that will not pay off in the short run. While the real costs of climate change will not be visible for a while, the only chance to limit the impacts of global warming is to act pre-emptively.

Unfortunately, political dynamics do not always work in favour of such long-term goals. Politicians shy away from unpopular, but necessary measures. Regime-actors, meaning stakeholders who might face high costs in transitions processes, lobby against those measures (see for example Jacobs, 2016). And climate change is, unfortunately, still perceived as a very abstract and presumably far away problem. This translates into two problems (amongst others) that generate a barrier for successful[14] low-carbon development policies:

[14] We do not want to engage in a debate on how to measure the success of policies or transition processes. Knowing, that successful low-carbon development policies will always be measured on various sustainability dimensions, we are deliberately reducing the issue of policy success to one indicator: the amount of emission reductions generated.

1| Transforming high-carbon economies into low-carbon economies requires the mainstreaming of climate mitigation goals. Economic policy, industrial policy, and innovation policy – these are all policy areas that tend to have certain inherent goals are not usually linked to ambitious climate targets. In order to enable low-carbon development at a scale that is needed by now, these policies must complement and reconcile their inherent goals with ambitious climate mitigation goals.

2| Against the backdrop of huge investments, possible negative effects on economies and societies and the corresponding fears, political, industrial, as well as civil society actors in high-carbon industry regions tend to lobby against low-carbon development. Here another kind of reconciliation is needed to prepare the ground for low-carbon economies: High-carbon industry regions need support in dissolving the close ties between a 'brown' industry and the region's identity. In other words, they need support in designing a positive vision for a low-carbon future.

Conclusion:
Political will on various governance levels is indispensable for a successful transition of high-carbon industry regions.

2.3.1 Mainstreaming climate change mitigation targets for low-carbon development

High-carbon industry regions are embedded in Europe's extremely refined multi-level system of government and governance, which functions according to the principles of subsidiarity and proportionality.[15] This means that the political framework, the principles and the political goals, are usually developed on the European or national level (depending on the policy area) and need to be translated into implementation measures at sub-ordinate levels. This leads to challenges with regard to vertical integration and coherence of policies between different levels.

Sometimes, we find that public authorities on the sub-national level are much more ambitious with regard to climate change mitigation policy: They are often the first to create and implement new climate policies. For example, 42 European regional governments[16] have publicly made a commitment to limiting emissions to 80-95% below 1990 levels or to below 2

[15] The political systems of the EU's member states are not all the same. Instead they differ with regard to the distribution of competences between governmental levels in terms of the degree of centralisation or federalisation. And there are differences in terms of the allocation of competences in different policy areas to different governmental levels.

[16] A map of all regional and state governments in the Under2 Coalition is available online: https://www.under2coalition.org/members

annual metric tons per capita, by 2050. They commit also to share learnings and cooperate with one another through the global Under2 Coalition. Almost 6,000 mayors of cities in the EU have committed to climate mitigation and developed appropriate plans within the framework of the Convenant of Mayors for Climate & Energy[17]. There are many more examples of sub-national and even local public authorities moving further than their respective national representatives. Thus, it's not only national policies that can drive emissions reductions, but state, regional, and city policies as well.

However, the emission data of high-carbon industry regions analysed by Mura et al. (2018b, 2018a) shows clearly that there are also local and regional laggards with either setting an ambitious climate mitigation policy and/or implementing an ambitious climate mitigation policy effectively. Thus, mainstreaming climate change mitigation targets and policies for low-carbon development across all levels of government and governance is of uttermost importance.

Cooperation problems between different stakeholders

It is important to reiterate our definition of a region at this point: In the context of Re-Industrialise, we understand regions as functional constructs that, in the case of high-carbon industry regions, evolved around a certain high-carbon industry and corresponding industrial clusters. One administrative authority does not necessarily govern a high-carbon industry region as a whole. In contrast, we can find many examples where the government of such a region is shared between different public authorities. In chapter 1.2 we described two German NUTS-3 regions as examples to explain the diversity of high-carbon industry regions and we used them as administratively demarcated proxies for their respective functional high-carbon industry regions: the Rhenish and Lusatian lignite mining regions. Both high-carbon industry regions, however, are not congruent with administrative boundaries of one NUTS-3 region. Instead, the Rhenish region is made up of parts of six different districts, three of which were amongst the Top20 emitting regions in 2017. The lignite mining area of Lusatia is made up of six districts as well and one county borough, two of which were amongst the TOP20 emitting regions in 2017 (see Figure 4). Moreover, parts of the Lusatia area are located in Brandenburg and parts in Saxony, in two different federal states in Germany.

Thus, we are looking at functional regions that constitute around a certain economic structure and cannot be governed by one particular public authority. Instead, the low-carbon transition of high-carbon industry regions requires coordination and cooperation between multiple public authorities on different levels of government. We know from scientific studies as well as from our own research and experience, that cooperation and coordination between different public authorities is not always easy. Instead it is costly in terms of human

[17] For more information visit the official website fort he CoM: https://www.covenantofmayors.eu.

resources. And it will always get complicated; at the latest when costs and benefits of transition processes need to be distributed.

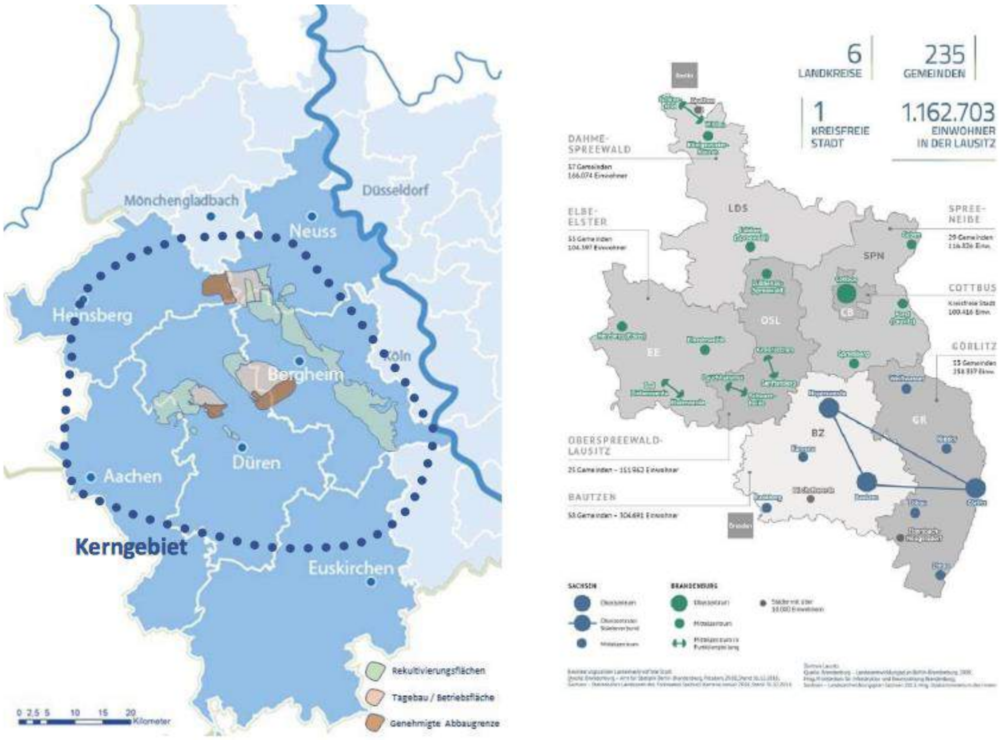

Figure 4 The location of the Rhenish (left) and Lusatia (right) lignite mining areas

Box 6 Example: Regionalverband Ruhr

Regionalverband Ruhr

Four distinct administrative districts govern the Ruhr area, the historic hard coal mining and steel production area of western Germany. The decline of profitability of the hard coal mining industry and the subsequent downturn of the socio-economic performance of the area showed that this separation of executive powers and, most importantly, regional planning competence did not work in favour of a consistent economic re-structuration of the area. Thus, the state government of NRW transferred the planning authority for the Ruhr area and several other competences to the *Regionalverband Ruhr (= regional association Ruhr)* in 2009 and 2015: Today, the regional association has several compulsory duties, for example the development and update of master plans for the region, the continuation of specific landscape development projects and the securing of green areas as well as spatial observation. Additionally, the association has several voluntary tasks (i.e. in the areas of cultural and spatial policy, mobility policy, European policy, and climate mitigation and energy transition policy) and tasks to fulfil upon requests of its municipalities (i.e. general landscape development as well as circular economy and waste disposal).
Within the context of Re-Industrialise, there is one compulsory task of the Regionalverband Ruhr that is of high interest: The association is responsible for the regional business development, regional site management, and public relations (see for an overview Schüle et al., 2017). The Business Metropole Ruhr GmbH is a 100 % subsidiary of the Regionalverband Ruhr and was founded to employ these tasks.

Thus, there is often no administrative or governmental level that neatly fits the functional borders of high-carbon industry regions. Then again, a low-carbon transition of high-carbon industry regions requires not only the cooperation between different political actors, but also between stakeholders from business and industry, public policy (on various levels), organised civil society and unions. Often intermediary actors (like regional development agencies, see chapter 2.1.2) can bridge this gap. Many examples exist, where intermediary agencies have been founded with a geographical scope relating to a specific challenge – and not necessarily in line with administrative boundaries.

In sum, governing low-carbon transitions in functionally determined, administratively incongruent regions is a complex issue. It does not only require the vertical integration and cooperation across many different levels of policy-making, but it also needs horizontal integration between different kinds of stakeholders (e.g. industry and business, political actors, civil society organisations, educational institutions, etc.).

Climate policy integration in other policy areas

We would like to further argue that ambitious climate change mitigation goals are a necessary condition for low-carbon development, but they do not automatically induce low-carbon development in industrial sectors. Instead we argue that mainstreaming climate policy, i.e. the integration of climate change mitigation in other policy areas, especially in economic (or industrial) policy and structural policy, could be the sufficient condition to overcome the innovation lock-in and socio-economic barriers for low-carbon transition in high-carbon industry regions.

„The degree to which climate change issues are considered and integrated into existing policy areas is therefore a key issue, along with climate-specific measures such as emissions trading" (Mickwitz et al., 2009).

Climate change is a crosscutting issue that does not follow the sectoral logic of policy areas. The root causes of climate change in modern societies are to be found not only in energy generation and use but also in other carbon-intensive practices in transport, housing, consumption of goods and sometimes services as well as in industrial production processes. All these policy areas often follow a very different logic than the one that is needed to realise our climate mitigation targets. According to Mickwitz et al. (2009, p. 23) the integration of climate change mitigation policy into other policy areas requires the *inclusion* of mitigation aims, the *consistency* of sectoral goals with mitigation goals, the relative *prioritisation* of climate mitigation, the *evaluation* of mitigation impacts in these policy areas as well as the *provision of adequate resources* for climate mainstreaming efforts (e.g. know-how and funds). In five case studies for European Member States (Denmark, Germany, Finland the Netherlands, Spain, and the UK) they found evidence that climate change mitigation has become a key topic on the political agenda (on various governmental levels) and is widely integrated into governmental programs. But they also encountered evidence that there are often significant inconsistencies between climate change mitigation targets and other policy aims. Moreover, these case studies show that climate change mitigation is not usually prioritised against other policy aims (ibid, 31ff.). As these case studies were conducted in 2009, there might have been radical improvements with regard to the integration of climate policy into other policy areas. But, based on our empirical knowledge and interaction with different stakeholders, we expect that this integration did not yet take place for industrial policy as well as structural policy.

Furthermore, based on insights regarding the low level of low-carbon innovations in high-carbon industries, we argue that there is a need for policy integration particularly for industry policy in Europe and on the adequate national and sub-national levels. As already explained in chapter 2.1, radical innovations are not in the nature of high-carbon industries mostly due to market conditions. Industry actors argue that the political framework is still too volatile for investing in low-carbon transitions that exceed mere increases in energy efficiency. Thus, we assume that the lack of a clear low-carbon development path for high-carbon industries reduces the willingness of stakeholders to take low-carbon decisions. These stakeholders include more than just the industrial companies that need to invest in innovations, but also the political and social stakeholders who need to invest in the social and human capital, and the individuals who live and work in high-carbon industries who need to make different personal choices with regard to education and jobs.

Committing to an ambitious long term GHG emissions reduction target and integrating this target into other policy areas is a meaningful action that a government at any level can take to:

1. show their long-term vision and commitment to climate action,
2. provide stability to local markets and stakeholders, and
3. systematically increase the pool of knowledge on how to reduce emissions in a way that minimizes cost and maximizes the benefits to society.

Hypothesis:
If climate mitigation policies are not integrated into economic, industrial, innovation and/or structural policies, a high-carbon industry region may not be able to transition to a low-carbon economy in a timely manner.

2.3.2 Decision-making for long-term, climate policy investments

"Why might a polity led by office holders who value long-run social outcomes, accountable to modestly impatient voters, reject policy investments that could convert a degree of present loss into much greater future gain?" (Jacobs, 2016, p. 438).

We all know about the devastating impact global warming could have on humankind if climate action is neither timely nor ambitious enough. The last IPPC report shows this very clearly. But still, the barriers for ambitious climate action are high and emissions reduction does not move fast enough. Thus, we can rephrase the question posed by Jacobs for our purposes: Why do politicians, stakeholders, and a majority of the European population alike agree that climate change is a real threat which needs to be tackled, but reject ambitious climate policy investments which could convert a degree of present loss into much greater future gain?

Jacobs identified three features of policy-making that are responsible for the tendency of politics to be short sighted: First, politicians as well as voters tend to lack sufficient information about long-term outcomes for various reasons (e.g. salience of issues on the public agenda, causal complexities). As a result, they often prioritise the present above the future. Second, once a long-term policy has been adopted, there is no guarantee that it will be maintained in the future; ergo there is no guarantee for long-term future gains of today's policy investments. Third, the immediate costs of climate policy investments are not necessarily distributed equally and often trigger the opposition of organised cost bearers as a result.

The latter is one issue of democratic politics that we would like to take a closer look at. We argue that the opposition of organised cost bearers[18] has a considerable effect on the willingness of high-carbon industry regions to drive low-carbon transitions. We assume to find at least two stakeholder groups in every high-carbon industry region that might form organised oppositions against low-carbon development: Representatives of high-carbon industries and the organised workforce within these carbon-intensive industries.

Thus, regional governments as well as governance institutions committed to making the low-carbon transition a reality need to find ways in gaining the support and engagement from the public and private sector. In addition to that, they need to find effective tools to communicate successes and benefits of the transition, to encourage behaviour change and to create a good environment for sustainable funding and investment models.

Regional identity

In a multitude of formal and informal interactions with regional stakeholders (ranging from representatives of public authorities to civil society actors), we found that many high-carbon industry regions are characterised by something we are inclined to call a regional identity[19]. The identity of the region as a whole, but also the individual and social identities of people

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[18] For the sake of stringency, we would like to mention that these would always be regime-actors as conceptualised by the transition theory. However, the regime comprises of much more than just ‚organised cost bearers', which is why we will stick to this term.

[19] The social sciences have been trying to grasp this fuzzy concept of regional identity and offer various conceptualisations (Blotevogel, 2001; Fürst, 2001; see for example Graumann, 1983; Paasi, 1986). In general, the idea of a regional identity presumes that a region is always more than just a spot on earth but a social construct delimited by either administrative borders, by geographical character, by economic or social connections or by cultural particularities.

seem to be deeply intertwined with the predominant industrial sector or even one chief industrial employer. Thus, in addition to the organised opposition against a low-carbon transition by regime-actors, there is often widespread support of this opposition amongst people living and working in high-carbon industry regions.

Research has shown that the self-perception of regional culture and values strongly influences what kind of future is considered a) desirable and b) in many cases even possible (thinkable). In social science in general, but also in transitions theory in particular, this is often referred to as paradigms and mindsets (Göpel, 2016; Kuhn, 1970). Those mindsets are considered hardest to change (much harder than for example more material features like infrastructures or institutions like laws) but would be most rewarding to change as those "leverage points" would promise deepest and long-lasting change (Meadows, 1999).

Again, coal regions seem to be the extreme case and are most suitable to illustrate this hypothesis: When talking to regional stakeholders in coal regions in Poland and Germany, we encounter a strong identification of individuals with the region, the coal-mining industry and sometimes even with the corresponding corporation. The “ethos of mine worker” is not only in itself a value of importance, but it is also connected to certain life models (e.g. the traditional breadwinner model) that are threatened by the structural change inherent in radical low-carbon transitions.

As a result, there is often a strong opposition towards low-carbon transitions by organised as well as unorganised cost bearers coming from high-carbon industry regions. Their representatives (unions, industry associations, etc.) often join forces to slow down or even attempt to stop a low-carbon transition at the appropriate governmental level.

Hypothesis:
Mindsets as well as perceptions of regional identity and cultural heritage can become strong barriers to structural change. Even if transition processes offer great benefits, public discourse may focus on losses. ‘Organised cost bearers’ may build on this discourse and attempt to slow down the transition process.

3 Summary and Conclusion

This working paper sheds light on three major challenges that high-carbon industry regions face with regard to low-carbon transitions. It is based on the fundamental presumption that high-carbon industry regions are not all the same, but have different socio-economic and political contexts that shape their willingness and capacity to drive low-carbon transitions. The paper argues that low-carbon transitions require innovation, human, social and economic capital as well as political will. And it shows, using examples and knowledge of regional stakeholders as well as scientific insights, how these challenges play out in high-carbon industry regions.

Table 3 Challenges identified for low-carbon transitions in high-carbon industry regions

Challenge: Lack of low-carbon innovations
High-carbon industry regions, which are not characterised by dynamic industry clusters, often lack the innovative capacity to drive low-carbon transitions.
A success factor for low-carbon innovation is established and well-coordinated networks that include R&D institutions as well as industry clusters. If such networks are weak, inefficient, lack critical mass or are not specifically geared towards a low carbon development, then a high-carbon industry region may lack the innovative capacity to drive low-carbon transitions.
Intermediaries (like regional development agencies) can strongly support low-carbon industrial innovations. However, to do so, such intermediaries need to be carefully designed and their activities need to be geared towards low-carbon innovations (in contrast to high-carbon economic development).
Challenge: Low capacity for low-carbon transition
If a high-carbon industry region is already structurally weak, it may lack the human and social capital needed to drive a low-carbon transition.
If a high-carbon industry region is already structurally weak, it may lack the resources and capacities to access funding at the required scale and use it in a systemic way.
Challenge: Lack of political will
Often regional climate mitigation policies focus on specific sectors (power generation, transport, housing) and are not integrated into economic, industrial, innovation and/or structural policies. To support a transition to a low-carbon economy in a timely manner, climate related targets should be mainstreamed into all policy areas specifically those relating to regional economic development and support for structural change.
Civil society and NGOs can assume the role of enablers but also that of opponents to ambitious low-carbon transitions. If unions and industry associations join forces as ‘organised cost bearers’ and are supported by a majority of people in high-carbon industry regions, regional representatives will lack the political will necessary for mainstreaming climate policy in economic/industrial and structural policy.

Table 3 summarises key challenges we have identified in high carbon industry regions in their transition towards a low-carbon economy. Knowledge about these challenges can be strategically used in all outputs (OUs) of the Re-Industrialise Flagship. To illustrate how this will be done, we exemplify this for the issue "intermediaries supporting a regional low-carbon transition". For each of the key elements of the Re-Industrialise approach (as sketched in Figure 5) we assess the relation to the role of intermediaries (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

Figure 5 Key elements of the Re-Industrialise approach

The example of intermediaries also shows how preliminary results of this analysis have already fed into strategic decision making and concrete actions of the Re-Industrialise Flagship throughout 2018: In one of the focus areas, North Rhine Westphalia, a key intermediary, the "Zukunftsagentur Rheinisches Revier" (formerly Innovationsregion Rheinisches Revier, see Box 5), has been identified early in the project as a key strategic partner. They have been engaged in knowledge creation. A successful pathfinder has been set-up by them. Several meetings and outreach activities have been implemented in co-operation. This collective effort is to be continued and intensified in the future.

Similarly, all of the results of this working paper will feed into the Flagship's strategy for 2019. The challenges identified here will be enriched in direct interaction with local stakeholders in our Re-Industrialise focus regions as well as from pathfinders. They will support and guide the solution lab activities in the upcoming project years. Moreover, we see potential in designing and approving stakeholder projects in high-carbon industry regions that reflect and mirror these challenges.

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