



Ministry of Economic Affairs



DEPARTMENT OF
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SCIENCE &
INNOVATION

Ministry of Economic Affairs,
Innovation, Digitalization and Energy of the
State of North Rhine-Westphalia



Trilateral strategy for the chemical industry

Striving to become the world's engine for the transition towards a sustainable and competitive chemical industry cluster in 2030.

Cross-border cooperation between the Netherlands, Flanders and North Rhine-Westphalia.

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Executive Summary

As one of the largest industries globally, the chemical industry is a key supplier for numerous sectors of the economy, providing innovative solutions to today's economic and environmental challenges.

With a turnover of 180 billion Euro and more than 350,000 persons employed in the chemical industry (2015), the **trilateral region of North Rhine Westphalia (DE), Flanders (BE) and the Netherlands is home to one of the world's most powerful chemical industry clusters** with a long history in the three regions. Almost 20% of the sector's total turnover at European level is generated by the trilateral chemical industry. Building upon its **Verbund structure**, i.e. the tight physical integration of chemical plants in the three regions, the trilateral chemical industry profits from a **very efficient production structure**. In terms of chemical sales per capita, the trilateral region is even by far the highest performing chemical region worldwide with approximately EUR 3,600 in sales per capita (China: EUR 1,300; Japan: EUR 1,500; USA: EUR 2,400).

The chemical industry is a **highly innovative industry** in the trilateral economy; no other industry gives rise to so many innovation impulses to downstream value chains. Being the **home base** for some of the world's largest chemical companies, the region also belongs to the **main R&D investors in Europe** with far more than EUR 38 billion of R&D spending in 2015. Against this background, a 30% increase over 2016 numbers in the generated chemical gross value added to EUR 58 billion by 2030, or a 1.7% p.a. on average, is achievable in the trilateral region.

Despite these impressive statistics, the trilateral chemical industry faces some **fundamental challenges** if it is to prosper and grow. The global competitive environment is changing drastically, and several competing regions, particularly China, India and Saudi Arabia, have made successful efforts to build up large and increasingly sophisticated production facilities in the chemical industry. The shale gas boom and the new 'America First' industrial policy have already boosted the competitiveness of the US chemical industry. Consequently, the European chemical industry overall and the trilateral region's chemical industry are facing strong headwinds and are losing both market share and investment. In particular in the still very relevant resource-intensive basic chemicals sector in the trilateral region, due to its competitive disadvantages in terms of energy and feedstock prices, growth in gross value added is projected to be slower through 2030 (approximately 0.5% p.a.; compared to an average growth of the chemical industry in the trilateral region of 1.7% p.a.).

Responding to these challenges and preparing for the future, the Ministry of Economics, Innovation, Digitalization & Energy of the State of North Rhine-Westphalia, the Department of Economy, Science & Innovation of the Flemish Government and the Netherlands Ministry for Economic Affairs have developed for the **first time a joint vision and strategy** on the future improvement of this flagship industry. This group has consulted and collaborated with many key stakeholders from industry, academia and cluster organisations leading to a collective vision:

VISION 2030

'Striving to become the world's engine for the transition towards a sustainable and competitive chemical industry cluster'

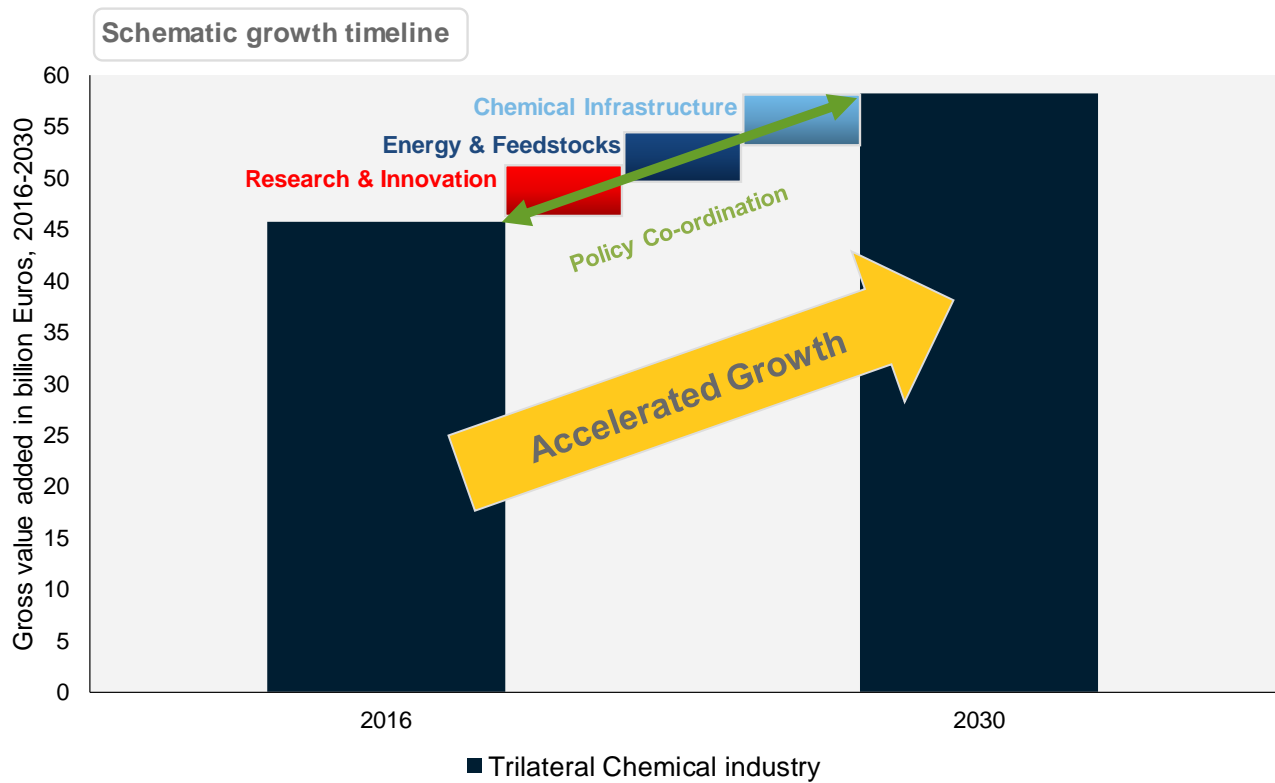
To achieve this ambition, the trilateral strategy for the chemical industry proposes the establishment of a comprehensive joint industry-academia-government partnership, that will build on the vision set out in this strategy and help the industry achieve the potential growth opportunities that have been identified.

Altogether, **21 measures** in the three vertical policy fields **(1) Research & Innovation, (2) Energy & Feedstocks, (3) Trilateral Chemical Infrastructure** and one horizontal field **(4) Policy Co-ordination**, have been developed to augment the strengths of the trilateral chemical industry, capture the benefits of a growing chemical market and to remove existing bottlenecks for this development.

Research & Innovation		Energy & Feedstocks		Chemical Industry Infrastructure	
N°	Measures	N°	Measures	N°	Measures
1	Improve the funding mechanisms for trilateral R&I actions	8	Develop a common trilateral approach for a competitive energy cost position	13	Develop a trilateral masterplan for chemical logistics and infrastructure
2	Intensify cross-regional R&D&I collaboration to improve the trilateral innovation ecosystem			14	Accelerate approval processes of infrastructure and construction projects
3	Accompany a holistic digital transformation towards a 'New Verbund' based on value chain networks and virtual partnerships	9	Form a level playing field for the use of sustainable feedstocks		
4	Elaborate a trilateral scheme for demonstration plants	10	Expand the trilateral availability of alternative feedstocks	16	Establish a trilateral dialogue platform for Logistics 4.0
5	Expand the framework for start-ups and up-scaling in support of a trilateral chemical entrepreneurship ecosystem	11	Establish a circular ecosystem of integrated material and energy flows within and across industries		
6	Enhance the vocational training and lifelong learning systems for blue collar jobs to develop the chemical industry skills of the future			12	Enable comprehensive Circular Economy processes in the trilateral chemical industry
7	Encourage trilateral academic exchange and partnerships to improve the formation of the future academic workforce				
Policy Co-ordination					
19	Implement an institutionalised trilateral dialogue among policy makers, academia and industry				
20	Trilateral positioning towards Europe in important policy fields				
21	Decrease administrative requirements and barriers for trilateral co-operation				

A trilateral High-Level Group (HLG) supported by an Inter-Ministerial Steering Group (IMSG) and thematic working groups, will provide **strategic leadership** to mobilise and utilise the wider community of the chemical and chemistry-using industries in pursuit of these three priorities.

By taking this new, long-term approach, and working in close partnership with businesses and experts from academia, greater confidence for investment and growth in the trilateral region can be established. The **strategy sets out a compelling case for action** from government, academia, and industry to secure and build upon the competitive advantage of the trilateral chemical industry in the global market and to deliver the growth and business opportunities identified. The schematic **growth timeline 2030** below illustrates that an increase in gross value added to EUR 58 billion and more will be possible in the future. The combination of the different measures of the trilateral strategy in the field of Research & Innovation, Energy & Feedstocks, Chemical Infrastructure and Policy Co-ordination shall facilitate this accelerated growth through dedicated joint actions.



The **coming years will be decisive** for the chemical industry to navigate towards the future into the direction of the shared vision. In cooperation with all stakeholders of the industry, the ministries will support this process to strengthen the regional capacity to innovate and to improve the framework conditions. Through joint efforts the global competitiveness of this unique chemical cluster in Europe can be ensured.

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1 Introduction: Scope and targets of the strategy

The trilateral region of **North Rhine-Westphalia (Germany), Flanders (Belgium) and the Netherlands** is home to one of the **most powerful clusters of the chemical industry in the world**. With its long-standing history, the region has developed a unique *Verbund* structure that cannot be found in any other macro-region in the world. This structure is made up of global players, SMEs, start-ups and a diverse and high-quality R&D landscape. Beyond its sectoral relevance, the chemical industry itself also has an important function for many industries in the region, from automotive to construction.

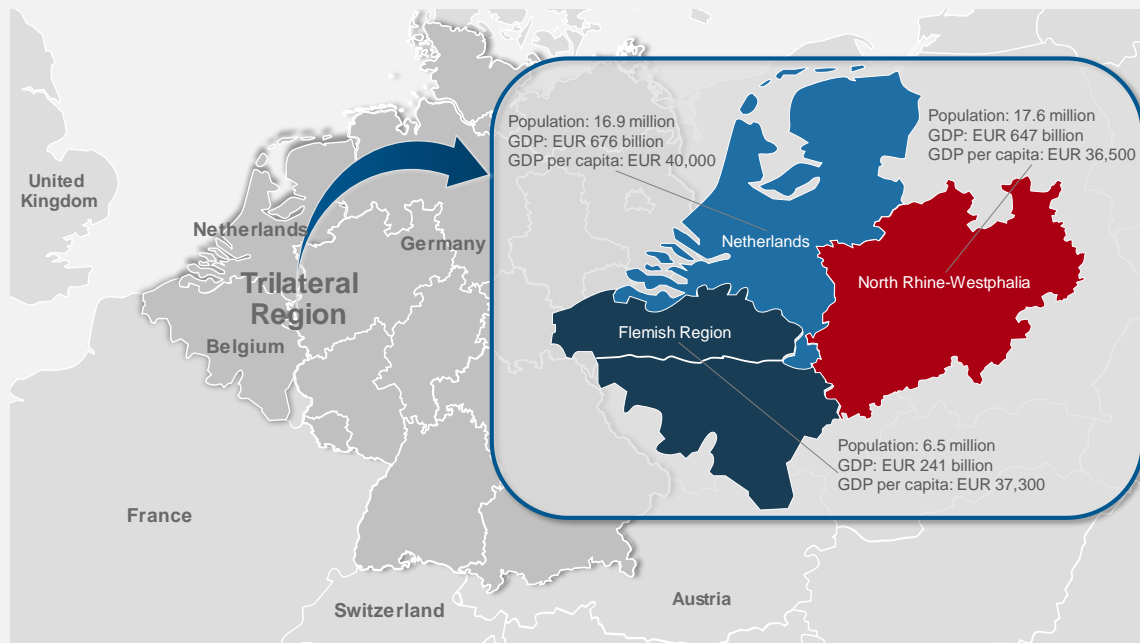
Products and solutions provided by the **chemical industry play an important role** in sustainable growth, clean energy, sustainable transport and, essentially, all the global megatrends that are being driven by the fast-growing world population. Against this background, a 30% increase in the generated chemical gross value added by 2030 (over 2016 numbers), or a 1.7% p.a. on average, is achievable in the trilateral region. In the resource-intensive basic chemicals sector, due to its competitive disadvantages in terms of energy and feedstock prices, growth is projected to be slow through 2030 at 0.5% p.a. At the same time, however, the **global competitive environment is changing drastically**, and several competing nations, particularly China, India and Saudi Arabia, have made successful efforts to build up increasingly sophisticated production facilities in the chemical industry. The shale gas boom and the new 'America First' industrial policy have already boosted the competitiveness of the US chemical industry. Consequently, the trilateral chemical industry is facing strong headwinds and is losing market share and investment.

To prepare for the future, capture the benefits of a growing chemical industry, and remove existing bottlenecks for this development, the Ministry of Economics, Innovation, Digitalisation & Energy of the State of North Rhine-Westphalia, the Department of Economy, Science & Innovation of the Flemish Region and the Netherlands Ministry for Economic Affairs have launched an important strategic process. Building upon a concise analysis of the trilateral chemical industry and a review of key transformation forces for its development, a joint vision on the future development of this flagship industry needs to be established alongside strategic roadmap with key activities for trilateral engagement. By taking this new, long-term approach and by working in close partnership with businesses and experts from academia, greater confidence for investment and growth in the trilateral region can be established. The trilateral strategy puts forward a compelling case for action from government, academia, and industry to secure and build upon the competitive advantage of the trilateral chemical industry.

The remainder of this **report is structured as follows**: Chapter 2 presents an analysis of the chemical industry, including the positioning of the trilateral region within the global industry, the evolution of the sector and its sub-sectors in the region and its infrastructure endowment. Chapter 3 provides an outlook on the future, building upon a global and regional forecast for the chemical industry through 2030 and a review of key drivers and trends for industry development. Chapter 4 summarises the key strengths, weaknesses, opportunities and threats for the chemical industry in the trilateral region. Chapters 5 and 6 present the overall vision and approach of the trilateral strategy for the chemical industry through 2030 and provide concrete measures for future trilateral action. Finally, Chapter 7 presents an overview of all measures, initial measures for 2017-2019 and an indicative plan covering the next few years to drive joint initiatives across the three regions.

BACKGROUND – OVERVIEW OF THE TRILATERAL REGION

The trilateral region comprises the German state of North Rhine-Westphalia, the Belgian region of Flanders and the Netherlands. It is one of the strongest European industrial regions in Europe and is often referred to as being the 'gateway' to the EU due to its international ports in Antwerp and Rotterdam as well as its ports along the Rhine and Ruhr (e.g., Duisburg – the largest inland port in Europe). With around 41 million inhabitants it is the most populated European region and a large market. Even though it represents only 8% of total EU population, the trilateral region accounts for 11% of European gross domestic product.¹ Moreover, GDP per capita in the trilateral region (EUR 38,150 in 2015) was 32% higher than the EU28-average (28,900 EUR in 2015).



Source: Prognos (2017), based on Eurostat. Figures are from 2015.

Taken together, the three regions form the 'industrial heart' of the European chemical industry. The infrastructural, industrial and academic interconnectedness and density creates short ways and potentials for synergies. The entire region offers a unique concentration of customer industries and markets, which is especially important for a cross-sector industry like the chemical industry.

So far, the three regions have applied different strategic approaches to strengthen their chemical industry (e.g. the 'Flemish-Dutch strategy for a future-oriented chemical sector' or the 'Enquete-kommission zur Zukunft der chemischen Industrie in Nordrhein-Westfalen'). Collaboration between the Netherlands, Flanders and North Rhine-Westphalia to strengthen the trilateral chemical industry cluster rather took place in individual cases or project-related, as for instance in the context of the 'Bio Innovation Growth Mega Cluster' (BIG-C) initiative. Following the Joint Cabinet Meeting of the State Government of North Rhine-Westphalia and the Flemish Government on 8 December 2015, it was decided to intensify the joint dialogue between all three countries (the Netherlands, Flanders and North Rhine-Westphalia) for a strengthened and competitive chemical industry cluster.

¹ GDP for all EU28 member states: EUR 14,714 billion in 2015.

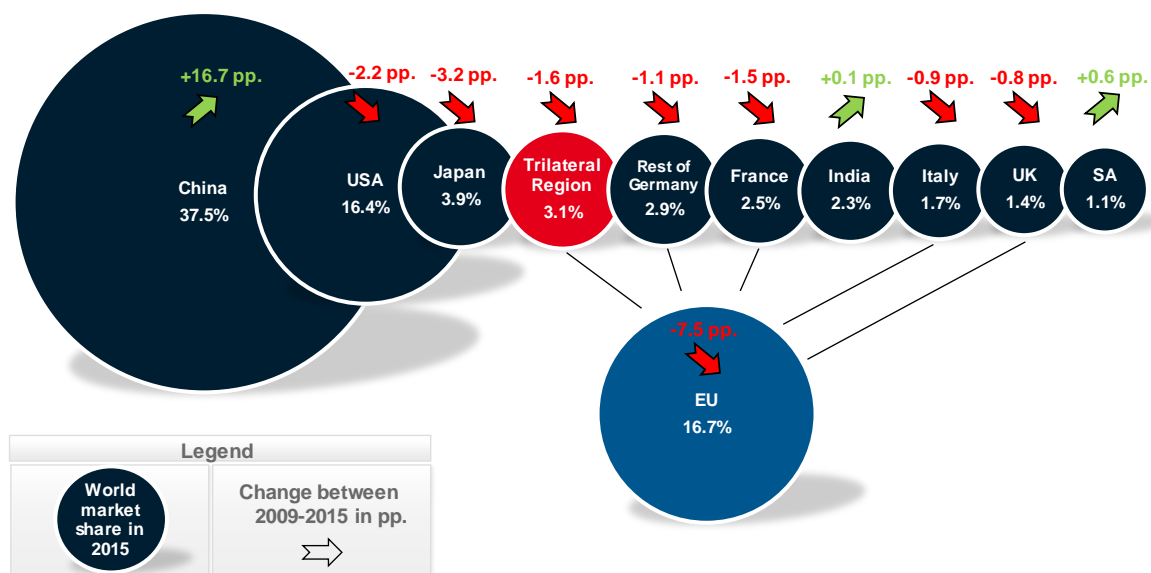
2 Chemical industry in the trilateral region: Development and structure

2.1 Chemical industry in the trilateral region from the global and European perspectives

GLOBAL PROFILE OF THE CHEMICAL INDUSTRY

As one of the largest industries globally, the chemical industry is a key supplier for numerous sectors of the economy, providing innovative solutions to today's economic and environmental challenges.² In 2015, world sales in the chemical industry reached EUR 4,700 billion,³ which represents an increase of close to 80% over 2009 levels (approximately EUR 2,620 billion) in total chemical revenue. This shows that the chemical industry has recovered well from the economic crisis in the late 2000s and furthermore is a sign of the **growing worldwide demand** for chemical products.

Figure 1: World market shares in the chemical industry of selected countries, 2015 (in terms of turnover)



Source: Prognos (2017), based on Eurostat, the turnover statistics of IT.NRW, Statistics Belgium and VCI, 'Chemiewirtschaft in Zahlen', Edition 2012 & 2016. **Note:** Due to different survey methods, there may be differences compared to the turnover data of other statistical offices.

In this globally growing chemical market, the **trilateral chemical industry** of North Rhine-Westphalia, Flanders and the Netherlands holds an important position. With a world market share of 3% in 2015, behind China, the USA and Japan, the trilateral region is the **fourth largest chemical cluster in the world**. In terms of chemical sales per capita,⁴ the trilateral region is by far the highest performing chemical region. With approximately EUR 3,600 in sales per capita, it leaves the United States (EUR 2,400), Japan (EUR 1,500) and China (EUR 1,300) far behind. However, considering developments in world market

² The definition of the scope of the chemical industry and the applied methodology for this strategy report are explained in the Annex. In general, the analysis considers the chemical industry in a wider sense and, unless otherwise noted, includes the chemical, pharmaceutical and rubber & plastics sectors.

³ The figure refers to total sales in the chemical and pharmaceutical sector.

⁴ The figure refers to sales per capita in the chemical and pharmaceutical sector.

shares over the past few years (see Figure 1), it becomes clear that the **growing competition from emerging economies**, and particularly from China, has led to a weakened position for the trilateral region in the world market. Whereas China, India and Saudi Arabia have been able to capture larger shares of the growing market, the **industrialised countries are losing ground**. The EU chemical industry has been struggling, and saw its market share decrease from 24.2% to 16.7% between 2009 and 2015, a trend that also hit the trilateral region's chemical industry. The **US chemical industry has been holding up better**, in part because of its advantageous raw materials situation and the 'shale gas revolution'.

THE CHEMICAL INDUSTRY IN THE TRILATERAL REGION IN COMPARISON TO EUROPEAN BENCHMARKS

At the **European level, the trilateral region is still the leading force of the chemical industry**, together with the rest of Germany. With a turnover of EUR 180 billion and more than 350,000 people employed in the chemical industry⁵ in 2015, the trilateral region represents approximately **17% of the total turnover** (see Figure 2) and **about 11% of the total employment** of the sector in Europe.⁶

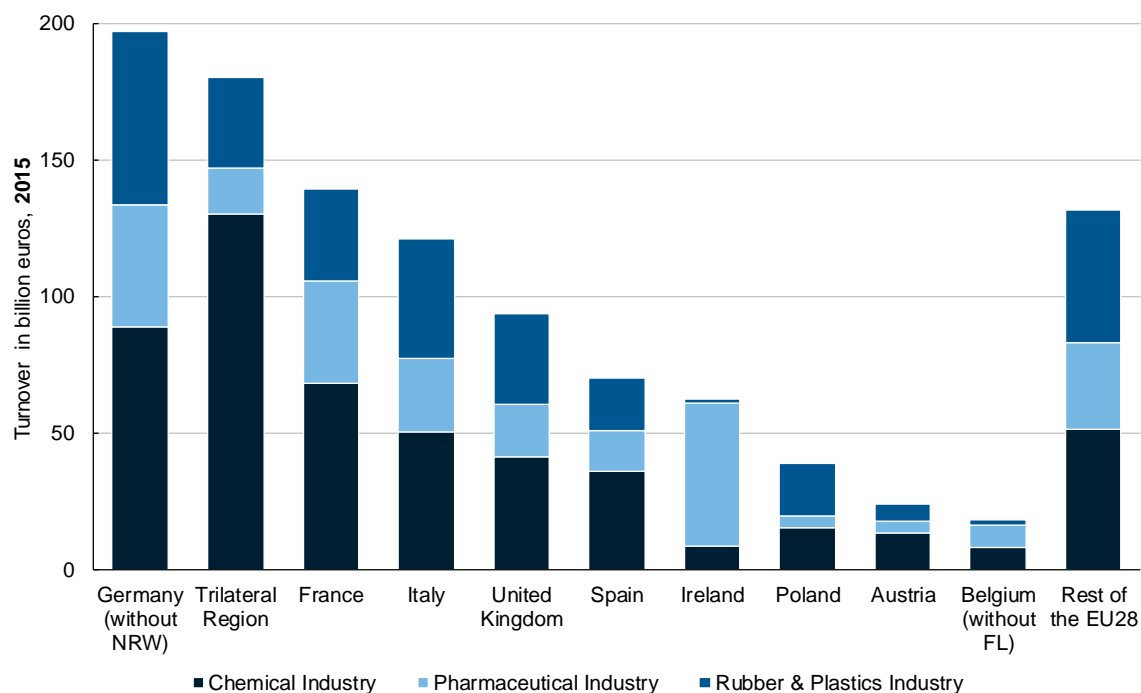
This leading position is due in particular to the very strong chemical sector, while the pharmaceutical sector plays a rather minor role in the trilateral region as compared to other European countries. Furthermore, the chemical industry profits from a **very efficient production structure**, which is strongly based on the *Verbund* structure, i.e. the tight physical integration of chemical plants in the trilateral cluster. This efficiency translates into a turnover per employee in the trilateral region of approximately EUR 520,000, which is more than 1.5 times the European average, or more than double when considering the turnover per local unit.⁷

⁵ The chemical industry refers here to the chemical, pharmaceutical and rubber & plastics industries.

⁶ Own calculations based on data from public statistical offices.

⁷ The local unit is an enterprise or part thereof (e.g. a workshop, factory, warehouse, office, mine or depot) situated in a geographically identified location. Economic activity is carried out at or from this place, in which – save for certain exceptions – one or more persons work (even if only part-time) for the same enterprise.

Figure 2: Turnover and market shares of selected EU-28 countries in the chemical, pharmaceutical and rubber & plastics industries, 2015



Source: Prognos (2017), based on Eurostat (SBS), the turnover statistics of IT.NRW, Destatis, Statistics Belgium and VCI, 'Chemiewirtschaft in Zahlen', Edition 2016. **Note:** Due to different survey methods, there may be differences compared to turnover data of other statistical offices.

In terms of employment, the trilateral chemical industry, **employing more than 350,000 people**, is the largest chemical region in the European Union.

The **growth trend of the trilateral region** is, however, **less dynamic** compared to other important chemical regions in Europe. Whereas employment in the trilateral region between 2010 and 2014 grew at only the European average, namely 0.4% p.a., the German benchmark regions of Hesse, Upper Bavaria and Rhineland-Palatinate, as well as North West England, showed much higher rates of employment growth. The dynamic development in these regions is due to their higher growth rates in the rubber & plastics and pharmaceutical industries. For the latter sector, the French benchmark regions Southern France and Rhône-Alpes have also shown rather high growth rates.

Table 1: Regional benchmarks of selected European chemical regions in terms of number of persons employed, 2010–2014

	Chemical Industry	Pharmaceutical Industry	Rubber & Plastics Industry	Total Chemical Industry	
	Change 2010–2014 in %			Employment, 2014	Change 2010–2014 in %
EU-28	-2.1	2.4	1.6	3,393,000	0.4
Trilateral region	-0.3	-8.4	4.1	354,600	0.4
Upper Bavaria	2.9	12.0	9.1	54,900	5.2
Hesse	0.6	4.5	5.1	109,900	3.1
Rhineland-Palatinate	8.3	17.0	3.8	96,100	8.0
Catalonia	-6.7	-6.1	-15.5	70,000	-9.3
Southern France*	-0.4	23.0	-3.5	37,500*	1.6
Rhône-Alpes*	-21.4	18.5	-31.5	54,000*	-15.8
Lombardy	-1.7	-15.9	-2.4	123,600	-4.8
Masovia	-0.3	-14.2	-2.1	41,100	-3.6
North West England	-10.0	33.5	35.5	56,000	14.7

Source: Prognos (2017), based on Eurostat (SBS). Note: Break in series 2014.

GLOBAL INVESTMENTS IN THE CHEMICAL INDUSTRY

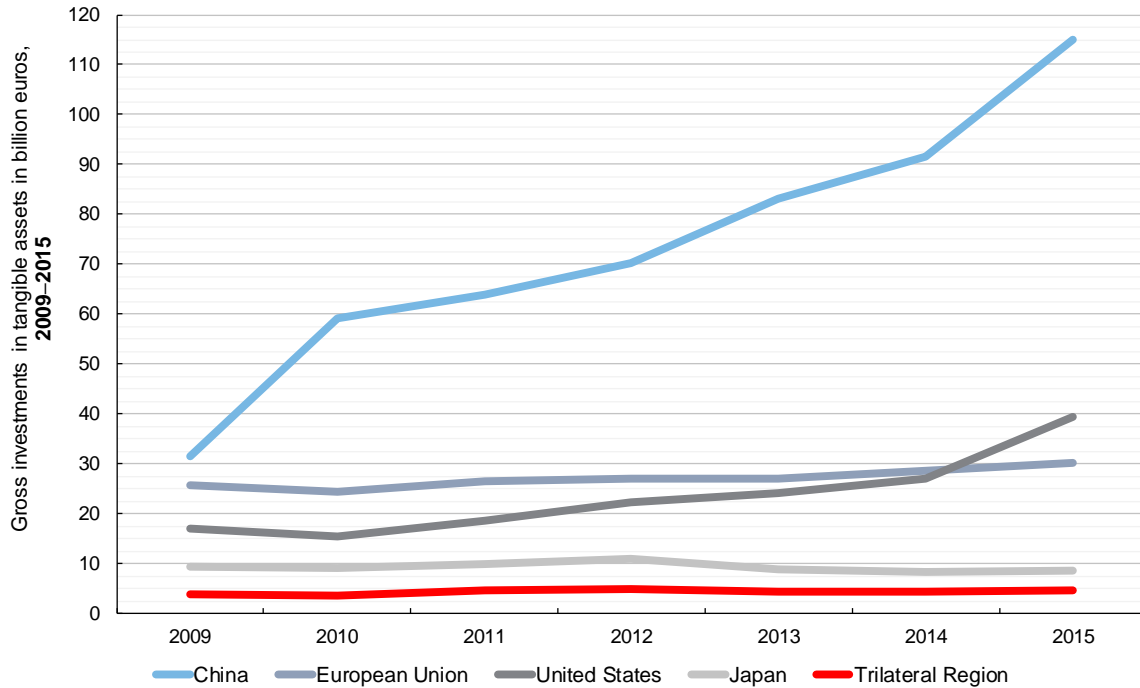
In the capital-intensive chemical industry, **regular investments are indispensable** in order to secure the industry's future production potential and to maintain its competitiveness. Broad changes in the global competitive environment have had an important impact on the development of chemical investments around the globe. China's steep increase in world market share between 2009 and 2015 was accompanied by an enormously dynamic investment development. The industrialisation taking place there, with its focus on the chemical industry, led to a veritable explosion of investments. Between 2009 and 2015, **China more than tripled its investment in the chemical industry**,⁸ from EUR 32 billion to EUR 115 billion. For the **US chemical industry**, the previously mentioned **shale gas boom brought a trend reversal**. Old cracker installations needed to be adapted to the cheap and newly available feedstock, and new plants were built to extend production capacity; thus, investments in tangible assets have more than doubled since 2009 and are now close EUR 40 billion, surpassing even the EU. The other industrialised regions, including the **trilateral region, did not experience similar investment development**. As there has been no feedstock advantage compared to the US (shale gas) or the Middle East (oil), or strong economic growth (Southeast Asia), investments in the trilateral region and the EU overall were primarily directed towards replacing obsolete facilities or increasing efficiency rather than towards capacity extensions. Considering the increasing investment activities in other emerging economies like India and Saudi Arabia (see Section 3.1), these developments show that **other chemical clusters in the world have visibly increased their attractiveness for investment projects** over the past few years.

The investments that the trilateral chemical industry missed out can be approximated by calculating what the investment levels would have been like if the region had grown on average like the US chemical industry (around 15% p.a. between 2009 and 2015). Without any further assumptions made, investments in the trilateral region would have in-

⁸ The figure refers to investments in gross tangible assets in the chemical and pharmaceutical sectors.

creased from EUR 3.8 billion in 2009 up to EUR 8.8 billion in 2015 in this scenario. Compared to the amount of EUR 4.5 billion that was invested in 2015, a **gap of around EUR 4.3 billion** is resulting.

Figure 3: Evolution of investments in gross tangible assets in the chemical industry of selected countries, 2009–2015



Source: Prognos (2017), based on Statistics Belgium, Eurostat (SBS), VCI, 'Chemiewirtschaft in Zahlen', Edition 2016 and the investment survey in the manufacturing and mining sector of IT.NRW and Destatis. **Note:** The investment survey in the manufacturing and mining sectors of IT.NRW and Destatis cover only enterprises and their business units that employ 20 people or more.

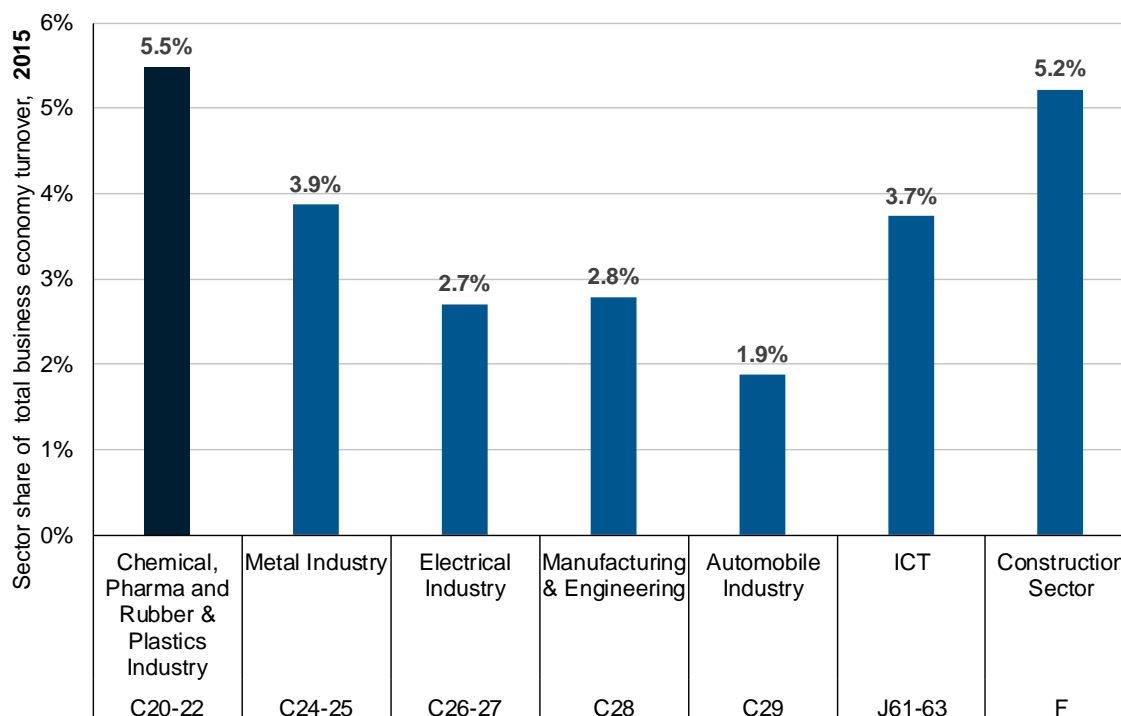
2.2 Profile of the chemical industry in the trilateral region

SECTORAL POSITIONING OF THE CHEMICAL INDUSTRY IN THE TRILATERAL REGION

The importance of the chemical industry for the trilateral region can clearly be seen in a sectoral comparison with other important industries. With a share of 5.5% of the economy,⁹ the chemical industry is, in terms of turnover, **one of the largest industrial sectors in the trilateral region** (see Figure 4).

⁹ Due to data limitations, the comparative figure is for the business economy. It includes the NACE categories B-N and S95 (repair of computers and personal and household goods). Not included are, amongst others, agriculture, financial and insurance activities, public administration, education and the health sector.

Figure 4: Sectors' share of the total business economy turnover in the trilateral region, 2015



Source: Prognos (2017), based on Eurostat (SBS), the turnover statistics of IT.NRW and Statistics Belgium.

Note: The business economy includes the NACE categories B-N and S95 (repair of computers and personal and household goods). Not included are, amongst others, agriculture, financial and insurance activities, public administration, education and the health sector.

In comparison to the turnover share, the employment share of the chemical industry of the trilateral region is somewhat lower, at 2.7%. Other sectors, like the construction sector (7.5%), the metal industry (3.7%) and the ICT sector (3.9%), are much more employment intensive. However, as many of those industries are relevant customer industries of the chemical industry, these employment shares act as an important catalyst for the chemical industries' development.

EVOLUTION OF TURNOVER AND GROSS VALUE ADDED

The chemical industry of the trilateral region has recovered quite well from the economic and financial crisis of 2008, with **sales that increased from about EUR 148 billion in 2009 to EUR 197 billion in 2012**. Already in 2010, the trilateral chemical industry achieved the pre-crisis level of around EUR 172 billion in 2007.¹⁰ However, the **industry was unable to maintain this momentum** and has been struggling with decreasing sales, **down to EUR 180 billion in 2015**, as Figure 5 (below) shows. This development particularly concerns the chemical sector, and has affected not only the trilateral region but also the European Union as a whole.

There are multiple **reasons for the fading growth** in the chemical industry. These include, for example, weaker economic growth rates in emerging economies, the sluggish growth of the European economy and the increasingly competitive environment. While China and the Middle East have profited from their increased self-supply capacity, which

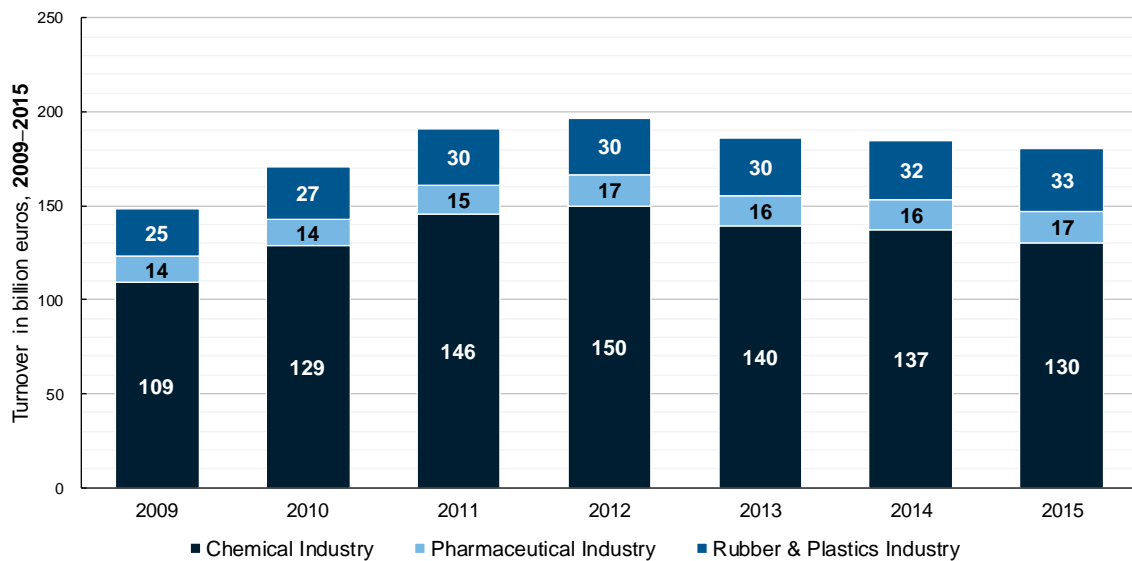
¹⁰ This figure is based on data from Statistics Netherlands, the turnover statistics of IT.NRW and Statistics Belgium. These numbers include the pharmaceutical and rubber & plastics industries.

in some cases has even led to considerable overcapacities, the United States has profited from the shale gas boom and the resulting cost advantage. One additional reason for the decreasing sales volume is price deflation for feedstocks in the past few years as, for instance, decreasing oil prices have been reflected in lower selling prices for chemical products.¹¹

At the same time, the **pharmaceutical and rubber & plastics industries have been growing almost continuously** in terms of turnover since 2009. The largest portion of the pharmaceutical turnover is generated in Flanders. In 2015, with a turnover of EUR 7.5 billion, Flanders had a share of approximately 45% of the total pharmaceutical turnover in the trilateral region, compared to EUR 5.3 billion in the Netherlands and EUR 3.8 billion in North Rhine-Westphalia.

In the Netherlands and North Rhine-Westphalia, more turnover is generated in the rubber & plastics sector than in the pharmaceutical industry. In 2015, the rubber & plastics industry in North Rhine-Westphalia achieved sales of close to EUR 19 billion. In the Netherlands, sales in the same sector amounted to EUR 9 billion, whereas in Flanders these were approximately EUR 5.3 billion. A similar pattern can be observed concerning the creation of gross value added (GVA) in these sub-sectors (see Section 2.3).

Figure 5: Evolution of turnover in the chemical, pharmaceutical and rubber & plastics industries in the trilateral region, 2009–2015



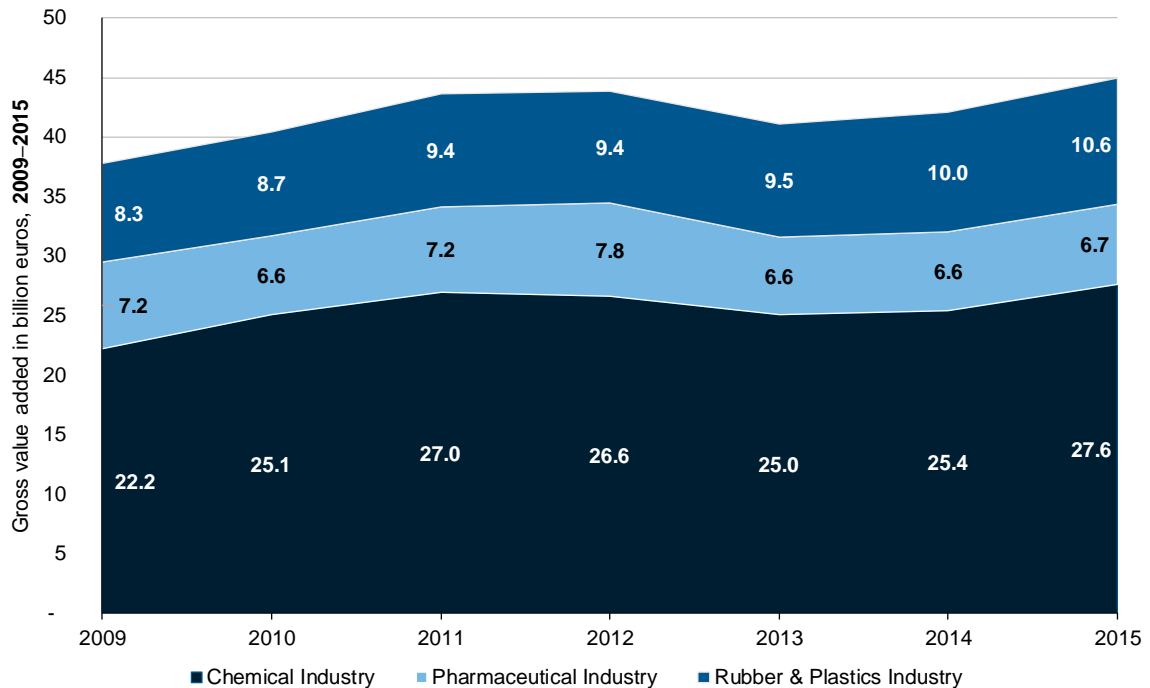
Source: Prognos (2017), based on Eurostat (SBS), the turnover statistics of IT.NRW and Destatis and Statistics Belgium. **Note:** Due to different survey methods, there may be differences compared to turnover data of other statistical offices.

Concerning the development of gross value added (GVA) produced in the trilateral region by the chemical, pharmaceutical and rubber & plastics industries, a similar pattern to the development of turnover can be identified, though with a recovery after 2014. The decrease in sales and the simultaneous increase in GVA indicate an **increased pressure on margins**, especially for the chemical industry in the trilateral region, due to increased global competition. At the same time, the increase in GVA in the chemical industry, in combination with stagnant growth in employment and a decreasing number of business units, is a sign that **productivity has been increasing** over the past few years in the

¹¹ (Hofman & Föndhoff, 2017)

trilateral region, a trend that will likely to continue. The up-scaling of existing plants, technological advances and the digitalisation and increasing interconnectedness of companies will help the chemical industry to further improve its productivity.¹²

Figure 6: Evolution of gross value added in the trilateral chemical industry, 2009–2015



Source: Prognos (2017), based on NBB.Stat, Statistics Netherlands, the turnover statistics of IT.NRW and the national accounts of Germany, Destatis. **Note:** The GVA data for NRW are based on own calculations. Due to different data sources, there may be differences between the methodologies used.

DEVELOPMENT OF INVESTMENTS IN THE TRILATERAL REGION

As previously explained, the trilateral region has not experienced a major investment boom in the past years, unlike other regions across the world. Nevertheless, since 2009, investments in the chemical, pharmaceutical and rubber & plastics industries have increased by approximately EUR 1 billion and have grown on average by 3.3% per year.

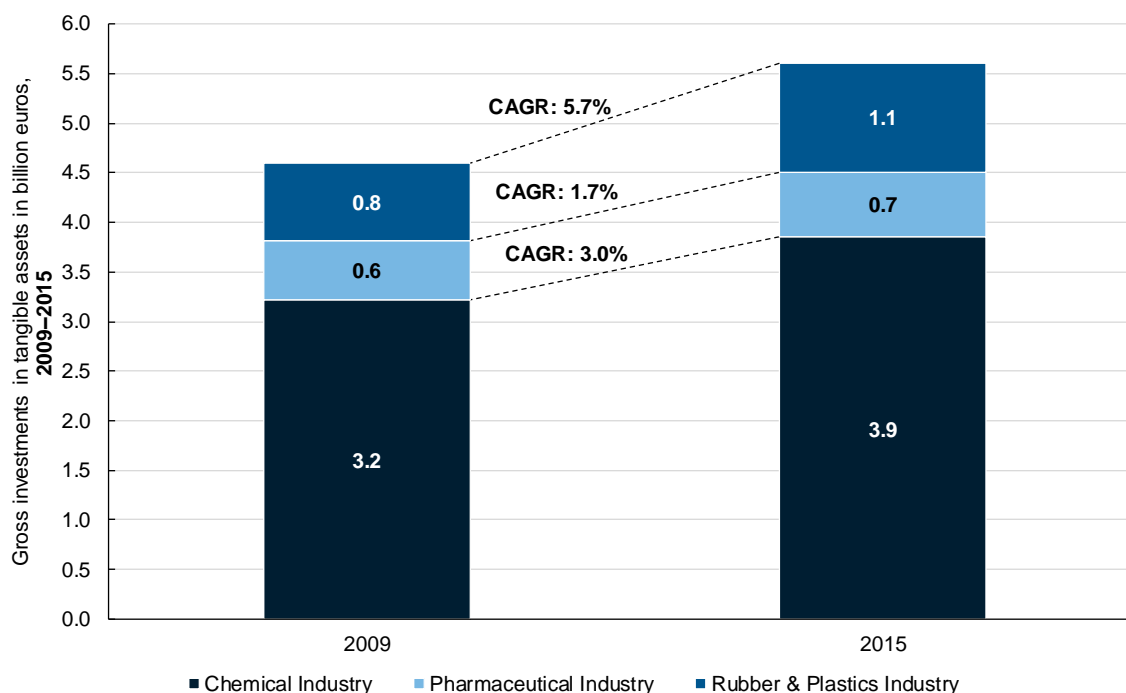
As Figure 7 shows, the **investments in the chemical sector** grew on average by 3.0% per year between 2009 and 2015, the same rate as the increase in sales over the same period (3.0%). Furthermore, the overall pattern of investments has been identical to the development of turnover, **with a peak in 2012 followed by a decline**. The largest drop can be seen in the Netherlands, where since 2012 investments have decreased by EUR 600 million, from approximately EUR 1.7 billion to EUR 1.1 billion, whereas in Flanders investments have stayed around EUR 1.2 billion and in North Rhine-Westphalia have increased slightly from EUR 1.5 billion in 2012 to EUR 1.6 billion in 2015.

The **most dynamic growth in investments in tangible assets** between 2009 and 2015 occurred in the **rubber & plastics industry**, with an increase of about EUR 300 million. Most of investments, close to 70%, were in North Rhine-Westphalia. The less dynamic development in the pharmaceutical industry can be explained by a drop in investments in the Netherlands between 2009 and 2012, when a restructuring of the pharmaceutical sector

¹² (Prognos AG & VCI, 2016)

occurred.¹³ After 2012, however, investments in tangible assets in the pharmaceutical industry grew faster on average than in the other two sectors.

Figure 7: Development of investments in tangible assets in the trilateral chemical industry, 2009–2015



Source: Prognos (2017), based on Statistics Belgium, Eurostat (SBS), VCI, 'Chemiewirtschaft in Zahlen', Edition 2016 and the investment survey in the manufacturing and mining sector of IT.NRW. **Note:** The investment survey in the manufacturing and mining sectors of IT.NRW covers only enterprises and their business units that employ 20 people or more.

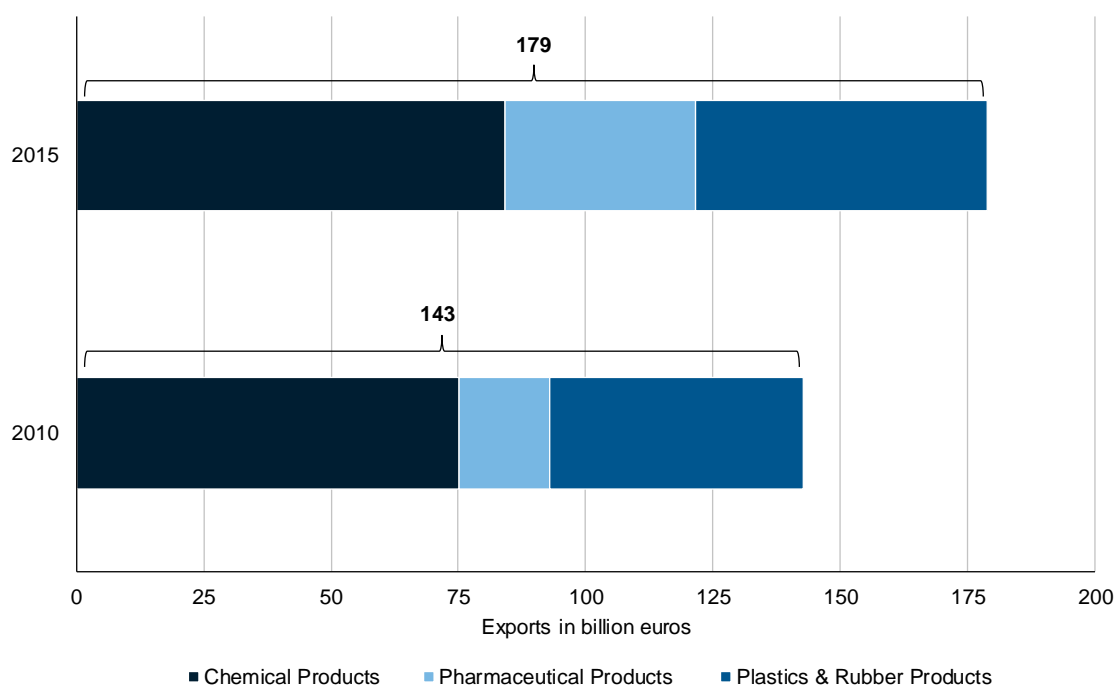
Several factors must be considered when interpreting the modest investment behaviour in the trilateral region. In addition to the previously mentioned reasons for the decreasing turnover figures, comparatively high energy and feedstocks prices as well as current discussions regarding the European climate and energy policy as well as the German renewable energy act (EEG) are two further reasons for the **reluctant investment behaviour**. Against this background, most investments in the trilateral chemical industry, especially in the base chemicals sector, are currently focused on merely replacing out-dated equipment or improving the resource and energy efficiency of existing facilities,^{14,15} as both the energy intensity of the sector and local energy costs are high. During the production process, energy consumption contributes between 5% and 10% of total costs, compared to only 0.8% in the manufacturing and engineering sector.¹⁶ For the same reason, some companies are investing in facilities for captive energy production.¹⁷

¹³ (Vos, 2010) & (Keuning, 2010)
¹⁴ (NIW, 2013)
¹⁵ (Prognos AG & VCI, 2016)
¹⁶ (Schmid & Wilke, 2013)
¹⁷ (Commerzbank Research, 2016)

DEVELOPMENT OF CHEMICAL INDUSTRY EXPORTS IN THE TRILATERAL REGION

The chemical industry of the trilateral region is a **strongly export-oriented** industry. In 2015, the whole sector exported chemical, pharmaceutical and plastics products with a total value of EUR 179 billion, representing nearly 23% of the total value of exports from North Rhine-Westphalia, the Netherlands and Flanders, making this one of the most important export sectors in the region.

Figure 8: Total export volume of the trilateral region for chemical, pharmaceutical and plastics and rubber products, 2010–2015



Source: Prognos (2017), based on NBB.Stat, Statistics Netherlands and the external trade statistics of IT.NRW, Harmonised System – Combined Nomenclature, Sections VI & VII, National Concept.

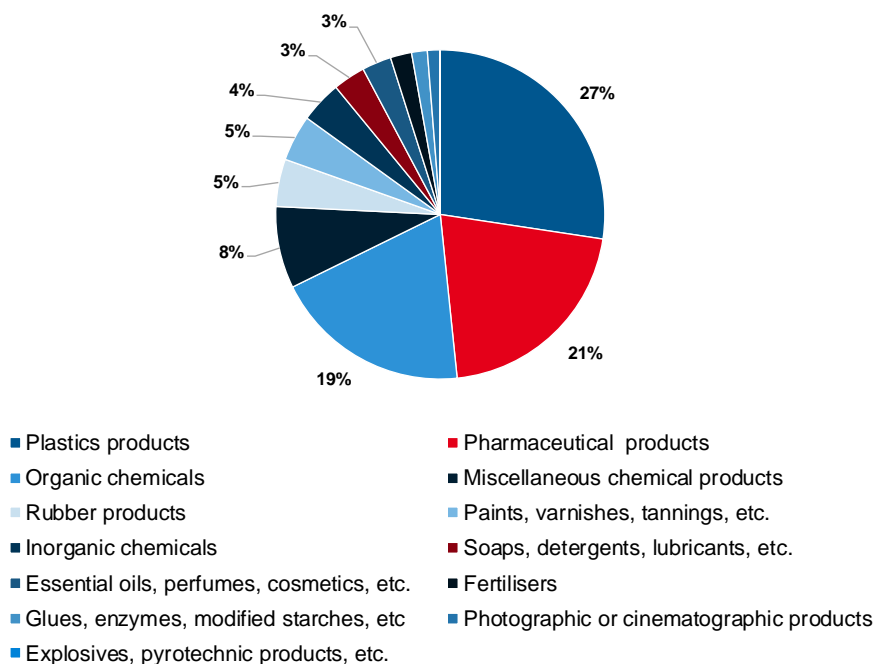
Regarding **export dynamics**, the export value¹⁸ has increased by more than EUR 35 billion since 2010, representing an increase of approximately 25%. In 2009, the total value of exported chemical products has been around 113 billion, indicating that the trilateral chemical industry between 2009 and 2010 recovered well from the economic crisis. Of the various sectors, the pharmaceutical industry has experienced the most rapid development, as exports more than doubled during the observed period, whereas the value of exported chemical and rubber & plastics products increased by only 12% and 15%, respectively.

Lower export rates in the chemical sector are due mainly to a rather restrained export growth of 2.4% for organic chemicals (though this is the third largest product category in terms of export value). In contrast, export growth for specialty chemical products like paints and varnishes (+23.2%), soaps and detergents (+22.6%) and cosmetics (+15%) has been stronger.

¹⁸ Figure 8 also includes interregional exports between North Rhine-Westphalia, the Netherlands and Flanders. A subsequent section, which discusses the current logistics and infrastructure situation of the trilateral chemical industry, gives an indication of the different freight flows that exist between North Rhine-Westphalia, the Netherlands and Flanders.

There are **several reasons for the more difficult export situation of organic chemicals**, and of **basic chemicals in general** (organic chemicals being a subcategory of basic chemicals). First, due to the specific nature of basic chemicals, and hence also organic chemical products, and their high transport costs, exports over long distances are less lucrative. Therefore, the most important export markets are in Europe. The **European market**, however, has been characterised by **saturated markets and slow growth**.¹⁹ Second, **fierce global competition**, especially in the basic chemical industry, allows for only a limited sales potential for organic chemical products beyond Europe. China and the Gulf countries have, as previously mentioned, made significant investments over the past few years to increase their self-sufficiency capacity, mostly for basic chemicals, resulting in a shift in this production towards these emerging markets. In addition, the increasing supply in these countries now exceeds their domestic demand and is being sold on the global market,²⁰ putting pressure on prices. A similar development can be observed for the rubber & plastics industry.^{21,22}

Figure 9: Export shares of different product categories of the total chemical exports of the trilateral region, 2015



Source: Prognos (2017), based on NBB.Stat, Statistics Netherlands and the external trade statistics of IT.NRW, Harmonised System – Combined Nomenclature, Sections VI & VII, National Concept.

For **specialty chemicals**, however, the degree of self-sufficiency, and hence global competition, is not at the same level. Emerging economies, particularly China, are still reliant on imports of these products.²³ Furthermore, plastics and pharmaceutical products have lower transport costs, making their export less locally bound. In addition to the lower international competition in these sectors and the higher global demand, these factors are the basis for their high share in the total export value (27% and 21%, respectively).

¹⁹ (Commerzbank Research, 2015)

²⁰ (Prognos AG & VCI, 2016)

²¹ (Commerzbank Research, 2016)

²² (Flemish department Economy, Science and Innovation (EWI), 2015)

²³ (Commerzbank Research, 2015)

2.3 Evolution of the sub-sectors of the chemical industry in the trilateral region

Within the chemical industry of the trilateral region, the largest sector in terms of turnover is the **basic chemicals industry**, as shown in Table 2. The 820 companies that are active in this sector generated EUR 92 billion in turnover in 2015, representing half the total sales in the industry. At the same time, the sub-sector of the basic chemicals industry represents only 13% of all businesses in the trilateral chemical industry, demonstrating that the sector is dominated by larger enterprises. With average sales per employee of approximately EUR 1 million in 2015, the sector is also by far the most productive one. The basic chemicals industry in the trilateral region profits in particular from its highly integrated production structure (*Verbund*). Often, different companies are located in the same chemical park. Also, customers and suppliers are geographically close to one another, and there is a tight physical infrastructure network. Given these advantages, it is not surprising that the concentration of this sector in the trilateral region's economy is much higher than the European average.

Table 2: Sub-sectors of the trilateral chemical industry, 2015

	Turnover		Employees		Companies	
	In billion EUR 2015	Share in %	Number 2015	Share in %	Number 2015	Share in %
Basic chemicals	92	51	91,854	28	824	13
Basic chemicals & fertilisers	89	49	87,579	27	762	12
Man-made fibres	3	2	4,274	1	62	1
Specialty chemicals	38.5	21	69,943	21	1,294	20
Agrochemicals	0.5	0.3	2,772	1	32	0.5
Paints & varnishes	7	4	21,362	6	265	4
Cosmetics, detergents & care products	10	6	22,338	7	480	7.5
Other chemical products	21	11	23,471	7	517	8
Pharmaceuticals	17	9	39,719	12	433	7
Rubber & Plastics	33	18	128,830	39	3,791	60
Rubber products	3.5	2	15,175	5	343	5
Plastics products	29.5	16	113,655	34	3,448	54
Total chemical industry	180.5		330,345		6,342	

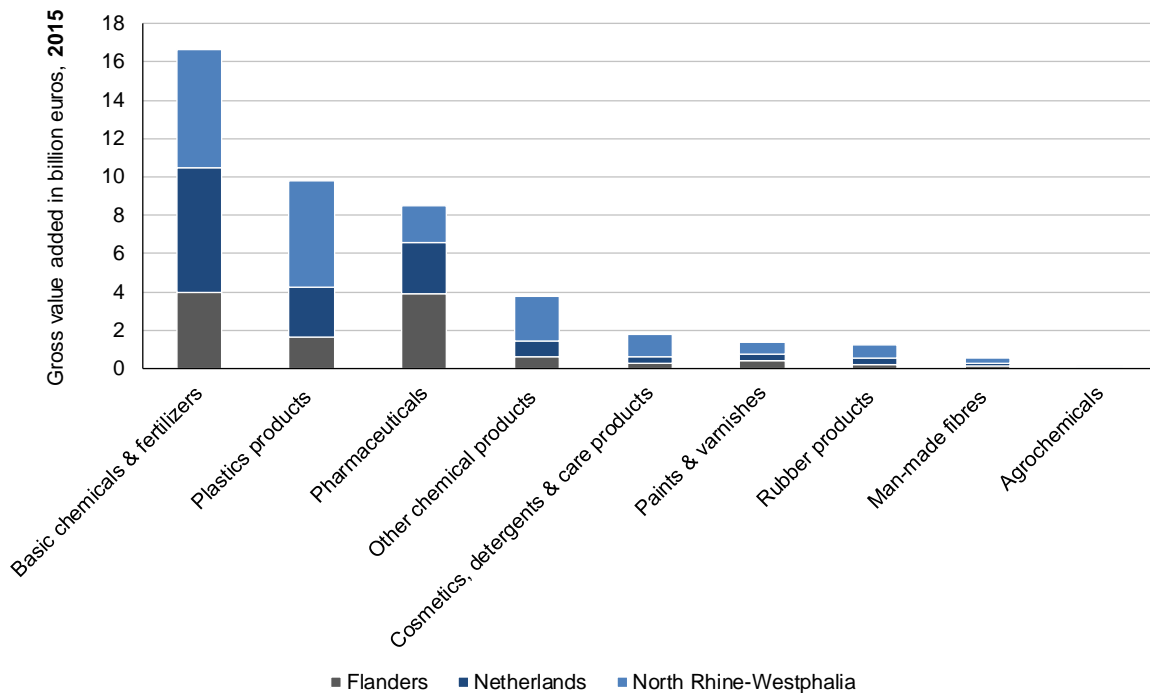
Source: Prognos (2017), based on Statistics Belgium, IT.NRW, Eurostat (SBS), the employment statistics of the German Federal Employment Agency and the decentralised employment statistics of the Belgian NSSO.

In terms of turnover, the **specialty chemicals and plastics industry** are, respectively, the **second and third largest sub-sectors** of the trilateral chemical industry, followed by the pharmaceutical sector. In 2015, sales amounted to approximately EUR 40 billion in the specialty chemicals sector and EUR 30 billion in the plastics sector, representing 21% and 16%, respectively, of total sales in the trilateral chemical industry. Given their larger shares in terms of companies compared to the basic chemicals industry, these sectors are characterised by an industry structure of **small and medium-sized businesses**. This is especially the case for the plastics sector, which, with its 3,800 companies, represents approximately 54% of all active companies in the trilateral chemical industry. For the **specialty chemicals sector**, this share represents approximately 20%.

When looking at GVA, the **basic chemical industry generates the largest share of GVA** in the trilateral region, **with close to EUR 17 billion (39%)**. However, the GVA contribution is somewhat lower than its share in turnover of 51%. For plastics (22%) and the

pharmaceutical sector (19%), GVA contributions are higher than their turnover contributions, highlighting their high value oriented production. In addition, as depicted in Figure 10, there are some regional differences. A relatively large part of the value added in the plastics and other chemicals sectors²⁴ is created in North Rhine-Westphalia, whereas the Netherlands and Flanders are responsible for a larger share of GVA in the pharmaceutical industry.

Figure 10: Gross value added of the different chemical sub-sectors in the trilateral region, 2015



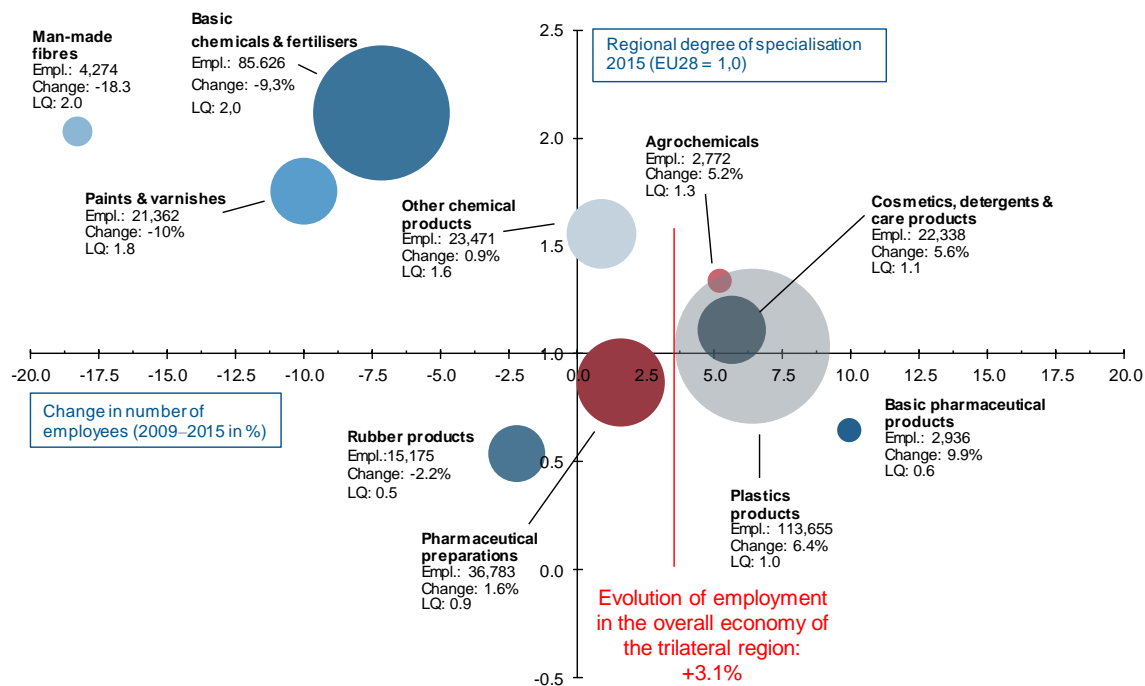
Source: Prognos (2017), based on Statistics Belgium, IT.NRW, Eurostat (SBS) and the national accounts: Federal Planning Bureau Belgium (FPB), Destatis and Statistics Netherlands. **Note:** Due to data limitations, the gross value added of the different sub-sectors is based on own calculations. Aggregated figures may differ from previous results.

Figure 11 shows the **degree of specialisation** for the different sub-sectors of the chemical industry. It indicates their concentration in terms of employment in the trilateral region's economy compared to the EU average. It is clear that in terms of its **specialisation profile, the chemical industry is more concentrated in the trilateral region than in the European Union**. In comparison to the EU economy, the trilateral region is more specialised in the production of basic chemical products. Whereas the basic chemicals industry in the EU is responsible for approximately 0.26% of total employment within the EU economy, this share is more than twice as high for the trilateral region. With close to 88,000 employees, the basic chemicals sector accounts for approximately 0.55% of total employment in the region. In addition to the basic chemicals sector, the production of man-made fibres (e.g. polyester or polyamide for textiles), as well of specialty chemicals like paints and varnishes, agrochemicals (e.g. pesticides and crop protection products) and explosives, glues and essential oils (grouped together under 'other chemical products'), are more concentrated in the trilateral region's economy than in the EU on average. The plastics sector, which is the most important sub-sector in terms of employment; the industry

²⁴ The category 'other chemical products' includes the manufacturing of explosives, glues, essential oils, lubricants and chemical preparations for photographic and cinematographic uses.

for pharmaceutical preparations (mostly drugs in their finished dosage form); and the production of cosmetics, detergents and care products have specialisation rates that are comparable to the EU average. The only chemical sectors with a below EU average concentration are the rubber sector and the basic pharmaceutical industry (e.g. production of antibiotics, basic vitamins and aspirin).

Figure 11: Degree of specialisation (2015) and trends in the number of employees (2009-2015)



Source: Prognos (2017), based on the employment statistics of the German Federal Employment Agency, the decentralised employment statistics of the Belgian National Social Security Office (NSSO) & Eurostat (SBS and nama10). **Note:** The degree of specialisation, or localisation rate (LQ), shows the concentration, in terms of employment, of the different sub-sectors in the trilateral region's economy in comparison to the EU average. If the LQ is equal to 1, then the sub-sector is as strongly represented in the economy of the trilateral region as it is in the EU on average. Values higher than 1 indicate an above-EU-average concentration. Values lower than 1 indicate a below-EU-average representation of the sub-sector.

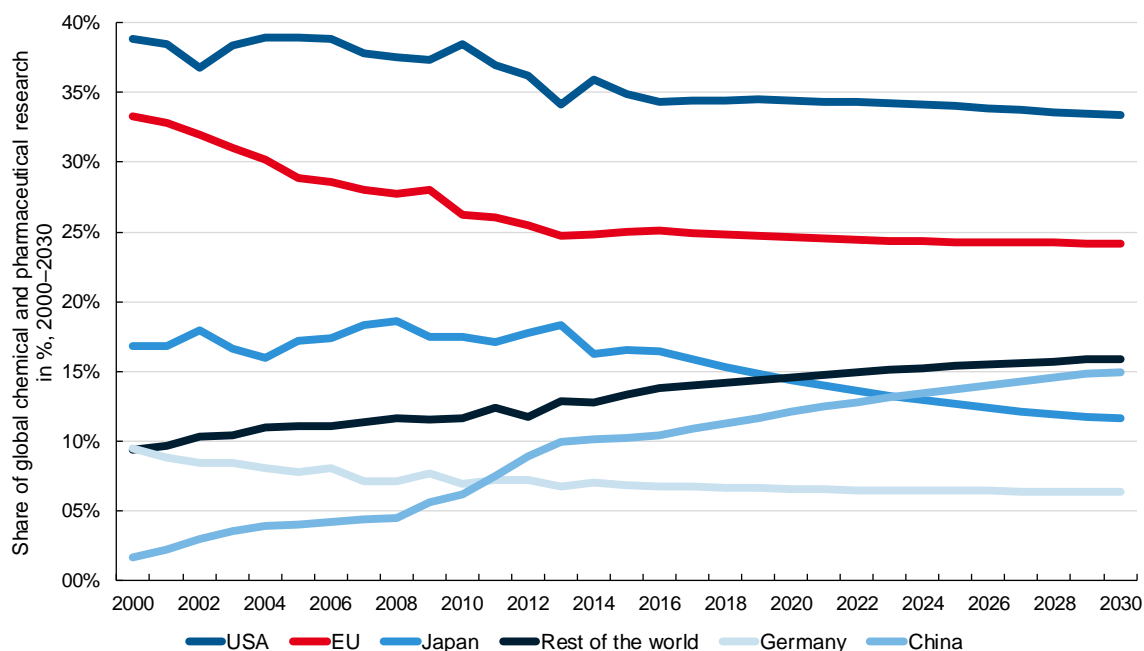
Figure 11 also gives a good picture of **employment development** in the chemical sector since 2009. It shows a more dynamic employment evolution for the sectors that are part of the specialty chemicals industry as compared to the basic chemicals industry, where employment has decreased by approximately 7.8% since 2009. Due to its difficult competitive position, which is not likely to change, and further productivity gains, the basic chemicals industry cannot expect much employment growth in the future. For the various segments of the more research-intensive and high-quality specialty chemicals industry, employment development has been generally positive, with the segment of paints and varnishes being the only exception. The pharmaceutical (preparations and basic products) and plastics sectors are, as previously mentioned, less concentrated in the trilateral region, but at the same time show a positive trend in employment. For the pharmaceutical industry, especially, a continuation of its dynamic development can be expected, given the aging population in industrialised countries and worldwide population growth, especially in emerging economies.

2.4 R&D landscape for the trilateral chemical industry

The chemical industry is one of the most innovative industries in the trilateral economy; no other industry gives rise to so many innovation impulses. The ideas and application know-how of chemical companies often represent the starting points for innovations in downstream value-added chains²⁵. From this point of view, **investments in research and development (R&D) not only set the basis for the future of the chemical industry, but are also important for the development of its customer industries.** As the global market for chemicals is growing, R&D expenditures are rising too. China, especially, is rapidly catching up and increasing its research efforts, thereby putting competitive pressure on the trilateral chemical industry. For some customer industries of the chemical sector, production and **research centres are already shifting to Asia.** Chemical research is likewise being drawn in this direction due to its need for proximity to its clients' R&D operations. Today, much of the global research for the electronics industry is taking place in Asia, including chemical research for electronic applications.²⁶

These developments can also be quantified in terms of **world chemical R&D expenditure shares.** As Figure 12 shows, China increased its share in the worldwide chemical and pharmaceutical R&D expenditure from 1.6% in 2000 to 10.4% in 2016, and has now surpassed Germany; it is expected that by 2030 China will reach a share of close to 15%. The largest part of this increase will be at the expense of Japan. Europe and the US will suffer significantly lower losses. The US will expand its technological leadership in many areas and will benefit from digitalisation. Europe owes its smaller losses mostly to its strong pharmaceutical industry and its corresponding R&D spending.²⁷ Considering only the chemical industry excluding pharmaceuticals, Europe must accept larger losses in R&D shares compared to the US.

Figure 12: Shares in global chemical and pharmaceutical research, 2000–2030



Source: Prognos AG & VCI (2016). *Die deutsche chemische Industrie 2030 – Update 2015/2016*, p. 36.

²⁵ (NIW & ZEW, 2015)

²⁶ (Prognos AG & VCI, 2012)

²⁷ (Prognos AG & VCI, 2016)

Europe and the US are still one step ahead when it comes to **intellectual property**; however, emerging economies such as India and China are catching up in this regard as well. For instance, China's share of patents in the chemical industry has grown from 1% in 2000 to almost 11% today.²⁸

Still, the **trilateral region is the home base for some of the world's largest chemical and pharmaceutical companies**, which also belong to the **most important investors in R&D in Europe**. Of the top 1,000 corporate R&D investors in the EU, 42 companies belong to the chemical sector and 133 belong to the pharmaceutical/biotechnological sector. No other industrial sector contributes more companies to this list. Their R&D spending volume of EUR 37.7 billion (a share of 19.5% of R&D spending by all 1,000 investors) is exceeded only by the highly research-intensive automobile industry, which has 47 companies on the list, comprising EUR 50.3 billion (26%) of R&D spending.

Of the 175 R&D investors in the top 1,000 belonging to the chemical and pharmaceutical industry, **22 have their headquarters in North Rhine-Westphalia, Flanders or the Netherlands and also further business units**. In terms of the number of top 1,000 R&D spenders, the trilateral region ranks third behind the UK (53) and France (23), and ahead of the rest of Germany (21). Exclusively considering the chemical sector, however, France (with a strong pharmaceutical/biotechnological sector) has only 3 companies among the top 1,000, while Germany, excluding North Rhine-Westphalia, ranks first with 11 companies, followed by the UK (10) and the trilateral region (8).²⁹

Table 3 gives an **overview of the ten most important R&D investors of the trilateral chemical industry**. These investors together represented R&D spending of EUR 6.9 billion in 2015 and show an average R&D intensity of 4.6%. The life sciences and chemical company Bayer, in operation for over 150 years, is by far the most important R&D spender headquartered in the trilateral region. At EUR 4.4 billion, its R&D expenditure represents 64% of the total expenditure of the top ten investors. Bayer is followed, with a considerable gap, by the generic and specialty pharmaceuticals company Mylan (EUR 617 million) and Evonik (EUR 434 million), a worldwide leader for specialty chemicals and high-performance materials. LyondellBasell, one of the largest plastics, chemical and refining companies in the world, which invested approximately EUR 94 million in R&D in 2015, rounds out the top ten.

Other companies also take advantage of the close network of the trilateral chemical industry, like the Flemish Tessenderlo Group (chemicals), which has seven additional locations in the region and spent approximately EUR 9.5 million on R&D activities in 2015. Another important R&D actor, with approximately EUR 15 million in R&D expenditure in 2015, is the Flemish biopharmaceutical company TiGenix, whose only additional plant was opened in the Netherlands in 2012.

Although their R&D spending cannot be accounted directly to the trilateral region, chemical companies with a presence but without headquarters in the region need to be considered as well. Most prominently, BASF, with a total of 18 facilities in North Rhine-Westphalia, Flanders and the Netherlands, must also be mentioned (BASF's second biggest plant is in Antwerp), as must its relevant R&D capacities. In 2015 alone, BASF spent some EUR 1.91 billion in R&D worldwide, an increase of more than 3% annually from 2013.

²⁸ (VCI, 2016)

²⁹ The volume of R&D spending generally reflects this trend, too, although Germany's spending in the combined sector of EUR 7.7 billion exceeds that of France at EUR 7.3 billion.

Also, Merck, a German multinational chemical, pharmaceutical and life sciences company headquartered in Darmstadt, has a major presence in the trilateral region, with considerable R&D capacities and a worldwide spending of EUR 1.70 billion on R&D in 2015.

Table 3: Top R&D spenders in the trilateral region; 2015

Location & Network				Research & Development		
Company	Industrial Sector	Head-quarters	No. of Other Locations in the Trilateral Region	R&D Spending 2015 in million EUR	R&D Growth 2013–2015 CAGR 3y, in %	R&D Intensity* 2015 in %
	Pharmaceuticals Biotechnology	Lever- kusen	8	4,436	11.7	9.4
	Pharmaceuticals Biotechnology	Amster- dam	0	617	18.7	7.1
	Chemicals	Essen	9	434	4.2	3.2
	Chemicals	Heerlen	9	387	0.3	4.3
	Chemicals	Arnhem	21	323	-5.2	2.2
	Pharmaceuticals Biotechnology	Aachen	3	233	-2.4	n/a
	Pharmaceuticals Biotechnology	Venlo	1	135	6.3	11.5
	Chemicals	Köln	11	130	-12.2	1.7
	Chemicals	Wesel	6	128	7.8	6.2
	Chemicals	Rotterdam	3	94	-12.3	0.3
	Chemicals	Ludwigs- Hafen*	18	1914	3.3	2.72
	Pharmaceuticals Biotechnology	Darmstadt*	7	1707	4.1	13.29
	Pharmaceuticals Biotechnology	Leuven	1	15.1	19.3	672
	Chemicals	Overpelt	7	9.5	-8.5	0.6

Source: Prognos (2017), based on the 2016 EU Industrial R&D Investment Scoreboard. **Note:** *R&D Intensity is the share of R&D expenditures in total sales of the company. * While BASF and Merck headquarters are not in the trilateral region, not all but considerable amounts of their R&D spending are invested in the trilateral region, due to their numerous sites there.

Against the background of this still-strong industrial base and growing R&D competition, a good R&D framework is needed to maintain the trilateral region as a centre for research in the coming decades. More than in other sectors, the basis for innovation in chemistry is science and research, as well as highly trained personnel. To maintain its status, the **trilateral region can build on a wide array of universities, including universities of applied sciences, as well as research institutes, pilot plants and cluster organisations**; these play a decisive role in bringing together industry and science. This R&D landscape establishes the basis for a highly qualified workforce and excellent research at both the fundamental and industrial levels. Figure 13 provides an overview of this landscape. Though it shows 56 relevant institutions in the area of chemical research and development, this map is not exhaustive.

Figure 13: R&D landscape and cluster initiatives for the chemical industry in the trilateral region



Source: Prognos (2017). An explanatory table with all institutions can be found in Annex 3.

In the following sections, **three selected examples of good practice** are presented. They illustrate how collaboration across the trilateral borders and between industry and science can create real value added for the chemical industry in the trilateral region. The insights and identified success factors should be considered in the development of measures that have the objective of maintaining the trilateral region as a hotspot for chemical research and innovation.

The first of these, the Aachen Maastricht Institute for Biobased Materials, is a prime example of a successful interregional co-operation between German and Dutch universities and research institutes. It further shows how research infrastructure can be shared efficiently. The second case explains how the new Flemish cluster organisation Catalisti seeks to

match scientific research with the needs of industry, an approach that can provide useful insights regarding improved science and industry collaboration in the trilateral region. Finally, the CAT Catalytic Centre is an interesting case as it shows the benefits of close co-operation between companies and universities.

Aachen Maastricht Institute for Biobased Materials (AMIBM; NL)

The AMIBM, located at the Brightlands Chemelot Campus in Sittard-Geleen, is a **cross-border co-operation** between Maastricht University, RWTH Aachen and the Fraunhofer Institute for Biology and Applied Ecology IME. The 'Brightlands' brand is part of the 'Kennis-As' strategy initiated by the Province of Limburg to strengthen both the knowledge base and the socio-economic structure of the region.³⁰

AMIBM's research covers the entire biobased materials value chain, from feedstocks to polymers to end products in the high-value segments (e.g. medical products and industry applications). Furthermore, Maastricht University's master's program in biobased materials is conducted at AMIBM.

The integration of the institute into the **Brightlands Chemelot Campus** ensures proximity to small and medium-sized as well as large chemical companies, which creates a breeding ground for synergies through knowledge spill-overs or the sharing of facilities. Beyond excellent research and publications, the valorisation of results through patents, spin-offs and translation into industry applications are the core objectives of the institute. These efforts are complemented by the Brightlands Innovation Factory, an incubator that is also located at the Chemelot Campus and is focused on materials, smart services, health and food, mirroring the thematic foci of the Brightlands Campuses in the province of Limburg.³¹

CATALISTI (FL)

A further example for good practice is the Antwerp-based cluster organisation Catalisti, which is the successor to FISCH (Flanders Innovation HUB for Sustainable Chemistry), and thus continues to accelerate the transition towards sustainability by promoting open innovation and identifying, stimulating and catalysing innovations. As a **'spearhead cluster'**, Catalisti is recognised by the Flemish government and takes a central role in translating Flanders's 'smart specialisation strategy' into action.³² To this end, the spearhead cluster supports small, medium-sized and large enterprises and knowledge institutions in defining, setting up and implementing innovation projects.

Catalisti boasts **some 100-member companies**, among them BASF and the Port of Antwerp, as well as research institutions like the University of Gent, KU Leuven, VITO, etc. The thematic foci of the cluster are renewable feedstocks, advanced sustainable products, process intensification and side stream valorisation. Through the building of partnerships between companies, research institutions, sector associations and governments, Catalisti follows a so-called triple helix approach. A central part of this approach is to match indus-

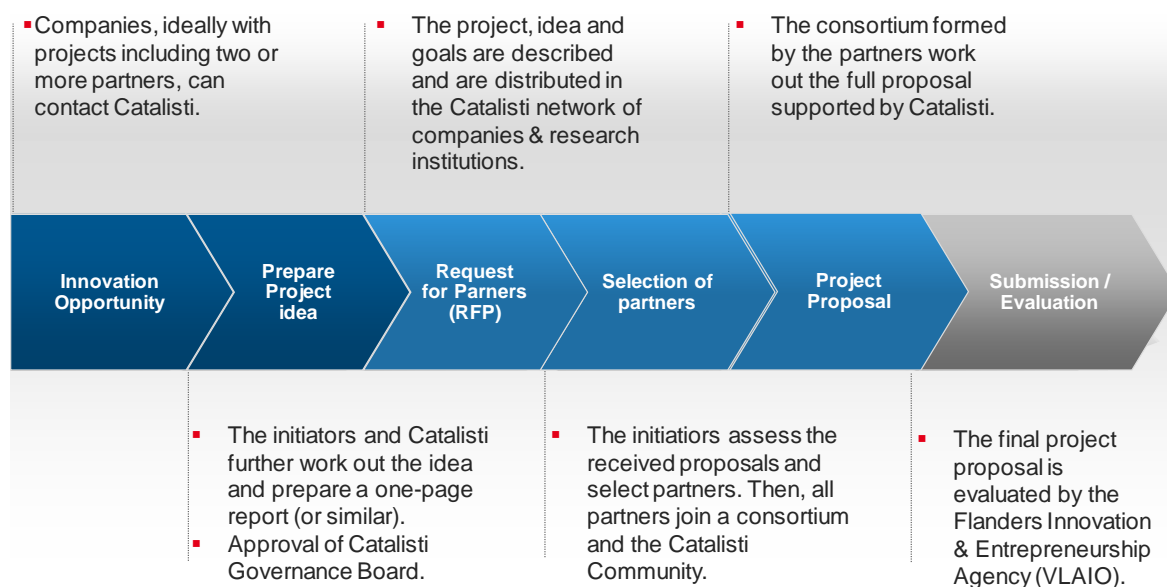
³⁰ Further, Brightlands campuses are the Maastricht Health Campus, the Greenport Venlo and the Smart Services Campus Heerlen.

³¹ See <https://brightlandsinnovationfactory.com/>

³² The Strategic Policy Framework for Smart Specialisation in Flanders. Policy Note of the Department Economy, Science and Innovation.

try needs with the research skills of other member institutions from both science and industry to realise innovation opportunities and facilitate easy access to funding. Figure 14 depicts such a process.

Figure 14: The Catalisti approach to matching R&I partners



Source: Prognos (2017), based on www.catalisti.be.

CAT Catalytic Centre (NRW)

The CAT is a **collaborative research centre** of RWTH Aachen and Covestro, where researchers from both organisations work on academic and industrial research in the field of catalysis. Natural scientists work in interdisciplinary teams with engineers and material scientists to explore how molecular expertise can turn into process design and finally into products.

Experts from Covestro are involved in both research and teaching at RWTH Aachen; hence, fundamental chemistry research, industrial development and professional training are interconnected. Thus, CAT provides a platform for the exchange of ideas, technology, innovations and people between academia and the chemical industry.

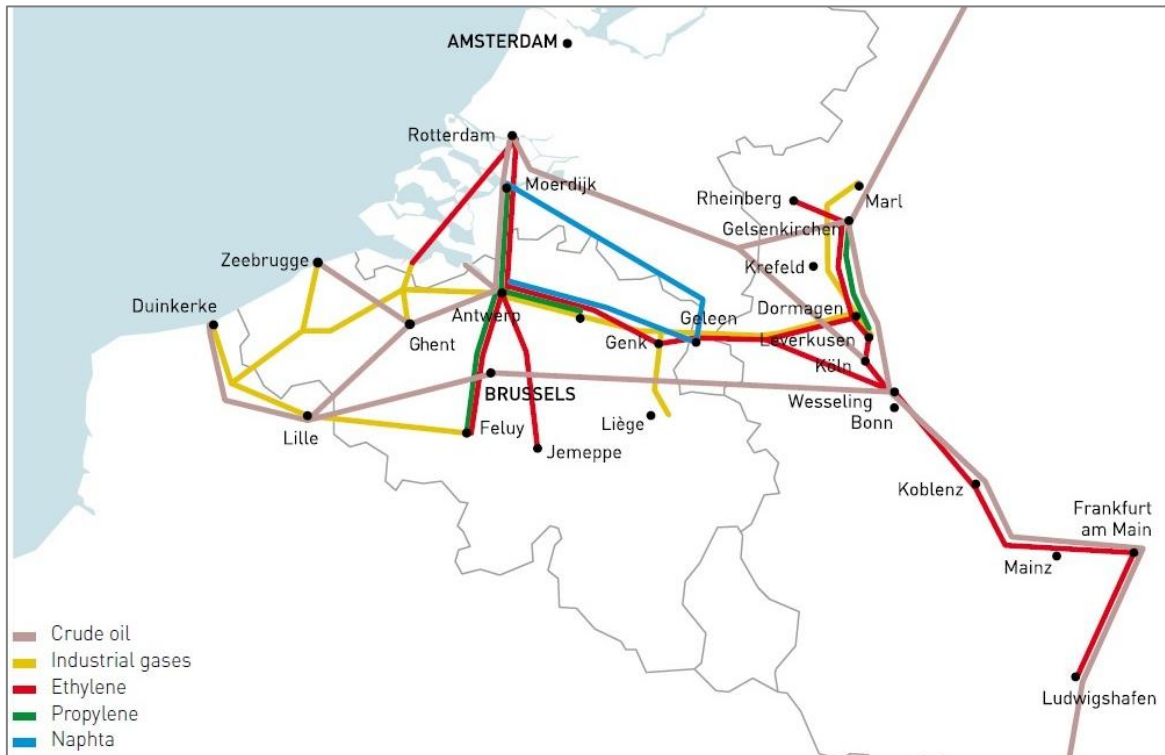
The current project '**Dream Production**', which is focussed on the utilisation of CO₂ as a feedstock to produce polyurethane through an innovative catalyst, is just one concrete example of innovative research at the CAT.

2.5 Logistics and specific infrastructure for the chemical industry

Transportation infrastructure and logistics are **cornerstones of the tightly integrated trilateral chemical industry** as production and consumption locations along the diversified value chain are mostly separated. Approximately 50% of the total cargo traffic of the major seaports in the EU passes through the ports of Flanders and the Netherlands.³³ The broad availability of the transport modes of road, rail, inland waterways and pipelines enables the effective transportation of chemical goods along the value chain in the trilateral region.

In particular, the **dense pipeline network** illustrated in Figure 15 is an asset for the trilateral region. Compared to other modes, pipeline transport possesses the great advantage of generating virtually no negative externalities when it comes to the transportation of gaseous and liquid bulk chemical feedstocks. Given the high population density in the trilateral region, pipelines offer transportation that is not only fast, efficient and cheap, but also safe and ecologically sustainable.

Figure 15: Illustration of the trilateral pipeline network



Source: Essenscia Flanders. Available at: http://www.essenscia.be/en/transport_logistics

Beyond pipelines, **inland waterways and rail** are very relevant transport modes for the trilateral chemical industry. These modes have advantages in terms of efficiency and costs compared to road transport and also have clear advantages in terms of safety, as certain hazardous goods are not authorised for road transport. While inland waterways are first and foremost suitable for the transportation of feedstocks and commodity goods, rail is also suitable for relatively small volumes per destination (i.e. for transport of individual wagonloads to different destinations), which is a key factor for the chemical industry. Most of the major chem parks are directly connected to the railway network; for example,

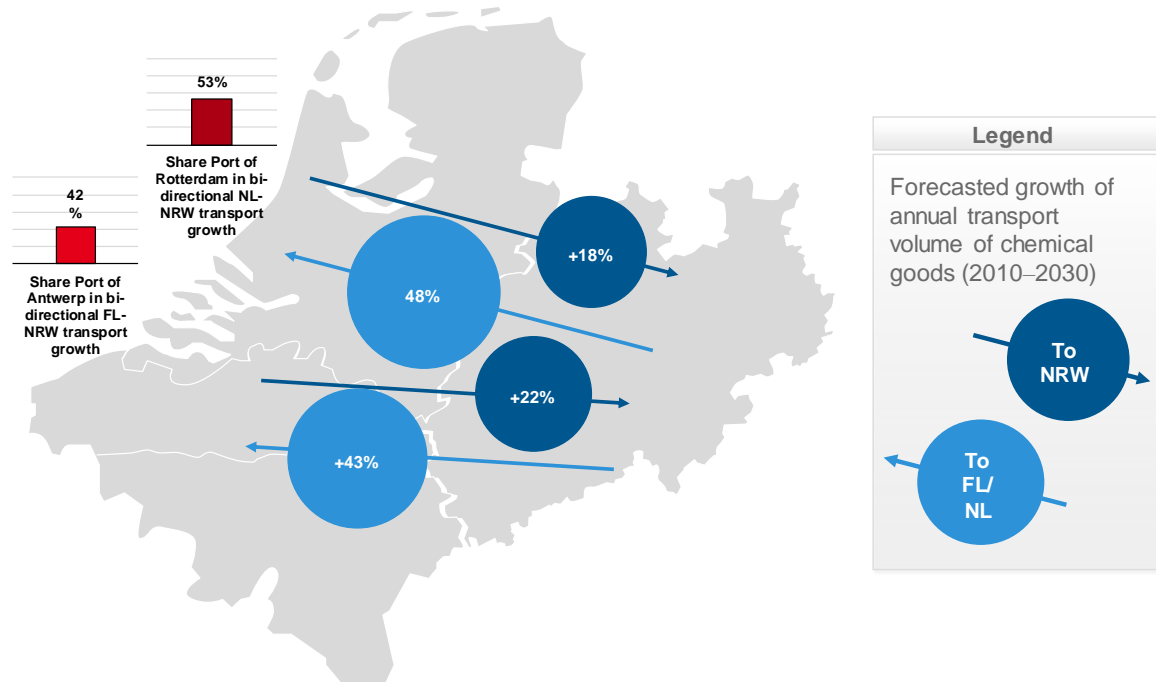
³³ (Brouwers, Gerrits, Forrez, & Devloo, 2014)

there are several shuttle trains connecting chem parks with central hubs for chemical logistics (e.g. Antwerp-Duisburg, Duisburg-Marl, etc.).

Finally, **road transport** enables the interconnectivity of all production and consumption facilities as well as the flexible planning of transport. Therefore, it becomes most relevant towards the end of the value chain, where there are decreasing volumes per lot and shorter distances.

Forecasts for the **future annual transport volumes** in the region indicate a significant increase of almost 30% through 2030 for all transport modes, excluding pipelines (see Figure 16). Approximately half of this annual growth is generated by the major seaports of Antwerp and Rotterdam.

Figure 16: Forecast of the growth of bi-directional annual transport volumes of chemical goods between NRW-FL and NRW-NL, 2010–2030



Source: Prognos (2017), based on the German Federal Transport Infrastructure Plan 2030. **Note:** Calculations are based on million tonnes of NST groups 32, 72 and 80 (fertilisers, liquid petroleum products, chemical products, rubbers, plastics, fibres and refined petroleum products). Forecast does not include pipeline transport.

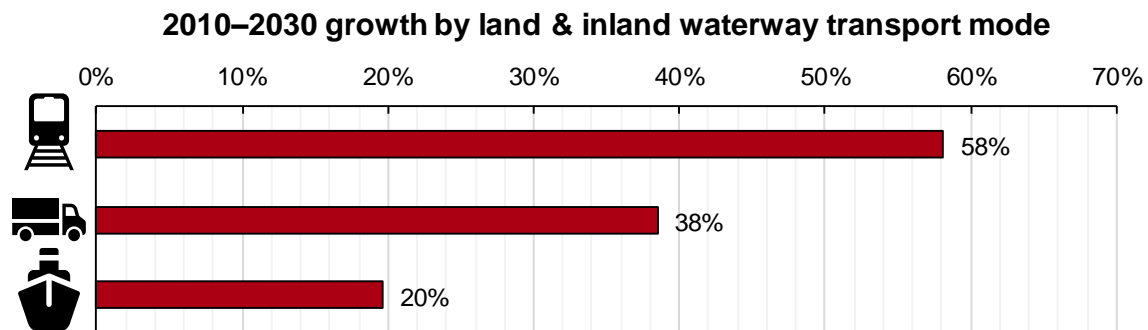
However, not only will the total volumes or quantities of chemical goods transported increase, but the **quality of transport and logistics are also in flux**: the increasing relevance of speciality chemicals, the extension of value chains and short-notice ordering based on market prices trigger decreasing transport volumes per lot.³⁴ Consequently, specialised logistics service providers and the chemical industry seek to cluster regionally to exploit proximity effects.³⁵ Furthermore, a possible future increase in the utilisation of alternative feedstocks will pose new challenges to the transportation infrastructure and logistics due to the differing characteristics of goods (e.g. biomass vs. liquids).

³⁴ (CEFIC, 2011)

³⁵ (Ketels, 2007)

A trend of **increasing volumes being transported by more flexible modes** of transport is also reflected in the 2030 forecast when differentiated by transport mode (Figure 17), and is further amplified by decreasing volumes per transport lot. Despite the increasing role of land transport modes, however, inland waterways will remain the most important transport mode for the overall volumes of chemical goods transported.

Figure 17: Forecast of the growth of bi-directional annual transport volumes of chemical goods by land and inland waterway transport between NRW-FL and NRW-NL, 2010–2030



Source: Prognos (2017), based on the German Federal Transport Infrastructure Plan 2030. **Note:** Aggregated volumes of from/to NRW-NL and from/to NRW-FL volumes. Calculations based on million tonnes of NST groups 32, 72 and 80 (fertilisers, liquid petroleum products, chemical products, rubbers, plastics, fibres and refined petroleum products). Forecast does not include pipeline transport.

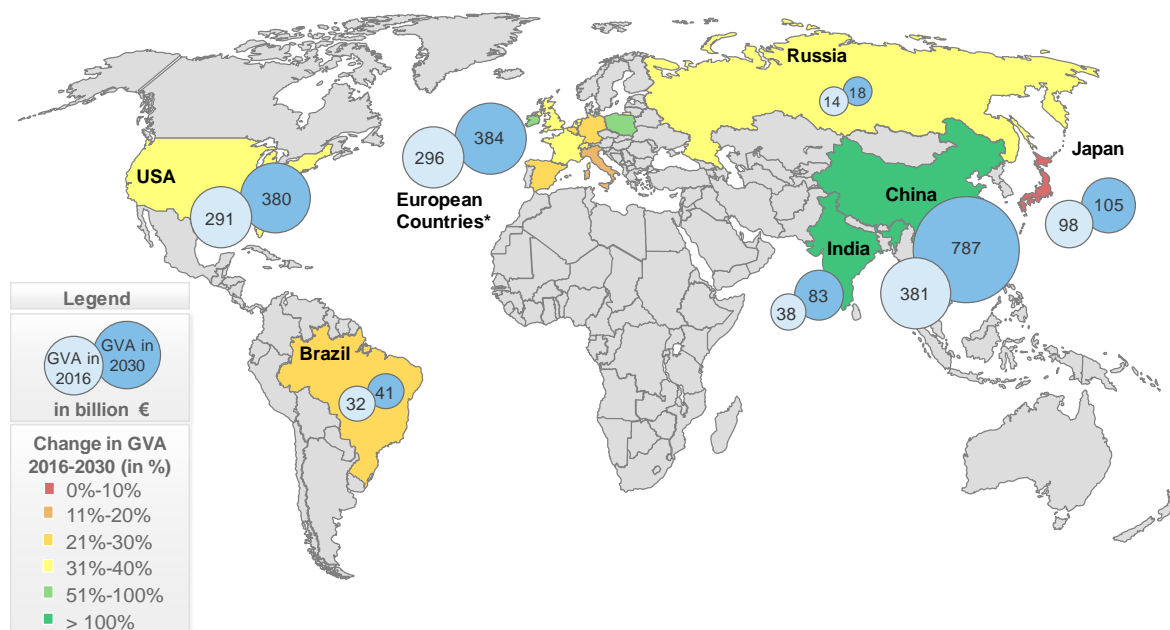
Consequently, as expert opinions clearly confirm, **resilient infrastructures will be key** to the future development of the chemical industry in the trilateral region. Infrastructures for the relevant transport modes of pipeline, rail, road and inland waterways must be maintained and extended – a pivotal task considering current infrastructural bottlenecks. **Future logistics need to be increasingly agile, flexible and adjustable** in order to respond to market changes quickly and effectively. ICT and digital technologies are already being applied by logistics service providers to improve their planning, monitoring and delivery capabilities. Tapping the potential of integrating the different systems will become increasingly important.

3 Chemical industry on the world market: Global outlook through 2030 and key drivers for industry development

3.1 Forecast for the international competitive environment in the chemical industry through 2030

In general, the **global chemical industry will grow quite significantly**. As Figure 18 shows, most countries can expect a growth rate in gross value added of between 20% and 40%. Growth in the chemical industry is based on several trends. First, the increasing demand from emerging countries is leading to a quantitative increase in the worldwide production of chemicals and pharmaceuticals. Second, there is an increasing demand, especially in industrialised countries, for high-cost and high-quality chemicals (qualitative increase). Further trends explaining the dynamic growth of the chemical industry are increasing chemical intensity and the aging world population, which increases the global demand for pharmaceuticals, in particular.

Figure 18: Forecast of gross value added in the chemical, pharmaceutical and rubber & plastics industries, 2016–2030



Source: Prognos (2017), based on Prognos Economic Outlook. **Note:** European countries = Belgium, Germany, France, United Kingdom, Ireland, Italy, Netherlands, Poland, Switzerland, Spain.

Below, the **developments in major competitor regions** are briefly summarised.

China and India

The most positive developments in terms of GVA for the chemical, pharmaceutical and rubber & plastics sectors are in India and China. In both countries, the generated value added will more than double until 2030.

In **India**, especially, the growing population (expected increase of 25%, up to 1.6 billion people by 2040) will have a positive impact on economic growth,³⁶ which will translate into a higher demand for chemicals, pharmaceuticals and plastics products. Considering only

³⁶ (Prognos AG, 2016)

the chemical industry, India will have surpassed even Germany in terms of generated gross value added by 2029.

Even though **China's** economic expansion is expected to slow down in the future, its importance as a consumer market will increase, leading to a shift in the growth paradigm from exports towards domestic demand.³⁷ This development can also be observed for the chemical industry.³⁸

Both countries are also **strongly supporting their chemical industries politically**. While China's 13th Five Year Plan foresees 'taking the lead' and becoming a 'great power' in the petroleum and chemical industry,³⁹ India has implemented the 'Made in India' strategy to increase its degree of self-sufficiency in the production of chemicals.⁴⁰ At the same time, both countries are trying to move up the value chain from bulk chemicals towards more value-added products. The objective to move up the value chain towards more research-intensive products, combined with their more dynamic economic growth, will be accompanied by higher R&D expenditure, which will increase the pressure on Europe's position as leader in innovation and R&D.⁴¹ It is expected that in 2030 China's share in worldwide R&D expenditure for the chemical and pharmaceutical industry will be approximately 15% (see Section 2.4).

Saudi Arabia

The Saudi Arabian chemical industry is very likely to grow significantly in the future. As with China and India, its government is actively supporting the chemical industry. Given the low price of oil, **Saudi Arabia is trying to diversify its economy**, with the chemical industry playing an important role. The objective is to use its expertise in oil and petrochemicals to invest in the development of adjacent and supporting sectors, thereby moving up the chemical value chain.⁴² However, domestic customers do not (yet) play a significant role in the Saudi Arabian economy.⁴³ At the same time, low oil prices, in combination with comparably higher prices for gas, are putting the mainly gas-based Saudi Arabian chemical industry under pressure (around 70% of the Middle East's petrochemical industry uses natural gas as feedstock).⁴⁴

Considering this diminishing feedstock advantage, and as China is investing in a modern coal-to-gas chemical industry⁴⁵ and the US is using its shale gas advantage, Saudi Arabia is taking steps to diversify its product lines beyond the basic gas-based chemicals industry. One example of this diversification is the \$20 billion joint venture plant between Saudi Aramco and Dow Chemical, which represents the first use of naphtha as a feedstock.⁴⁶

³⁷ (Prognos AG, 2016)

³⁸ (Prognos AG & VCI, 2016)

³⁹ (KPMG, 2016)

⁴⁰ <http://www.makeinindia.com/sector/chemicals/>

⁴¹ (Deloitte & VNCI, 2012)

⁴² <http://english.alarabiya.net/en/perspective/features/2016/04/26/Full-text-of-Saudi-Arabia-s-Vision-2030.html>

⁴³ (Commerzbank Research, 2016)

⁴⁴ (American Chemical Society, 2016)

⁴⁵ (Yingge, 2017)

⁴⁶ (American Chemical Society, 2016)

United States

The American chemical, pharmaceutical and rubber & plastics industries will, in terms of gross value added, **increase of 31% by 2030**, representing an annual growth rate of 1.9%. The chemical industry is the driving force behind this growth, with an annual growth rate in GVA of 2.1%, compared to 1.8% and 1.4%, respectively, for the pharmaceutical and rubber & plastics industries.

In particular, the **resource-intensive base chemicals sector is profiting** from low energy and feedstock costs as result of the shale gas revolution. Major investments have been made and are still planned for new, significantly more efficient and larger plants⁴⁷. In 2017, the total industry capital investments linked to the shale gas revolution have reached \$179 billion,⁴⁸ with the US Gulf Coast being the driving region.⁴⁹ Much of this new investment is geared towards the export market, especially for base chemicals, thereby increasing international competition and putting future margins under pressure.⁵⁰ However, it is expected that the construction of new plants will be finished by 2020, leading to normalised growth rates in investments.⁵¹

Europe

The gross value added generated in the **European chemical, pharmaceutical and rubber & plastics industries will increase by approximately 30%** by 2030, or 1.9% annually on average. The European chemical industry is especially profiting from the increasing demand for high-value chemicals, the increasing chemical intensity in its customer industries, and the economic growth in emerging markets. The domestic demand for chemicals, however, will grow by less than the global demand, in part due to the rather low growth expectations for the European economy. The higher chemical intensity in customer industries and the demand for high-value chemicals will be especially favourable for the innovative European specialty chemicals sector, whose production is expected to grow by approximately 1.9% per annum through 2030. Due to its competitive disadvantages in terms of energy and feedstock prices, production in the resource-intensive basic chemicals sector, on the other hand, will grow slowly through 2030 (approximately 0.5% per annum).⁵²

However, a **European Energy Union** and an increased commitment by the European Commission to a **Circular Economy** could lower these costs and lessen the resulting disadvantages. The highest growth expectation for the European chemical industry in terms of gross value-added lies in the pharmaceutical sector. This sector will grow more vigorously than in the US, even surpassing it in terms of total value added in 2030, thereby mitigating the competitive disadvantage in the (basic) chemicals industry compared to the US. An additional uncertainty has been introduced by the Brexit proceedings, which potentially threaten a market with over EUR 40 billion a year in two-way trade. On the other hand, successful trade agreements with the US and Japan (TTIP and JEFTA) would offer new trade opportunities with two major chemical export markets.

⁴⁷ (Prognos AG & VCI, 2016)

⁴⁸ (American Chemistry Council, 2017)

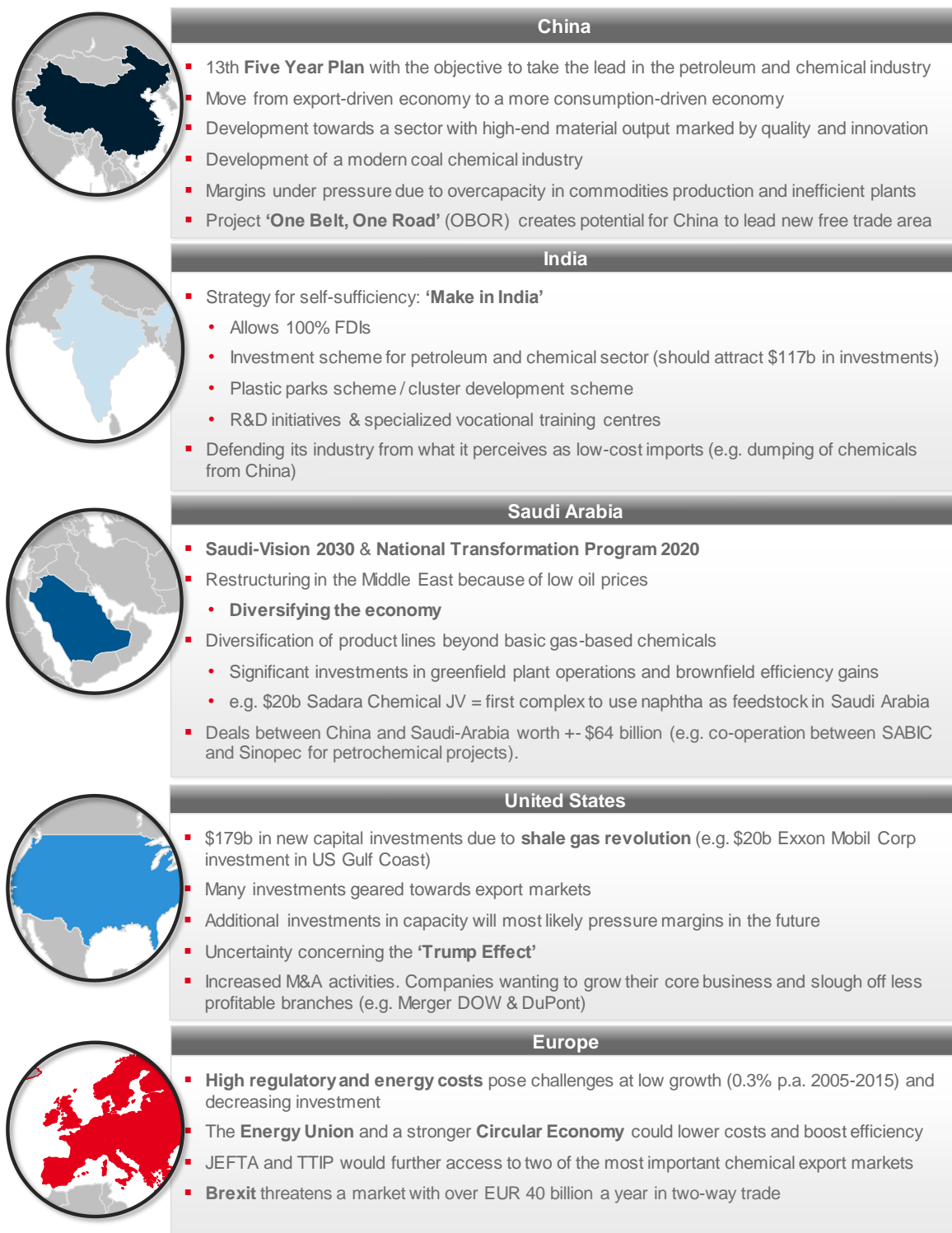
⁴⁹ (Scheyder, 2017)

⁵⁰ (Bos, 2017)

⁵¹ (Prognos AG & VCI, 2016)

⁵² idem

Figure 19: Country-specific profiles for the development of the global competitive environment in the chemical industry



Source: Prognos (2017), based on own research.

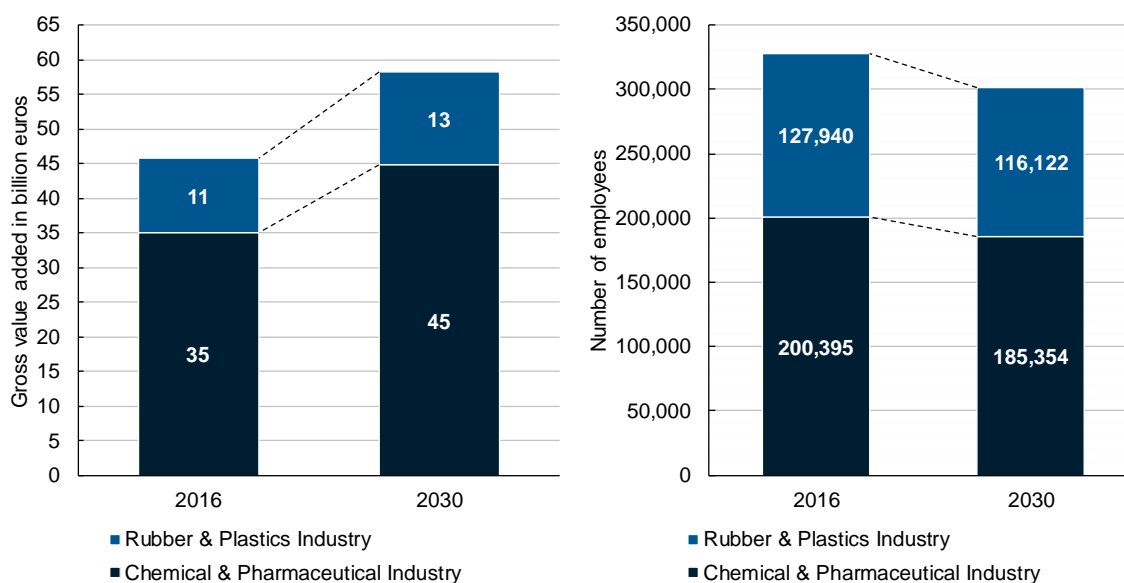
3.2 Forecast for gross value added and employment in the chemical industry in the trilateral region through 2030

The **gross value added generated in the trilateral chemical industry will increase** by about 27%, or 1.7% per annum, by 2030, as can be seen in Figure 20. This is somewhat lower than the European average and can be explained by the relatively lower importance of the pharmaceutical industry in the trilateral region, which nevertheless is growing more dynamically than the chemical sector.

By 2030, **employment in the sector is expected to decrease** by almost 27,000 people throughout the trilateral region. As Figure 20 shows, employment in the rubber & plastics sector is expected to decrease by approximately 9.2%, or 11,800 people, compared to 2016. For the chemical and pharmaceutical industries, a decrease of 7.5%, from approximately 200,000 to 185,000 employees, is expected between 2016 and 2030. However, the decline in employment will differ across and within the chemical and pharmaceutical sectors. It is expected that the basic chemicals sector will experience the highest loss, as production volumes cannot be significantly increased in the future, while a consolidation of production sites is likely.

The **sector will further increase its productivity** due to the upscaling of existing plants and technological advances, most prominently digitisation and automation. The specialty chemicals and pharmaceuticals sectors will improve their efficiency by profiting from digitalisation and an increased interconnection with other companies. A further trend explaining the foreseen decrease in employment is the outsourcing of several operational processes. However, as both sectors will most likely experience more dynamic development at the same time, employment will decrease to a lesser extent.⁵³

Figure 20: Forecast of GVA and number of employees in the trilateral chemical industry by 2030



Source: Prognos (2017), based on Prognos Economic Outlook, NBB.Stat, Statistics Netherlands, the turnover statistics of IT.NRW and the national accounts of Germany, Destatis.

⁵³ (Prognos AG & VCI, 2016)

There are also, however, some regional differences regarding the GVA and employment dynamics among North Rhine-Westphalia, Flanders and the Netherlands. Concerning the GVA forecast for the chemical industry, including pharmaceuticals and rubber & plastics, it is expected that Flanders and the Netherlands will experience a higher growth rate than North Rhine-Westphalia. For Flanders and the Netherlands, it is expected that the GVA produced by the sector will grow on average 1.86% and 1.91% per annum respectively between 2016 and 2030, whereas in North Rhine-Westphalia an average growth rate of approximately 1.5% within the same period is expected.

With regards to employment development the differences are less pronounced. For North Rhine-Westphalia and the Netherlands, employment in the chemical industry, including pharmaceuticals and rubber & plastics, will decrease between 2016 and 2030 by approximately 8% (or -0.6% on average per annum). At 9% (or -0.7% on average per annum), this drop is somewhat larger in Flanders. This, however, is mainly due to a larger employment loss in the rubber & plastics sector, at 13% between 2016 and 2030, as compared to North Rhine-Westphalia (-8%) and the Netherlands (-10%).

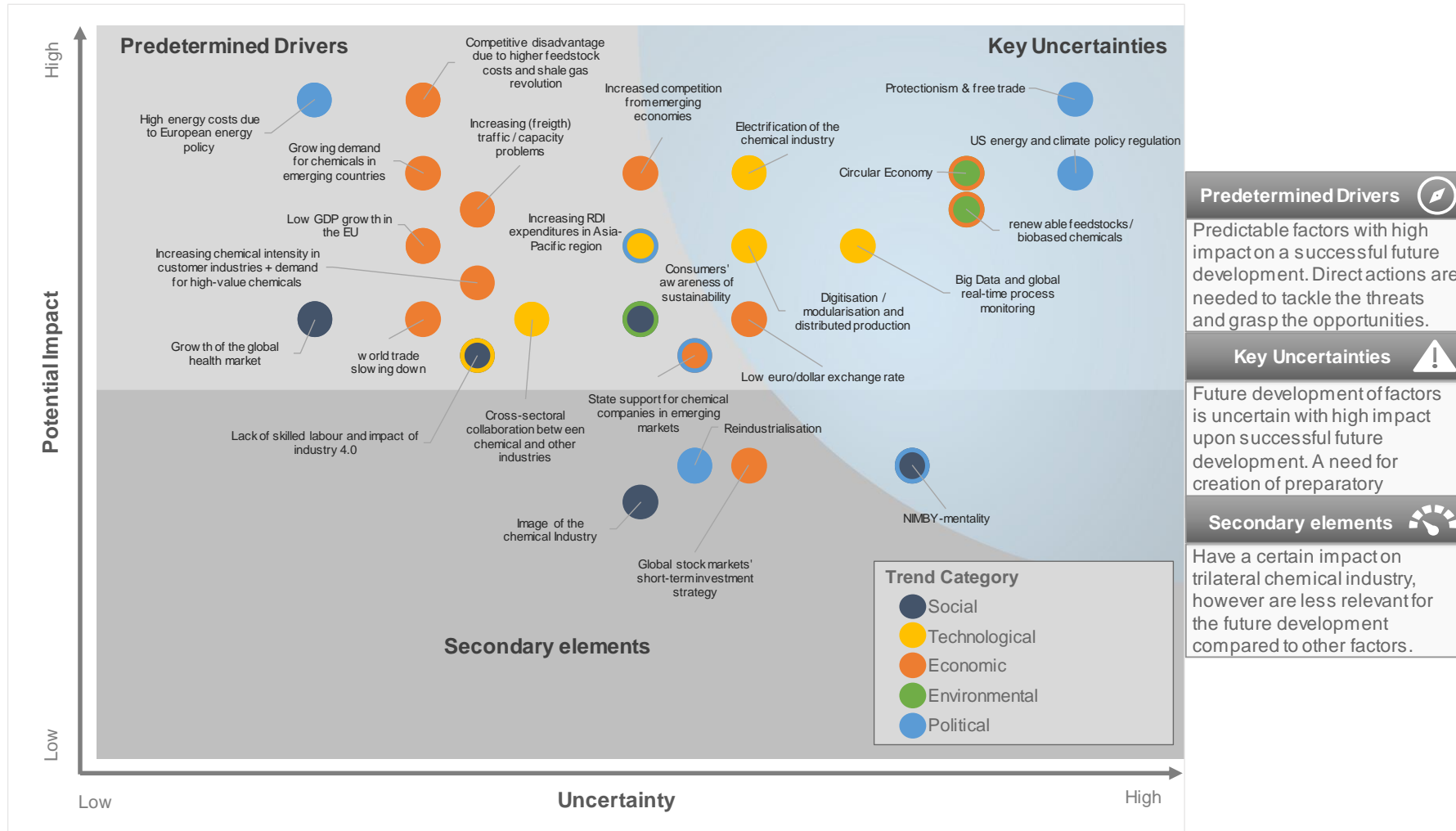
3.3 Key drivers and central trends for the chemical industry

There are many potentially game-changing trends, weak signals, relevant influencing factors, and uncertain developments with important implications for the trilateral chemical industry. Identifying all the different developments and trends is indispensable for deriving the whole spectrum of potential strategic options for a forward-looking development of the trilateral chemical industry. To this end, **Figure 21 displays all identified factors with a more or less strong influence on the trilateral chemical industry through 2030.**

The upper left part of Figure 21 displays the **predetermined drivers**. These are the trends that we consider to be quite certain in their development and that will have a quite important impact on the trilateral chemical industry in terms of its competitive environment, value networks or its future market opportunities and potential growth platforms. Some of these have already been presented in the previous analysis and include, amongst others, the **increased competition from emerging markets and the US**, especially for the basic chemicals industry; the increasingly **disadvantageous feedstock and energy position** of the trilateral region; the **weak growth forecasts for Europe**, compensated for in part by the increasing **demand for chemicals in emerging economies**; and the **increasing R&D pressure** from emerging economies trying to move up on the chemical value chain.

The upper right part of Figure 21 shows the **key uncertainties**. These are the factors we see as potentially having a high influence on the development of the chemical industry in the trilateral region, but whose concrete impact and shape cannot yet be completely determined. These include, for instance, the possible **comeback of protectionism and new restrictions on free trade areas** due to the Brexit vote and the new US presidential administration (e.g. TTIP negotiations). Furthermore, there are some uncertainties concerning the impact of **US decisions regarding energy and climate policy regulations**. On the one hand, the dismantling of environmental protection measures (e.g. the repeal of the US Clean Power Plan, withdrawal from the Paris climate agreement) *could* strengthen the US energy and feedstock advantage. On the other hand, the trilateral chemical industry *could* profit from a higher availability of cheap LNG overseas, given the presence of the necessary infrastructure and production capacities.

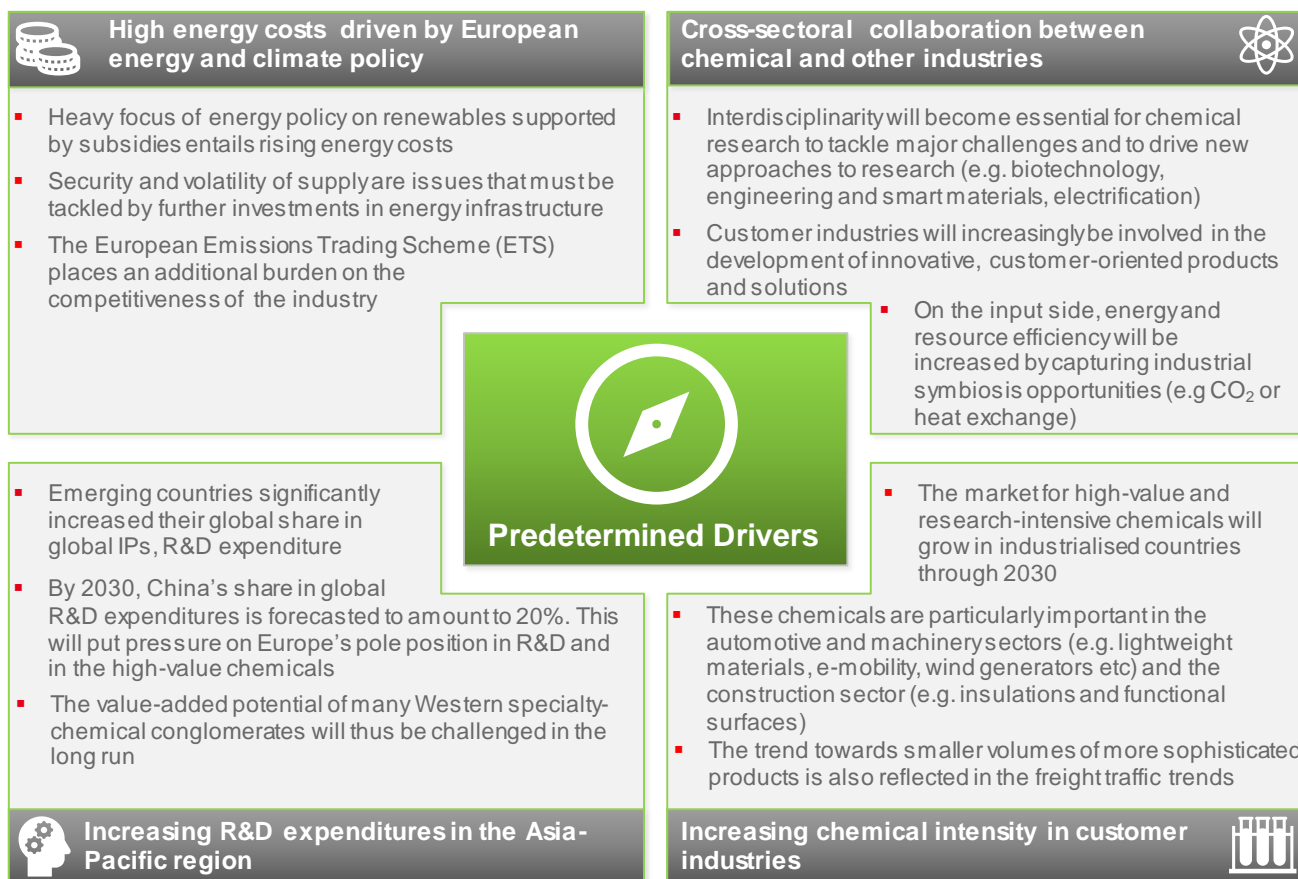
Figure 21: Trend analysis for the chemical industry through 2030



Source: Prognos (2017), based on desk research and interviews. Icons: copyright flaticon. **Note:** The depicted trends and uncertainties were analysed, rated and validated by means of desk research, expert interviews and stakeholder workshops and finally assigned to one of the five interdependent trend areas: social, technological, economic, environmental and political. A more detailed explanation of the methodology is presented in the Annex.

However, even though some of the **predetermined drivers** displayed in Figure 21 have a high impact, stakeholders in the trilateral region cannot directly influence them (e.g. sluggish European growth, development of feedstock prices in other world regions, etc.). Figure 22 therefore displays some **additional identified trends that can be directly influenced by actors in the region**. Given their quite certain development, direct action is needed to either tackle the imminent threats or grasp the upcoming opportunities that these trends represent for the development of the industry.

Figure 22: Most important predetermined drivers for the trilateral chemical industry



Source: Prognos (2017), own research. Icons: copyright flaticon.

Similarly, the exertion of influence on the **key uncertainties** outlined in Figure 21 is often beyond the reach of policymakers and other stakeholders in the trilateral region. However, in some fields the right framework conditions can already be created today. To this end, Figure 23 gives a **more detailed overview of those uncertain developments for which actors in the trilateral region are able to create the right framework** so that companies and institutions in the trilateral chemical sector can master the forthcoming challenges and opportunities and use them to their advantage.

Figure 23: Most important key uncertainties for the development of the trilateral chemical industry



Source: Prognos (2017), own research. Icons: copyright flaticon.

All in all, these **drivers and trends will drive the global competitive environment** of the chemical industry, with many factors exerting influence on the firms in the trilateral region even today. Preparing to meet these global challenges is of the utmost importance, and in a volatile global environment, fast and smart reactions to unexpected changes will remain pivotal.

4 Strengths, weaknesses, opportunities and threats for the chemical industry in the trilateral region

4.1 Strengths and weaknesses of the trilateral chemical industry

The SWOT approach sketches an overall profile of the chemical industry in North Rhine-Westphalia, Flanders and the Netherlands. It serves as the basis for identifying and adapting future fields of action that – supported by measures and projects – make a significant contribution to economic development, helping to generate long-term competitive advantages for the chemical industry in the trilateral region.

Against this background, clarifying the strengths and weaknesses of the chemical industry in the trilateral region represents an important intermediate step for evidence-based strategy development. Analysing the current development status of the trilateral chemical industry as well as the externally acting framework conditions is important in order to identify those points and competitive advantages upon which the industry can build and where adaptations are necessary in order to not lose these advantages. Table 4 gives an overview of the trilateral chemical industry's strengths and weaknesses.

Table 4: Strengths and weaknesses of the chemical industry in the trilateral region, ordered in terms of their importance

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Highly educated & productive workforce ▪ Integrated value chain & proximity to customers and suppliers (Verbund) ▪ Geographical location in the heart of Europe ▪ Interregional R&D co-operation ▪ Operational excellence / high efficiency of production facilities / regular investments in repair and maintenance (compared to US) ▪ High infrastructural integration (road, rail, water, pipeline) ▪ Dense higher education and research landscape ▪ Presence of good working cluster organisations ▪ Strong agricultural sector 	<ul style="list-style-type: none"> ▪ Uncertainty about climate & energy policy leading to lower investments ▪ Persisting infrastructural bottlenecks ▪ No profound EU industry policy ▪ Low number of start-ups ▪ Image and visibility of the chemical industry ▪ Need for more policy co-ordination (research, infrastructure, energy policy, etc.) ▪ Ageing production facilities compared to other competitors ▪ Other chemical clusters are more attractive to investors ▪ Feedstock, energy and labour cost disadvantage ▪ Limited cross sectoral co-operation within and across the chemical value chains ▪ Lack of venture capital for innovative activities (risk aversion) ▪ Limited interregional exchange of talent ▪ Difficult planning and approval of infrastructure projects ('not in my backyard mentality') ▪ Lack of long-term funding

Source: Prognos (2017), own research.

The **highly educated and productive workforce** is one of the most important strengths of the trilateral chemical region and is highly recognised. This highly qualified workforce is closely connected with another strength of the trilateral region, namely its **dense higher education and research landscape** (see Figure 13).

Jos Keurentjes

TNO

Research Organisation

NL

“The trilateral region is the European hotspot for research in chemistry.”

Scope for improvement, however, was still found in the potential for a stronger **interregional exchange of talent in the trilateral region** and more intensive co-ordination of regional education systems. At the same time, the region already benefits from well-functioning **interregional R&D co-operation**, which constitutes an important part of future competitiveness. The Aachen-Maastricht Institute for Biobased Materials and the trilateral BIG-C research initiative of CLIB2021 are good working examples for

existing knowledge exchange in the trilateral region and have been indicated as a major strength. In addition, the trilateral region can build on **many well-functioning industry clusters**, which are facilitating the exchange among industry, science and public authorities, as exemplified by the ‘lighthouse’ Catalisti (see Section 2.4).

However, there is still **room for improvement in terms of policy co-ordination among the three regions**. In particular, administrative hurdles, e.g. different eligibility and selection criteria for funding and European state aid rules, are hindering more intensive and more interregional co-operation. In addition, more co-ordination is needed to streamline important R&D infrastructure investments (e.g. pilot facilities) to maximise synergies and benefit from peer-to-peer learning.

Looking at the sectoral structure of the chemical industry it becomes clear that a major competitive advantage of the trilateral region is that it is rooted in a **large network of strongly integrated plants**, the so-called *Verbund* structures. By interlinking production plants, energy flows and infrastructure in an intelligent way, the *Verbund* systems in the trilateral region create efficiently integrated flows that cover almost the complete chemical value chain, extending from basic chemicals up to high value added products such as coatings and agrochemicals. In combination with the operational excellence in the region, the strongly developed *Verbund* structure forms the basis for the extremely high efficiency of the trilateral chemical industry.

Dr. Cornelia Bähr

CLIB2021

Cluster Organisation

NRW

“With its many chemical firms, research centres and its exceptional infrastructure the trilateral region is the chemical heart of Europe.”

However, most of the **existing production plants in the trilateral region are relatively old** compared to those of competitors in China and the US. Regular investments for maintenance and repair are made in the trilateral region (see also Section 2.2), but **other clusters** in China (coal-based chemistry), the US (gas-based chemistry) and Saudi Arabia (naphtha-based chemistry) are **building new plants** in strategically important fields. Furthermore, the current debates concerning **climate and energy policy in Europe tend to discourage investment in the region**. This creates uncertainties concerning future energy prices, energy supply security and potential support schemes (e.g. carbon leakage). In addition, the **relatively high energy, feedstock and labour costs** put pressure on the price competitiveness of the trilateral region. Given this difficult and uncertain competitive environment, **other world clusters are currently more attractive for new investments**. This is further underlined by the fact that the chemical industry in emerging countries like China, India and Saudi Arabia can count on strong public support for their development (see Section 3.1). In particular, the energy and feedstock-intensive basic chemicals sector, which is highly concentrated in the trilateral region (see Figure 11), is being affected by this situation.

A strong advantage of the trilateral chemical industry compared to other chemical regions in the world, however, is its **high infrastructural integration**. In no other chemical cluster in the world – not in Houston (US), Jubail (India) or Shanghai (China) – is there such an integrated network of all four infrastructure links (road, rail, water and pipeline). High infrastructural interconnectivity combined with its advantageous **geographical location in the heart of Europe** allow the trilateral chemical industry access to almost all of the major Western European centres of industry and consumption, giving it exceptional market coverage.⁵⁴

⁵⁴ (Port of Antwerp, 2015)

Even though infrastructural integration is generally seen as a great advantage, **there exist important bottlenecks** that should be addressed in order to maintain this position. The rail and road infrastructure, in particular, is less than satisfactory in the trilateral region. As mentioned in Section 2.5, both infrastructure links are currently at their capacity limits.

In light of the current evolution of the chemical industry towards more specialised chemical solutions, and of global transformation forces (e.g. digitalisation, personalisation etc.), the role of start-ups and spin-offs as drivers of innovation is increasing. The trilateral region still demonstrates a considerable amount of untapped potential or, in other words, a comparatively **low number of start-ups**. This is closely linked to the **limited availability of risk capital** in the region. Mobilising financing for upscaling remains challenging (seed phase funding is less of a problem).

4.2 Opportunities and threats for the trilateral chemical industry

Preparing for the future not only requires understanding the status quo in terms of the strengths and weaknesses of the chemical industry in the trilateral region, it also requires an in-depth understanding of changing and oftentimes extra-regional parameters (both opportunities and threats). Identifying threats and opportunities and contrasting them with the previously identified strengths and weaknesses is ultimately more helpful in illustrating the challenges ahead for the chemical industry than looking at either internal or external parameters in isolation. Furthermore, this contrast helps reveal which developments the trilateral region is already well equipped to handle and where further action is needed to either grasp opportunities or tackle imminent threats to the industry.

Table 5: Opportunities and threats for the chemical industry in the trilateral region (in order of importance)

Opportunities	Threats
<ul style="list-style-type: none"> ▪ Increased cross-sectoral collaboration ▪ Build on current strengths for future investments (i.e. infrastructure, R&D co-operation) ▪ Electrification of the chemical industry ▪ Increased cross-border co-operation and co-ordination ▪ Circular Economy ▪ Development of new value chains, e.g. bio-based, with high value products ▪ Increased chemical intensity in customer industries ▪ Growth of the global health care market ▪ Refitting of old production facilities ▪ Low euro/dollar exchange rate 	<ul style="list-style-type: none"> ▪ Low investments in tangible assets ▪ Changing value chain: shrinking basic chemicals industry ▪ Complex & hindering regulations with negative impact on innovation (e.g. REACH) ▪ Security of supply & high feedstock and electricity prices ▪ More dynamic development of other chemical clusters due to higher investments and fewer legal restraints ▪ Public image of the chemical industry ▪ Long-term disintegration of certain chemical value chains ▪ Increased competitive pressure on customers, especially for the manufacturing industry ▪ Demographic change (lack of skilled labour) ▪ Difficult economic situation in Europe ▪ Rising protectionism (globally)

Source: Prognos (2017), own research.

In terms of existing opportunities in the trilateral chemical region, an **increased cross-sectoral collaboration** within and across the chemical value chain is considered one of the most important opportunities for the industry, and is an opportunity that is still too little capitalised on in the trilateral region. The growing importance of increased collaboration is the result of the aforementioned **increase in chemical intensity in many customer industries**, amongst other factors. The need for more customised/individualised products, developed in close co-operation with the chemical industry, will be an important driver of the demand for chemical products. However, it is not only collaboration with customer industries

Gerard van Harten
Topsector Chemie

Chemical Sector Association
NL

“The Circular Economy can be a potential game changer for the chemical industry like Tesla is for automotive.”

that presents an opportunity, but **co-operation with new industries**, for instance as suppliers of feedstocks (biobased, waste) or heat, will also become increasingly important. For instance, the agricultural sector, which is strongly represented in the trilateral region, could provide biomass in the future. Another example is the steam network 'Ecluse',⁵⁵ which is currently under construction in Flanders, and will connect two waste incineration plants and the majority of the chemical companies located in the Waasland Port. Other potential options are integrated heat networks and the exchange of CO₂ with, for instance, the steel industry.

Jan van Havenbergh **Catalisti**

Cluster Organisation **FL**

"The trilateral chemical industry still possess great potential and has a certain tradition in the search for new feedstocks."

These examples underline the opportunities that the shift towards a **Circular Economy** brings. In line with the shift towards more sustainable production processes, another opportunity for the chemical industry is seen in the increased use of **biobased feedstocks**. As mentioned above, these feedstocks are able to not only complement fossil-based feedstocks ('drop-ins') but also offer the **opportunity for the development of new value chains** with high-value products that display completely new characteristics ('novels'). At

the same time, the trend towards more biobased feedstocks creates opportunities for **retrofitting old chemical sites** that previously used commonplace feedstocks into new biobased chemical plants.

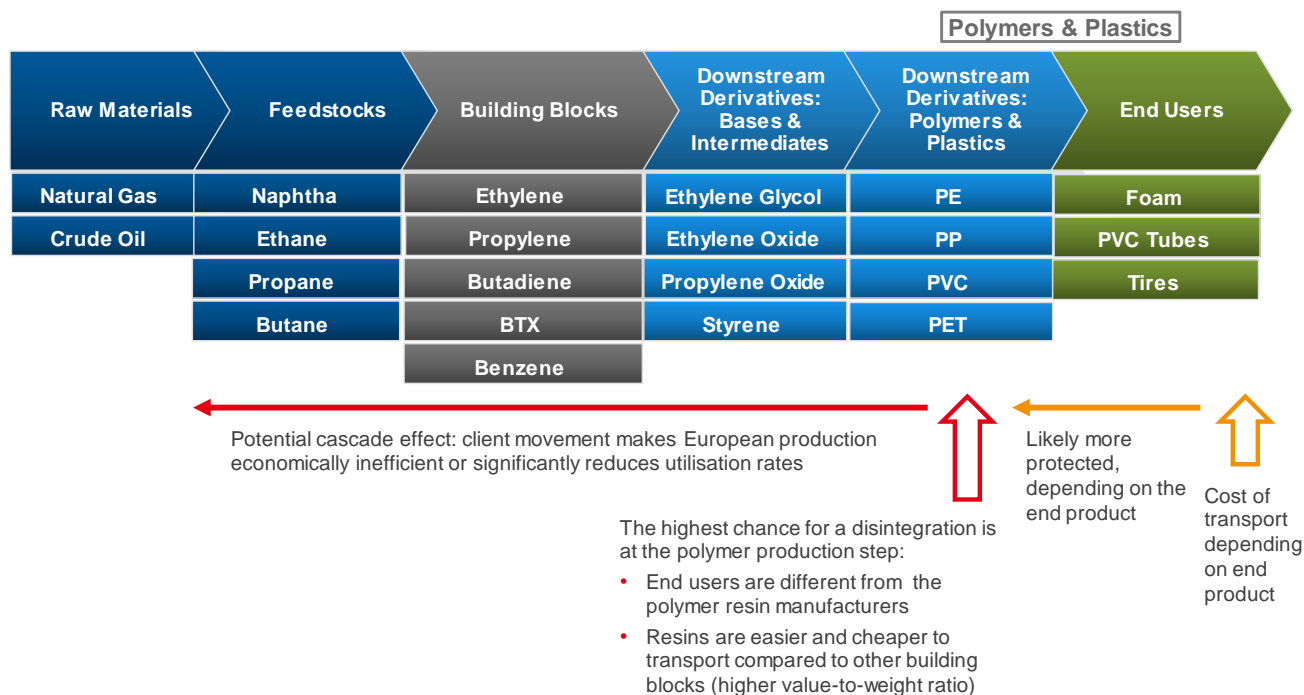
However, there are also **several threats** for the chemical industry in the trilateral region.

The increasing global pressure on the trilateral chemical industry, and its challenging competitive environment due to, for example, higher input prices (feedstocks, labour costs), is also creating the **risk of a potential disintegration of certain chemical value chains** in the region. As described above, the trilateral chemical industry shows high integration along the value chain. This integration has its benefits (e.g. efficiency due to the *Verbund* structure), but at the same time it makes the industry more vulnerable to potential cascade effects. Two effects can potentially lead to the disintegration of chemical value chains, which can be shown using the example of the polymers and plastics chain (see Figure 24).⁵⁶ First, the cost disadvantage at the level of crackers is passed along the whole value chain up to the level of polymers and plastics production. Second, polymer resins have lower transport costs compared to other building blocks earlier in the value chain.

⁵⁵ See <http://www.ecluse.be/steam-network/>

⁵⁶ A more detailed overview of the chemical value chain can be found in the Annex.

Figure 24: Potential disintegration of the chemical value chain using the example of the polymers and plastics chain



Source: Prognos (2017), based on Brouwers, E., Gerrits, R., Forrez, I., & Devloo, T. (2014). Contribution to a future-oriented energy strategy for the chemical industry: Impact of energy and feedstock costs on the competitiveness of the chemical industry in the ARA-cluster. (Essenscia, & VNCl, Eds.), p. 42.

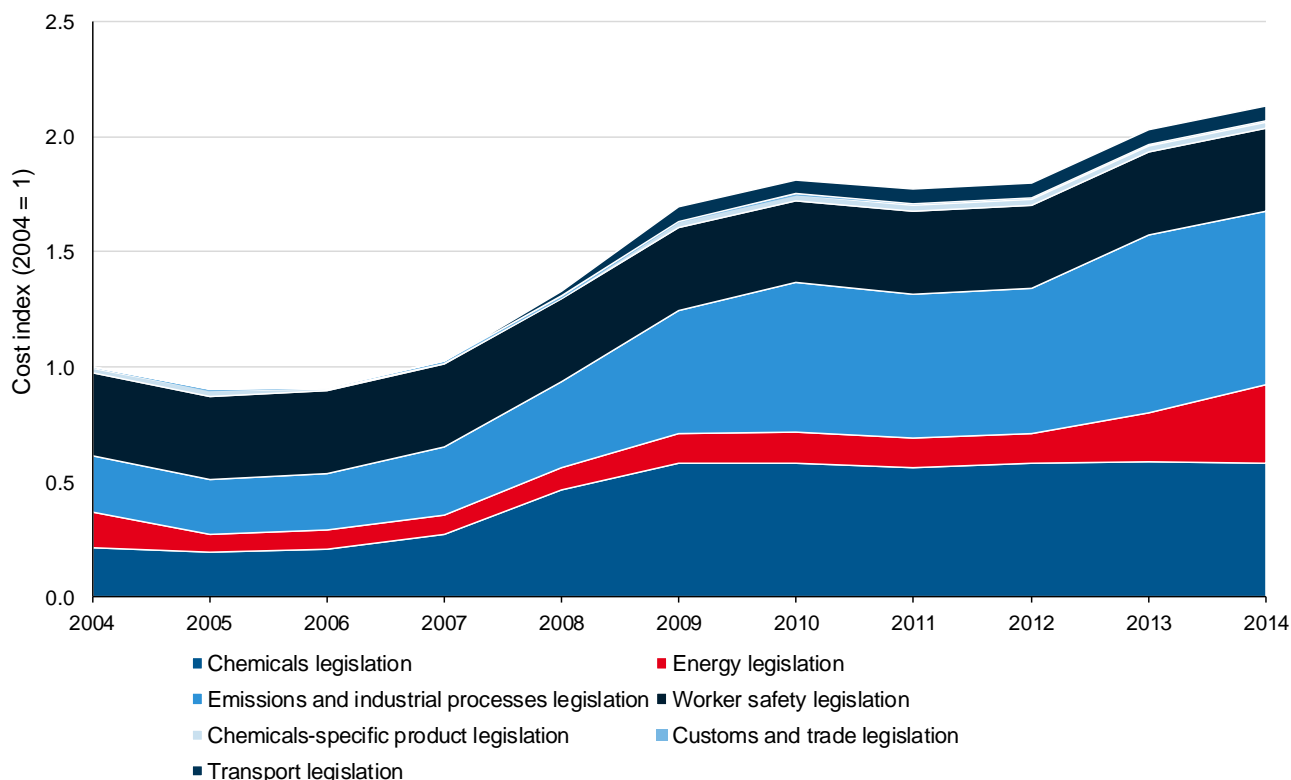
The combination of these two factors can lead to a situation where the landed costs of downstream products made abroad and then shipped to Europe are lower than the cost of locally manufactured resins. In a worst-case scenario, this could lead to a relocation of the local polymer resins manufacturers, with cascade effects that also impact the upstream industries. Possible consequences are significantly reduced utilisation rates and the economically inefficient production of upstream products.⁵⁷

However, not only the relocation of downstream chemical industries, but also the **growing relocation of other manufacturing industries** to Southeast Asia poses a threat for the trilateral chemical industry, as it depends on a strong industrial customer base. A coherent **European industrial policy** that creates attractive operating conditions for the European manufacturing industry and stimulates innovation and investments is needed.

Finally, another exogenous factor that can hamper the development of the trilateral chemical industry is **increasingly complex regulations**, which can have a negative influence on operating costs and investment decisions. Figure 25 clearly illustrates the rise in legislation costs between 2004 and 2014.

⁵⁷ (Brouwers, Gerrits, Forrez, & Devloo, 2014)

Figure 25: Legislation costs during the period 2004–2014



Source: Prognos (2017), based on CEFIC (2016). *The European Chemical Industry: Facts & Figures 2016*, p. 26.

In particular, the introduction of REACH⁵⁸ in 2007 and CLP⁵⁹ in 2008 have had a significant impact on operating costs. Furthermore, costs have risen due to increasing investments by companies after 2009 in anticipation of the enforcement of Seveso III (2012)⁶⁰ and ETS Phase 3 (2013). Energy legislation also contributes to rising costs, especially since 2012.⁶¹

⁵⁸Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) is a European Union regulation that addresses the production and use of chemical substances and their potential impacts on both human health and the environment. (For further information see http://ec.europa.eu/environment/chemicals/reach/reach_en.htm)

⁵⁹ The CLP Regulation (Classification, Labelling and Packaging) is a European Union regulation that aligns the European Union system of classification, labelling and packaging of chemical substances and mixtures to the Globally Harmonised System (GHS). (For further information, see https://ec.europa.eu/growth/sectors/chemicals/classification-labelling_de)

⁶⁰ The Seveso III directive is a European directive that deals specifically with the control of on-shore major accident hazards involving dangerous substances. (For further information, see <http://ec.europa.eu/environment/seveso/>)

⁶¹ (CEFIC, 2016)

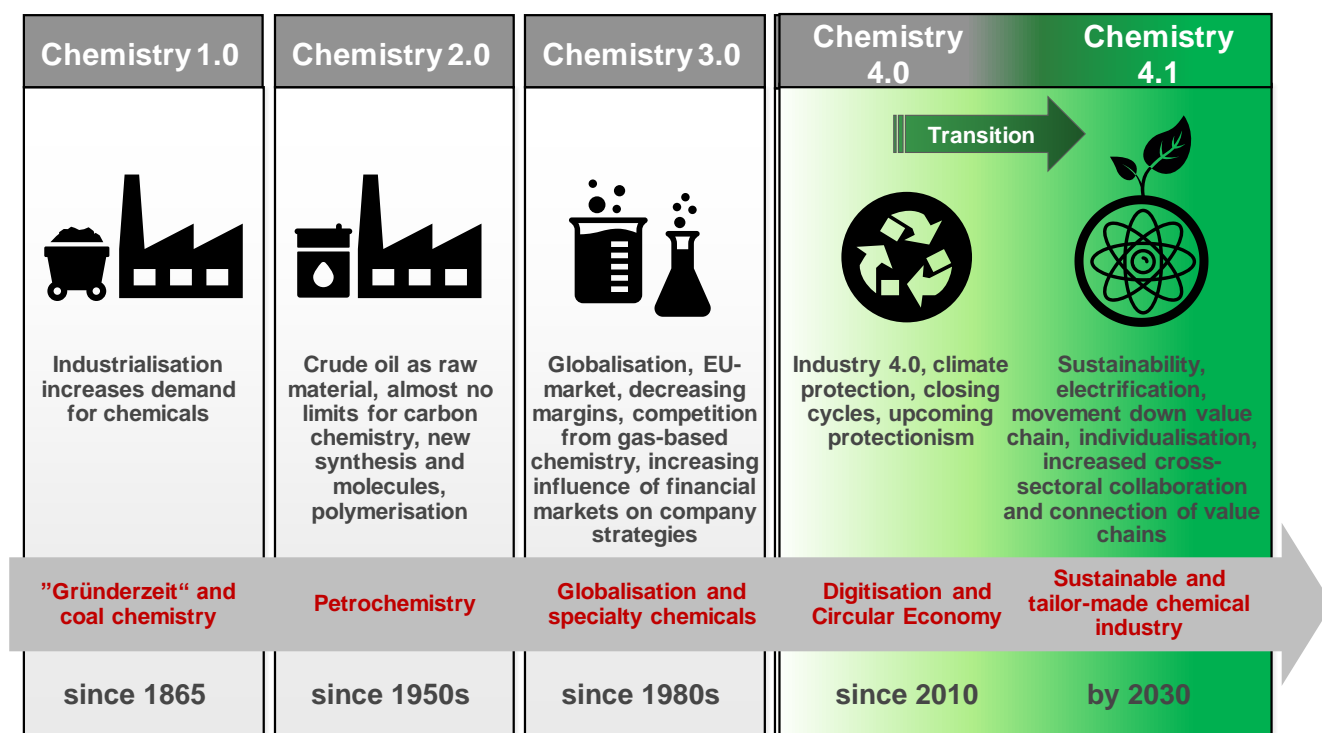
5 Vision 2030 and a strategic agenda for the chemical industry in the trilateral region

5.1 Vision 2030: The world's engine for the transition towards a sustainable and competitive chemical industry

The trilateral region of North Rhine-Westphalia, Flanders and the Netherlands has a long history as the home of one of the world's most powerful chemical industry clusters.

Building upon the foundations of the Industrial Revolution, the chemical industry in the three regions evolved in the mid-1900s around the coal industry in the industrial heartland of Europe (see Figure 26, **chemistry 1.0**). Numerous innovations continuously enlarged the product portfolio of the chemical industry, starting with patents for the hydrogenation of coal; subsequent innovations produced fertilisers, petrol, catalysers and polymers. Several transformation forces shaped the subsequent development of the chemical industry in the three regions. The constant substitution of crude oil for coal enabled numerous product innovations to emerge in the basic chemicals sector and, later on, the specialty chemicals industry, including surfactant, polyvinylchloride, varnish materials, polystyrene and softener. Such developments gave rise to the petrochemical industry starting in the 1950s (**chemistry 2.0**) and the subsequent growth of the specialty chemicals industry since the 1980s (**chemistry 3.0**). Globalisation forces have also played an important role in shaping the trilateral chemical industry, leading to the establishment of global production networks and multinational chemical industry corporations.

Figure 26: The transition path and new transformation agenda of the trilateral chemical industry



Prognos (2017), based on VCI. Icons: copyright flaticon.

Today, after **over 150 years of development**, the trilateral chemical industry still holds a **top position in the world** and is home to the fourth-largest chemical industry cluster on the globe. When it comes to operating excellence, the region ranks in first position, far ahead of the USA, Japan and China.

However, there are **several changes under way** that the industry must address to remain competitive in the long run. Digitisation is providing many new opportunities for cyber-physical production systems in the chemical industry, while the need for climate protection and altering resource endowments require major efforts towards sustainability. The transformation from a linear to a Circular Economy

will require far-reaching changes in the industry's business model alongside significant innovations in product design and recyclability. Future challenges, such as the energy transition and the related generation of excess electricity, require interdisciplinarity and must be addressed with greater urgency if chemistry is to remain an influential subject. This underlines a clear paradigm shift from blue-skies to problem-driven research as well as the need for more tailor-made products (**chemistry 4.0 to chemistry 4.1**). All this, along with many other drivers of development, will ultimately lead to significant changes in the chemical industry in the trilateral region through 2030 and beyond.

Aware of the changing landscape for the trilateral chemical industry and acknowledging the strong value chain integration within the region, the Ministry of Economics, Innovation, Digitalisation and Energy of North Rhine-Westphalia (MWIDE, DE), the Department of Economy, Science and Innovation (Flanders, BE) and the Ministry of Economic Affairs (NL) have, using a trilateral approach for the first time, formulated a smart, holistic **transformation strategy built upon the following vision**.

This vision and the trilateral strategy is the result of a **joint working process of key stakeholders** from the industry from all three regions in 2017, including the ministries, industry representatives, academic thought leaders and intermediaries (industry associations, cluster initiatives, etc.).

'Striving to become the world's engine for the transition towards a sustainable and competitive chemical industry cluster – in North Rhine-Westphalia (DE), Flanders (BE) and the Netherlands 2030.'

Through 2030, the trilateral chemical industry is very likely to see a moderate consolidation of the basic chemicals sectors due to global market pressures, most prominently from China and the US. At the same time, the movement downstream in the value chain towards specialty chemicals and, even more so, tailor-made innovation products for new solutions (e.g. the development of custom-made high-performance lightweight materials for the automotive industry) will continue. This will be strongly driven by increased cross-sectoral collaboration and blurring sectoral lines between the chemical industry and the pharmaceutical, biotech and energy sectors. New market niches will open up for a new generation of start-ups and spin-offs emerging from a strong academic foundation and within the chemical industry parks of the trilateral region. In particular, discoveries in materials science such as nanoscale materials (e.g. graphene, silicene) with wide fields of application in markets such as healthcare, manufacturing or consumer goods could lead to a new era of growth. Underlying this will be a new growth narrative for the trilateral chemical industry, building upon systemic innovation towards a sustainable chemical industry in all dimensions of sustainability, i.e. ecological, human, and economic health and vitality. The chemical industry in the trilateral region is contributing to environmental and energy innovation and is in certain areas driven by the electrification of the sector, reusing waste and further forms of feedstock diversification.

Despite a lower probability compared to other industries, **value chain disruption is not impossible** in the chemical industry; this could happen, for example, through the entry of new external market players from other industries (such as digital platform leaders like Amazon or Alibaba in the retail industry). This could lead to far-reaching changes in value chain configuration, customer relations and, ultimately, value capture.

These elements together map out the vision for the trilateral chemical industry by 2030 and the most important drivers underlying this vision. The coming years will be important ones for **steering the trilateral chemical industry towards the future** in the direction of the shared vision.

5.2 Trilateral strategy for the chemical industry: Supporting future growth platforms

The trilateral chemical sector plays an important role in the sustainable development of industry as well as the overall growth and prosperity of the three regions. It is a central supplier of materials for many industrial sectors and has the ability to innovate and thus develop various solutions to important social challenges. For these reasons, **sustainable development of the trilateral chemical industry** and maintaining and improving its competitiveness are important tasks for the industry leaders, academics and policymakers of North Rhine-Westphalia, Flanders and the Netherlands.

Despite the current boom in mergers and acquisitions observed in 2016/2017 and the high stock-market valuations of many corporations in the trilateral chemical industry, there are a **number of strategic challenges** facing the industry throughout Europe, as the SWOT analysis has shown (see Chapter 4). Growth of the chemical industry in the trilateral region, and in the EU overall, has been relatively flat in recent years, and gross value added is expected to grow by less than 2% per annum in the coming years – a cumulative growth of 27% by 2030. China and India will double their GVA during this period, and the much more mature US chemicals industry is expected to grow by more than 40%. With increasing production capacities and quality improvements, Chinese state-owned enterprises, such as ChemChina and SinaChem, will significantly fuel global price competition for both basic and speciality chemicals.

At the same time, no other chemical cluster in the world can rely on such a highly educated and productive workforce, such highly integrated value chains and such a proximity of customers and suppliers (the *Verbund* advantage) coupled with a profound R&D base and operational excellence.

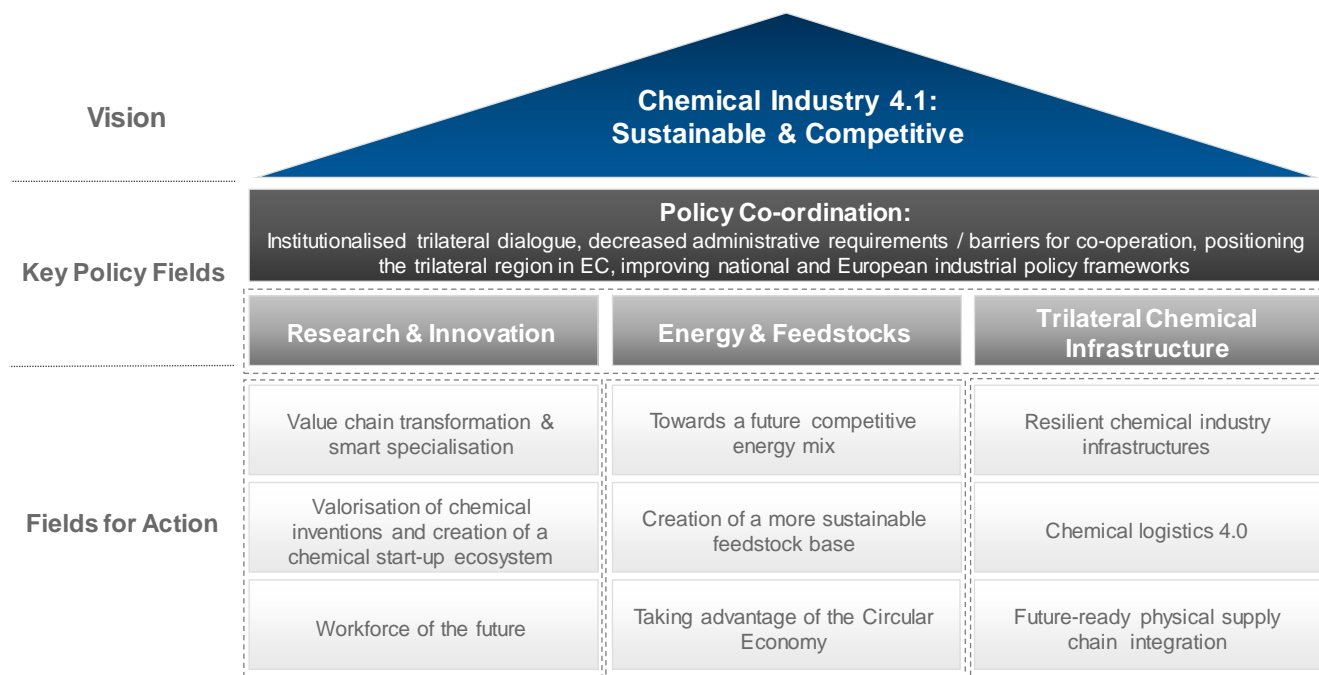
Taking into account these **market developments, scientific changes and ambitious government plans** in many competing regions throughout the world, and considering the intra-regional strengths and weaknesses of the trilateral chemical industry, a holistic strategic agenda has been developed. A so-called gap analysis was performed to systematically identify the most important areas for value-adding actions to move towards the desired state of the trilateral chemical industry.

The **coming years will be decisive in determining future market shares** for many established EU chemical players, including those in the trilateral region. Based on the vision for the trilateral chemical industry in 2030 and the principal design of the trilateral strategy, **five overarching objectives** must be achieved:

1. Facilitate a **value chain transformation** towards a digital, sustainable and circular chemical industry in the trilateral region.
2. Augment the quality and integration of **trilateral education and qualification systems** towards the development of a regional labour pool for a knowledge-based chemical industry.
3. Improve the weakened competitive **energy cost position** of the trilateral region and build a level playing field for the use of **sustainable feedstocks**.
4. Secure the **critical infrastructures** for the chemical industry and make advances in building up a **chemical logistics system 4.0**.
5. Strengthen the quality and effectiveness of **trilateral policy co-ordination** in areas of high cross-border priority for the chemical industry.

To emerge as an industry leader region in the future global chemical industry landscape, **three key policy fields (vertical) and one horizontal aspect** will guide the common actions of the trilateral chemical industry over the coming years. These have been supplemented by **specific fields for actions**, which address more detailed the most critical issues that need to be matched with concrete measures.

Figure 27: Trilateral strategy for the chemical industry through 2030



These policy fields will guide the common actions of the trilateral region over the coming years to strengthen its chemical industry and support its position as industry leader. Each of these policy fields tackles several issues that are hampering achievement of the overarching goals and have been identified in the previous analysis. Furthermore, for each key policy field, **strategic objectives** are specified to further indicate where action is required. In this way, the key policy fields represent the starting point for the development of **concrete measures and project proposals**.

Below, the **four policy fields** and how they can tackle current and future issues for the trilateral chemical industry are described in more detail.

KEY POLICY FIELD 1: RESEARCH & INNOVATION (R&D&I)

The trilateral region can draw on a vast array of universities, universities of applied sciences, basic and applied research institutions and pilot plants, in addition to cluster organisations, all of which play a decisive role in bringing together industry and science. This **R&D&I landscape** lays the foundation for a highly qualified workforce as well as excellent research at both a fundamental and an industrial level. The region is also home to some of the **most R&D&I-intensive chemical companies and strongest private research institutions**, which together comprise the majority of European chemical innovation capacity (see Section 2.4).

Recently, however, **innovation strategies of the chemical industry as a whole are being challenged** and the differentiation of product portfolios is becoming increasingly difficult, even for specialty chemicals. Global competition with the trilateral chemical industry is also increasing, and China, in particular, has been significantly increasing its R&D&I activities; it is expected to reach an estimated 15-20% of global R&D&I expenditure by 2030. As many customer industries of the European chemical industry are today producing in Asia and purchasing decisions in the industry are significantly influenced by R&D&I in customer industries, R&D&I co-operation with customers and academic institutes is becoming increasingly important. To ensure value capture in the arising new (and more complex) value chains, strategic and cross-sectoral alliances will become ever more important.

Against the background of the outlined framework conditions for R&D&I in a global context, the policy field of 'Research & Innovation', with its measures and fields for action, shall contribute to reaching the following **strategic objectives**:

1. Improve the strategic targeting and support of trilateral R&D&I activities for the most relevant innovation opportunities.
2. Strengthen joint action in the field of R&D&I to allow for greater scale and specialisation.
3. Increase the value capture from joint R&D&I in the trilateral region.
4. Position the trilateral region as a global hub for chemical industry start-ups.
5. Prepare the workforce of the future for the trilateral chemical industry.

KEY POLICY FIELD 2: ENERGY & FEEDSTOCKS

The companies of the trilateral chemical industry belong to the most resource- and energy-efficient companies in the world. Many investments have been made over the past decades to improve the efficiency of chemical production facilities in the trilateral region and have led to a network of strongly integrated plants, the so-called *Verbund* structure. In combination with the **operational excellence** in the region, the trilateral chemical industry thus possesses an important advantage with respect to other chemical clusters worldwide.

However, **further efficiency gains** to offset its comparatively high energy and feedstock costs are becoming increasingly difficult to achieve, leading to mounting global pressure on the trilateral chemical industry. The US advantage in shale gas and energy prices, China's strong state support for its chemical industry and Saudi Arabia's oil advantage are not likely to vanish; these threaten the basic chemicals sector in particular. Further losses in production capacities could potentially lead to a disintegration of certain value chains, not least because of the strong value chain integration in the region. Therefore, **a trilateral approach is more necessary than ever** to ensure competitive energy and feedstock costs and to capture the opportunities of alternative feedstocks so that the survival of chemical companies and of the entire value chain can be assured.

In view of the outlined situation, the key policy field 'Energy & Feedstocks', with its measures and fields for action, has the following **strategic objectives**:

1. Ensure competitive energy and feedstock prices.
2. Strengthen trilateral co-operation regarding EU climate and energy policy.
3. Develop a coherent and predictable regulatory framework for energy and climate policy to assure and regain investment confidence.
4. Create attractive conditions for the use of alternative feedstocks to prepare for the transformation towards new value chains.
5. Fully exploit the opportunities of the Circular Economy, including reducing overlapping costs through other European instruments.

KEY POLICY FIELD 3: TRILATERAL CHEMICAL INFRASTRUCTURE

Against the backdrop of evolving global production flows and both longer and changing value chains, industry-specific forecasts through 2030 show a **significant increase in transport volumes** by weight within the trilateral region for all transport modes.⁶² This factor is amplified by decreasing transport volumes per lot as modularisation and specialisation of production gain relevance. In a similar vein, the utilisation of new feedstocks, from biomass to the Circular Economy, poses new challenges to infrastructure and logistics.

Not only must infrastructure in the trilateral region be strengthened, but **logistics** must also be improved through the smart exploitation and sharing of data. This can only be tackled using a co-ordinated trilateral approach.

⁶² Road, rail and inland waterways; pipelines excepted.

Considering the outlined framework conditions, the policy field 'Trilateral Chemical Infrastructure' shall contribute to reaching the following **strategic objectives**:

1. Increase the resilience of the trilateral transportation infrastructure through co-ordinated planning involving the relevant stakeholders.
2. Upgrade logistics to the next level by capitalising on the opportunities of digitisation.
3. Enable future investments in the trilateral *Verbund* by reserving sufficient space for key infrastructures.

HORIZONTAL KEY POLICY FIELD: POLICY CO-ORDINATION

The analysis of the trilateral chemical industry has shown that many trans-regional projects among North Rhine-Westphalia, Flanders and the Netherlands have already been initiated, especially for research and innovation activities. However, although increased co-operation across borders can be observed, there are still regulatory and administrative requirements for experienced by companies and research institutions in the trilateral region that represent obstacles to innovation and research undertakings (e.g. cross-border financing or different regulations regarding energy, climate or waste). These obstacles need to be tackled jointly to allow for more intensive and streamlined trilateral collaborations in relation to the key policy fields.

Given this situation, the horizontal policy field 'Policy Co-ordination', with its various measures, pursues following the **strategic objectives**:

1. Establish well-co-ordinated planning for a streamlined implementation of the intended measures.
2. Reduce administrative obstacles to enable more intensified trilateral collaborations.
3. Improve industrial policy frameworks for a more investment-friendly climate.

In what follows, the **concrete measures** for the trilateral strategy in support of the chemical industry are presented, organised by the key fields for action summarised above.



6 Call to action: Strategic measures for supporting the chemical industry in the trilateral region

6.1 Policy field 1: Research & Innovation in the trilateral chemical industry

By leveraging and implementing new knowledge in the development of new products, processes and services, companies in the chemical industry can open new markets and create the basis for sustainable employment, growth and profitability. The chemical industry is also an engine of innovation. Several other industries, particularly the automotive, electrical, machinery, and construction industries, rely on innovations from the chemical industry to remain competitive. Therefore, the innovative capacity of the chemical industry is so important for the trilateral region.

The trilateral region is home to a vast pool of R&D&I excellence, based on the highly competitive landscape of basic research and applied research institutes, universities and industrial R&D&I labs. Despite this good starting position, further improvements in bi-directional knowledge transfer and a better utilisation of this innovation potential is needed in the future. New growth platforms, which are vital for the future competitiveness of the trilateral chemical industry, rely increasingly on an intensified interplay between academic and industrial R&D&I (including start-ups). This requires (new) formats for applied R&D&I collaboration and commercialisation in order to benefit from the upcoming innovation opportunities and ensure value capture in the newly formed value chains.

Overview of proposed measures in the field of **Research and Innovation**

  Research & Innovation		
Field for action	Proposed Measures	
1 Value chain transformation and smart specialisation	#1	Improve the funding mechanisms for trilateral R&I actions
	#2	Intensify cross-regional R&D&I collaboration to improve the trilateral innovation ecosystem
	#3	Accompany a holistic digital transformation towards a 'New Verbund' based on value chain networks and virtual partnerships
2 Industrialisation/valorisation of chemical inventions and creation of a chemical start-up ecosystem	#4	Elaborate a trilateral scheme for demonstration plants
	#5	Expand the framework for start-ups and up-scaling in support of a trilateral chemical entrepreneurship ecosystem
3 Workforce of the future	#6	Enhance the vocational training and lifelong learning systems for blue collar jobs to develop the chemical industry skills of the future
	#7	Encourage trilateral academic exchange and partnerships to improve the formation of the future academic workforce

6.1.1 Field for action 1: Value chain transformation and smart specialisation of the chemical industry in the trilateral region

The chemical industry today faces several trends and uncertainties that have the potential to transform almost every part of the chemical value chain, from R&D&I, supply chains and production to services, marketing and sales (compare Chapter 3). For the trilateral chemical industry to be competitive in the future, **priorities need to be identified** among industry, academia and, in support, among policymakers and intermediaries, to allow for the value capture of upcoming innovation opportunities and shape uncertain developments to the region's benefit.



MEASURE 1: Improve the funding mechanisms for trilateral R&I actions (INITIAL-MEASURE NO. 1)

CONTEXT AND OBJECTIVES OF THE MEASURE

The **intensification of trilateral R&D&I actions** is essential in facilitating the value chain transformation and sustainability transition of the trilateral chemical industry. Currently, the industry's innovation strategies are facing far-reaching challenges, while differentiation of the trilateral region in the market through new developments and special products has become increasingly difficult. Meanwhile, global competition is intensifying, with emerging markets being estimated to contribute close to one-third of global R&D&I expenditure in the chemical industry by 2030.

Against this background, an improved funding mechanism is decisive in facilitating and scaling joint actions, particularly for flagship projects and demonstration plants (regarding the latter, see also Measure 2 below). It is of utmost importance that through this improved funding mechanism for R&D&I actions a clear **change-plan for the transition of the trilateral chemical industry** will be pursued.

CONCRETE STEPS AND ACTIONS

The improvement of the funding mechanism for trilateral R&D&I action shall be realised through the following **concrete steps and actions**:

- **Forming an 'innovation working group'**: To develop the funding mechanisms for trilateral R&I actions and a trilateral chemical industry's innovation roadmap for 2030⁺, an innovation working group should be formed following a triple-helix structure, i.e. involving experts from academia, industry (including start-ups) and policymakers/intermediaries for all three regions (see relevant stakeholders below). This group will organise the process and provide the necessary information for guiding the content-related discussion. The financing of the process is foreseen to come from the participating institutions, and supplemental financing for cross-border actions shall be acquired (e.g. via INTERREG).
- **Specification of key fields for smart specialisation of the trilateral chemical industry**:
A main task of the innovation working group is to specify the key priorities for trilateral action in the field of R&D&I through 2030 and beyond. Building upon the collection of trends and drivers identified in the overarching strategy and the insights provided in other relevant documents (e.g. the smart specialisation strategies), an extended stakeholder process shall be used to define these priorities. **Key fields for smart specialisation** relate to the following topics:
 - **R&D&I on chemical conversion, process technology and synthesis** (e.g. chemical valorisation of CO₂/carbon-capture utilisation, electrification, new use technologies for renewable resources)
 - **R&D&I on alternative feedstocks** (including the Circular Economy; see also policy field 'Energy & Feedstocks')
 - **R&D&I on advanced materials and nanotechnology** (including nanoscale materials, materials with added functionalities, materials for sustainability)
 - **R&D&I in the field of the most relevant Key Enabling Technologies (KET)**, including demo-plants, most prominently micro and nanoelectronics, advanced materials, industrial biotechnology and nanotechnology.
- **Development of the Joint-Trilateral R&D&I Programme 2030⁺**: The programme will specify the identified priorities and how they will be supported, and will include a framework outlining the available budgetary resources to be committed, indicating the various sources of finance (EU, national, private and other sources as appropriate, including call-based and budgetary funds; see also section on financing). The Joint-Trilateral R&D&I Programme 2030⁺ will be instituted as a publicly driven intergovernmental programme for the trilateral chemical industry. To that end, an

'innovation contract' shall be signed by all responsible parties to underline their commitment to the programme.

- **Elaboration of two to three trilateral 'Flagship Projects' and 'Demonstration Plants':** The first-mover projects in the defined areas of specialisation shall be prepared at the end of this process. These flagship projects or proposals for demonstration plants shall include market-driven R&D&I projects that are strategically and scientifically linked to the defined innovation priorities of the trilateral chemical industry and are of substantial size in their scientific and financial scope. These identified projects will then be positioned for joint R&D&I funding and shall contribute to positioning the trilateral chemical industry within the value chain transformation and sustainability transition.

In addition to the four key actions outlined above, three **complementary actions** shall be pursued:

- **Mapping of lighthouse initiatives in the trilateral region** (including major R&D&I projects): A mapping of the most relevant lighthouse initiatives in the field of R&D&I, including major R&D&I projects, will be performed to establish a baseline for existing assets; a baseline for this exercise is provided in Annex 3 of the report. All this information can be fed into a common trilateral knowledge platform to increase transparency about the intellectual capital already available (see strategy proposal below). This mapping exercise shall also analyse the most relevant roadmaps at the EU and international levels (e.g. SusChem Roadmap 2030 in the EU; equivalents in the US, such as the Agenda to Mainstream Green Chemistry) as well as national or regional priority reports such as the Top Sector Chemie NL 2040 or the Smart Specialisation Strategies of the three regions.
- **Establish a common knowledge/working platform:** Increasing transparency about the numerous academic and research institutions, various companies (including start-ups) and regional intermediaries supporting the development of the chemical industry is an important foundation for future joint efforts. By building upon existing repositories, such as the 'Cluster-Atlas' in the Ruhr area of North Rhine-Westphalia (<http://maps.chemieatlas.de/>) and expanding their coverage to the entire trilateral region, relevant contributions can be made for establishing a common knowledge platform.

For the **on-going co-ordination and implementation** of the concrete actions resulting from this process (e.g. accompanying the Joint-Trilateral R&D&I Programme and fostering joint R&D&I activities in European programmes), a permanent task shall be established within the Working Group on R&D&I (see Chapter 6.4). This group should include the key stakeholders involved in the preparation of the programme, but will also be linked to the public institutions in charge of R&D&I funding management.

RELEVANT ACTORS AND STAKEHOLDERS

Relevant actors and stakeholders for implementation (list is not exhaustive)
<ul style="list-style-type: none">▪ Ministries responsible for economic affairs, science, research, innovation and investment▪ Financial intermediaries: NRW.BANK, ZENIT (NRW), NOW, RVO (NL), Vlaio / IWT (FL)▪ Cluster organisations/intermediaries: BIG-C Initiative/CLIB 2021, Chemie.NRW (all DE), Catalisti, Flanders.bio (all FL), Brightlands Chemelot Campus, TI-COAST, Biobased Delta, BE-Basic (all NL)▪ Universities/universities of applied sciences: RWTH Aachen, TU Dortmund, Hochschule Ruhr-West (all DE), TU Eindhoven, TU Delft, University of Twente (all NL), KU Leuven, University of Antwerp (all BE)▪ Research institutes: VITO, TNO, Energy Research Center of the Netherlands – ECN, Dutch Polymer Institute – DP, DIFFER (all NL), VITO, IMEC, Flemish Institute for Biotechnology- VIB (all BE), Forschungszentrum Jülich, Fraunhofer IME/UMSICHT/IWS, Max-Planck Institute of Molecular Physiology / Chemical Energy Conversion / Coal Research (all DE)▪ Industrial partners: SMEs and larger enterprises with a focus on research

FINANCING

The financing of the process is foreseen to come from the participating institutions. Moreover, the European Commission, in close partnership with the Member States, is planning to put in place **pilot actions involving a limited number of test regions to test approaches to commercialise and scale up inter-regional innovation projects**.⁶³ The trilateral strategy for the chemical industry, in combination with the respective smart specialisation strategies, provides an excellent basis for this planned initiative.

Relevant financing sources for the different components of the Joint-Trilateral R&D&I Programme 2030+ and many of the measures of this policy field include:

European funding possibilities

- **EUROSTARS:** Eurostars is a transnational innovation programme supporting research-performing SMEs developing innovative processes, products and services to gain competitive advantage. The programme is administered by EUREKA! and covers all technology areas. Applications are welcomed from SME-led project consortia consisting of at least two independent legal entities from at least two different Eurostar countries. Funding varies from project to project. On average, the total cost of a project is EUR 1.4 million.
- **Fast Track to Innovation (FTI):** FTI is a bottom-up measure in Horizon 2020 to promote close-to-market innovation. Applicants must involve consortia of three to five legal entities established in at least three EU Member States. At least two of the participants must be from industry. Project proposals should involve close-to-market innovation, preferably at technology demonstration level or higher (TRL6 or more). On offer is a maximum contribution from the EC of up to EUR 3 million per proposal with a time-to-grant of around 6 months.
- **EUREKA Cluster:** E! Clusters are long-term, industry-led initiatives. They pursue an objective of strategic significance for the European economy in a particular domain (e.g. sustainable chemistry). They are public-private partnerships with broad industrial participation aiming to foster innovation. EUREKA Clusters organise themselves bottom-up to best reflect their individual scope, members and goals. Funding and support are received by national/regional public authorities. Furthermore, at least three different member countries must be involved, providing a very good basis for the trilateral collaboration, while also allowing further international co-operation partners to be brought in from other important regions.
- **European Structural and Investment Funds (ESIF; in particular ERDF):** In the current 2014–2020 period, cross-border investments in R&D&I activities from the respective ERDF Operational Programmes are already possible: Article 70(2) of the CPR stipulates a possibility of up to 15% of the support from the ERDF at the level of the thematic priorities to be allocated to operations located outside the programme area. This financing option should also be considered for the post-2020 funding period.
- **Multi-Region Assistance (MRA):** MRAs can provide EU funding to co-operation projects of at least two managing authorities from different EU Member States that aim to assess the possible use of ESIF financial instruments in specific thematic areas, such as R&D&I of common interest.

Also, there should be further exploration of the new offer by the EC, ACCESS4SMEs, which is a 30-month co-ordination and support action directed at National Contact Points in the domains of access to risk finance and SMEs. It also aims to foster the use of financial instruments (including through the exchange of best practices) while including the establishment of a community of practice facilitating access to cross-border finance. Horizon 2020, as the EU's flagship R&D&I programme, remains rele-

⁶³ (European Commission, 2017)

vant, but does not envision a primarily trilateral collaboration for R&D&I. However, a larger co-operation could be envisaged within the framework of the ERA-Net programme⁶⁴ or the Knowledge and Innovation Communities (KICs), which are part of the EC's initiative of the European Institute of Innovation and Technology (EIT).⁶⁵ Open opportunities under INTERREG (e.g. Interreg V-A – Belgium-Germany-the Netherlands) should also be explored. However, in the field of INTERREG the opportunities are currently limited as the remaining financial volumes for innovation support are either too small or exhausted. Further financing options shall be developed in collaboration with CEFIC, which maintains the database <http://www.grant-it.eu/>.

National/regional funding possibilities

In addition to the possibilities available at the EU level, there exist several potential options for regional or national funding of trilateral R&D&I collaborations.

- **North Rhine-Westphalia:** Opportunities for trilateral research co-operation exist within the framework of the funding directive 'Promotion in the research, development and innovation sector' (FEI-Directive). In particular, the **funding competitions** related to the lead markets '**Energy and Environment**' and '**New Materials**' show links to chemistry-related innovation fields. In the case of joint projects within the framework of the lead market competitions of the ERDF, up to 20% of the eligible costs of the project may be carried out outside the state of North Rhine-Westphalia. Furthermore, funding options from the German federal ministries could be examined, such as the '**central innovation programme for SMEs (ZIM)**' or the **framework programmes 'Material for Innovation'** and '**Research for Sustainable Development (FONA3)**'. Co-operation projects and networks under these funding directives can involve foreign partners, though they are not eligible for funding. Hence, co-financing is needed from partner countries.
- **Netherlands:** The **public-private partnership top-up** ('PPS-toeslag') can be used to subsidise private-public partnerships with a focus on research and development that include at least one Dutch research institute and one private company (based anywhere). The amount of the PPS top-up is 25% of the company's total private contribution to the research institute. Other opportunities are provided by the Dutch **chemistry innovation fund** ('Innovatiefonds Chemie'), which also supports public-private partnerships between at least one Dutch university or research institute and a private company. The fund is open to new initiatives that fit within the knowledge and innovation agenda of the 'Topsector Chemie', including the Dutch Biobased Economy Research Agenda 2015–2027. Furthermore, the **subsidies energy innovation** ('subsidies energie-innovatie') within the context of the Dutch 'Topsector Energie' can be explored. Support is given to co-operative projects undertaking research in topics related to chemical innovation fields like CCUS or the biobased economy and green gas, amongst others.
- **Flanders:** Various funding opportunities that aim at realising innovation projects in companies are provided. The **funding measure 'R&D&I company projects'** ('O&O bedrijfsprojecten') supports, amongst others, joint innovation projects between at least one Flemish company and other (international) research partners with funding provided for up to 25% of eligible costs for development and 50% for research activities. The beneficiary needs to be located in Flanders, but no preference is given to any sectors, application domains or knowledge areas. In addition, a similar funding mechanism with a special focus on R&D&I in small and medium enterprises, the '**SME innovation project**' ('Kmo-innovatieproject'), has been established.

TIME HORIZON AND MILESTONES

This measure is foreseen to be **implemented in the short term**, i.e. within the next two years. Global pressures are increasing and many competing regions are investing heavily in their innovation capacities. The trilateral innovation roadmap 2030+ is therefore an important component in navigating R&D&I activities within the trilateral region over the coming years. The roadmap shall be presented in

⁶⁴For example: **M.ERA.NET 2** (research in material innovation, including materials for low carbon energy technologies and related production technologies) and the **ERA-Net SmartGridPlus** (research in electric power systems that integrate renewable energies and enables flexible consumer and production technologies)

⁶⁵ For example, **EIT InnoEnergy**: addressing sustainable energy, **EIT Raw Materials**: addressing sustainable exploration, extraction, processing, recycling and substitution of raw materials or the **EIT Climate-KIC**: addressing climate change mitigation and adaptation.

autumn 2018 during a high-level event within the trilateral region. Following this, the Joint-Trilateral R&D&I Programme 2030+ should be established by mid-2019 to incorporate the new (and announced) framework of EU funding opportunities and to position, early on, the investment needs of the trilateral chemical industry in the context of the ESI Funds and beyond.



MEASURE 2: Intensify cross-regional R&D&I collaboration to improve the trilateral innovation ecosystem

CONTEXT AND OBJECTIVES OF THE MEASURE

The **great societal and industrial challenges** of the future are characterised by the high complexity of the related problems. Interdisciplinarity will become more important for chemical research and the industry and will be essential for tackling major challenges and driving new approaches to the market. Also, the increasing demand for higher-quality chemicals will continue to rise, requiring customer-driven solutions, e.g. for the automotive industry (chemical solutions for electromobility, lightweight construction, etc.), the construction industry (chemical innovations for building insulation, etc.) and green industries (no high-performance wind turbine could work without chemical innovations).

Most of the outlined challenges and opportunities can only be addressed by means of a **targeted networking** of the various actors (academia, industry, etc.) and by involving all participating disciplines. To exploit the existing potential for innovation within the trilateral region, the networking of different industrial sectors is necessary. The parameters for this networking must be based on future models for research, education and training. These models should link the competences existing at research centres and universities in the trilateral region, involving scientists from industrial R&D&I centres, which are of particular importance for the region's chemical industry. Similar approaches must be developed in education and training with a view to ensuring broad interdisciplinarity and high-quality training (see Field for action 3).

POSSIBLE ACTIONS

The future success of the trilateral chemical industry depends very much upon on how well teaching and higher education, as well as R&D&I, are guided by current and future social, economic and environmental requirements. Inventions from science should be developed as quickly as possible into innovations, be they marketable products, processes and services, or new business models. A **strategic knowledge and technology transfer** is essential to utilise these potentials and contribute to strengthening the trilateral region as a competitive location. Such a strategy should include the following actions:

- **Develop future models for further intensifying academia-industry linkages across the trilateral region:** A key model for intensifying knowledge and technology transfer must build upon personal knowledge interchange. The so-called 'transfer-via-people' remains a highly effective transfer channel independent of the format. This applies to both the personal exchange of information among transferor, transfer agent and transfer intermediary and spin-offs from the scientific institutions and the permeability between the scientific system and the private economy, i.e. the reciprocal mobility of persons between companies and universities/research facilities. Besides established formats, such as 'endowed professorships', complementary models should be explored, including 'shared professorships' (professors are half-employed at university and industry, as established, for example, at the Karlsruhe Institute of Technology), 'industry fellowships' (post-docs are employed partly by the university and partly by an industrial partner) and other 'reach-out-and-return' models (temporary transitions of researchers from the university to the economy or vice versa) in order to increase the number of researching, teaching and co-operating scientists.

Good Practice – Special Interest Groups of Clusterland Oberösterreich:

Clusterland Oberösterreich initiates so-called ‘special interest groups’ on a regular basis. External companies and cluster members come together to form a new subordinate network based on a long-term working plan. These new temporary networks thus foster cross-cluster exchange. Since 2011, the special interest group on ‘Smart Plastics’ has linked expertise from the clusters of automotive, plastics and mechatronics. The activities are financed by contributions from the members. www.clusterland.at

Good Practice – BAYER OPEN INNOVATION FAMILY:

Bayer has established a ‘Bayer Open Innovation Family’ comprising five different partnership models (Grants4Targets, Grants4Traits, Grants4Tech, Grants4Indications and Grants4Apps). Since 2009, Bayer has used its good experiences with Grants4Targets and expanded its open innovation activities to one central platform to foster co-creation. The value of this approach is seen in the possibility to ‘start small’, i.e. engage with new partners without greater commitment, but then build on this to drive co-creation more strategically. In addition to its open innovation platform, Bayer has several other partnership types, ranging from joint labs (characterised by very close interaction) to joint ventures (characterised by an ‘arm’s length’ relationship). These different partnership models require regular ‘landscape’ analyses to identify the best partners (based on status as key opinion leaders, scientific excellence, etc.), which is easier for larger corporations to manage than for SMEs. Also, being part of a scientific or innovation ecosystem is considered vital for partner identification purposes.

- **Initiate cross-industry innovation partnerships:** Cross-industry innovation, in the sense of cross-sectoral and cross-cutting innovation (e.g. in new application areas or in the sense of system solutions), is often based on the use of Key Enabling Technologies, and shall be specifically supported by knowledge and technology transfer measures. Relevant approaches for intensifying cross-industry innovation should include appointing ‘cross-industry innovation managers’ at the various R&D&I transfer centres related to the chemical industry, early identification of the complementarities in R&D&I projects and the support of cross-cutting collaboration projects (R&D&I stage), and supporting the establishment of multidisciplinary user groups that continuously collaborate around specific future R&D&I topics (e.g. innovation partnerships around specific challenges in R&D&I of the chemical and automotive industries).
- **Facilitate trilateral co-operation in European R&D&I programmes:** Participating in R&D&I collaboration projects across the trilateral region and, even more so, trilateral participation in multilateral R&D&I collaborations have very important functions for maintaining competitiveness by building new growth platforms or entering new markets. To further intensify trilateral collaboration, both the development of trilateral funding advisory capacities and more constant institutional frameworks for trilateral R&D&I collaboration are relevant. The former should lead to a systematic and continuous pre-qualification of the funding possibilities for the trilateral chemical industry (e.g. content-related ‘call-fit analysis’ to evaluate the suitability of funding offers for trilateral activity and the chemical industry). The latter should focus on the identification of relevant R&D&I funding frameworks that allow for the development of a more constant institutional framework for trilateral collaboration, such as the EUREKA Cluster programme (compare Measure 1). Another possibility to explore is the Knowledge and Innovation Communities (KICs, being part of the EC’s initiative of the European Institute of Innovation and Technology/EIT). Stronger trilateral activity shall also be explored in the already established KIC-Climate,⁶⁶ in which key stakeholders of the trilateral region engage in highly relevant initiatives such as the EnCO2re project on enabling CO₂ re-use. Finally, INTERREG funding is generally an option. However, as previously mentioned, the opportunities within the German-Dutch and Flemish-Dutch INTERREG programmes are rather limited. Overall, to increase the potential of these given opportunities, a stronger network among trilateral academic institutions should be formed, e.g. by an exchange of young and senior professors for a given time, such as one semester (see also Measure 7).

⁶⁶ <http://www.climate-kic.org/>

Good Practice – BIG-C / CLIB (NRW):

The Bio Innovation Growth Mega Cluster (BIG-Cluster) is a cross-border 'Smart Specialisation Initiative' aimed at transforming Europe's industrial mega cluster in Flanders, the Netherlands and North Rhine-Westphalia into the global leader in biobased innovation growth. The BIG-Cluster was established by the three cluster organisations BE-Basic (NL), Catalisti (formerly known as FISCH, FL) and CLIB (NRW) in 2014. The overarching goal is a comprehensive feedstock change with a focus on regionally available biobased and sustainable raw materials, along with climate protection and safeguarding jobs in the mega region.

Based on a commitment to a low-carbon economy, the objective of the BIG-Cluster is to create demonstration plants for the production of chemicals and fuels based on sustainable resources – namely biomass and material streams from industrial waste gasses – in the region. To realise these demo plants, attempts are made to leverage industrial investments and combine them with European and regional funds. The BIG-Cluster aims to establish novel value chains within the topics 'aromatics and fine chemicals from woody biomass', 'chemicals from CO and CO₂' and 'aviation fuels from various feedstocks', as well as to create new teaching approaches for educational programmes ranging from master's degrees to lifelong learning. Its partners in these aims include Biobased Delta, BIO.NRW, CEF.NRW, Chemelot, Clean-TechNRW, FlandersBio.



Source: www.biqc-initiative.eu

- **Strengthen R&D&I and investment in the field of new use technologies for alternative resources, use of residual streams, use of sustainable energy and possibilities for the use of CO₂ (chemical valorisation of CO₂/carbon-capture utilisation):** The common initiation and support of R&D&I projects that develop technologies enabling the use of CO₂ or other raw materials, biomass streams, synthesis gas, residual waste streams or coal as a resource in the chemical industry is of key importance for the future competitiveness of the trilateral region. Potential actions include the promotion of a pilot plant for hydrothermal carbonisation (HTC) processes and the material conversion of organic residues into platform chemicals; support for a demonstration plant for the material use of CO₂ (for example, on the basis of a microbial process); the establishment of a pilot plant for the material conversion of coal into platform chemicals; and joint demonstration projects for gas fermentation from gaseous waste streams or gasified biomass (as in the case of the Vanguard Initiative 'Bio-economy pilot', with Flanders leading the project).⁶⁷ Given the strong linkages within the field for action 5 and its measures, the described actions should be considered jointly.

Good Practice – Dream Production Plant:

A good practice example for the use of CO₂ is the **Dream Production Plant** developed by the **CAT Catalytic Center** (Covestro/RWTH), which uses an industrial process to produce CO₂-based polyols. These chemical building blocks are used in turn for the production of polyurethanes – high-grade foams that are found in numerous everyday items such as upholstery, sports equipment and automotive components. Polyols and polyurethanes are normally based on petroleum. The new process, however, allows the scarce resource of petroleum to be replaced by CO₂. In this way, the plant supports the transformation of the raw material basis and contributes to sustainability. The Dream Production Plant for CO₂-based polyols has been built at the Dormagen site and has an annual capacity of 5,000 tons. In total, the investment amounts to some EUR 15 million.



Source: www.covestro.de

⁶⁷ <http://lifescience.pl/wp-content/uploads/2016/01/AI-Concept-Note-Gas-Fermentation.pdf>

RELEVANT ACTORS AND STAKEHOLDERS

Relevant actors and stakeholders for implementation (list is not exhaustive):

- Ministries responsible for economic affairs, science, research, innovation and investment
- Cluster organisations / intermediaries: BIG-C Initiative / CLIB 2021, Chemie.NRW (all DE), Catalisti, Flanders.bio (all FL), TI-COAST, Biobased Delta, BE-Basic (all NL)
- Universities/universities of applied sciences: RWTH Aachen, TU Dortmund, Hochschule Ruhr-West (all DE), TU Eindhoven, TU Delft, University of Twente (all NL), KU Leuven, University of Antwerp (all BE)
- Research institutes: TNO, Energy Research Center of the Netherlands – ECN, Dutch Polymer Institute – DP, DIFFER (all NL), VITO, IMEC, Flemish Institute for Biotechnology-VIB (all BE), Forschungszentrum Jülich, Fraunhofer IME / UMSICHT / IWS, Max-Planck Institute of Molecular Physics / Chemical Energy Conversion / Coal Research (all DE)
- Financial intermediaries: NRW.BANK, ZENIT (NRW), NOW, RVO (NL), Vlaio / IWT (FL)
- Industrial partners: SMEs and larger enterprises with a focus on research

Annex 3 provides an extended list of additional relevant R&D&I institutions and intermediaries.



MEASURE 3: Accompany a holistic digital transformation towards a 'New Verbund' based on value chain networks and virtual partnerships

CONTEXT AND OBJECTIVES OF THE MEASURE

The digital transformation, and Industry 4.0 in particular, are drivers of significant changes: from changes to our value chains as we know them today to the creation of digital value-generating networks beyond the individual branch and company. Chemical companies will belong to digital ecosystems driven by the digitisation of factories and production processes. Although it is in the early stages, the debate surrounding Industry 4.0 is heavily focused on the manufacturing industry; it is becoming clearer that it will also be a critical domain for process industries – such as the chemical, pharmaceutical and plastics industries. Advanced technologies relevant to these industries, such as the Internet of Things (IoT), advanced materials, additive manufacturing, advanced analytics, artificial intelligence and robotics, have reached a level of cost and performance that enables widespread application.

POSSIBLE ACTIONS

Even though the chemical industry is well accustomed to precise process control and automation, especially in the trilateral region, there is still the need to fully capture all the possibilities of the digital revolution and transform the *Verbund* structures into a 'New Verbund' (see explanation below). This will require a holistic approach including technological and process innovations as well as business model innovations. Value chain networks, strongly driven by the Internet of Things (IoT), will gain importance and lead to the transformation of the classic *Verbund* strategy focused on on-site synergies. In order to benefit from digital change, the trilateral region should initiate transformation projects and prepare the framework conditions for the future, as follows:

- **Accompany the digital transformation towards a 'New Verbund' through transformation projects:** The *Verbund* structure has for a long time been a central asset for the competitiveness of the trilateral chemical industry and will remain so in the future. Considering the effects of digital transformation and changes to the portfolio development strategies of big chemical companies, however, purely integrated business models are unlikely in the future. To develop towards a New Verbund in the trilateral chemical industry, transformation projects regarding companies' internal processes as well as their external supplier/customer relationships need to be supported in the field of Industry 4.0. An example of such an initiative is evaluating the potential of new digital technologies to improve supply and demand planning and to satisfy the need for better linkages and

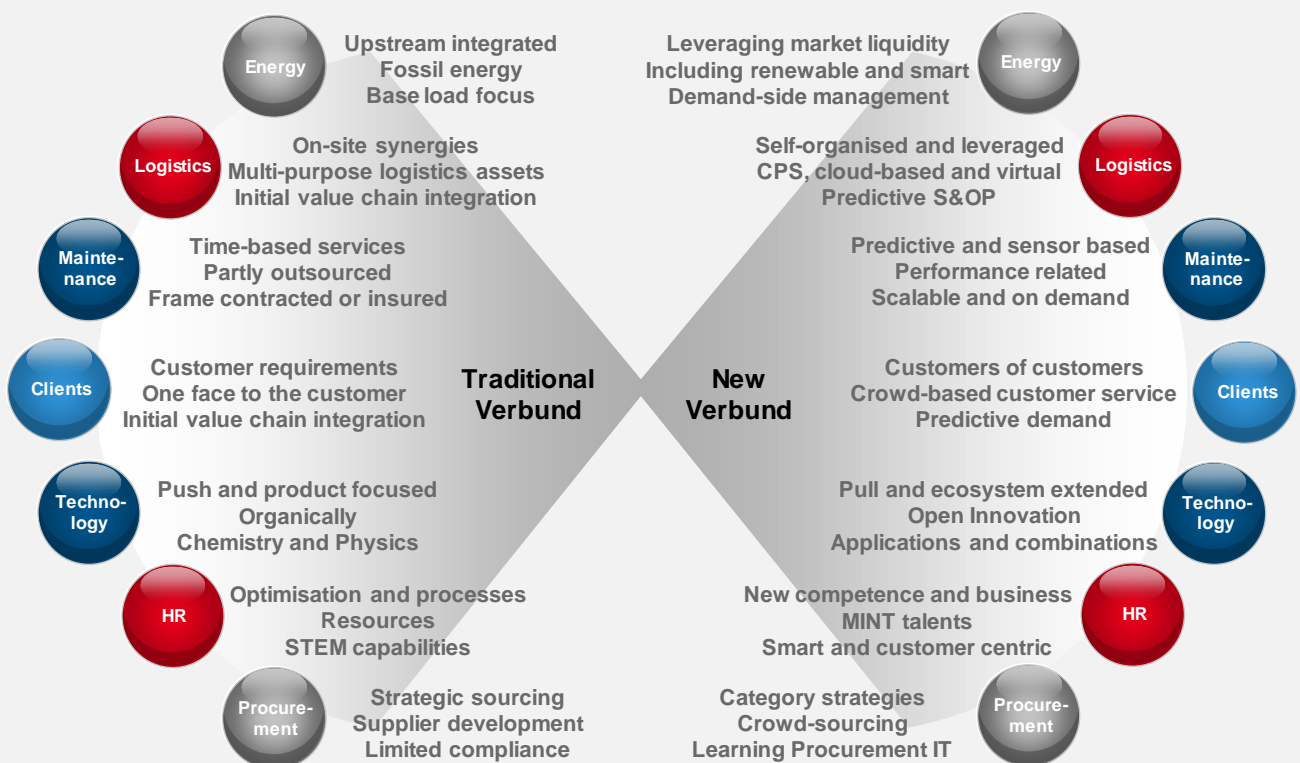
transparency across the entire value chain – from procurement via manufacturing to distribution. Another instance is evaluating the potential of predictive maintenance models, which can be enabled by gathering and analysing data throughout production processes. Other relevant fields include the potentials of wireless tracking systems, GPS, sensors, analytics, cloud computing and the Internet of Things (IoT) for production processes, sales approaches and business models.

- **Support open innovation and crowd production for digital chemical industry innovation:** In the field of digital transformation, the trilateral chemical industry can strongly benefit from external innovation impulses. Open Innovation and crowd-production, i.e. the involvement of customers and end-consumers in the customisation process of chemical products (e.g. at the stage of assembling components), will become decisive. To enhance this process, supporting pilot projects such as ‘creator spaces’ around digital chemical industry innovations will be explored. Relevant trends to cover include 3D printing, digital farming and predictive maintenance.
- **Upgrade infrastructure in chemical parks to provide the foundation for Industry 4.0:** Establishing the technological foundation and management capacity for the digitisation of the chemical industry value chain in chemical parks will be essential steps forwards. Operators of chemical parks need to be supported in upgrading the necessary infrastructure solutions for smart operations and on-site connectivity. Moreover, trilateral systems that support transparency and the self-organised co-ordination of value-generating activities through the IoT must be established both within and across the chemical parks.

Digital skills, i.e. the change in required skills and working patterns in the chemical industry, will also be of great importance (see Field for action 3: ‘workforce of the future’).

Key development – Transition of the Chemical Industry to a New Verbund:

Figure 28: Key elements in the traditional and New Verbund



Source: Prognos (2017) based on (Wehberg, 2015)

To realise the potential of digital innovation, logistics must become self-organised, outsourced and connected to address synergies across sites, steps of the value chain, product lines and businesses. To effectively manage market complexity, future demand needs to be properly anticipated on a day-to-day basis through predictive analytics and an improved S&OP.

Energy management has to leverage the enhanced market liquidity of primary energy, renewables and energy services while driving demand management within operations via smart solutions.

Maintenance must reliably anticipate needs and proactively act to support the effectiveness of production facilities even further. Contractors should be involved more systematically with an on-demand and performance-based, rather than time-based, status. Procurement must improve with respect to compliance, leveraging crowds and developing category-specific strategies. Simply conducting strategic sourcing is no longer sufficient. Innovation management in chemicals companies has to become pull-oriented and ecosystem extended rather than focusing on product development only.

Value added services and digital services are becoming a main field of interest, with consumers participating in Open Innovation. HR needs to develop real talent with a focus on Chemicals 4.0 rather than merely managing resources, while client management in terms of sales and marketing needs to better understand end consumers in order to capture real market needs and predict customer behaviour from a strategic point of view. In many cases, it must leverage crowds to operate customer services more efficiently.⁶⁸

RELEVANT ACTORS AND STAKEHOLDERS

As for Measures 1 and 2, an interdisciplinary approach is required that brings together companies, industrial parks, research institutes, universities etc. active in the chemical industry. Apart from these central players, research institutes acting in the field of digitisation should be considered as well. The following list of relevant actors and stakeholders for implementation is not exhaustive:

- Ministries responsible for economic affairs, science, research, innovation and investment
- Cluster organisations / intermediaries: BIG-C Initiative / CLIB 2021, Chemie.NRW (all DE), Catalisti, Flanders.bio (all FL), TI-COAST, Biobased Delta, BE-Basic (all NL)
- Universities/universities of applied sciences: RWTH Aachen, TU Dortmund, Hochschule Ruhr-West (all DE), TU Eindhoven, TU Delft, University of Twente (all NL), KU Leuven, University of Antwerp (all BE)
- Research institutes: TNO, Energy Research Center of the Netherlands – ECN, Dutch Polymer Institute – DP, DIFFER (all NL), VITO, IMEC, Flemish Institute for Biotechnology-VIB (all BE), Forschungszentrum Jülich, Fraunhofer IME / UMSICHT / IWS / ISST, Max-Planck Institute of Molecular Physiology / Chemical Energy Conversion / Coal Research (all DE)
- Financial intermediaries: NRW.BANK, ZENIT (NRW), NOW, RVO (NL), Vlaio / IWT (FL)
- Industrial partners: SMEs and larger enterprises with a focus on research and digitisation

⁶⁸ (Wehberg, 2015)

6.1.2 Field for action 2: Industrialisation/valorisation of chemical inventions and the creation of a chemical start-up ecosystem

The trilateral chemical industry can already draw upon a pool of highly qualified graduates from the various chemical sciences as well as excellent researchers at all different career levels. This capability provides a profound basis for knowledge exploitation both within and outside the classical career paths in the industry, most prominently through start-ups and spin-offs. Start-ups in the chemical industry will be very important for the future competitiveness of the trilateral region due to their ability to tap into and develop new market niches and react to changing trends in the market. A sustainable competitive environment in the trilateral region requires a vibrant ecosystem of start-ups interacting with established companies.

At the same time, many of the technologies that have been developed and tested by academic or industrial R&D&I labs in the chemical industry do not reach the necessary level for industrial application and thus the market. The availability of demonstration plants is decisive for the implementation of new technological procedures and in securing a technological lead for the production facilities of the trilateral chemical industry.



MEASURE 4: Elaborate a trilateral scheme for demonstration plants

CONTEXT AND OBJECTIVES OF THE MEASURE

Demonstration plants are a **vital yet weak link in the successful industrialisation and valorisation** of new chemical innovations, requiring greater attention in the EU's industrial R&D&I policy. A demonstration plant is defined as an industrial system used to validate an industrial process for commercialisation. Demonstration plants are typically larger than pilot plants and are key to the final stage of R&D&I for the demonstration of new chemical components and processes (verification, close-to-market). Due to the technological risks involved in the design of the chemical components and the high investment costs, the verification of the technology at an industrial scale is required before it can be put to commercial use. Pilot and, to an even greater degree, demonstration plants require huge investments to cover infrastructure, equipment and highly specialised multi-disciplinary personnel.⁶⁹

Significant investments are required before uncertainties can be reduced, a condition that is unappealing to private investors and enterprises, since there is no guarantee that a product or process will be successful. Public support for piloting and demonstration remains an important factor in this commercialisation stage, enabling society to benefit from prior public investments in R&D&I.

Against this background, this measure will lead to the elaboration of a trilateral **support scheme for demonstration plants** (funding for stages after TRL 5-7).

POSSIBLE ACTIONS

The following steps outline a systematic trilateral approach to ensure a successful industrialisation and valorisation of new chemical innovations:

- **Mapping of existing demonstration plants in the trilateral region:** The trilateral region already hosts several pilot and demonstration plants in different fields of chemical industry innovations (e.g. the Bio Base Europe Pilot Plant in Flanders and the Power-to-Gas Pilot Plant in NRW). As a first task, a comprehensive mapping shall be performed to identify all existing and, where possible, planned demonstration plants. The second task of the mapping exercise will be to collect the most relevant R&D&I projects and prototyping activities receiving public support within the trilateral region.

⁶⁹ It is estimated that the cost of pilot production and demonstration is five times higher than the earlier research stages. In the industrial biotechnology sector, more than 50% of pilot production projects require an investment of more than EUR 1 million.

eral region (e.g. based on a consultation of chemical industry associations using the CORDIS database for EU Framework Programme projects) to gain an overview of potential areas for follow-up investment in the form of a demonstration plant.

- **Identification of investment projects of trilateral interest:** Based on a longlist of relevant demonstration plants for potential public investment in the trilateral region, the trilateral High-Level Group should be involved in the selection of the most promising projects (key selection criteria being cross-border relevance, degree of innovation spill-over, transformation potential for the chemical value chain/*Verbund* etc.). These criteria can help select a defined number of first-of-a-kind investment projects, which then need to be further specified by the stakeholder involved (industry, academic institutions, policymakers, public financing bodies). Relevant topics could include, amongst others, large-scale modular chemicals process development, catalyst regeneration and gas-to-chemicals.
- **Joint preparation of financing options:** As has been outlined in the overall description of the measure, typically, significant investments that carry risk are needed for demonstration plants. At the same time, due to EU state aid law, prior approval by the EC is needed before public funding can be granted for demonstration plants (while thresholds for R&D&I projects up to the prototyping phase and of up to EUR 15 million have been allowed in the new GBER).^{70,71} During compatibility assessments, the rating criteria⁷² should be strategically addressed against the background of the trilateral strategy and its cross-border objectives. To finance the demonstration plants, two relevant sources at the European level include:
 - **InnoVFin – Large Projects:** With this scheme, the EIB aims to improve access to risk finance for R&D&I projects, including demonstration projects, via long-term (up to 10 years) loans and guarantees. A minimum of EUR 25 million to a maximum of EUR 300 million, to cover up to a maximum of 50% of the total R&D&I project cost, is envisaged. Time-to-grant decision is typically four to six months. Proposals can be submitted at any time.
 - **European Fund for Strategic Investments:** EFSI helps to finance strategic investments in key areas, such as infrastructure, research and innovation, education, renewable energy and energy efficiency. EFSI and the EIB are currently targeting Circular Economy projects with medium-to-high risk profiles. Large businesses and medium-sized companies with up to 3,000 employees (midcaps) can benefit from project loans or loans to finance R&D&I. Also, local authorities or other government-related entities may benefit from project loans or loans to finance R&D&I.
- **Joint positioning for new financing models of cross-border activities in EU programmes for the establishment of demonstration plants:** Closely linked to the previously described action, a joint positioning of the trilateral chemical industry, amongst other industries, through a public position paper should be undertaken to improve the financing conditions for demonstration plants under the R&D&I state aid framework and, particularly, for cross-border investment projects in this field. The recent reflection paper by the European Commission on the future of EU finances clearly articulates the need to increase the ‘European Added Value’ from EU investments.⁷³ Cross-border programmes/projects that create new economic opportunities and value added will be a key priority for initiatives in the future. This provides a good entry point to create better financing conditions for joint R&D&I activities in the trilateral chemical region.

All in all, various forms of **public-private partnerships** will be required to enable the full exploitation of the existing potential for industrialisation and valorisation of R&D&I findings in the trilateral chemical industry. Considering the framework conditions of EU state aid law, new financing models for cross-border activities will be necessary.

⁷⁰ General Block Exemption Regulation with limited aid intensities (in the field of energy, e.g. promotion of energy from a renewable source).

⁷¹ Recent examples include Hydro Aluminium AS (construction of a demonstration plant in Norway, 2015).

⁷² (1) Contribution to well-defined objectives of common interest, (2) need for state intervention, (3) appropriateness of state aid as a policy instrument, (4) existence of incentive effect, (5) proportionality of the aid amount, (6) avoidance of undue negative effects on competition and trade, (7) transparency.

⁷³ (European Commission, 2017)

RELEVANT ACTORS AND STAKEHOLDERS

The following actors and stakeholders should be considered (list is not exhaustive):

- High-level groups, thematic working groups, inter-ministerial working groups
- Ministries responsible for economic affairs, science, research, innovation and investment
- Universities/universities of applied sciences/research institutes: Brightlands Chemelot Campus, RWTH Aachen, VITO
- Financial intermediaries: NRW.BANK, ZENIT (NRW), NOW, RVO (NL), IWT (FL)
- Industrial partners: large enterprises seeking to promote innovation and the development of new products

TIME HORIZON AND MILESTONES

The implementation of this measure shall begin in early 2018 and shall be completed within the next three years, by 2021 (iterative cycle needed).



MEASURE 5: Expand the framework for start-ups and up-scaling in support of a trilateral chemical entrepreneurship ecosystem

CONTEXT AND OBJECTIVES OF THE MEASURE

Over the past few years, efforts to stimulate entrepreneurship by including it in (chemistry) students' curricula or by providing early-stage financing for start-ups have been increased throughout the trilateral region. There are several **successful general programmes and support schemes** throughout the trilateral region, including support from the STARTERCENTER NRW, Start-to-Start in Flanders and activities under the Ambitious Entrepreneurship Action Plan in the Netherlands. Furthermore, the region's chemical industry can already draw on a pool of highly qualified graduates from the various chemical sciences as well as excellent researchers at all different career levels; these provide an excellent talent pool for start-ups and spin-offs.

However, there is still **considerable room for intensifying and improving the support for a trilateral chemical entrepreneurship ecosystem**, including improvements in framework conditions such as growth financing, start-up infrastructure (especially incubators) and new forms of support for the up-scaling of promising start-ups directly targeting the needs of the chemical industry. All this will be necessary to maintain a sustainable competitive environment in the trilateral region that is fuelled by a vibrant ecosystem of start-ups interacting with established companies.

POSSIBLE ACTIONS

Based on a review of the current support system and existing infrastructure for start-ups and up-scaling in the chemical industry, a strengthening of the trilateral chemical entrepreneurship ecosystem shall be achieved through the following actions:

- **Facilitate new methods of entrepreneurship within the key universities/research institutes for the trilateral chemical industry:** To prepare the ground for future chemical industry start-ups, entrepreneurship skills and attitudes must be developed at an early stage. To facilitate this, new models need to be developed, such as the opening of research infrastructures to students (for young start-ups) and local SMEs (see the open clean room for nanotechnology research at the University of Twente), setting up models for SME collaboration with student companies (so-called 'junior enterprises'⁷⁴), implementing a chain of (many different) 'awareness events' for chemical start-ups (pre-start-up: contests, gaming-workshops, start-up days, motivation campaigns using

⁷⁴ A junior enterprise is a local non-profit organisation entirely executed by students. For more information see e.g.: <http://www.jadenet.org/the-junior-enterprise-concept/>.

successful local entrepreneurs as ambassadors; post-start-up training: business knowledge, finance, scaling) or establishing so-called 'research institutes' across faculties to raise awareness among entrepreneurship faculty and promote innovation partnerships with industry.

- **Establish trilateral incubator initiative:** Business incubators are organisations that are geared towards speeding up the growth and success of start-ups and early stage companies. Business support can range from resources and services including physical space, capital, coaching and common services to networking connections. The trilateral region already boasts several such start-up support schemes.⁷⁵ Based on a first overview, a more detailed and systematic mapping of existing incubators and initiatives in the trilateral region should be performed. The mapping of incubators that currently offer dedicated support and facilities to chemical industry start-ups is necessary for an assessment of the potential and demand for further incubators in the three regions and to substantiate the needs identified in this strategy. Special focus should be placed on networking possibilities among existing schemes and initiatives that have high trilateral value-added potential. In a closely connected point, the demand for support schemes for demo and pilot projects for less capital-intensive companies in the trilateral chemical industry should be explored to enable them to test their ideas and new processes extensively and on a large scale. As an outcome of this action, it should be decided to what extent new incubators for the chemical industry are needed and whether existing incubator locations need to be expanded with facilities that meet the needs of chemical industry start-ups.
- **Scale up the experiences of the Brightlands Chemelot Campus:** the Brightlands Chemelot Campus is one of the lighthouse examples in the trilateral region. It stimulates entrepreneurship through a range of services to support entrepreneurs in the successive development stages of their company, from start-ups to corporate enterprises (i.e. start-up facilities, multi-purpose pilot plant and talent development programmes), offering many learning experiences for the trilateral region to stimulate its entrepreneurial ecosystem.



Source: www.brightlands.com

Good Practice – Brightlands Chemelot Campus:

The campus, which is run by Royal DSM, the Province of Limburg and Maastricht University, offers an ecosystem for industry, SME, start-ups and advanced education and research. The Brightlands Innovation Factory was established to stimulate entrepreneurship in the complementary fields of life sciences and health, agriculture and food, smart services and data, and chemistry, processes and materials.

To accommodate these organisations, state-of-the-art facilities were constructed, including laboratories, cleanrooms, conference centres, start-up facilities and pilot plants. At the beginning of 2017, the number of people at the campus was 2,500. The objective is to grow this number to almost 3,900 community members by 2023.

- **Develop a trilateral scale-up programme:** In collaboration with clusters, industry associations, universities, universities of applied sciences, chemical industry companies and financial institutions, a scale-up programme shall be developed for the trilateral region. Key components of the programme should include discovering talent, improving skills and leadership and creating access to venture and, especially, growth capital for promising start-ups (see e.g. the Scale-up Institute⁷⁶ in the UK). The main goal must be to help start-ups scale and grow their companies.

⁷⁵ In the Netherlands, the initiative '[ChemieLink](#)' helps entrepreneurs who wish to innovate, finding locations with appropriate facilities and equipment in the chemical sector. Currently, The Netherlands has 14 recognised locations where innovative chemical starting businesses (iLABs) and growing businesses (COCI's) can establish themselves and access several services. In 2013 in Belgium, François Cornélis, ex-CEO of Petrofina, created the '[Innovation Circle](#)', a permanent structure offering start-ups and SMEs in the chemical and life sciences sectors free assistance and mentoring as well as financial support (via the [Innovation Fund](#)). In North Rhine-Westphalia, the initiative '[existenzgruendung-chemie](#)' offers an extensive range of services to interested entrepreneurs. The support provided goes far beyond the basic advisory and support services of technology centres. In addition to the know-how of many experts, the main focus is on being the 'switch center for the chemical industry' and the 'door opener to the most innovative areas of modern chemistry'.

⁷⁶ <https://www.scaleupinstitute.org/>

RELEVANT ACTORS AND STAKEHOLDERS

The key actors and stakeholders are the same as for the improvement of the funding mechanisms for trilateral R&D&I actions (Measure 1).

6.1.3 Field for action 3: Workforce of the future

The trilateral chemical industry can rely on a wide spectrum of excellent educational institutions that provide the basis for innovation excellence and a skills-rich labour force. However, there are also profound changes ahead for the chemical industry in terms of skills and education, including the need for sustainability and related innovation demands as well as digital transformation, or working with new business models in a Circular Economy. To remain competitive and to speed up the delivery of solutions for various business and societal challenges, the trilateral chemical industry needs the right workforce, one that is prepared to push innovation forward.

To this end, to realise the creation of the workforce of the future in the trilateral chemical industry, the following two measures are important. While **Measure 6 targets vocational training** and lifelong learning for blue-collar workers, **Measure 7 focuses on academic training** and thus on university students and post-graduate academics.



MEASURE 6: Enhance the vocational training and lifelong learning systems for blue-collar jobs to develop the chemical industry skills of the future

CONTEXT AND OBJECTIVES OF THE MEASURE

With the current developments in Industry 4.0 and the digitisation of the industry, there will be qualitative as well as quantitative impacts on employment in all sectors. Many of the worker's current skills will become obsolete, and new ones will be needed. These implications, however, differ according to the degree of qualification and the type of task. According to a study from the University of Oxford, only around 2% of jobs for chemical engineers are automatable, whereas the percentage for process operators and maintenance technicians stands at about 85%.⁷⁷ Therefore, it can be expected that the skillset for blue collar workers will change, and will be more focused on tasks that require creativity and social intelligence ('up-skilling'), skills that cannot be computerised. This will lead in the coming years to increased expectations of companies with respect to the required skills for technical personnel; currently, these profiles are scarce in the trilateral region.

Considering the qualitative changes in skills patterns and the newly needed skills, especially for more technical and non-academic profiles, vocational training and lifelong learning opportunities need to be further improved to adapt the skillset of the current workforce and to assure the correct formation of the future workforce. In this way, the strong skill foundation of the trilateral chemical industry can be maintained.

POSSIBLE ACTIONS

The 'up-skilling' of the technical workforce requires adapted education models. To this end, a focused collaboration of the relevant stakeholders from industry and higher education (HE) is necessary, building upon the philosophy of increased transdisciplinarity:

- **Strengthen the dissemination of 'good practices' to build skills for innovation into HE courses:** Considering the different education systems in the trilateral region, in both HE and vocational training, a better exchange of good practices and the joint advancement of curricula (e.g. regarding methodologies, course design, the involvement of industry and demonstrating the value of active learning) can substantially improve the fit-for-purpose quality of training programmes and help provide a stronger connection within the educational system. Amongst other initiatives, the dual education system, which is used in Germany, could be a good starting point for this activity,

⁷⁷ (Osborne & Frey, 2013)

as this system is a good practice example of how to provide a highly skilled and technical workforce.

- **Develop flexible solutions for lifelong learning:** HE institutions should continue to develop lifelong learning provisions to promote further skill enrichment and up-skilling in the sector, in particular for skilled workers and master craftsmen. Flexible training opportunities should be prioritised to minimise disruption, including part-time courses. The scale and relevance of the activities could be increased through active employer involvement in course design (see above), as long employers are willing to share equipment and staff resources, while institutions in the trilateral region could share course materials and possibly staff with each other.

There are additional paradigm changes in the labour market that need to be strategically addressed by the trilateral chemical industry. Chemical companies will certainly continue to have a substantial employee and contractor base. However, demographic and digital changes will lead to an increasing share of 'digital natives' in the workforce pool who have new skills and different expectations regarding their job environment. In addition, employers' expectations regarding required skills are changing. These developments will change the working environment of the future. The trilateral region is exceptionally well positioned to accompany this transition.

RELEVANT ACTORS AND STAKEHOLDERS

Relevant players in the implementation of the measures are, on the one hand, the relevant institutions of the educational system, including vocational schools and HE institutions (e.g. universities of applied sciences). On the other hand, industry needs to be closely involved, as they know best which skills will be needed in the future. In addition, the relevant ministries responsible for higher education in North Rhine-Westphalia, Flanders and the Netherlands should be included. Furthermore, the involvement of social partners is required.



MEASURE 7: Encourage trilateral academic exchange and partnerships to improve the formation of the future academic workforce

CONTEXT AND OBJECTIVES OF THE MEASURE

Increased co-operation between the HE institutions in North Rhine-Westphalia and institutions in the Netherlands and Flanders shall contribute to the enhancement of the mutual mobility of students and post-graduates in the sense of the Bologna Declaration, for example through the expansion of further joint courses of study. In addition, the chemical sector will in the future need engineers and scientists who have a broader scientific skillset that goes beyond the traditional 'single disciplines' (so-called 'T-shaped skills'), including strategic awareness of business and innovation management competencies. By enhancing trilateral co-operation within the trilateral region, both the advancement of skills development and the convergence of the regional labour market for the chemical industry can be reinforced.

POSSIBLE ACTIONS

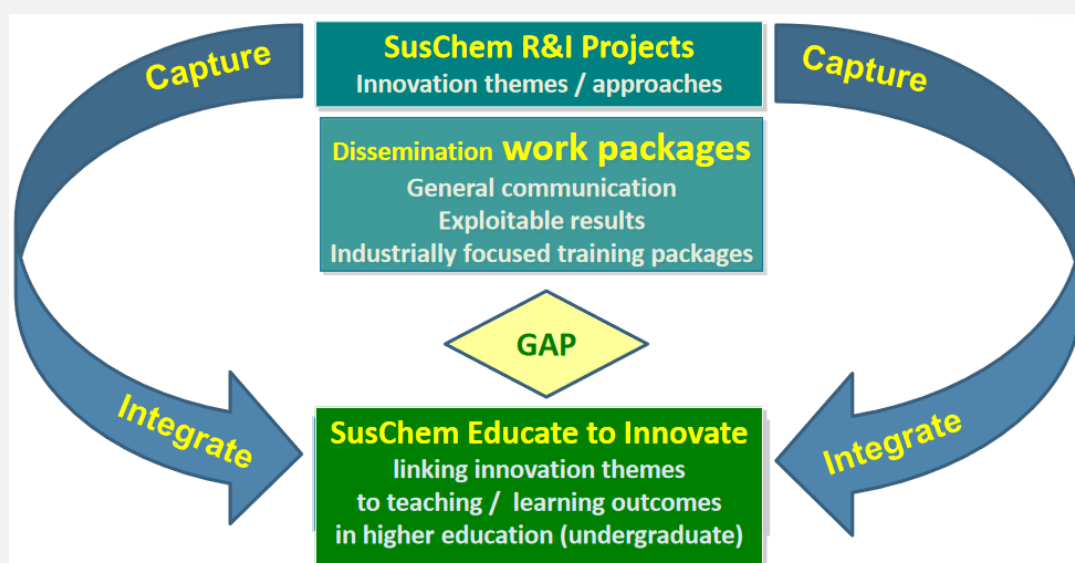
In close connection with the possible actions defined under Measure 6, three further actions to support the workforce of the future are outlined below:

- **Encourage a trilateral dialogue and collaboration between HE institutions and industry regarding skills for innovation issues and course development:** Context- and problem-based learning is increasingly important for the trilateral chemical industry and needs to be considered when developing new courses. The dialogue between employers and HE institutions can create a win-win situation for both. Companies can stay up to date and gain insights into the most recent innovation fields, while academic institutions can profit from the state-of-the-art training infrastructure of the chemical sector. Furthermore, this will allow the latest information on the industrial applications of chemistry and its commercial relevance to be included in a course. This activity should also help to avoid duplication and redundancy of the training provided in the trilateral region.

- **Set up joint degree programmes for innovation-driven education:** As outlined above, the creation of joint degree programmes has several benefits, most prominently the pooling of complementary excellence from the involved partners as well as the strengthening of a joint labour market. The master's degree in Bio-based Materials offered by Maastricht University in co-operation with the Aachen Maastricht Institute for Bio-based Materials (AMIBM) provides an excellent example of such a joint initiative, which can provide relevant knowledge to other planned joint degree programmes. Potentially the programme could be even expanded to further partners within the trilateral region. Future programmes should be closely linked to the key research and innovation opportunities of the trilateral chemical industry and systematically link innovation themes and approaches from R&D&I projects with teaching.
- **Increase digital skills development in the chemical industry:** The evolving digital transformation and new technologies will continue to require new skills in the chemical industry, in areas such as predictive analytics, artificial intelligence, cyber security and operations technology. Ideal skillsets that combine, for example, analytics and process engineering are rare and hard to identify, and will need to be developed in the trilateral region. By pooling interdisciplinary excellence from the trilateral region, a unique digital skills programme dedicated to the chemical industry could be established.

Good Practice: SusChem Educate to Innovate – Leveraging value from investment in strategic innovation programmes

The Educate to Innovate programme is part of SusChem's strategy to facilitate a continuing, constructive dialogue and create synergies between the chemical industry and higher education (HE). The programme aims to systematically introduce key skills for innovation into HE curricula following the logic described below:



In addition, SusChem is developing a good practice innovation skills database. This online resource will compile case studies of EU industry-university collaborations on course work, internships and industrial placements. It will help to show the value of context- and problem-based learning and help ensure that courses are relevant and up to date. Academia and industry will be invited to share details of successful collaborative innovation skills development projects.

Source: <http://www.suschem.org/initiatives/educate-to-innovate>

RELEVANT ACTORS AND STAKEHOLDERS



The relevant actors for the implementation of the above-mentioned measures are the relevant HE institutions (e.g. universities, universities of applied sciences); industry should also be closely involved. Furthermore, the relevant ministries responsible for higher education in, respectively, North Rhine-Westphalia, Flanders and the Netherlands need to be consulted as well. This list of potential actors and stakeholders, however, is not exhaustive.

6.2 Policy field 2: Energy and feedstocks for the chemical industry

The economic performance of the manufacturing industry in the region is based to a large extent on the availability of raw materials. This applies especially to the raw material-intensive chemical industry, which is highly concentrated in the trilateral region. Therefore, the functionality of the industry is directly dependent on a continuous and reliable supply of raw materials. Although there will not be a shortage of carbon feedstocks from oil to gas until 2030 and crude oil will remain the dominant resource basis, there is certainly going to be a change in the composition of the raw material base in the medium-to-long term. Alternative feedstocks will gain importance and contribute to the further diversification of the raw material supply as well as the transition to a more sustainable chemical industry.

The Circular Economy and the reuse of residual waste streams also represent an important opportunity, not least because of the potential to decrease price volatilities with respect to traditional feedstocks. Therefore, it is important to support this transition by creating the right policy framework and incentives so that alternative resources can be used in an ecological and economical way. In addition, the chemical industry is on average far more energy intensive than most other sectors in the manufacturing industry. Energy consumption costs represent 5-10% of total costs, compared to 0.8% on average for the manufacturing and engineering sectors. Therefore, assuring a competitive energy mix is essential to foster new investments and industrial growth in the trilateral chemical industry.

Overview of proposed measures in the field of Energy and Feedstocks

 Energy & Feedstocks 		
Field for action	Proposed Measures	
4 Future competitive energy mix	#8	Develop a common trilateral approach for a competitive energy cost position
5 Creation of a more sustainable feedstock base	#9	Form a level playing field for the use of sustainable feedstocks
	#10	Expand the trilateral availability of alternative feedstocks
6 Taking advantage of the Circular Economy	#11	Establish a circular ecosystem of integrated material and energy flows within and across industries
	#12	Enable comprehensive Circular Economy processes in the trilateral chemical industry

6.2.1 Field for action 4: Towards a future competitive energy mix

Electricity and gas comprise a major share of the operating costs in the trilateral chemical industry, especially for the energy-intensive basic chemicals sector, which has a strong presence in the trilateral region. Therefore, chemical companies need competitive and secure supplies of energy and feedstocks. This means that an affordable balance in the energy mix must be found (renewables, nuclear sources – not relevant in Germany after 2022 – coal, waste and natural gas). Moreover, clarity is needed with regards to European and national climate and energy policies, which have a direct impact on companies' operating costs.

To that end, the **Field for action 4 'Towards a future competitive energy mix'** concentrates on strengthening trilateral co-operation regarding EU climate and energy policy to improve the security of the energy supply, tackle the issue of demand-side management and investigate the possibilities of diversification of the gas supply to enable natural gas as a fuel and feedstock in the chemical industry.



MEASURE 8: Develop a common trilateral approach for a competitive energy cost position (INITIAL-MEASURE NO. 2)

CONTEXT AND OBJECTIVES OF THE MEASURE

Despite its higher operating efficiency, one of the main challenges of the trilateral chemical industry remains its higher gas and electricity prices compared to other chemical clusters in the world, which are due to the ambitious EU climate and energy policy. The impact on the industry of energy policy and, consequently, climate policy is of major importance for the chemical industry. Accordingly, the measure aims to **establish a level playing field** with regards to prices in the rest of the world and to **avoid a further deviation of the cost disadvantage** on feedstock and energy prices. In addition, the measure aims to capture the **opportunities** of the growing availability of **sustainable electricity and its increasing supply** as shared innovation is needed to connect the (renewable) energy sector to the chemical industry to support the conversion of renewable energy to heat, hydrogen and chemicals.

As most of the decisions impacting the input costs of the chemical industry are driven by European and national legislation, common positions of the trilateral region in these matters are indispensable to better **influence and inform European and national policymakers** and to defend its regional interests. Therefore, the main focus of the measure is to develop a **co-ordinated position towards the EU and national levels**, but at the same time, the measure should ensure a **co-ordinated implementation of climate- and energy-related policies** in North Rhine-Westphalia, Flanders and the Netherlands.

CONCRETE STEPS AND ACTIONS

The **subject-specific working group 'Energy & Feedstocks'** (see institutionalised dialogue in Section 6.4) should be used for the setup of trilateral projects tackling the disadvantageous cost position of the chemical industry. The working group should **initiate discussions** and, if necessary, **ad hoc specific task forces** that tackle the following key topics: climate policy, energy and the diversification of supply by gas, which hereafter will be described in greater detail. These discussions need to include the most important stakeholders. Preferably, meetings should take place at least twice a year. The monitoring of the results and progress of the discussion groups/task forces can also be undertaken by the working group 'Energy & Feedstocks'.

Key topic 1: Climate Policy

- **Mapping of the different compensation schemes and the total cost of contributions in the trilateral region:** Based on the results of the existing exchange between the Dutch and Flemish regions, a mapping of all factors influencing energy and feedstock prices needs to be performed in order to give an overview of the total cost burden compared to other regions. This includes regional and national taxes and levies, compensation for indirect emissions and digressive tariffs or exemptions for the cost-pass through of contributions and taxes for renewable energy. This approach allows for the identification of the areas where mitigating actions are needed. Potential actions should focus on the change from a high price- and production-oriented strategy to an innovation- and consumption-based strategy. For instance, incentivising chemical innovations by providing tax reductions or exemptions for companies making products with CO₂ reduction potential should be considered. In this way, investments in innovation and the development of new technologies allowing further CO₂ reduction by society can be supported.
- **Compilation of a trilateral position paper on European and national climate policies:** Based on the previous analysis, a joint position paper shall be formulated with a focus on those areas where national and European climate and energy policy need to be adapted to strengthen growth in the trilateral chemical industry and avoid (further) disinvestments in the three regions.
- **Joint approach to climate and energy-related policies:** In addition to influencing current climate and energy policies, the feasibility of a common approach to climate policies and the coordination of different support schemes should be explored (e.g. taxes and tax breaks or compensations). In

combination with the previously mentioned measures, this could contribute to a level playing field for chemical companies active in the trilateral region and create a more investment-friendly environment.

Key topic 2: Trilateral Energy System

- **Establishment of a ‘Trilateral Energy Conference’:** Through the extension of the existing ‘Netherlands-NRW Energy Conference’⁷⁸ to Flanders, the collaboration between companies and scientific institutions in the trilateral region should be intensified by offering a platform for trilateral projects/activities in the field of energy. In addition, such a conference would provide an interesting platform for the development of a joint position on the (EU) market model for renewables and the discussion around planning of electricity sites.
- **Assessment of the amount of excess electricity:** The assessment of the amount of excess electricity not needed for the energy transition could serve as a basis for the development of future chemically relevant opportunities. The growing availability of intermittent renewable energy increases the need for stabilisation of the electrical grid. Here the chemical industry can make an important contribution by developing chemical processes that are adapted to the fluctuating energy supply and allow flexible demand-side management of the electrical grid. Other opportunities lie in the growing demand for efficient long-term storage possibilities to compensate for the volatile impact of renewable energies; the Power-to-Gas/Chemicals concepts, in particular, will become essential for the provision of long-term storage possibilities combined with a further extension of renewable energy capacities.
- **Initiation of projects exploring the opportunities for demand-side management (DSM) in the trilateral region:** Existing projects in the regions such as ‘Voltachem’ (TNO and ECN) and ‘Power-to-X’ (RWTH Aachen, research centres in Jülich and Dechema) are already investigating opportunities for demand-side management by the chemical industry. Based on this knowledge, the initiation of an additional study should be examined with a special focus on the existing industrial DSM-potentials in the trilateral region as a baseline for the initiation of joint pilot projects. A good example is provided by the pilot project ‘DSM Bavaria’ of Dena.⁷⁹ Furthermore, the idea of targeted DSM consulting, especially for SMEs, should be developed further (e.g. within the framework of company energy management).

Good Practice – Pilot Project Demand-Side Management Bavaria

With the goal of improved utilisation of the DSM potential in the industrial and business sectors, the German Energy Agency ‘Dena’ launched the pilot project DSM Bavaria. During the project, interruptible loads were identified and recorded together with Bavarian companies and other relevant stakeholders, and with support from the Bavarian state government. Subsequently, the project illustrated how the identified potential can be used and marketed to energy suppliers while also helping with implementation. Within the scope of the project, more than 170 companies were approached, from which more than 50 detailed datasets were collected and more than 35 companies were advised on the spot by Dena experts. One of the outcomes of the project was the compilation of a DSM roadmap. Based on the experiences in the pilot project, recommendations were formulated so that DSM potentials could be better exploited.



Source: www.dsm-bayern.de

⁷⁸ <http://www.combined-energy.eu/page.asp?RubrikID=17176>

⁷⁹ <https://www.dena.de/en/topics-projects/projects/energy-systems/pilot-project-dsm-bavaria/>

Key topic 3: Gas supply

- **Common study to determine the potentials of a replacement of crude oil by gas in the trilateral region:** Natural gas represents one of the highest potentials for the diversification of chemical feedstocks in the trilateral region. The worldwide growing availability of LNG and its import to the EU represent opportunities for better security and a flexible supply. A first step should be to fully understand the opportunities for the trilateral region. Therefore, a common assessment of the impact on the highly interconnected value chains in the trilateral region, the currently available infrastructure and the economic and environmental impacts of an increased use of LNG should be conducted.
- **Assessment of the potential for diversification by domestic gas reserves:** In addition to the evaluation of the LNG potentials, a joint study should be conducted to identify whether the use of domestic natural gas resources (e.g. mine gas or biogas from waste) can have environmental and economic advantages over imported gas. This approach should enable a better overview of the available options for the diversification of feedstocks by gas.
- **Development of viable business models:** Based on the previous findings, potential and necessary expansions of natural gas infrastructure will be identified (e.g. storage, pipelines, and addressing a lack of LNG terminals in seaports.). However, to ensure the necessary construction of gas-related infrastructure, potential and viable business models need to be discussed in advance so that the responsibilities of industry and public authorities are clear, for instance, by providing a framework for trilateral public-private partnerships (see also the policy field 'Infrastructure').

RELEVANT ACTORS AND STAKEHOLDERS

Relevant actors and stakeholders for implementation (list is not exhaustive)
<ul style="list-style-type: none">▪ Ministries responsible for economic affairs, energy, environment, infrastructure, research and innovation including federal ones for infrastructure (e.g. BMVI in DE and FPS Mobility and Transport in BE) <p>Depending on the key topic:</p> <ul style="list-style-type: none">▪ Public agencies: Netherlands Enterprise Agency (RVO), Flemish Energy Agency (VEA), EnergieAgentur NRW▪ Chemical industry organisations: Essenscia, VNCI, VCI▪ Topsector Chemie, Topsector Energie▪ Grid-operators: Elia (BE), TenneT (NL), Ampirion/TenneT (NRW)▪ Research institutes/networks: TNO, DIFFER, ECN (all NL), VITO, IMEC (all BE), Dechema, Forschungszentrum Jülich (all DE)▪ Universities/organisations: RWTH Aachen, KU Leuven, TU Delft

FINANCING

Concerning the financing of research programmes in the areas of the energy sector or the extension of energy-related infrastructure, the EU provides several funding programmes and lending schemes to help companies, regions, and countries successfully implement energy projects.

The following programmes, in particular, focus on **energy infrastructure-related topics**:

- **European Energy Programme for Recovery (EEPR):** The EEPR was established in 2009 to address, on the one hand, Europe's economic crises, and on the other hand to achieve the European energy policy objectives. The EEPR provides financial support to selected highly strategic projects in three areas of the energy sector, namely gas and electrical connections, offshore wind energy and carbon capture and storage. So far, the EUR 3.98 billion programme has helped fund 44 gas and electricity infrastructure projects, nine offshore wind projects, and six carbon capture and storage projects.

- **Connecting Europe Facility (CEF – Energy):** Under the CEF, around EUR 5.85 billion are available for trans-European energy infrastructure projects (gas pipelines, transmission grids, LNG terminals, gas storage, and smart grids) for the 2014–2020 period, of which EUR 4.7 billion are in the form of grants managed by the Innovation and Networks Executive Agency (INEA).
- **ERDF Operational Programmes in NRW, Flanders and the Netherlands:** Under Thematic Objective 7, ‘Promoting sustainable transport and improving network infrastructures’, support is granted for investments in sustainable transport and mobility as well as smart energy distribution, storage and transmission systems. Moreover, a minimum percentage of ERDF funding must be channelled towards low-carbon projects in regions (e.g. 20% for more developed countries). For instance, the NRW funding competitions related to the lead markets ‘Energy and Environment’ or the Dutch subsidies for energy innovation (‘subsidies energie-innovatie’) within the context of the Dutch ‘Topsector Energie’ are potential financing sources that profit from the ERDF (see also Measure 1).

The following European programmes are more **research related**:

- **Horizon 2020:** The Horizon 2020 programme provides EUR 5.93 billion towards energy projects for the period 2014–2020. These projects should help to create and improve clean energy technologies such as smart energy networks, tidal power and energy storage.
- **NER 300:** The NER 300 is funded through the EU emissions trading system (ETS) and provides EUR 2.1 billion in co-funding to projects demonstrating environmentally safe carbon capture and storage (CCS) and innovative renewable energy (RES) technologies on a commercial scale within the European Union. The programme is implemented at the EU level but with important roles both for the Member States and for the European Investment Bank (EIB). The NER 300 provides 50% of relevant costs. The other 50% of relevant costs, as well as all the conventional costs of the project, should be funded by private investment and through Member State support.

TIME HORIZON AND MILESTONES

The implementation of the measures, especially those related to the development of a common position on European energy and climate policies, should be realised, if possible even before the end of 2017, not at least because the advanced negotiations concerning the new ETS system for the period 2021–2030. Since the European Parliament and the Council finalised their respective positions in February 2017, the interinstitutional trilogue negotiations have been on-going.

Regarding the need for additional research initiatives, envisaged projects should be presented with the innovation roadmap at the high-level event in autumn 2018, and their implementation should be planned at the latest for the end of 2020.

6.2.2 Field for action 5: Creation of a more sustainable feedstock base

The wide scope of the trilateral chemical industry uses as prime feedstock the oil derivate naphtha. However, in a global context of increasing demand for fossil-based resources coupled with diminishing reserves, geopolitical uncertainty and the threat of climate change, the petrochemical industry is becoming increasingly unsustainable. Against this background, the partial replacement of traditional petrochemical feedstocks by more sustainable alternatives (e.g. lignocellulose, biomass, CO₂) will become a necessity. Furthermore, renewable feedstocks (e.g. biomass), in particular, not only have the potential to substitute for or complement fossil feedstocks (‘drop-ins’), they also offer opportunities for new bio-based chemicals with new and improved characteristics (‘novels’). This trend also benefits from consumers’ increasing awareness of the demand for sustainable products, thereby providing a new growth platform and the opportunity to create a sustainable competitive advantage for the trilateral chemical industry.

Even though sustainable raw materials are playing an increasingly important role in the trilateral chemical industry, there are still critical uncertainties concerning more intensive use of these resources (geographical availability, climate condition, precise environmental impact, etc.). Further ad-

vances are therefore necessary, particularly regarding regulations, to provide economically viable alternative resources and to consider the pathway to the manufacture of these resources. In a wider perspective, the share of biomass used for energy purposes is currently relatively small compared to other biomass uses such as feed.

Against this background, the measure intends to create favourable framework conditions for the economic and ecological use of alternative feedstocks and, in this way, support the transition towards a more sustainable and competitive chemical industry. An EU-wide mandatory and coherent sustainability framework is a major objective in this matter.



MEASURE 9: Form a level playing field for the use of sustainable feedstocks

CONTEXT AND OBJECTIVES OF THE MEASURE

The diversification of the raw material base is a central element of the chemical industry's raw materials strategy towards more sustainable feedstocks like natural gas, carbon dioxide (CO₂), synthesis gas, lignocellulose and biomass streams. However, amongst other issues, continued subsidies for the energetic use of these materials, especially biomass, are still contributing to a non-level playing field with respect to material use. This leads to a situation where biofuels for transport, which are less efficient (in terms of CO₂ reduction) than the utilisation of biomass in the chemical industry, are advantaged. Conversely, the non-level playing field is discouraging investments in facilities that produce high value added biobased materials because they limit access to biomass for other uses and increase net costs.

Against this background, the measure intends to create favourable framework conditions for the economic and ecological use of alternative feedstocks and, in this way, support the transition towards a more sustainable and competitive chemical industry.

POSSIBLE ACTIONS

For the implementation of a level playing field for the use of sustainable feedstocks in the chemical industry, the regions of North Rhine-Westphalia, Flanders and the Netherlands need to work closely together. An alignment of their positions on several aspects of the different uses of biomass and other sustainable feedstocks is necessary. Therefore, the following actions should be taken:

- **Develop a common position on the introduction of a statutory equality for the material and energetic use of biomass by ending the demand for the energetic use of plants:** The first tasks consist of mapping and exchanging already existing research and recommendations in the three regions of North Rhine-Westphalia,⁸⁰ Flanders⁸¹ and the Netherlands.⁸² Moreover, given the considerable competition in the use of available land, all relevant stakeholders (see below) should be consulted during the process so that a social consensus on the most efficient use of biomass from an economic, ecological and social point of view can be achieved. On this basis, a common understanding regarding statutory equality should be developed as well as a trilateral position towards the new proposal of the European Commission for the Renewable Energy Directive (RED II) published on 30 November 2016. For instance, the possibility of reducing subsidies and support for the energetic use of biomass in order to create a level playing field with the less-supported material use of biomass should be examined. Even though some elements of the RED II point in the direction of fairer competition, the directive still contributes to the continuation of a non-level playing field for the material and energy uses of biomass.
- **Support the introduction of the 'cascade' principle for the use of alternative feedstocks:** Like the previous action, the first step consists of developing a joint understanding of the 'cascade' principle. It is important that the cascading use of biomass be carried out as a principle to support the comprehensive goals of politics and strategies rather than as an individual policy strategy; the

⁸⁰ (Umweltbundesamt, 2017)

⁸¹ (Flemish department Economy, 2013)

⁸² (Dutch Sustainable Biomass Commission (CDB), 2012)

common understanding should be integrated and closely aligned with the different regional bio-economy strategies. The cascade principle should also include other sustainable feedstocks like CO₂ and waste. In this regard, the improvement of the availability of municipal waste streams as a raw material base for the chemical industry represents an important element of cascade utilisation.

- **Investigate the possibility of introducing appropriate legal measures to increase the allure of the use of alternative feedstocks and the material use of CO₂ in the chemical industry:** The utilisation of biomass is already efficient in the chemical industry, and is even more efficient, in terms of CO₂-reduction, than the utilisation of biomass as bioenergy or biofuels (keeping in mind that in general the use of biomass for energy is already more positive than the fossil reference). In this regard, government policies should be redirected from resources (e.g. biofuels directives) towards goals (e.g. CO₂ reduction goals). Possible actions could be the realisation of a European 'Feedstock Directive' analogous to the Fuel Quality Directive, or the implementation of 'Bio-tickets' for the chemical industry as proposed by the Dutch Sustainable Biomass Commission.⁸³ This would include an examination of the transferability (especially in a legal context) of these measures to Flanders and North Rhine-Westphalia.

RELEVANT ACTORS AND STAKEHOLDERS

For the implementation of these actions, a profound collaboration with different sectors, such as transport and energy, is necessary for the optimum utilisation of biomass in the chemical industry. Furthermore, the limited availability of land for biomass production and the competition among possible uses (food, energy, material, etc.) must be considered. At the ministerial level, the different ministries responsible for environmental issues need to be considered as well. The description of stakeholders mentioned here is not exhaustive, and action should remain open to other actors.



MEASURE 10: Expand the trilateral availability of alternative feedstocks

CONTEXT AND OBJECTIVES OF THE MEASURE

By linking material flows across industry and sector boundaries, material cycles can be closed, new sources of raw materials opened up and resources used more efficiently. However, given the current data situation, it is not yet possible to adequately assess in what quantities these alternative carbon sources can be used in an ecologically and economically sustainable way in the trilateral region. The limited availability of many alternative raw materials of sufficient quality (e.g., agricultural biomass), as well as their decentralised production, currently limit their potential for substitution of basic chemicals. The use of CO₂ is constrained as well by the limited availability of CO₂-free hydrogen. The availability of renewable sources is crucial to increase further the proportion of renewable materials in the chemical industry, with the development of economically attractive conversion paths representing an important prerequisite as well. Biorefineries have the potential to address these challenges. A successful implementation of the technology concept represents also an important building block for the transition towards a knowledge-based bio-economy. To this end, the establishment of and support for demonstration and pilot projects are essential (see also Measure 4). In addition, the trilateral region possesses of a very good competitive position in terms of technology development, as the focus in the region lies more on the production of chemicals than on biofuels.

To tackle the previously mentioned shortcomings by simultaneously building on the existing strengths in the region, the measure's objective is to identify concrete volume potentials for the use of biomass in the trilateral chemical value chain as well as to support and scale up technologies for the conversion of renewable raw materials into chemical building blocks.

⁸³ For more Information see: <http://www.corbey.nl/>

POSSIBLE ACTIONS

Two elements are important to guarantee the transition towards more sustainable feedstocks in the chemical industry. First, the security of supply with raw materials of the same quality plays a central role in the establishment of biorefineries; in the case of a classical plant concept, the raw material base must be secured for several decades. Secondly, biorefineries and the corresponding conversion technologies for renewable raw materials need to become more performant in order to compete with traditional feedstocks. The following actions address each of these issues.

- **Increase the knowledge base and amount of exchange regarding the current and future volume potentials and quality of alternative feedstocks and the exchanges:** Potential sustainable raw materials flows, such as sustainably produced agricultural biomass (e.g. wood, straw, sugar), CO₂ (e.g. from the cement and steel industries or direct coal gasification) and agricultural food and waste streams, should be further examined to enable an economic analysis of their transport, handling and storage in the trilateral region. Furthermore, this analysis should allow for a strategic orientation of the regional research and project landscape, particularly regarding the development of biorefineries and corresponding technologies. To this end, the German-Dutch INTERREG-project 'Study on the biomass potential of the cities Krefeld, Venlo and their surroundings' represents a good starting point for extending the initiative to the whole trilateral region.
- **Scale up technologies for the production of sustainable chemicals:** In order to increase the proportion of renewable feedstocks in the chemical industry, conversion technologies should be scaled up and made economically viable. The utilisation of lignin (i.e. from wood) represents a particular challenge and will become more important in the future. An interesting alternative would be synthesis gas biorefineries, which use the same residues and in which synthesis gas can be used both chemically and biotechnologically. In this regard, the establishment of demonstration plants and pilot projects for the development of new, efficient production technologies, within the framework of joint research and innovation alliances between industry and science, should be supported (strong linkage to measure 4). Current projects for joint demonstration as developed in the Vanguard Initiative 'Bio-economy pilot' (e.g. 'Gas fermentation from gaseous waste streams/gasified biomass', with Flanders leading) should be further pursued.

Good practice – GoBiGas: World's largest biomass gasification plant (Sweden)

GoBiGas (Gothenburg Biomass Gasification Project) is a major demonstration project set up by Göteborg Energi to produce biogas via the gasification of biomass and waste from forestry. Biofuel is transformed into syngas, which is purified and upgraded to biogas, with a quality that is comparable to natural gas. In consequence, both gas types can be mixed in the same gas grid. When the plant is at optimal production it will deliver 160 GWh, which corresponds to fuel provision for 16,000 cars. The aim of the demonstration is two-fold: demonstrating the possibilities of gasification technologies and meeting the growing need for renewables and CO₂-neutral biogas.



Source: <https://gobigas.goteborgenergi.se>

RELEVANT ACTORS AND STAKEHOLDERS

In addition to the involvement of the central players of the trilateral R&D&I landscape (see Annex 3) and the co-operation of the traditional chemical companies located in the trilateral region, the realisation of the measure requires (new) co-operation along the value chain between the chemical, forestry, agriculture and energy industries. The (very complex) questions regarding the development of sustainable biorefinery concepts can only be answered by interdisciplinarity. Therefore, the description of relevant actors and stakeholders here is not exhaustive.

6.2.3 Field for action 6: Taking advantage of the Circular Economy

The Circular Economy represents many opportunities for the trilateral chemical industry and could provide it with an important competitive advantage. Its application allows, amongst other things, further efficiency gains in the chemical industry by avoiding energy and material losses throughout product lifecycles, as well as by circulating resources often treated as waste (e.g. by utilising CO₂ from other industries as a feedstock and closing water loops). Furthermore, resource scarcity, as well as changing geopolitical conditions, make the availability and costs of resources more uncertain. Material-intensive industries like the chemical, automotive and construction sectors are highly affected by fluctuating raw material prices, benefitting the Circular Economy particularly. Thus, there are incentives for expanding the Circular Economy not only from an environmental standpoint but also from a business perspective. Therefore, increasing demand for substitutes and materials that fit easily in sustainable closed cycles are potential game changers.

To fully exploit the opportunities of the Circular Economy in the trilateral chemical industry from both an environmental and a business point of view and to turn it into a competitive advantage, the following measure should be pursued.



MEASURE 11: Establish a circular ecosystem of integrated material and energy flows within and across industries

CONTEXT AND OBJECTIVES OF THE MEASURE

Industrial organic chemistry is currently based primarily on the material and energetic use of fossil raw materials, with carbon dioxide being the last coupling product. However, the direct use of CO₂ has the potential to close the organic material cycle. The material use and subsequent fixation of carbon dioxide, as well as the reuse of residual steam or heat on a local level by the chemical industry, can make significant contributions to sustainable economic development, the reduction of greenhouse gases and the shrinking of fossil footprints in the trilateral region (despite the fact that it is a predominantly local solution). In this regard, stronger industrial symbiosis between the chemical sector and other sectors in the trilateral region, such as the steel, energy, cement and lime industries, represents an important opportunity. Such a symbiotic relationship could secure and promote employment in the sectors mentioned above, which are of particular industrial importance in the trilateral region. Furthermore, synergistic co-operation between various industries provides the potential for new business models and thus for new employment opportunities.

Against this background, this measure intends to support the exploitation of existing local infrastructures and to strengthen industrial clustering so that an improved material flow management can be achieved.

POSSIBLE ACTIONS

To achieve the establishment of a circular ecosystem across industries, the following action should be considered:

- **Support projects that improve the integration of material and energy flows within or between the chemical and other sectors (e.g. energy or steel):** The raw material use of carbon dioxide and its exchange between different sectors is the subject of intensive research efforts. Initiatives that examine opportunities for the exchange of different material or energy flows, explore viable business models, identify infrastructure needs or look for collaboration opportunities in the region require support. The initiation of a trilateral platform for industrial symbiosis analogous to the Smart Delta Resources initiative⁸⁴ could help to exchange existing knowledge in the region and to identify the most promising projects eligible for further support.

⁸⁴ <http://smartdeltaresources.nbproject.nl/en>

Good practice – LanzaTech: ‘Turning waste carbon from a liability into an opportunity’

Founded in 2005, the New Zealand company LanzaTech is a pioneer in the field of direct CO₂ use and has developed an interesting biotechnological recycling approach for industrial waste gases (containing carbon monoxide, carbon dioxide, and/or hydrogen). They are commercialising a pioneering carbon capture and reuse technology that converts carbon-rich waste gases from the steel industry (e.g. pilot plant Baosteel, China) by means of fermentation with clostridia into high-quality, advanced biofuels and platform chemicals like butanol and ethanol.

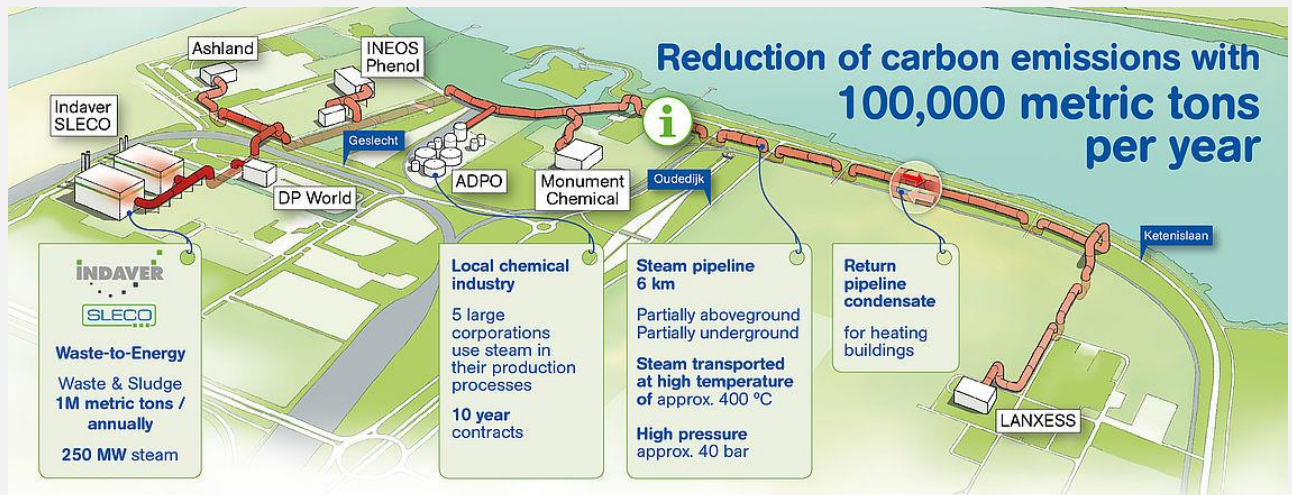


Source: <http://www.lanzatech.com/>

- **Determination of residual heat potentials in geographical proximity suitable for the chemical industry:** Given its high density of and spatial proximity to both heat producers (e.g. waste incineration plants and paper and steel industries) and consumers, the trilateral region offers synergy potential for the creation of heat-generating compounds that go beyond a production site or chemical park. Such opportunities, however, have not yet been fully identified and require further investigation. In addition, the cost-effectiveness of heat storage solutions depends on various factors (e.g. energy costs, investment costs and temperature). The development of new sustainable business models is therefore crucial to fully exploit these waste heat potentials. With this perspective, the ECLUSE-project (see below) represents an interesting example and could function as a good practice case for other trilateral projects. The platform for industrial symbiosis could provide a good framework for the initiation of such projects.

Good practice – ECLUSE: Waste-to-energy–powered industrial heat network (BE)

The project aims to, among other initiatives, lay a network of steam and condensate pipes between the waste-to-energy facilities operated by the joint venture of Indaver and SLECEO and several other companies in the Waasland Port. In this way, the distribution network can replace the individual natural gas-fired energy supplies of several large chemical companies (i.e. Ineos Phenol, ADPO, Ashland, Lanxess and Monument Chemical).



Six incinerators will produce steam with a maximum capacity of around 250 MW. This will yield annual CO₂ savings of 100,000 tonnes, comparable with 50 wind turbines of 2.3 MW each. Moreover, the network is designed to allow for further growth equivalent to the CO₂ savings afforded by 100 wind turbines. Once the ECLUSE project is operating at full capacity (project completion expected in January 2018) it will be one of the largest industrial heating clusters in Europe, supplying a good 10% of all ‘green’ heat produced in Flanders.

Source: <http://www.ecluse.be/homepage/>

RELEVANT ACTORS AND STAKEHOLDERS

As for the previous measure, its realisation requires co-operation along the value chain between the chemical sector and various other sectors, such as the steel, cement and energy industries. Furthermore, the various port authorities and chemical parks in the trilateral region play an important role as they can provide the necessary infrastructure and space. Additionally, representatives of existing initiatives regarding the integration of material and energy flows between industries should be consulted as they can provide interesting insights (e.g. Smart Delta Resources (NL), 'Carbon2Chem' (DE) and ECLUSE (BE)). Given the important infrastructural needs of potential projects, the inclusion of the ministries responsible for infrastructure-related policies, and federal support where necessary, should be considered as well. The description of actors mentioned here is not exhaustive, and actions should be open to other stakeholders.



MEASURE 12: Enable comprehensive Circular Economy processes in the trilateral chemical industry

CONTEXT AND OBJECTIVES OF THE MEASURE

The growing world population, growing prosperity and the spread of urban lifestyles are increasing the demand for raw materials and the production of goods, and thus are also increasing the availability of secondary raw materials (e.g. food and agricultural waste, urban mining, technical/industrial waste) at the end of the product lifecycle. This growing availability represents important substitution potentials for traditional chemical raw materials like oil and gas, which could contribute to an increasingly independent and secure supply of inputs and a further closing of product cycles. This is only possible, however, where secondary raw materials have developed a cost and/or quality advantage compared to primary raw materials, and where long-standing, independent and economically viable recycling systems have established themselves. However, the chemical industry not only helps to optimise the use of raw materials by transforming waste and by-products into new or secondary raw materials. As the industry is a supplier to virtually every other industry, it is a central player in enabling the Circular Economy throughout all value chain processes in its downstream industries, opening new market opportunities. For instance, in the automotive sector, innovative chemical products can help to reduce emissions, increase efficiency, improve recyclability and provide solutions for the development of increasingly durable cars with longer average usage.

To this end, the measure's objective is two-fold. First, preconditions for recycling need to be improved such that secondary raw materials in the trilateral region may be more readily available and their use more profitable economically. Second, innovation for highly engineered recycling methods, in close co-operation among raw-material producers, manufacturers and recyclers, should be strengthened to create new circular value-added networks.

POSSIBLE ACTIONS

To achieve the aforementioned objectives, the following actions should be envisaged:

- **Development of a common trilateral approach for the closing of material cycles:** The three regions should define a common concept concerning how they want to proceed in the future to further advance the closing of material cycles in their regions, with a special focus on the role of the chemical industry (e.g., waste to chemicals). This approach should consider ecological, economic and social sustainability criteria and be based on the lifecycle assessments of the different recycling opportunities to identify the most promising recycling options for the chemical industry. In this process, the possibility for the alignment of different standards and regulations concerning material lifecycles (product design, waste management, etc.) in North Rhine-Westphalia, Flanders and the Netherlands should be investigated; different rules make it more difficult to transport and process secondary raw materials (e.g. food or industrial waste) from one region to another.

- **Perform feasibility check regarding an energy and material flow register:** Based on insights gained from lifecycle assessments of the various recycling opportunities, an energy and material flow register should be set up. This register should increase the transparency of the different flows and facilitate the identification of innovation potentials (e.g. identification of niche markets); the costs for such a register still need to be taken into account. A recently released study by Fraunhofer UMSICHT and WiN Emscher-Lippe⁸⁵ represents a good basis and example for this process. The study developed a register including information about all relevant companies in the area of recycling and production of metal residues and provided a spatial representation of the different interlinkages in a cartographic form. Furthermore, the approach allowed for the inclusion of neighbouring regions as well as integration of the information into their existing online tool, 'chemieatlas.de'.
- **Initiation of a trilateral/European Innovation platform for 'sustainable resource management and product development':** This platform should bring together all recycling-related actors (raw material producers, manufacturers, industrial designers, disposal companies, etc.). The platform should foster collaboration and exchange among the different actors along and across value chains and enable the development of joint innovation processes; this should finally lead to a sustainable integrated material and product development process. The bundling of competencies and experiences should feed into innovation projects for economically viable material recycling technologies for the chemical industry (e.g. new and efficient solutions for the recycling of cross-linked materials and high-performance composite materials).
- **Scale up technologies for the use of potential recyclable material flows:** Although the existing technological knowledge and the number of research projects for material recycling have increased over the past few years, many of the newly developed technologies are far from being ready for industrial implementation. To close the technological gap and scale up existing technologies towards marketable solutions, new pilot and demonstration projects are needed. Pilot plants for the recycling of complex products that can be transformed later into economically viable recycling facilities are key for developing a competitive advantage (see also Measure 4).

RELEVANT ACTORS AND STAKEHOLDERS

To enable economically viable and efficient recycling, co-operation among raw material producers (e.g. operators of (bio)refineries), manufacturers (e.g. chemical or automotive industry) and recyclers (recycling plants, waste-sorting plants, etc.) is needed. From a research perspective, the various research institutes with a focus on Circular Economy processes, like the German Fraunhofer UMSICHT or VITO from Flanders (for further relevant institutes see Annex 3), represent important stakeholders as well.



In addition to the North Rhine-Westphalian, Flemish and Dutch Ministries for economic affairs, the various ministries responsible for environmental issues need to be considered as well. This description, however, is not exhaustive. Other actors and stakeholders should be given an avenue for consultation.

⁸⁵ (Krause & Nühlen, 2017)

6.3 Policy field 3: Trilateral chemical infrastructure

Transportation infrastructures and logistics are the backbone of the chemical industry's tight supply-chain integration ('Verbund') in the trilateral region. The availability and quality of all transport modes in the trilateral region is a significant asset, as production and consumption locations are spatially separated. Viable infrastructure is not only a critical precondition of efficient and effective logistics, but an essential feature for future investment decisions by industry as well. Maintaining and extending transportation infrastructures is essential for the future development of the trilateral chemical industry in the globalised market. Future logistics need to be increasingly agile, flexible and adjustable to respond to market needs quickly and effectively.

Overview of proposed measures in the field of Trilateral Chemical Infrastructure

 		Chemical Industry Infrastructure	
Field for action		Proposed Measures	
7	Resilient chemical industry infrastructures	#13	Develop a trilateral masterplan for chemical logistics and infrastructure
		#14	Accelerate approval processes of infrastructure and construction projects
8	Chemical Logistics 4.0	#15	Initiate a trilateral telematics system of transport and logistics undertakings
		#16	Establish a trilateral dialogue platform for Logistics 4.0
9	Future-ready physical supply chain integration	#17	Plan and reserve space around chemical industry locations
		#18	Plan and reserve space for new pipelines

6.3.1 Field for action 7: Resilient chemical industry infrastructure

From an industrial point of view, all trilateral infrastructures are interconnected and must be approached holistically. Given the complexity of trilateral interlinkages, co-ordinated action including the relevant stakeholders is needed to take stock of present and future needs and to prioritise projects of trilateral relevance. To make the trilateral chemical industry's infrastructure more resilient in the future, the whole process chain, from evaluating and prioritising through financing to planning and approval, needs to be addressed.



MEASURE 13: Develop a trilateral masterplan for chemical logistics and infrastructure

CONTEXT AND OBJECTIVES OF THE MEASURE

To accommodate increasing annual transport volumes and the modal shift, which results from changes in the kinds of goods transported (see Section 2.5), amongst other factors, the transport infrastructure needs to be strengthened and adapted. This is even more important if the chemical industry in the trilateral region will grow stronger than currently expected in the forecasts. To this end, co-ordinated and pro-active action is needed to assure that the infrastructure develops correctly. Based on an analysis involving the relevant stakeholders, present potentials for optimisation and future needs at the trilateral interfaces should be identified within the framework of a master plan for the chemical industry's logistics and infrastructure. The masterplan will provide guidance to and strengthen the commitment of all actors involved. The existing co-operation between North Rhine-Westphalia and the Dutch provinces of Gelderland, Limburg, Overijssel and Nordbrabant can serve

as a basis for what extended collaboration is like. Currently, the five partners have, amongst other aims, the objective to improve cross-border traffic, with a specific focus on rail transport as well as mobility and traffic management.⁸⁶ Furthermore, this measure will enhance the visibility of the trilateral endeavours and the related financial needs vis-à-vis other relevant levels of government, i.e. at a federal or European level.

POSSIBLE ACTIONS

To achieve the aforementioned objectives, the following actions should be envisaged:

- **Involve stakeholders and experts in the stock-taking process:** Volumes of chemical goods transported in the trilateral region are forecasted to grow significantly until 2030. A major share of this growth results from the sea ports (see Section 2.5). The identification and prioritisation of relevant infrastructure needs for the chemical industry, especially of critical infrastructural bottlenecks in the trilateral region, should provide a basis for future investment decisions. For example, rail infrastructure and the capacities of storage facilities could be extended to improve co-modality and inland transport from and to the ZARA sea ports. The missing links in the trilateral rail network should be closed and overall capacities must be extended to secure the future sustainability of rail transport connecting the ZARA sea ports with the hinterland. The assessments and opinions of various stakeholders from government and industry as well as from external experts need to be fed into this process.
- **Establish trilateral co-ordination mechanisms:** Co-ordination among the three regions for the planning and implementation of the existing and/or expanding measures must be assured, e.g. by creating a virtual 'Competence Centre for Trilateral Infrastructure Planning'. This should be linked to the High-Level Group (see Policy field 4: Policy co-ordination).
- **Ensure co-operation at the European level:** The plan should ensure the further development of the Trans-European Transport Network (TEN-T) in connection with the European support policy for this area (Connecting Europe Facility). Existing steering groups (transport side) should be used to position the needs of the chemical industry. A joint positioning at the European Commission should be considered to provide access to other financing instruments (e.g. EFSI).
- **Explore the opportunities of PPP activities jointly (depending on transport mode):** Public-private partnerships (PPP) can contribute to a more efficient and rapid realisation of infrastructure projects. For example, this procurement model has gained significant relevance in the Netherlands since 2006. Furthermore, PPP is being increasingly utilised at the German federal level. Since 2015, new generation projects have been launched totalling around EUR 15 billion.

Good practice – Procurement of public-private partnerships in the Netherlands:

Since 2006, a stronger focus has been placed on using PPP in the Netherlands. This was effectively enforced by public procurement regulation: for large infrastructure projects with a volume above the threshold of EUR 60 million, a mandatory 'Added Value Assessment' was instituted. First, a market scan is conducted at an early stage of the project to assess whether the involvement of private sector actors has the potential to induce positive effects. Second, before the procurement process, a 'Public-Private Comparator' (PPC) analysis shows whether the project would be realised more efficiently in a PPP as opposed to a conventional realisation. Finally, the PPC analysis is further refined by the 'Public Sector Comparator' (PSC) as the cheapest PPP tender is compared to a public realisation based on the contractual details.⁸⁷

This process was supported by the establishment of the 'PPP Knowledge Pool' at the executive agency 'Rijks-waterstaat', where PPP knowledge was systematically centralised.

- **Establish concise follow-up infrastructure reports (e.g. every two to three years):** 'Hands-on' reports should periodically assess of the progress, achievements and new challenges in the trilateral region. Thereby, the trilateral infrastructure agenda should be updated regularly.

⁸⁶ <https://www.land.nrw/de/pressemitteilung/gemeinsame-verkehrskonferenz-nrw-und-vier-niederlaendische-provinzen-vereinbaren>

⁸⁷ (BDI, 2013)

RELEVANT ACTORS AND STAKEHOLDERS

Beyond the key stakeholders (ministries for economic affairs in NL, FL and NRW), the trilateral ministries for infrastructure and transport should be involved, as well as their federal counterparts. Furthermore, the trilateral business associations of the chemical industry, key industry players, port authorities and chem park operators should be included in the process.



MEASURE 14: Accelerate approval processes of infrastructure and construction projects

CONTEXT AND OBJECTIVES OF THE MEASURE

The tight integration of infrastructures is a key asset of the trilateral region. Thus, the acceleration of approval processes is key to the maintenance and extension of infrastructures, as planning security for all stakeholders and transparent and quick approval processes are two sides of the same coin. Developing a master plan (Measure 13) is a first step. A second step should include more careful long-term infrastructure planning, lean and effective regulations and the dissemination of information to affected municipalities and individuals to tackle the 'not in my backyard' issue at an early stage. As Flanders, the Netherlands and NRW face different framework conditions in this respect, the sharing of best practices and mutual learning could create trilateral added value.

POSSIBLE ACTIONS

To accelerate approval processes, the following action should be considered:

- **Create organisational and regulatory conditions allowing for more careful planning and accelerated implementation:** Sufficient personal resources are a critical precondition for accelerated planning procedures; creating a common trilateral competence centre as a one-stop shop for planning is also an option, which is also highlighted by a recent report from the European Commission on TEN-T projects.⁸⁸ Furthermore, closer co-ordination between the bodies involved in regional planning and plan approval procedures could prevent silos and administrative issues during the process; lawmakers should assess the potential for simplification and exchange good practices in this respect.
- **Facilitate a rapid planning approval process approach for chemical infrastructures:** Rapid planning is an effective form of integrative planning which provides the essential tools and capacity necessary to establish sustainable and resource efficient infrastructure management for the chemical industry in an adequate time. Building upon the rapid planning approach, instruments shall be set-up to accelerate the approval processes of infrastructure and construction projects relevant to the trilateral chemical industry.
- **Tackle the 'not in my backyard' issue (NIMBY):** Infrastructure or industry projects in the trilateral region often face resistance from affected municipalities and individuals. As a result, planning and approval processes are often shaped by critical inquiries and a variety of objections, leading to significant delays. High quality procedures for public information, dialogue and participation at an early stage of planning can lessen the juridical risks and thus enhance planning security for the parties involved (see recent guidance⁸⁹). The examples below offer good practices for further consideration.

⁸⁸ (European Commission, 2016)

⁸⁹ See e.g. (VDI, 2015) Available at: https://www.vdi.de/fileadmin/vdi_de/redakteur/bg-bilder/Richtlinie7000/VDI_7000_Inhaltsverz_.pdf.

Good practice – Public consultation in Baden-Württemberg:

Against the background of the massive public protest during the planning and construction of the Stuttgart central station ('Stuttgart 21'), the federal government of Baden-Württemberg established a high-profile platform for dialogue and participation. The responsible unit is assigned to the state ministry of Baden-Württemberg and headed by a state counsellor. The platform offers various options to citizens for information, participation and for the provision of new input at an early stage of planning.⁹⁰

Good practice – 'Bündnis für Mobilität'

To quickly and efficiently realise the necessary infrastructure development in NRW, the government, with partners like the Chamber for Commerce and Industry in NRW and the Federation of German Trade Unions – Region NRW, formed an alliance to promote the benefits of long-term infrastructure investments for both industry and citizens. The project further develops new approaches to citizen participation, encourages local alliances for critical projects and identifies ways to simplify and more efficiently facilitate the planning and construction process.⁹¹

RELEVANT ACTORS AND STAKEHOLDERS

Beyond the key stakeholders (ministries for economic affairs in NL, FL and NRW), the trilateral and federal ministries for infrastructure and transport as well as the responsible planning agencies should be involved. Key industry players and chem park operators should be consulted regarding space requirements. At the planning stage, inclusive consultation processes must include the public and municipalities. In addition, other concerned parties should be given an avenue for consultation as the description of stakeholders and actors included here is not exhaustive.

6.3.2 Field for action 8: Chemical Logistics 4.0

The digitisation of logistics or 'Logistics 4.0' through the utilisation of satellite navigation, low-cost sensors and big data analysis could potentially increase the effectiveness and the efficiency of the trilateral chemical industry (see Measure 3). Beyond a reduction of costs, this could potentially increase the sustainability of the trilateral industry through a reduction of transport-related greenhouse emissions. Even though the necessary technology is often already available, efforts to effectively use Logistics 4.0 are still relatively fragmented. A trilateral approach is needed to set common standards and to jointly exploit economies of scale. The following measures should be followed:



MEASURE 15: Initiate a trilateral telematics system of transport and logistics undertakings (INITIAL-MEASURE NO. 3)

CONTEXT AND OBJECTIVES OF THE MEASURE

Against the backdrop of increasing transport volumes, the initiation of a trilateral telematics system could potentially make transport and logistics more effective and efficient by improving flexibility and capacity planning as well as the timing of transport lots. This will not only be beneficial for producers and customers along the value chain, but will also make the industry more sustainable by reducing greenhouse emissions.

This system can be realised by tapping the potentials of technologies such as GPS, low-cost sensors and cloud computing. These technologies are already successfully applied in the field, but to fully capitalise on the available data and realise a trilateral telematics system, common standards, a uniform communication platform and a viable provider model are needed. On this basis, intermodal traffic within chemical supply chains can also be strengthened. It will also be important to assess the systems and standards of transport streams coming into the trilateral region to ensure that no interference emerges.

⁹⁰ See: <https://beteiligungsportal.baden-wuerttemberg.de/de/startseite/>

⁹¹ <http://www.vw.nrw.de/service/Buendnis-fuer-Infrastruktur/index.php>

Since consensus on common standards is key in providing planning security for all actors involved, this measure is supported by the establishment of a trilateral dialogue platform on Logistics 4.0 (see Measure 16).

CONCRETE STEPS AND ACTIONS

The following concrete steps and actions should be taken:

- **Specify platform requirements, provider models and financing:** Experts should assess options for a common technology standard and a possible provider model, as data security is a sensitive issue. Furthermore, all (historical) costs and viable financing models must be evaluated. This assessment could create the basis for a sound trilateral agreement on a telematics system among industry, academia and governments.
- **Initiation of a trilateral telematics system:** The Flemish project 'NxtPort Antwerp' provides an ideal starting point for trilateral upscaling of a joint telematics system for Chemical Logistics 4.0.⁹² A trilateral objective should be to collect and pool data from various stages in the supply chain of the ports to improve data sharing and interoperability of existing platforms. The most relevant ports in the trilateral region (e.g. ZARA ports and the Port of Duisburg) would serve as hubs for a rollout. Furthermore, the relevant chem park operators (e.g. Chemelot and Currenta) should be included in future steps forward.
- **Strengthen intermodal traffic within chemical supply chains:** The trilateral telematics system should provide a more profound and smart data basis; this would be utilised to improve the competitiveness and reliability of intermodal transport in the trilateral region. By building on the Dutch experiences in the 4C4Chem⁹³ project, a trilateral follow-up project would set the basis for strengthening intermodal traffic in order to develop more innovative supply chain processes within the chemical industry. Possible foci could be to improve co-ordination between off- and on-site logistics and to secure more precise forecasting of future transportation needs, sharing transport and storage capacities as well as the bundling of transport flows.

RELEVANT ACTORS AND STAKEHOLDERS

Relevant actors and stakeholders for implementation (list is not exhaustive)
<ul style="list-style-type: none"> ▪ Ministries responsible for economic affairs as well as transport and infrastructure (including federal counterparts BMVI in DE and FPS Mobility and Transport in BE) ▪ Cluster organisations: EffizienzCluster LogistikRuhr (NRW), Logistik.NRW / LOG-IT Club, Top-teams Chemie and Logistiek ▪ Research institutes and universities: RWTH Aachen, Fraunhofer IML, Fraunhofer ISST, TKI Dina log (Erasmus University Rotterdam), TNO, Flanders Institute for Logistics, University of Antwerp ▪ Trilateral sector associations: VNCI, Essenscia Flanders, VCI ▪ Industry and logistics service providers ▪ Port authorities (e.g. Zeebrügge, Amsterdam, Rotterdam, Antwerp – ZARA, Duisburg) ▪ Chem park operators (e.g. Chemelot, Currenta and ChemCologne.)

FINANCING

Financing of the telematics system will come from the participating organisations. While public authorities should primarily engage in R&D&I as well as pilot activities, a scale-up should be financed by private institutions and supported by funding programmes, e.g. by European Structural Funds or related financial instruments. Relevant financing sources for the various working packages could include:

⁹² <http://nxtport.eu/>

⁹³ <https://www.dinalog.nl/en/project/4c4chem/>

- **National funding programmes:** For example, the programme mFUND set up by the German Federal Ministry for Transport and Infrastructure offers funding for improved data exploitation through sharing platforms and new navigation services.⁹⁴
- **Horizon2020, Smart, Green and Integrated Transport:** ‘Innovative ICT solutions for future logistics operations’ are part of the 2016–2017 Work Programme.
- **The Connecting Europe Facility (CEF Transport):** This provides funding to European Traffic Management Systems (ERTMS), the Intelligent Transportation System for Roads (ITS)⁹⁵ and the River Information Services (RIS)⁹⁶ and for Freight Transport Services aiming at horizontal integration and logistics optimisation.
- **ERDF Operational Programmes in NRW, Flanders and the Netherlands:** This provides funding through Thematic Objective 4 (Supporting the shift towards a low-carbon economy in all sectors) and Thematic Objective 7 (Promoting sustainable transport and removing bottlenecks in key infrastructures). For instance, in North Rhine-Westphalia funding competitions related to the ‘Mobility and Logistics’ lead market provide opportunities for financing some of the measures.
- **Public-private partnership:** The option of a public-private partnership should be evaluated. The trilateral public authorities should exchange experiences regarding this funding option (see Measure 13).

TIME HORIZON AND MILESTONES

The expected timeframe for this measure is mid-to-long-term (2020–2025), as technical and operational questions must be thoroughly assessed. The first milestone of this project will be the initiation of a trilateral dialogue platform for Logistics 4.0 (see Measure 16), which shall begin in 2018.



MEASURE 16: Establish a trilateral dialogue platform for Logistics 4.0

CONTEXT AND OBJECTIVES OF THE MEASURE

Concerning projects and efforts to push forward Logistics 4.0, improved co-operation among the three regions of North Rhine-Westphalia, Flanders and the Netherlands is still needed. To fully capitalise on the advantages offered by Logistics 4.0 through a trilateral scale-up, an institutionalised dialogue among the three regions should lay the foundation for common standards and mutual information sharing on planned and existing projects. Consequently, planning reliability can be provided, which is essential for all actors involved.

POSSIBLE ACTIONS

To establish the trilateral dialogue platform for Logistics 4.0 the following actions should be explored:

- **Ensure trilateral information sharing:** The platform should be composed of relevant actors from government, business associations, industry, logistics service providers, academia, etc. Planned and ongoing activities in the area of Logistics 4.0 should be shared as a first step. The aforementioned co-operation between North Rhine-Westphalia and the Dutch provinces of Gelderland, Limburg, Overijssel and Nordbrabant provides a platform for information sharing that shall be extended. Also, the new coalition agreement in North Rhine-Westphalia expects to strengthen its current collaboration agreements with the Netherlands in the field of transport and logistics. An extension of co-operation towards Flanders, including ‘Logistics 4.0’ in the chemical industry, should be targeted.

⁹⁴ (BMVI, 2107)

⁹⁵ See https://ec.europa.eu/inea/sites/inea/files/2016-cef-transport_map_general_call_text.pdf

⁹⁶ See <https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/projects-by-transport-mode/ris>

- **Define common standards:** Common standards, a uniform communication platform and a viable provider model are critical aspects to tap the potentials of a telematics system in the trilateral region. Therefore, consensus on common standards is key in providing planning security for all actors involved (see Measure 15). Technical preconditions and standards for a trilateral telematics system should be analysed and formulated by experts in industry and academia.
- **Strengthen co-modality:** Beyond the effective utilisation of digital technology, hard infrastructures, e.g. for storage, are needed in the trilateral region to strengthen co-modality. The dialogue platform can provide the needs of industry and logistics service providers.
- **Bi-annual meetings:** Meetings would be held about twice a year at different venues in the trilateral region. This could further promote trilateral networking and information sharing.

RELEVANT ACTORS AND STAKEHOLDERS

Relevant actors and stakeholders for implementation (list is not exhaustive):

- Ministries responsible for infrastructure, transport and economic affairs (including BMVI (DE) and FPS Mobility and Transport (BE))
- Cluster organisations: EffizienzCluster LogistikRuhr (NRW), Logistik.NRW / LOG-IT Club, Top-teams Chemie and Logistiek
- Research institutes and universities: RWTH Aachen, Fraunhofer IML, Fraunhofer ISST, TKI Dinalog (Erasmus University Rotterdam), TNO, Flanders Institute for Logistics, University of Antwerp
- Trilateral sector associations: VNCI, Essenscia Flanders, VCI
- Industry and logistics service providers
- Port authorities (e.g. Zeebrügge, Amsterdam, Rotterdam, Antwerp – ZARA, Duisburg)
- Chem park operators (e.g. Chemelot, Currenta and ChemCologne)

6.3.3 Field for action 9: Future-ready physical supply chain integration

The *Verbund* structure of the trilateral chemical industry is one of its most important assets. To secure this structure and ensure its future competitiveness, infrastructures such as chem parks and pipelines are essential. To pave the way for future extensions of chem parks and investments in pipelines, a reliable space planning and reservation policy is needed. Two measures are of high importance:



MEASURE 17: Plan and reserve space around chemical industry locations

CONTEXT AND OBJECTIVES OF THE MEASURE

As large integrated chemical companies evolve towards smaller, more specialised firms, chemical parks will be increasingly characterised by higher concentration of specialised firms and logistics service providers. Though future parks will not be constructed on ‘green-field sites’, existing chemical parks at large sites will remain central to the industry and must have the necessary development scope as the clustering of the trilateral chemical industry will continue. Furthermore, the highly interconnected chemical value chains across North Rhine-Westphalia, Flanders and the Netherlands ensure that many companies are based in chemical parks in each of the three regions or have suppliers or customers who are located there. High quality and safe development plans in and around chemical industry locations are necessary to keep crucial investments in the trilateral region; it is especially necessary if the trilateral chemical industry does not want to be left behind compared to other chemical clusters in the world, where higher investment activities can be observed (see Sections 2.1 and 3.1). Development investments are also important to produce potential cascade effects in the chemical value chain that can potentially affect all three regions. Cascade effects are most likely to materialise for the basic chemical companies that are dependent on large material flows and for which the *Verbund* structure is the most important. However, since most of the specialty chemical products are based on basic chemical products, the cascade effect risk exists for this segment of the industry as well.

POSSIBLE ACTIONS

To achieve the aforementioned objectives, the following actions should be envisaged:

- **Ensure sufficient expansion space for chemical industry sites:** To take advantage of clustering, sufficient space around chemical industry locations and chem parks must be proactively reserved for the chemical industry and related services. The European Seveso III directive,⁹⁷ which requires a reasonable safety distance between industrial and public buildings and recreational and residential areas to prevent acute hazards for adjacent areas, can especially hinder the extension of chemical parks. Moreover, to improve these industry-wide problems, sharing experiences, which the chemical parks in the trilateral regions and their local authorities have done in the past, should be encouraged (e.g. report by TÜV Nord commissioned by Evonik concerning the impact of the Seveso III directive for the chemical park in Marl⁹⁸).
- **Perform a regular mapping of spatial expansion needs:** In order to integrate the needs of the chemical industry sites, in particular those of chem parks, in spatial development plans, a regular mapping of spatial needs should be performed. The results should feed into the masterplan for chemical logistics and infrastructure and should improve both long-term spatial development planning and the attractiveness for investments.

RELEVANT ACTORS AND STAKEHOLDERS

Beyond the key stakeholders, i.e. the ministries of economic affairs in NL, FL, NRW, the trilateral ministries of infrastructure and transport, their federal counterparts and the corresponding planning agencies should be involved in this measure. Key industry players and chem park operators should be consulted regarding space requirements. At the planning stage, inclusive consultation processes must include the general public and municipalities.



MEASURE 18: Plan and reserve space for new pipelines

CONTEXT AND OBJECTIVES OF THE MEASURE

Pipelines are crucial components in the trilateral chemical industry, as they secure the continuous supply of liquid or gaseous bulk chemical feedstocks (e.g. naphtha, LNG and hydrogen). They are also relevant when CO₂ from other industries is utilised as a feedstock by the chemical industry. Compared to other modes of transport, they have clear advantages in terms of safety, land use, costs and emissions. Furthermore, an extension of the trilateral pipeline network could effectively reduce congestion on other modes of transport. A further improvement in the pipeline infrastructure (e.g. the planned CO₂ and NH₃ pipelines across the trilateral region) would significantly increase the attractiveness and competitiveness of the trilateral region in the long run. As a long-term measure, the planning and reservation of space for new pipelines needs to be addressed from the outset of the trilateral strategy.

POSSIBLE ACTIONS

To improve the planning for new pipelines, the following actions should be considered:

- **Reserve cross-border space corridors:** Proactively reserving space for new pipelines is a first step to enable new business models for building and operating new pipelines in the trilateral region. This would lay the foundation for new pipeline connections between large chemical sites in NRW and the seaports of Antwerp and Rotterdam, as well as other chemical sites in the Netherlands and Flanders. Therefore, pipeline corridors should be considered in long-term spatial development planning. A specialist dialogue of the responsible planning authorities shall be supported

⁹⁸ <http://corporate.evonik.de/DE/PRESSE/PRESSEMITTEILUNGEN/Pages/news-details.aspx?newsid=65436>

from this strategy to improve the long-term planning procedures across the trilateral region (see also Policy Field 4).

- **Initiate public consultation at an early stage:** Long-term planning sets the stage for an early consultation of affected municipalities and individuals to prevent potential NIMBY issues in the planning and construction phase. This should be embedded in an extended framework for participation and consultation (see Measure 14).
- **Track the progress of permits ('pipeline permits track'):** To fasten the construction of new pipeline systems, it is necessary that the process in gaining permits be accelerated as well. To this end, one important point is the optimisation of time-consuming interactions among the various entities involved (e.g. environmental and infrastructure authorities).

RELEVANT ACTORS AND STAKEHOLDERS

Beyond the key stakeholders, i.e. ministries of economic affairs in NL, FL and NRW, the trilateral ministries of infrastructure and transport, their federal counterparts and the responsible planning agencies should be involved. Key industry players and chem park operators should be consulted regarding space requirements. At the planning stage, inclusive consultation processes must include the general public and municipalities. Additionally, other concerned parties should be given an avenue for consultation, as the above-mentioned list of stakeholders and actors is not exhaustive.

6.4 Policy field 4: Policy co-ordination

In an ever more globalised and interconnected economy, companies are acting increasingly in cross-regional value-added networks that increase and improve co-ordination among the different regions. Thus, their public authorities become essential in tackling social, environmental and economic challenges that cannot be solved by a unilateral approach. This is particularly applicable for the trilateral chemical industry which, over the years, has built up strongly interconnected industrial value chains and a highly integrated infrastructural network.

Against this background and in the context of increasing global pressure for the chemical industry, it is important that **challenges are tackled jointly**, so that competitiveness and sustainable development of the chemical industry can be maintained by policymakers in the trilateral region.

Overview of proposed measures in the field of Policy Co-ordination:

Policy Co-ordination	
Proposed Measures	
#19	Implement an institutionalised trilateral dialogue among policy makers, academia and industry
#20	Trilateral positioning towards Europe in important policy fields
#21	Decrease administrative requirements and barriers for trilateral co-operation

A description of the three measures in the field of policy co-ordination is presented below.



CONTEXT AND OBJECTIVES OF THE MEASURE

The current strategy process, which began in early 2017, should be considered the starting point for increased cross-border co-operation among the regions of North Rhine-Westphalia, Flanders and the Netherlands in order to strengthen the chemical industry.

In this **first phase**, the vision for the future of the trilateral chemical industry along with a corresponding strategic roadmap with key activities for trilateral engagement have been developed in a stakeholder-driven process. The **second phase** now consists of **implementing the proposed three-point action plan** described above as well as **translating the other identified fields for action into concrete measures and action plans**. Furthermore, in view of a rapidly changing world, continuously updating strategies and objectives should be assured, including assuring the commitment of all relevant stakeholders.

Measure 19 seeks to establish an **institutionalised structure that has different levels of governance** (strategic, operational, activity-based), ensuring a continuous and sustainable dialogue among the relevant stakeholders of the trilateral chemical industry and a co-ordinated implementation of the strategy at all levels.

POSSIBLE ACTIONS

In the following sections, a revised and more sophisticated governance structure is presented in order to strengthen the level of information exchange initiated among ministries, industry and science in the trilateral region. This governance structure is based on three different levels:

- **Strategic level – Set up a trilateral High-Level Group:** The trilateral High-Level Group (HLG) should bring together the most important high-level representatives from industry, science and relevant governmental ministries. The main objective of the HLG is to provide a strategic monitoring of the implementation of the trilateral strategy across the different policy fields. The HLG thereby assures the commitment, prioritisation and updating of existing strategic guidelines, makes recommendations for further policy development and action fields, recommends strategic projects and takes a follow up function for the implementation of the selected strategies. The trilateral HLG will meet at least once a year under the patronage of a HLG chair; operational support for the HLG will be provided by the Inter-Ministerial Steering Group (see below).
In addition, a **public conference/symposium** should be organised every (two) year(s) to discuss and report on the achieved progress. The event should present an additional and broader platform for active information sharing among representatives from politics, sciences and industry.
- **Operational level – Establish an Inter-Ministerial Steering Group (IMSG):** The IMSG involves the three involved ministries responsible for economic affairs, science, research, innovation and investment from North Rhine Westphalia, Flanders and the Netherlands. The steering group should organise and co-ordinate strategy implementation, execute top-measures and support the organisation of the High-Level Group. It also assures, when necessary, the co-ordination with other ministerial departments as well as the co-ordination with existing consultation structures in the trilateral region. The group should meet at least twice a year with additional ad-hoc meetings. An annual rotation in leadership in the IMSG is envisaged in which one of the ministries is responsible for the organisation of the process. An external service provider could be involved to support the process with sectoral expertise, moderation and workshop organisation as well as reporting as needed.
- **Activity level – Establish thematic working groups:** To support the inter-ministerial steering group, **subject-specific working groups** with additional stakeholders from the key policy fields such as R&D&I, energy and feedstocks and infrastructure will be established, which will provide assistance for developing annual actions plans, initiating and mentoring projects (e.g. making innovation roadmaps) and reviewing progress. As in the case of the IMSG, a rotating leadership of

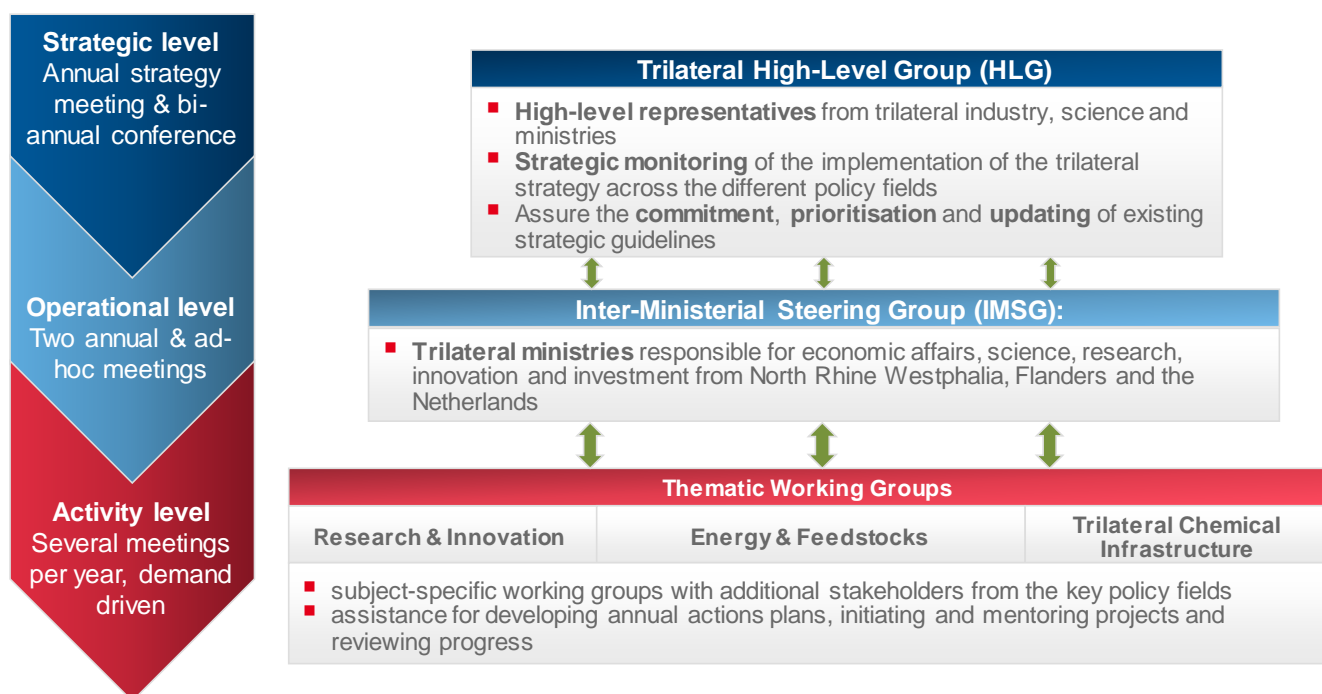
the spokespeople and organising institutions of the thematic working groups during 2018 should be considered.

Concerning the **ideal calendar** for the meetings of the three different governance levels, the following cycle should be considered:

- **Trilateral High-Level Group:** One annual strategy meeting, complemented by a bi-annual conference.
- **Inter-Ministerial Steering Group:** Two annual meetings (beginning of the year: annual workplan meeting; fall: status-quo meeting), complemented by ad-hoc meetings and support from the subject-specific working groups.
- **Thematic Working Groups:** Several meetings per year, demand driven. A minimum of three meetings per working group is expected.

Below, an overview of the envisaged functioning of the governance mechanism is shown, combining the three levels of governance, their main role and the indicative calendars for along the cycle.

Figure 29: Overview of envisaged governance mechanism for policy-coordination



Given the pre-existing structure of an Inter-Ministerial Steering Group and the previously conducted stakeholder consultations (i.e. roundtable discussions in April and June of 2017), the **next step is to form subject-specific working groups**. These should be organised as soon as possible to accomplish the complete governance structure (end of 2017). This will ensure that the first subject of specific actions plans can be presented in the course of 2018.

RELEVANT ACTORS AND STAKEHOLDERS

Key stakeholders for the implementation and institutionalisation of the trilateral dialogue are the ministries of economic affairs in NL, FL and NRW and their relevant departments. At the strategic level of the trilateral HLG, they assure to bring together the key representatives of the chemical industry, for instance the industry associations, relevant actors from academia and research institutes (see Annex 3 for a comprehensive list of potential participants) etc. In addition, other ministries that are concerned with the strategy (science and research, infrastructure and mobility; or education) and existing sectoral advisory boards with the government should be considered as well.

On the activity level of the working groups key industry players and actors will be included (some of which that have already been mentioned in the specific policy fields). For the policy field 'R&D&I' a list of relevant actors can be found in Annex 3. For the policy field 'infrastructure' stakeholders are, amongst others, chem park operators, port authorities, research institutes, logistics providers and the ministries responsible for infrastructure and mobility, as well as their federal counterparts. For the policy field 'energy & feedstocks', relevant stakeholders are research institutes and the ministries responsible for energy, as well as representatives of relevant initiatives (see Measure 11) or industry.



MEASURE 20: Trilateral positioning towards Europe in important policy fields

CONTEXT AND OBJECTIVES OF THE MEASURE

Europe is the cradle of the manufacturing industry and has always been at the forefront of technological innovations. Throughout Europe, the industry employs more than 34 million people and includes hundreds of thousands of SMEs and large enterprises. However, because of the increasing competitive pressure on the global market, particularly from Southeast Asia, the manufacturing share of the economy has decreased, which has been associated with significant job loss over the past few decades. At the same time, large economies are planning to further strengthen their industrial base, including India with its 'Made in India' strategy, China with its ambitious five-year plan and the U.S. shift towards 'America First'. In this context, an ambitious and co-ordinated European industrial strategy is urgently needed for the chemical industry.

POSSIBLE ACTIONS

The following actions should be considered for developing a joint position on active-minded European and national industry policies:

- **Regular co-ordination by the key ministries and permanent representation for the preparation of important dossiers:** The institutionalised dialogue mentioned in Measure 19, as well as the IMSG, should, where appropriate, start a target effort in a **strategic dialogue** with the relevant European entities to express, amongst others, the points of interest listed below:
 - New approaches to **commercialise and scale up inter-regional innovation projects** (Measure 1)
 - Joint positioning for **new financing models of cross-border activities** in EU programmes for the establishment of demonstration plants (Measure 4)
 - Compilation of a trilateral position paper on **European and national climate policies**, including the development of a joint position on the (EU) market model for renewables (Measure 8)
 - Common position on the introduction of a **statutory equality for the material and energetic use of biomass** (Measure 9)
 - Ensure sufficient **expansion space for chemical industry sites** (Seveso III directive; Measure 17)
- **Support the implementation of the innovation check/innovation principle for the introduction of new industrial regulations throughout the trilateral region:** Consistent and reliable regulatory frameworks are indispensable for attractive investment conditions in the trilateral manufacturing and chemical industry as they provide legal certainty that allows for planning. It is therefore important to carefully examine new regulations before they are adopted and to consider potential interactions with other national, European and international regulations. New laws regulating the manufacturing industry and their products often unconsciously and unintentionally inhibit innovation. To avoid such situations in the future the Inter-Ministerial Steering Group and other relevant stakeholders should be advocated for that new regulations in the EU and within the trilateral region should consider potential innovation-critical elements such as implementation periods, changes in standards and implementation costs (e.g. within a regulatory impact analysis).

- **Advocate for an explicit and thorough competitiveness proofing:** linked to the above, a periodical benchmarking exercise of the total cost position of the chemical industry in comparison with other competing regions (i.e. sum of all regional and national taxes and levies), especially at EU level should be performed. A first step could be taken by implementing Measure 8, which recommends an impact analysis of energy- and climate-related policies. In this, it will be important that analyses take a holistic value chain approach as the preservation of a continuous value chain of the chemical industry in the trilateral region remains a key driver for innovation and growth.

RELEVANT ACTORS AND STAKEHOLDERS

The key stakeholders for implementing Measure 20 are the ministries responsible for economic affairs, science, research, innovation and investment. In addition, consultation with the different national and regional industrial associations is necessary.



MEASURE 21: Decrease administrative requirements and barriers for trilateral co-operation

CONTEXT AND OBJECTIVES OF THE MEASURE

Many companies, research institutes and universities from all over North Rhine-Westphalia, Flanders and the Netherlands are jointly undertaking R&D&I projects and other activities. Accordingly, related administrative processes involve many authorities and offices. This naturally leads to additional reconciliation efforts and longer process duration at the expense of innovation-related activities. Therefore, the pooling of responsibilities and the creation of clearer responsibilities among the different administrations are important approaches. To this end, more service-friendly approaches and solutions should be examined along with the responsibilities distributed throughout the entire process.

POSSIBLE ACTIONS

The following actions can be considered ways to decrease administrative requirements and other barriers for trilateral co-operation between companies and institutions in the trilateral region:

- **Improve cross-border financing and internal co-operation between public administrations working on trilateral and international projects:** Within the framework of the Inter-Ministerial Steering Group and in close co-operation with the beneficiaries of financial and other support in the region, the current subsidy framework and processes for obtaining support within the scope of cross-border projects should be checked. Based on the exchange and analysis, potentials for alignment and acceleration of the most important administrative processes should be identified and, where legally possible, implemented. Even with clear and transparent administrative procedures, the co-ordination of these procedures remains, for the most part, within the company and accordingly uses resources there. The appointment of several responsible persons at the administration level would simplify co-ordination across the different entities.
- **Initiation or link to a ‘Trilateral Innovation Contact Point’:** Especially for SMEs, the administrative burden associated with cross-border funding and support for R&D&I, as well as the missing knowledge concerning potential partners for co-operation, represents an important barrier for trilateral projects. To this end, setting up a service centre-like trilateral contact point that could provide information and advice for companies and other institutions regarding administrative requirements for cross-border activities could be a solution. Establishing an innovation contact point should be closely co-ordinated with the establishment of the common knowledge/working platform as explained in Measure 1.⁹⁹

⁹⁹ The previously discussed expansion of the online-platform ‘Cluster Atlas’ (<http://maps.chemieatlas.de/>) represents opportunities for providing relevant information for the implementation of trilateral projects.

Good practice – GRANT-IT: ‘Fast-track access to EU funding information’

GRANT-IT is a web portal that can be used by SusChem and CEFIC members to search and propose research, development, demonstration and innovation projects in the field of sustainable chemistry. The portal provides users with several different services. It offers a searchable database of funding programmes (regional, national and European), which makes it possible to identify projects that are currently being developed and where interested companies and institutions could potentially join as partners. Furthermore, the archives describing past and present European projects make it possible to carry out benchmarks and state-of-the-art analyses for different research domains and related actors. In addition, GRANT-IT gives personalised advice on project ideas, such as suitable funding programmes, positioning of the project ideas and how to search for partners.



Source: <http://www.grant-it.eu/>

- **Common procurement of EU funding:** Prepare at an early stage the use of cross-border financing in the next ESI Funding period. The 15% cross-border financial scope that is laid out in the 2014–2020 regulation (Article 70(2) of the CPR) currently goes unutilised.

RELEVANT ACTORS AND STAKEHOLDERS

The key stakeholders for the implementation of Measure 21 are the ministries responsible for economic affairs, science, research, innovation and investment. In addition, other concerned parties should be given an avenue for consultation for other concerned parties.

7 Summary of all measures and overview of initial measures for 2017–2019

The trilateral strategy for the chemical industry with its 21 measures in four policy fields is a milestone in cross-border cooperation between the Netherlands, Flanders and North Rhine-Westphalia. Based on a comprehensive approach for policy co-ordination through the institutionalised trilateral dialogue among policymakers, science and industry, this strategy shall enable a sustainable and competitive chemical industry throughout the three regions.

The Figure below provides an **overview of all 21 measures of the trilateral strategy**, organised by the three policy fields and the horizontal field 'Policy Co-ordination'.

Figure 30: Summary overview of all measures of the trilateral strategy

Research & Innovation		Energy & Feedstocks		Chemical Industry Infrastructure	
N°	Measures	N°	Measures	N°	Measures
1	Improve the funding mechanisms for trilateral R&I actions	8	Develop a common trilateral approach for a competitive energy cost position	13	Develop a trilateral masterplan for chemical logistics and infrastructure
2	Intensify cross-regional R&D&I collaboration to improve the trilateral innovation ecosystem	9	Form a level playing field for the use of sustainable feedstocks	14	Accelerate approval processes of infrastructure and construction projects
3	Accompany a holistic digital transformation towards a 'New Verbund' based on value chain networks and virtual partnerships	10	Expand the trilateral availability of alternative feedstocks	15	Initiate a trilateral telematics system of transport and logistics undertakings
4	Elaborate a trilateral scheme for demonstration plants	11	Establish a circular ecosystem of integrated material and energy flows within and across industries	16	Establish a trilateral dialogue platform for Logistics 4.0
5	Expand the framework for start-ups and up-scaling in support of a trilateral chemical entrepreneurship ecosystem	12	Enable comprehensive Circular Economy processes in the trilateral chemical industry	17	Plan and reserve space around chemical industry locations
6	Enhance the vocational training and lifelong learning systems for blue collar jobs to develop the chemical industry skills of the future			18	Plan and reserve space for new pipelines
7	Encourage trilateral academic exchange and partnerships to improve the formation of the future academic workforce				
Policy Co-ordination					
19	Implement an institutionalised trilateral dialogue among policy makers, academia and industry				
20	Trilateral positioning towards Europe in important policy fields				
21	Decrease administrative requirements and barriers for trilateral co-operation				

The following **overview of initial measures** describes the key actions that will be undertaken as starting points for trilateral action to support the growth ambitions of the chemical sector in North Rhine-Westphalia, Flanders and the Netherlands. The selection of the three initial measures has been taken jointly with the relevant governmental ministries as well as industry and other stakeholders to respond to key priorities of the sector in the coming years. The overview in Figure 31 provides a short description of the measures, relevant partners and inception timescales.

Figure 31: Overview of initial measures for 2017–2019

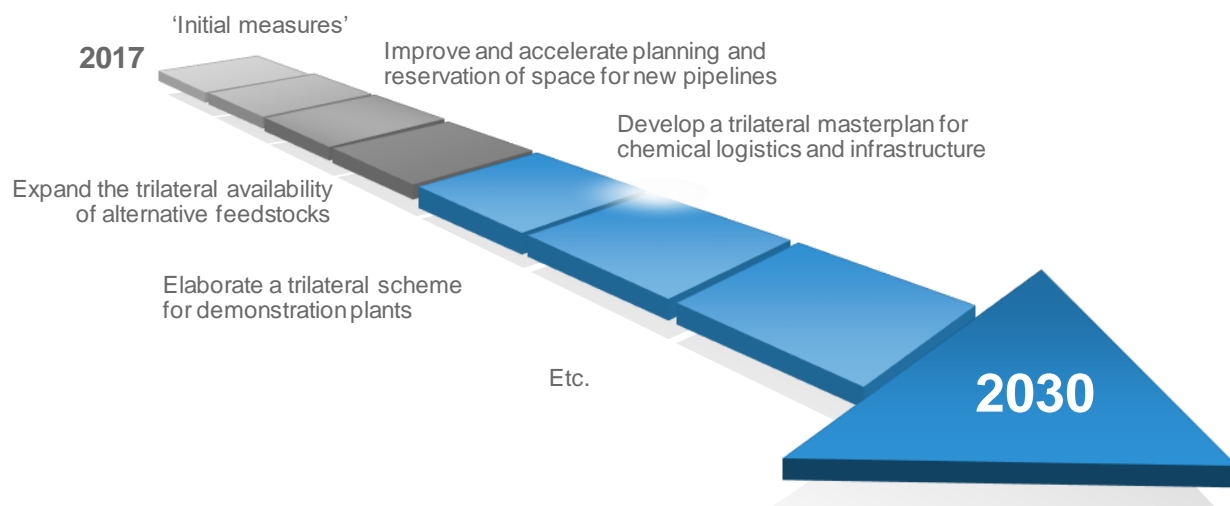
Overview of initial measures for 2017–2019			
	Research & Innovation	Energy & Feedstocks	Chemical Industry Infrastructure
	Improve the funding mechanisms for trilateral R&D&I actions	Develop a common trilateral approach for a competitive energy cost position	Initiate a trilateral telematics system of transport and logistics undertakings
			
	© Fotolia - Alexander Raths	© Fotolia – Stephan Leyk	© Fotolia - Magnifier
Description	<ul style="list-style-type: none"> Improve funding mechanisms for joint actions (e.g. flagship projects and demonstration plants) Pursue a clear change-plan for the transition of the trilateral chemical industry Facilitate the value chain transformation and sustainability transition 	<ul style="list-style-type: none"> Avoid further deviation of the cost disadvantage on feedstock and energy prices Developing a co-ordinated position and implementation of climate- and energy-related policies Capture the opportunities of increasing sustainable electricity and gas supply 	<ul style="list-style-type: none"> Specify platform requirements, provider models and financing Initiate a trilateral telematics system by upscaling existing initiatives Strengthen intermodal traffic within chemical supply chains based on a trilateral telematics system.
Partners*	Ministries of Economic Affairs (NRW, FL, NL) Cluster organisations & intermediaries Universities Research institutes	Ministries of Economic & Environmental Affairs (NRW, FL, NL) Chemical industry associations Grid-operators Research institutes Universities	Ministries of Economic Affairs & Infrastructure/Transport Cluster organisations Industry associations Port authorities Chem parks
Start Date	Q1 2018–Q3 2018	Q4 2017–Q1 2018	Q1 2018–Q4 2018

Note: This is not an exhaustive list of all relevant actors and stakeholders.

In addition to the vertical measures of the action plan for 2017-2019 in the fields of Research & Innovation, Energy & Feedstocks and Chemical Industry Infrastructure, it will be of highest importance to implement the envisaged **policy co-ordination measures**. Operating through a structure with different levels of governance (strategic, operational, activity-based) is necessary to ensure a continued and sustainable dialogue among the relevant stakeholders of the trilateral chemical industry and a co-ordinated implementation of the strategy at all levels. Besides the establishment of the institutionalised trilateral dialogue among policymakers, science and industry (see Measure 19), the **trilateral positioning towards Europe** will be of vital importance (see Measure 20).

Furthermore, besides the initial measures outlined above it will be important to **start the preparation of the remaining measures in parallel**. Particularly long-term measures such as the **expansion of the trilateral feedstock** or the **planning and reservation of space for new pipelines** need to be addressed from the outset. Based on a proposed working plan for the next years (compare description in Measure 19), the HLG will assess the relevance of the necessary actions and decide on the next measures to implement. Below, a selection of possible next measures is presented.

Figure 32: Selection of possible next measures



Note: This is not an exhaustive list of all measures of the trilateral strategy.

Depending on the joint work of the Inter-Ministerial Steering Group and the Thematic Working Groups, also new topics and priorities might evolve in the course of the next years, which need to be evaluated and taken into consideration. Thus, a **dynamic approach to strategy implementation** will be necessary for making the right choices at the right times and to ensure sustainable change over the long term. All in all, a necessity for successful implementation of the strategy will be sound policy co-ordination through the trilateral dialogue among policymakers, science and industry.

8 References

- American Chemical Society. (2016). Chemical Outlook 2016 by Region. *Chemical & Engineering News*, 94 (2), pp. 9-15. Retrieved from <http://cen.acs.org/articles/94/i2/Chemical-Outlook-2016-Region.html>
- American Chemistry Council. (2017). *Factsheet: U.S. Chemical Investment Linked to Shale Gas*. Retrieved from <https://www.americanchemistry.com/Policy/Energy/Shale-Gas/Fact-Sheet-US-Chemical-Investment-Linked-to-Shale-Gas.pdf>
- BDI, e. a. (2013). *Best-Practices-Studie zur Verkehrsinfrastrukturplanung und -finanzierung in der EU. Endbericht*.
- BMVI. (2017). *Freight Transport and Logistics Action Plan - Towards a Sustainable and Efficient Future*. Retrieved from https://www.bmvi.de/SharedDocs/EN/publications/freight-transport-logistics-action-plan.pdf?__blob=publicationFile
- Bos, W. (2017). Warren Buffett Does Not See Any Value In Dow Chemical. *Seeking Alpha*. Retrieved from <https://seekingalpha.com/article/4052323-warren-buffett-see-value-dow-chemical>
- Brouwers, E., Gerrits, R., Forrez, I., & Devloo, T. (2014). Contribution to a future oriented energy strategy for the chemical industry: Impact of energy and feedstock costs on the competitiveness of the chemical industry in the ARA-cluster. (Essenscia, & VNCI, Eds.)
- CEFIC. (2011). *Chemical Logistics Vision 2020. The next decade's key trends, impacts and solution areas*.
- CEFIC. (2016). *Facts & Figures 2016 of the European chemical industry*.
- Commerzbank Research. (2015). *Branchenbericht: Chemie*.
- Commerzbank Research. (2016). *Branchenbericht: Kunststoffverarbeitung*.
- Deloitte & VNCI. (2012). *The Chemical Industry in the Netherlands: World leading today and in 2050*.
- Dutch Sustainable Biomass Commission (CDB). (2012). *Sustainable biomass in the chemical industry*.
- European Commission. (2016). *Study on permitting & facilitating the preparation of TEN-T core network projects*. Brussels.
- European Commission. (2017). *Reflection Paper on the Future of EU Finances*. Brussels.
- European Commission. (2017). *Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth*. Brussels.
- Flemish department Economy, S. a. (2013). *Sustainable use and creation of value from renewable raw materials for biobased industrial production such as biomaterials and green chemicals in Flanders*.
- Flemish department Economy, Science and Innovation (EWI) & Dutch Ministry of Economic Affairs . (2014). *Flämisch niederländische Strategie für einen zukunftsorientierten Chemiesektor*.
- Flemish department Economy, Science and Innovation (EWI). (2015). *Industriële Biotechnologie: Een roadmap voor Vlaanderen*.
- Hofman, S., & Föndhoff, B. (2017). Auf der Such nach neuem Treibstoff. *Handelsblatt*, 19-17.
- Ketels, C. (2007). *The Role of Clusters in the Chemical Industry*. Harvard Business School.
- Keuning, W. (2010). Vijfhonderd banen weg bij farmaciebedrijf Abbott. *de Volkskrant*. Retrieved from <http://www.volkskrant.nl/economie/vijfhonderd-banen-weg-bij-farmaciebedrijf-abbott~a1025776/>
- KPMG. (2016). *The 13th Five-Year-Plan- China's transformation and integration with the world economy*.
- Krause, S., & Nühlen, J. (2017). *Studie zur Potentialanalyse zum Metallreststoffrecycling in der Emscher-Lippe Region (und angrenzend)*. Fraunhofer-Institut für Umwelt-, Sicherheits- und Energietechnik UMSICHT (Hrsg.), on behalf of WiN Emscher-Lippe Gesellschaft zur Strukturverbesserung mbH.
- Landtag Nordrhein-Westfalen. (2015). *Enquetekommission zur Zukunft der Chemischen Industrie in Nordrhein-Westfalen im Hinblick auf nachhaltige Rohstoffbasen, Produkte und Produktionsverfahren*.
- NIW & ZEW. (2015). *Innovationsindikatoren Chemie 2015*. (V. d. (VCI), Ed.) Retrieved August 14, 2017, from <http://www.niw.de/uploads/pdf/publikationen/InnoChemie15.pdf>
- NIW. (2013). *Die chemische Industrie: Branchenanalyse*.

- Osborne, M. A., & Frey, C. B. (2013). *The future of employment. How Susceptible Are Jobs to Computerisation?* Oxford. Retrieved from http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf
- Port of Antwerp. (2015). Port of Antwerp: Europe's leading integrated oil and chemical cluster. Retrieved from http://www.portofantwerp.com/sites/portofantwerp/files/imce/POA-1635_Boe_Investeringsgids_Chemie_perpagina.pdf
- Prognos AG & VCI. (2012). *The German Chemical Industry in 2030: A summary of the VCI Prognos study.*
- Prognos AG & VCI. (2016). *Die deutsche chemische industrie 2030 - Update 2015/2016.*
- Prognos AG. (2016). *Prognos Economic Outlook 2040: Demografische und ökonomische Prognosen für 42 Länder (Update Oktober 2016).*
- Scheyder, E. (2017). Exxon to invest \$20 billion on U.S. Gulf Coast refining projects. *Reuters*. Retrieved from <http://www.reuters.com/article/us-ceraweek-exxon-idUSKBN16D2G6>
- Schmid, K., & Wilke, P. (2013). *Die Chemie-, Pharma- und Kunststoffindustrie in Norddeutschland.*
- Umweltbundesamt. (2017). *Biomassenkaskaden: Mehr Ressourceneffizienz durch Kaskadennutzung von Biomasse – von der Theorie zur Praxis.*
- VCI. (2016). *Ausführungen von Thomas Wessel, Vorsitzender des Ausschusses Forschung, Wissenschaft und Bildung im VCI, auf der VCI-Forschungspressekonferenz am 14. November 2016.* Retrieved from <https://www.vci.de/presse/mediathek/weitere-downloads/forschung-und-entwicklung-in-der-chemischen-industrie-im-ueberblick-hintergrundmaterial.jsp>
- VCI. (2017). *Eckdaten der chemisch-pharmazeutischen Industrie zu Forschung, Entwicklung und Bildung: Stand Februar 2017.*
- VDI. (2015). *VDI Guidelines for early public participation in industrial and infrastructure projects.* Retrieved from https://www.vdi.de/fileadmin/vdi_de/redakteur/bg-bilder/Richtlinie7000/VDI_7000_Inhaltsverz_.pdf.
- Vos, C. (2010). Massaontslag Organon is 'mokerslag'. *de Volkskrant*. Retrieved from <http://www.volkskrant.nl/economie/massaontslag-organon-is-mokerslag~a1007151/>
- Wehberg, G. (2015). *Chemicals 4.0 Industry digitization from a business-strategic angle.* Königswinter: Deloitte Consulting GmbH.
- Yingge, S. (2017). Modern coal chemical industry to be developed. *Shanghai Daily*. Retrieved from <http://www.shanghaidaily.com/business/energy/Modern-coal-chemical-industry-to-be-developed/shdaily.shtml>

Annex

Methodological approach and structure of the study

The development of the strategy, is based on a comprehensive analysis of the macroeconomic importance as well as the past and potential future development of the chemical industry in the trilateral region.

In a **first step**, the **status quo** of the trilateral chemical industry is determined. Based on **secondary statistical data** of important economic indicators (turnover, employment, investments, gross value added, R&D&I expenditures, etc.) the current industry structure, its past development as well as its regional and global competitive environment are identified. The **statistical analysis considers the chemical industry in a wider sense**. Because of the importance of the chemical industry as a supplier for the pharmaceutical and rubber & plastics industry, the last two sectors are considered as direct extensions of the chemical value chain and therefore have been included as well in the analysis. Therefore, references to the chemical industry include all three sectors, unless otherwise specified.

In a **second step**, the international positioning, **relevant industry trends**, weak signals and uncertain developments of the trilateral chemical industry are identified and examined by means of a STEEP-Analysis. This approach allows to assess accurately the perspectives for the trilateral chemical sector in the mid-term. This part uses a more qualitative approach and is based on an **extensive literature review** and **expert interviews** with representatives from all relevant sectors (i.e. industry, cluster organisations, research centres, sector associations) and every region.

Building upon the empirical analysis of the previous two steps, a comprehensive **assessment of all information sources** (statistical analysis, interviews, literature review, STEEP-analysis) is conducted to sketch an overall profile of the chemical industry in the trilateral region and to **identify its strengths and weaknesses as well as the existing opportunities and threats for the sector** (SWOT-matrix). A preliminary version of the SWOT-analysis was **presented in a first roundtable workshop**, comprised by experts on the chemical industry from all three regions. The intensive discussion of the findings led to a further refinement, validation and prioritisation of the strengths and weaknesses.

By analysing the **future trends** (opportunities & threats) as well as the input from the first roundtable, the relevant topics, market areas and policy fields that are key for a successful, long-term and future oriented development of the trilateral chemical industry, were identified. Based on these key areas, a **vision**, which defines the desired state of the trilateral chemical industry for 2030, was developed. In a next step, the opposition of the desired state to **the status-quo** (strengths & weaknesses), allowed to identify **strategic gaps** and to derive **overarching central strategic objectives**. On the one hand, these strategic objectives for the development of the industry sharpen the strategic focus on clearly defined strategic options and led to the determination of **key policy fields** as well as relating **fields for action**. On the other hand, they have been the starting point for the development of **concrete measures and project proposals**, which are needed to overcome the strategic gaps that currently are hindering the achievement of the strategic goals. A **second roundtable workshop**, was organized to validate and adapt the vision as well as the derived strategic recommendations. In addition, first proposals for concrete measures were evaluated and new ones elaborated.

As a result of this process, **three vertical key policy fields and one horizontal aspect** emerged to guide the common actions of the trilateral region in the next years for strengthening their chemical sector. Furthermore, **nine specific fields for actions**, addressing the most critical issues for a successful transformation of the industry have been elaborated and matched with **concrete measures**. In addition, some of the most **relevant actors and stakeholders** that are needed for a successful implementation of the measures are mentioned. The selection has been based on the input received during the interviews and the roundtables and was complemented by own research. This list, however, is not exhaustive and does not exclude the inclusion of further actors.

Finally, a **first action plan for the years 2017-2019**, including concrete project proposals, has been drafted in order to respond to the key priorities of the sector in the coming years. The action plan sets out specific short-term and long-term actions, partners and inception timescales.

Statistical branch classification for the chemical industry based on NACE

The analysis concerning turnover, employment, gross value added and investment data is based on 2- and 3-digit levels of the European NACE (2nd revision, 2008) classification. The chemical industry has been subdivided into three sectors (2-digit levels) and ten sub-sectors (3-digit levels). Furthermore, an additional differentiation has been made for the chemical sector, distinguishing between the basic and specialty chemicals industry

Annex 1: Statistical branch classification for the chemical industry based on NACE

NACE-2008	Statistical description	Description used in the report
20	Manufacture of chemicals and chemical products	Chemical industry
		Basic chemicals industry
201	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	Basic chemicals & fertilisers
206	Manufacture of man-made fibres	Man-made fibres
		Specialty chemicals industry
202	Manufacture of pesticides and other agrochemical products	Agrochemicals
203	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	Paints & varnishes
204	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	Cosmetics, detergents & care products
205	Manufacture of other chemical products	Other chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	Pharmaceutcial industry
211	Manufacture of basic pharmaceutical products	Basic pharmaceutical products
212	Manufacture of pharmaceutical preparations	Pharmaceutical preparations
22	Manufacture of rubber and plastic products	Rubber and plastics industry
221	Manufacture of rubber products	Rubber products
222	Manufacture of plastics products	Plastics products

Statistical branch classification for the chemical industry based on the Combined Nomenclature

The statistical branch classification of the export data is based on the Combined Nomenclature, the European classification for traded products, which is established on the international trade classification of the Harmonised System. Given the different statistical definitions of the chemical industry, the NACE classification and Combined Nomenclature are only comparable to a limited extent.

Annex 2: Statistical branch classification for the chemical industry based on the Combined Nomenclature

Combined Nomenclature	Statistical description	Description used in the report
Section VI	Products of the chemical or allied industries	Chemical and pharmaceutical products
Chapter 28	Inorganic chemicals; organic or inorganic compounds of precious metals, of rare-earth metals, of radioactive elements or of isotopes	Inorganic chemicals
Chapter 29	Organic chemicals	Organic chemicals
Chapter 30	Pharmaceutical products	Pharmaceutical products
Chapter 31	Fertilisers	Fertilisers
Chapter 32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other colouring matter; paints and varnishes; putty and other mastics; inks	Paints, varnishes, tannings, etc.
Chapter 33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations	Essential oils, perfumery, cosmetics, etc.
Chapter 34	Soap, organic surface-active agents, washing preparations, lubricating preparations, etc.	Soaps, detergents, lubricants, etc.
Chapter 35	Albuminoidal substances; modified starches; glues; enzymes	Glues, enzymes, modified starches, etc
Chapter 36	Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations	Explosives, pyrotechnic products, etc.
Chapter 37	Photographic or cinematographic goods	Photographic or cinematographic products
Chapter 38	Miscellaneous chemical products	Miscellaneous chemical products
Section VII	Plastics and articles thereof; rubber and articles thereof	Plastics and rubber products
Chapter 39	Plastics and articles thereof	Plastics products
Chapter 40	Rubber and articles thereof	Rubber products

R&D&I landscape: Name and location of institutions

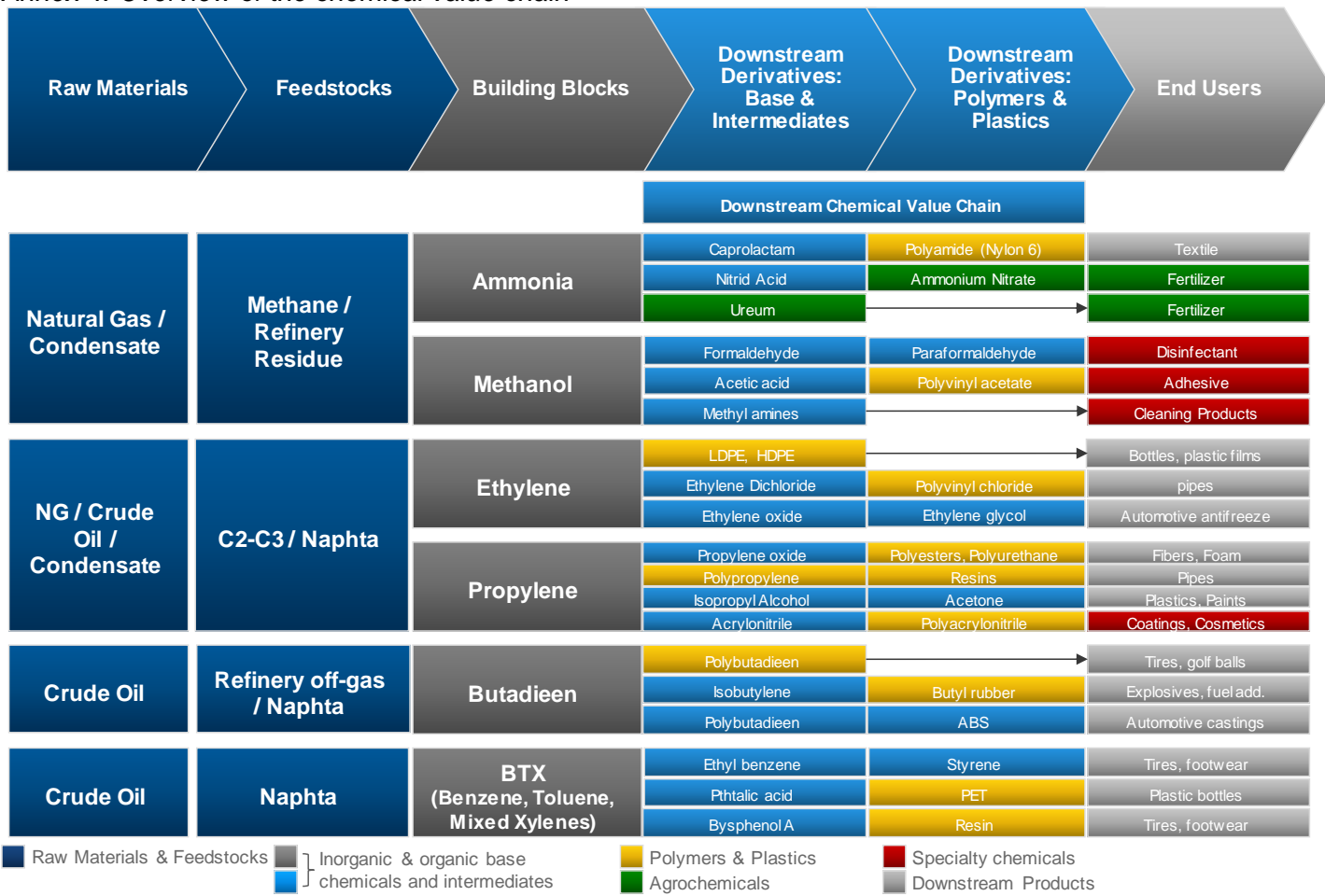
Annex 3: R&D&I Landscape and Cluster Initiatives for the Chemical Industry in the trilateral region

No.	Cluster Organisations	Location
1	Flanders.bio	Gent
2	Catalisti	Antwerp
3	Chemie.NRW	Düsseldorf
4	CLIB2021	Düsseldorf
5	Landescluster Kunststoff / Kunststoffland NRW	Düsseldorf
6	Topsector Chemie (covers all NL)	Den Haag
7	TI-COAST (covers all NL)	Amsterdam
8	BE-Basic (covers all NL)	Delft
9	Biobased Delta	Bergen op Zoom
No.	Research Institutes & Pilot Facilities	Location
10	Bio Base Europe Pilot Plant	Gent
11	Flemish Institute for Biotechnology - VIB	Gent
12	Research institute for Agriculture, Fisheries and Food - ILVO	Gent
13	Flemish Institute for Technological Research - VITO	Mol-Antwerp
14	Fraunhofer Institute for Molecular Biology and Applied Ecology IME	Aachen
15	Institute of Plastics Processing (IKV) in Industry and Crafts at the RWTH Aachen	Aachen
16	Research Centre Jülich: IBG-1: Biotechnology	Jülich
17	Plastics-Institute Lüdenscheid	Lüdenscheid
18	German Institute for Textile Research North-West e.V.	Krefeld
19	Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT	Oberhausen
20	Max-Planck Institute of Molecular Physiology	Dortmund
21	Green PAC	Emmen
22	Pivot Park	Oss
23	Dutch Polymer Institute - DPI (covers all NL)	Eindhoven
24	Dutch Institute for Fundamental Research - DIFFER (covers all NL)	Eindhoven
25	Brightlands Chemelot Campus	Sittard-Geleen
26	Aachen Maastricht Institute for Biobased Materials	Sittard-Geleen
27	Green Chemistry Campus	Bergen op Zoom
28	Plant One	Rotterdam
29	Biotech Campus	Delft
30	TNO - Dutch Organisation for Applied Research (covers all NL)	Delft
31	Top Institute Pharma (covers all NL)	Leiden
32	Dutch Institute for Catalysis Research (covers all NL)	Den Haag
57	Max-Planck-Institut für Chemische Energiekonversion	Mülheim an der Ruhr
58	Max-Planck-Institut für Kohlenforschung	Mülheim an der Ruhr

No.	Universities & Universites of Applied Sciences	Location
33	University of Gent	Gent
34	Free University of Brussels	Brussels
35	KU Leuven	Leuven
36	University of Antwerp	Antwerp
37	University of Hassel	Hasselt
38	RWTH Aachen	Aachen
39	Aachen University of Applied Sciences	Aachen
40	University of Bonn	Bonn
41	University of Düsseldorf	Düsseldorf
42	University Duisburg-Essen	Essen
43	University of Bochum	Bochum
44	Technical University of Dortmund	Dortmund
45	Hamm-Lippstadt University of Applied Sciences	Lippstadt
46	Niederrhein University of Applied Sciences	Krefeld
47	University of Münster	Münster
48	University of Twente	Enschede
49	University of Groningen	Groningen
50	University of Utrecht	Utrecht
51	Free University of Amsterdam	Amsterdam
52	University of Leiden	Leiden
53	Technical University of Delft	Delft
54	University of Applied Sciences Zuyd	Heerlen
55	University of Maastricht	Maastricht
56	University of Wageningen	Wageningen

Representation of the complete chemical value chain

Annex 4: Overview of the chemical value chain



Source: VNCI/Essenscia. **Note:** This figure does not display an exhaustive list.

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