



Green Economy Report

North Rhine-Westphalia 2017

Management Summary

Foreword



Today, the future is also in the fields. While the world talks of driverless cars, digitally networked tractors and agricultural machinery in North Rhine-Westphalia are already bringing in the harvest. Fertilising and watering are controlled by sensors and carried out according to need. The digital revolution is already a feature of modern agriculture, enabling specialised and perfectly adapted cultivation of each individual field. This increases yields and allows environmentally-friendly and sustainable management, which is why we consider agricultural technologies like precision farming to be part of the green economy in North Rhine-Westphalia.

The green economy is a modern and dynamically developing interdisciplinary sector, currently employing around 368,000 people in North Rhine-Westphalia. Alongside the classic fields of pollution monitoring, mitigation and restoration technologies, resource management and water and sewage systems and management, it also includes interfaces with important industrial sectors such as machine engineering and the electrical industry. It simultaneously encompasses the services sector and skilled trades, and different strengths are firmly anchored in different regions. This variety has one common denominator: the green economy always combines economic benefit with advantages for the environment.

North Rhine-Westphalia is the largest provider of environmentally-friendly products and services in Germany. We are already No. 1 in Germany for the green economy and this prominence gives us both a clear perspective for the future and an incentive: by 2030, our aim is that over 460,000 people will be employed in the green economy in North Rhine-Westphalia.

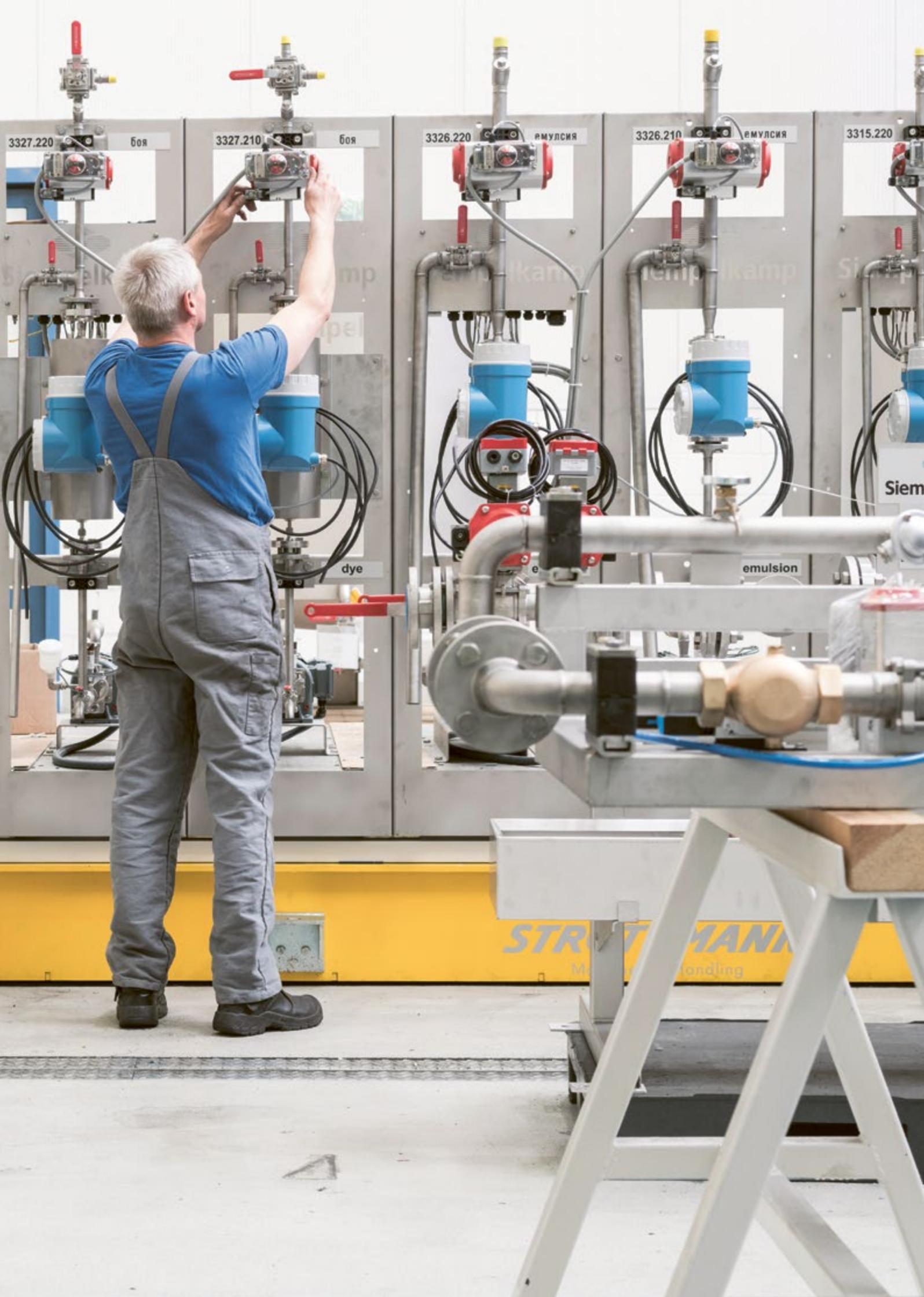
With our green economy strategy, we aim to build on our pioneering role and to support our companies in adjusting to the challenges of climate change and environmental protection with new products, services and business models. A core element is this report, which provides orientation and a continuation to the green economy success story. It serves to determine the position, offers insights into the relevant topics and draws a detailed picture of the economic regions within our state.

As said, the future is sometimes in the fields. But first and foremost, the future is in our hands and heads. Governmental and regional economic policies are successful when they promote industrial activities, drive innovation and strengthen the competitiveness of our state, often by implementing new ideas and methods. In many respects, the green economy is about making the future better. And here in North Rhine-Westphalia, we're good at that.

Yours, Christina Schulze Föcking
State Minister for the Environment, Agriculture, Conservation and Consumer Protection
in North Rhine-Westphalia

Contents

Foreword	3
1 Management Summary	7
1.1 The Green Economy in North Rhine-Westphalia	8
1.2 Innovations in the North Rhine-Westphalian Green Economy	12
1.3 International Markets in the Green Economy	13
1.4 The Submarkets of the Green Economy	15
1.5 The Green Economy in the Regions	19
Imprint	23



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1 Management Summary

Largest provider

North Rhine-Westphalia is the largest provider of green economy products and services in Germany.

€ 27.7 billion

is generated by the green economy, which is over 6% of the gross value added in North Rhine-Westphalia (2015).

19%

of all German patents and around 2% of all green economy patents worldwide originate in North Rhine-Westphalia (2014).

40%

export rate from the North Rhine-Westphalia green economy, when local construction and services are disregarded (2015).

Growth

At +1.6% p.a. (2010–2016), the number of employees in the green economy is growing faster than in the state's other key sectors; these include machine engineering, the chemical industry and the metal and electrical industries.

368,000

employees or every 20th employee in 2016: North Rhine-Westphalia has more employees in the green economy than any other state in Germany.

€ 10.4 billion

in exports is generated by the green economy, which amounts to 5.8% (2016) of exports from North Rhine-Westphalia.

69%

of North Rhine-Westphalia green economy exports go to the EU (2016).

43%

of employees in the green economy are employed in the North Rhine-Westphalia services sector. More than one quarter of employees currently work in industry and the skilled trades (2016).

From Krefeld in North Rhine-Westphalia, the Siempelkamp machine and plant engineering company delivers the Ecoresinator, an energy efficient, glue-saving and formaldehyde-free glue/fibre blending system, to bonded-product manufacturers all over the world.

1.1 The Green Economy in North Rhine-Westphalia

The green economy encompasses all companies that offer environmentally-friendly and resource-efficient products and services. As an interdisciplinary sector with links to key industries like machine engineering and the electrical industry, it plays a central role in the economic development of North Rhine-Westphalia.

In 2016, the North Rhine-Westphalia green economy boasted a work force of around 368,000. Its share of overall employment is 5.1%, which is higher than any other key sector in the state. With a turnover of 66.3 billion euros, the green economy contributed around **6.2% to North Rhine-Westphalia's gross value added** and has devel-

oped into a significant and integrated component of the state's economic structure.

The featured themes of the green economy encompass sustainable farming and forest management, classic sectors such as sewage and waste disposal and pollution mon-

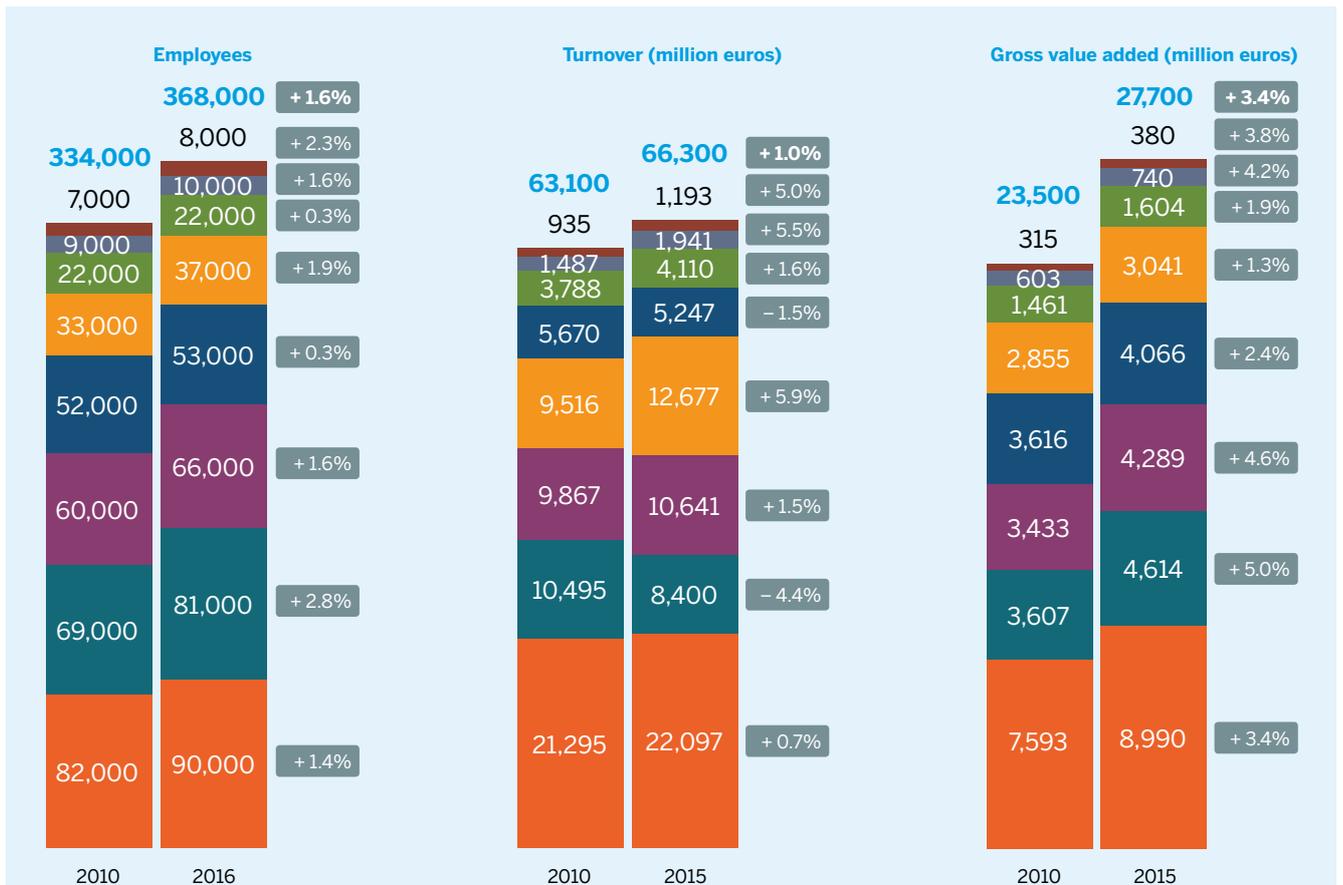


Figure 1: Employees, turnover and gross value added in North Rhine-Westphalia by submarket in 2010 and 2015/16 and average growth rates (in % p.a., in grey)

Source: BA, IT.NRW, own calculations Prognos 2017

EEC Energy efficiency and energy conservation **MER** Materials, material efficiency and resource management **PMT** Pollution monitoring, mitigation and restoration technologies **SFW** Sustainable forest management and wood industry **ETS** Environmentally friendly energy conversion, transportation and storage **EFF** Environmentally friendly farming **GMO** Green mobility **WSM** Water and sewage systems and management

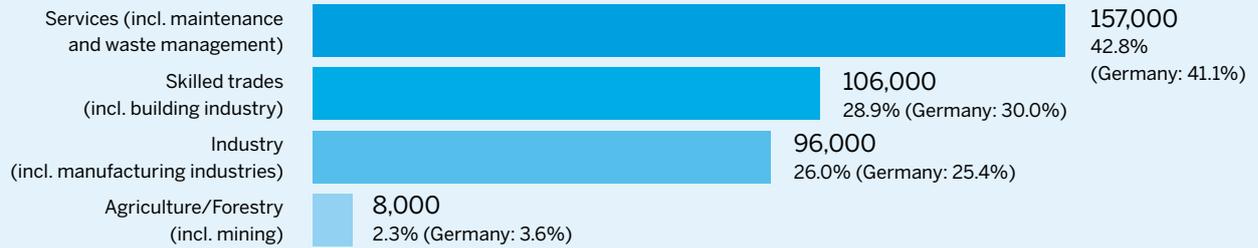


Figure 2: Structure of the green economy, employees and share by sector in North Rhine-Westphalia and Germany 2016

Source: BA, IT.NRW, own calculations

itoring, mitigation and restoration technologies, as well as new topics like green mobility and renewable energy.

Against this background, the green economy can also be seen as a sector of transformation, tackling the greatest challenges of our time – climate change, urbanisation, resource efficiency, decarbonisation – with new ideas, innovative technologies and state-of-the-art services. For established key industries, such as machine engineering and the electrical industry, the green economy has an integrating effect; it combines and channels skills and innovations with prospects for sustainable growth.

North Rhine-Westphalia has intentionally developed its economic prospects as **the largest provider of green economy products and services in Germany**. An annual average turnover growth of 1% (2010–2015) and an annual growth in gross value added of 3.4% (2010–2015) paint a glowing picture (FIGURE 1). North Rhine-Westphalia is also the place to be for Germany's green economy innovations: Around 2% of all patented green economy innovations worldwide, and 19% of those in Germany, are taken through the patent application process by companies based in North Rhine-Westphalia.

Between 2010 and 2016, **the number of employees increased** in the North Rhine-Westphalia green economy by **34,000 to around 368,000. Employment in the green economy is therefore growing faster than in other key industries in the state**. With an average of 1.6% p.a., the annual growth in employment since 2010 is slightly higher than in the chemical industry (+1.5% p.a.) and is significantly higher than in the metal industry (–0.1% p.a.). For machine engineering (+0.8% p.a.), automotive manufacturing and the electrical industry (each +1% p.a.), the green economy continues to drive growth. It is worth noting that in these three sectors, around 10–11% of employees can also be considered part of the green economy.

Industry represents one quarter of employees in the North Rhine-Westphalia green economy (FIGURE 2). At least two fifths (43%) are employed in the services sector. The role of the skilled trades is not to be underestimated with around one third of employees working in the green economy.

The Green Economy as an Interdisciplinary Sector

The green economy is not listed in official sectoral classifications by industry and type of product so some delimitation is necessary when considering its economic significance in an empirical way. The first North Rhine-Westphalia Green Economy Report 2015 attempted for the first time to develop a foundational delimitation model.

The delimitation model envisaged developed by Prognos AG has been developed moderately for this report and

the key variables have been updated. This is to take into account both technological developments in the very dynamic interdisciplinary sector and important specific stimuli from the dialogue process in the North Rhine-Westphalia Green Economy Masterplan (see box page 21). Specifically, two green economy submarkets were also included. This is to be taken into account in any direct comparison with key variables from previous publications about the North Rhine-Westphalian green economy.

Figure 3: Submarkets in the North Rhine-Westphalia green economy

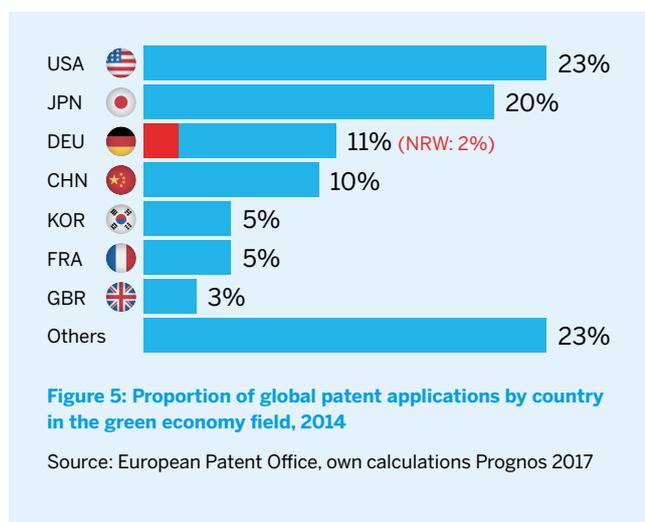


Figure 4: Submarkets, market segments and technology fields in the North Rhine-Westphalia green economy

Submarket	Market segment	Technology field	
	Renewable energies	Consultancy and research	
		Bioenergy	
		Geothermics	
	Intelligent energy systems and grids	Solar	
		Hydropower	
		Wind energy	
	Storage technology	ICT for energy systems	
		Network expansion and operation	
		Network technology	
	Energy efficient buildings	Electrochemical storage of energy	
		Mechanical storage of energy	
		Thermal storage of energy	
	Energy efficient production processes and technologies	Construction and installation services	
		Insulation materials	
		Building technology	
		Waste heat utilisation	
		Air compression and pumping systems	
		Installation and consultancy services	
	Waste treatment and recovery	Process control engineering and ICA technology	
		Waste disposal	
		Energy recovery	
	Waste collection and transportation	Materials recovery	
		Waste collection and transportation	
	Material-efficient production processes and technologies	Street cleaning	
		Installation, repair and consultancy services	
		Material-efficient process technologies	
	Renewable primary products and environmentally friendly materials	Measuring, regulating and controlling technologies	
Cosmetics and detergents from renewable resources			
Technology for waste management	Materials from renewable resources		
	Systems engineering		
	Vehicle technology		
	Collection and transportation containers		
	Other		
	Intelligent traffic management systems and infrastructure	Environmentally friendly transport infrastructure	
		Traffic management	
	Environmentally friendly logistics and mobility services	Public transport and sharing systems	
		Environmentally friendly logistics	
	Green mobility and propulsion technologies	Alternative vehicles	
		Propulsion technologies	
	Monitoring and analysis procedures, water and sewage management	Automotive technologies	
		Water 4.0 (Measurement, analysis, control, regulation)	
	Water and sewage infrastructure	Water and sewage network	
		Sewage treatment	
	Water extraction and preparation, sewage treatment	Water extraction and preparation	
		Soil remediation	
		Soil protection technologies and remediation	Soil protection technologies
			Exhaust gas recirculation systems
		Noise mitigation and air cleaning technologies	Filter technology and catalytic converters
Noise mitigation in buildings			
Measurement technology and services			
Traffic noise mitigation			
	Wood processing and wood materials	Wood materials	
		Sawmill industry	
	Sustainable forest management	Forest management	
		Wood materials	
	Environmentally friendly technologies for farming	Green farming technologies	
		New types of farming	
	Organic and regional farming	Environmentally friendly livestock technologies	
		Organic and regional farming	

1.2 Innovations in the North Rhine-Westphalian Green Economy

In 2014, 19% of all German patents in the green economy were applied for in North Rhine-Westphalia. Together with Bavaria and Baden-Württemberg, North Rhine-Westphalia is in the top three innovation locations in Germany for patent applications. One of the greatest drivers of innovation in the green economy in North Rhine-Westphalia is the submarket **Materials, material efficiency and resource management**, with almost one quarter of green economy patents falling into this category. Equally rich inspiration for patents are the three submarkets **Green mobility, Water and sewage systems and management** (17% each) and **Energy efficiency and energy conservation** (14% for North Rhine-Westphalia).



In a global comparison, Germany and North Rhine-Westphalia apply for a higher than average number of patents in the green economy. North Rhine-Westphalia makes up around 2% (2014) of worldwide patents in the green economy. In total, around 11% (2014, [FIGURE 5](#)) of green economy patent applications worldwide come from Germany; this is 2.5% higher than the share of German patents in the economy overall. In terms of patent activity, Germany is the most innovative green economy location in Europe by a fair margin. Both in European and global competition, the green economy is proving to be one of the most exciting innovation fields in Germany. International research competition is increasing though with the strongest competition coming from technology leaders USA and Japan.

The innovations themes in the North Rhine-Westphalia green economy are extremely varied and demonstrate an entrepreneurial spirit oriented towards R&D. Besides individual innovations within the submarkets, many innovation themes are more horizontal and interdisciplinary in character. The big data analysis carried out for this report shows that **digitalisation** is above all the most significant driver of innovation. Precision farming, intelligent power networks, smart buildings, digital disposal logistics, comprehensive urban mobility management, Water 4.0 (intelligent water management), networked measurement sensors and the virtual forest – digital innovations feature in all submarkets. Arising more recently alongside digital technologies but different in their effect are innovative fields that more strongly address **systems thinking services**. Combining new knowledge into comprehensive customer-specific solutions is becoming ever more significant. Besides technologies, the new market players from the Information and Communications sector (ICT) are also important.

In the big data analysis, **new and intelligent materials** showed up as a further interdisciplinary innovation field. Intelligent material properties, their biogenic origin and their recyclability and management are important themes. Also significant in the field of innovation is the topic of **energy efficiency**, which has a strong presence in various submarkets. The best example are pumps that not only optimise water management properties but also reduce energy consumption.

1.3 International Markets in the Green Economy

The export business is of great significance to the green economy in North Rhine-Westphalia. Global demand is determined on the one hand by considerable backlog on international markets, e.g. for mitigation and restoration technologies, and on the other hand by enormous innovative efforts, for example in electromobility. For North Rhine-Westphalia this offers various opportunities for growth. The world market for green economy goods boasts a volume of 550 billion euros (2015). Looking back at the last 15 years, the green economy has shown above-average growth in comparison to the world market for all goods; in the first decade of the new century alone, the global export volume for the green economy doubled. **On average, the global export volume for green economy goods rose by 6% annually between 2000 and 2015, while the global export volume for all goods increased by only 4.9% p.a.**

The export rate for the North Rhine-Westphalia green economy is around 40% when construction and services are disregarded and only the turnovers generated from exportable green economy goods are taken as a basis. Including construction and services, the export rate for the green economy is 15.5%. For North Rhine-Westphalia, **secondary raw materials, railway vehicles and water infrastructures are the most important export goods in the green economy.** In 2016, the North Rhine-Westphalia green economy was responsible for 5.8% of all German exports (FIGURE 6) with an export volume of 10.4 billion euros.

From 2010 to 2016, the export volume of the North Rhine-Westphalia green economy rose annually as a whole by 1.5%, which was close to the increase in export volume for the economy as a whole in North Rhine-Westphalia (+1.9% p.a.). In the same period, the export volume for the green economy in Germany rose by a slightly higher 2.7% p.a., but this is considerably lower than the growth rate of 4% p.a. achieved by the German economy as a whole.

The five most important export destinations for the North Rhine-Westphalia green economy - the Netherlands, the United Kingdom, Belgium, France and Austria - are all members of the EU. Overall, over 69% of North Rhine-Westphalia green economy exports currently go to the EU. Trade with both neighbours to the west - the Netherlands (1st place) and Belgium (3rd place) - is dominated by products from the submarket Materials, material efficiency and resource management, in particular from the technology field Materials recycling (FIGURE 7). Exports to the United Kingdom have shown a particularly positive trend; these increased annually by 18.8% between 2010 and 2016 with the UK developing into the second most important sales market for the North Rhine-Westphalia green economy. This is particularly attributable to the submarket Green mobility, where export volumes to the UK increased more than tenfold between 2010 and 2016. Against this background, the Brexit negotiations are of great significance for the green economy in North Rhine-Westphalia.

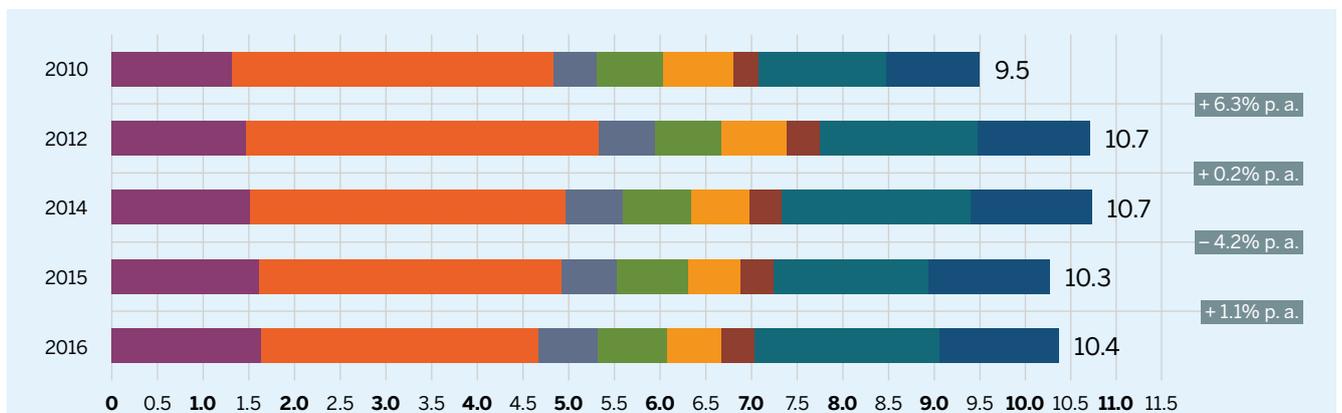


Figure 6: Export volumes from the North Rhine-Westphalia green economy (in billion euros) by submarket, 2010–2016, and development 2010–2016 (in grey)

Source: Destatis, own calculations Prognos 2017

EEC Energy efficiency and energy conservation **MER** Materials, material efficiency and resource management **PMT** Pollution monitoring, mitigation and restoration technologies **SFW** Sustainable forest management and wood industry **ETS** Environmentally friendly energy conversion, transportation and storage **EFF** Environmentally friendly farming **GMO** Green mobility **WSM** Water and sewage systems and management

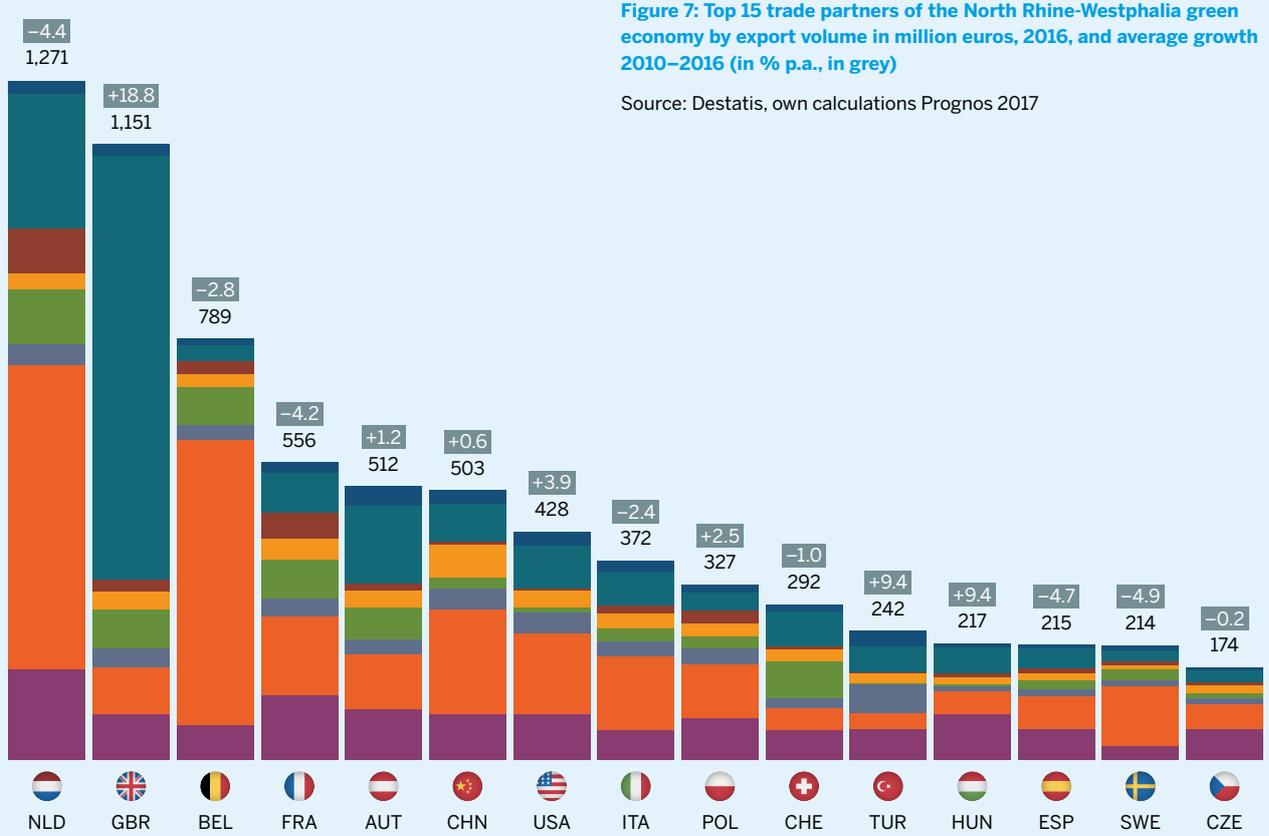


Figure 7: Top 15 trade partners of the North Rhine-Westphalia green economy by export volume in million euros, 2016, and average growth 2010–2016 (in % p.a., in grey)

Source: Destatis, own calculations Prognos 2017

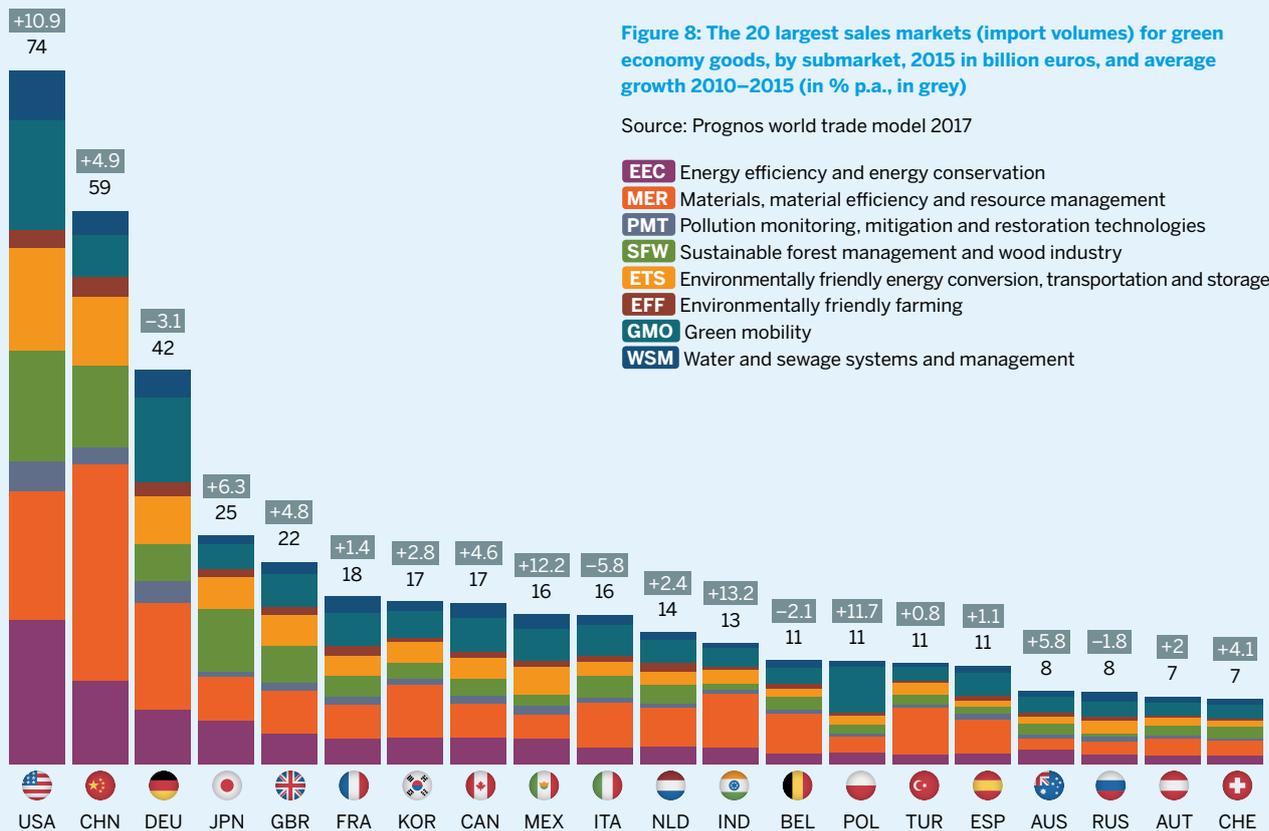


Figure 8: The 20 largest sales markets (import volumes) for green economy goods, by submarket, 2015 in billion euros, and average growth 2010–2015 (in % p.a., in grey)

Source: Prognos world trade model 2017

- EEC** Energy efficiency and energy conservation
- MER** Materials, material efficiency and resource management
- PMT** Pollution monitoring, mitigation and restoration technologies
- SFW** Sustainable forest management and wood industry
- ETS** Environmentally friendly energy conversion, transportation and storage
- EFF** Environmentally friendly farming
- GMO** Green mobility
- WSM** Water and sewage systems and management

The most important sales markets outside of Europe for green economy companies in North Rhine-Westphalia are China and the USA. While exports to China have remained stable at a high level in recent years (+0.6% p.a.), the USA has increased in importance as an export destination (+3.9% p.a.).

The United States significantly increased its imports of green economy goods between 2010 and 2015 by an average of 11% p.a. With an import volume of 74 billion euros

in 2015, the United States was at the same time the largest international sales market for green economy goods (FIGURE 8). In second place is China with an import volume of 59 billion euros. In third place is Germany with an import volume of 42 billion euros. The strongest growth rates for imports of green economy goods are shown by emerging markets such as Mexico and India (+12% and +13% p.a. between 2010 and 2015) and EU member Poland (+12%).

1.4 The Submarkets of the Green Economy

The green economy consists of eight submarkets, in turn divided into 23 market segments each with different technology fields. The following paragraphs provide a breakdown of key results by submarket.

The submarket **Environmentally friendly energy conversion, transportation and storage** is a digital powerhouse of ideas and factory for the energy transition. Turnover in this fifth largest submarket exceeded 10 billion euros in 2011, thus overtaking the second energy-oriented submarket Energy efficiency and energy conservation. Between 2010 and 2015, the submarket Environmentally friendly energy conversion, transportation and storage achieved an average growth rate of 5.9% p.a. with the overall turnover increasing to 12.7 billion euros annually. The number of employees has risen since 2010 by 1.9% p.a. to 37,000 in 2016. The primary focus here is the market segment *Renewable energies* with a total of 30,000 employees. The energy and industrial region of North Rhine-Westphalia demonstrates high levels of expertise in the development and production of components for renewable energy systems.

Important innovations here are adjustable rotor blades and optimised drives for wind energy plants. In solar technology, intelligent inverters are an important innovative trend. The digital revolution features strongly in the conversion of energy systems and networks with smart metering, load management and the introduction of the virtual power plant. Power-to-X and battery storage devices highlight the role of storage technology in the field of integrated energy.

The market segment *Renewable energies* is a driver of exports, with the most important export destination being China (61 million euros in 2016). France is in second place with an export volume of 40 million euros. With an expandable 32 million euros the USA is on fifth place. Overall in this submarket, a fall in the export rate from

8.1% to 4.5% could be observed. The global market share fell to 0.8%.

The most significant location in the submarket Environmentally friendly energy conversion, transportation and storage by turnover (4.7 billion euros, 2015) and employment (10,700 employed, 2016) is the Ruhr Metropolis. Measured by degree of specialisation, the Aachen region boasts a localisation quotient of 1.4. In the Bergische Städtedreieck region and Düsseldorf, the submarket is the strongest in terms of turnover.

Since 2010, the number of employees in the submarket **Energy efficiency and energy conservation** has risen by around 6,000 (+1.6% p.a.), so with 66,000 employees (2016) this continues to be the third largest of the eight submarkets. At the same time, it is most characterised by the skilled trades: 60% of employees in the submarket fall into the skilled trades, primarily in the market segment *Energy efficient buildings*. This market segment also saw the third largest absolute growth in all the submarkets with 3,500 new employees. A stronger employee growth rate was shown by the second market segment *Energy efficient production processes and technologies*, which is less characterised by the skilled trades (2.4 compared to 1.3% p.a.). With the high gross value added of 4.3 billion euros (2015), the submarket took third place in North Rhine-Westphalia. From 2010 to 2015, turnover increased by 1.5% p.a. to 10.6 billion euros, with the gross value added growing particularly strongly by 4.6% p.a. from 2010 to 2015.

The submarket's share of North Rhine-Westphalia patents for the green economy is 14%. Central to innovations are both tangible products and services and more generalised efficiency concepts like intelligent buildings. These bring together a wide spectrum of technologies. Many innovation themes are evidence of the many opportunities presented by the digital revolution. Particularly relevant

for companies in the industrial region of North Rhine-Westphalia are the innovation theme Industry 4.0 and the interdisciplinary energy topic of smart metering.

Between 2010 and 2016, the export volume of the submarket rose annually by 3.6%. The most important destination countries can be divided by export volume into two classes: the Netherlands and France with 168 and 121 million euros respectively, and a group comprising Austria, the USA, China, Hungary and Poland each with annual import volumes from North Rhine-Westphalia between 94 and 78 million euros (2015).

From a regional perspective, outstanding areas are Münsterland (7,300 employees, turnover 1,162 million euros), the Cologne/Bonn region (11,500 employees, turnover 1,845 million euros) and the Ruhr Metropolis (16,700 employees, turnover 2,751 million euros). Münsterland (1.21), the Aachen region (1.18) and Südwestfalen (1.2) demonstrate the highest levels of specialisation in this submarket.

In many respects, **Materials, material efficiency and resource management** tops the submarket rankings in North Rhine-Westphalia: in 2015, this submarket achieved the highest turnover with 22.1 billion euros and by far the largest gross value added of 9 billion euros. With 90,000 employees, the submarket comes above second-placed Green mobility, both in terms of employment and gross value added. At 1.4% p.a. overall, growth is not so impressive. However, the two market segments *Waste collection and transportation* and *Material-efficient production processes and technologies* showed positive trends with annual employment growth of 2.2% and 3.1% respectively (2010–2016).

Regarding its innovation contributions, the submarket leads the field with almost a quarter (23% in 2014) of all North Rhine-Westphalia patent applications in the green economy. North Rhine-Westphalia companies lead the way with innovative approaches to classic recycling issues and innovative materials. Technical developments increasingly focus on creating a circular economy that enables closed material loops. In the Ruhr Metropolis, the focus of innovation is to bring the circular economy as a topic more clearly into public perception. In the field of recycling, the focus of innovation is on sorting and separating techniques. Companies are developing new procedures for the technically demanding recycling of composite materials, lightweight construction materials and components like solar modules for the renewable energies industry. Alongside this, innovative materials and surfaces are prominent themes for companies in the submarket. The multifunctional and “thinking” properties of materials as well as bio-based materials and composites are taking centre stage here.

Between 2010 and 2016, exports from this submarket were subject to significant fluctuations. The share of the global market fell by 0.3% to 2.5% and the export rate by 16.5% to 15.0%. As secondary raw materials gained from the materials recycling technology field, iron, steel and copper demonstrated a high export volume in the market segment, especially in the Netherlands and Belgium (488 and 490 million euros respectively in 2016). However, this was closely related in the export trade to price movements on the international primary products markets.

In this submarket, the most outstanding locations were the Ruhr Metropolis (27,900 employed in 2016, turnover 9.5 billion euros in 2015), the Cologne/Bonn region (11,800 employed in 2016, turnover 3.3 billion euros in 2015), Ostwestfalen-Lippe (10,300 employed in 2016, turnover 1.4 billion euros in 2015) and Niederrhein (10,200 employed in 2016, turnover 3 billion euros 2015).

Green mobility is developing at great speed into a focus of the North Rhine-Westphalia green economy. Between 2010 and 2016, the number of employees increased by 12,000 (+2.8% p.a.) to around 81,000. The majority of growth was generated by the market segment *Intelligent traffic management systems and infrastructure*, where the number of employees increased by 5,000 to 12,000 (+11% p.a., 2010–2016) and has therefore almost doubled. The market segment *Environmentally friendly logistics and mobility services* likewise grew by 5,000 to 57,000 employees (+1.6% p.a., 2010–2016), making it the green economy market segment with the highest number of employees.

With a gross value added of 4.6 billion euros (2015), the submarket takes second place in North Rhine-Westphalia. Particularly significant here is the market segment *Environmentally friendly logistics and mobility services* (gross value added 2.9 billion euros, turnover 4.3 billion euros). Public transport also plays a prominent role here.

Particular drivers of innovation are e-vehicles and intermodal mobility and logistics systems (intermodal transport), e.g. the StreetScooter and innovative mobility apps. 17% of all patent applications in the North Rhine-Westphalia green economy are in this submarket. Companies and research facilities work on developing battery technology, on new configurations for engines close to wheels and wheel hubs, on modular drive trains and on fuel cells and hydrogen technology. Some innovations concentrate on logistics and delivery services within the “last mile” to the end consumer and the e-vehicles required for these deliveries. Overriding innovation themes are digital solutions in the fields of mobility and logistics (Smart Mobility) and concepts for CO₂-free supply chains.

With vigorous growth in exports of 6.4% p.a. since 2010 to 2.02 billion euros (2016), the submarket is among the strongest exporters in the state. The most significant driver of growth has been the export of railway vehicles, particularly because of large individual orders from the United Kingdom. Between 2010 and 2016, this export volume rose by 7.3% p.a., twice as quickly as in Germany overall (+3% p.a.). The global market share of the submarket is 1.1% and the export rate is 20.1%.

The most significant locations are the Bergische Städtedreieck region (3,400 employees, turnover 88 million euros), the Ruhr Metropolis (28,400 employees, turnover 3.351 billion euros) and the Cologne/Bonn region (17,200 employees, turnover 1.957 billion euros).

In **Water and sewage systems and management**, employment figures remain comparatively stable at a very high level (2016: 53,000 employees) with slight growth (+0.3% p.a., 2010–2016). However, gross value added grew between 2010 and 2015 by 2.4% p.a. The annual turnover fell by 1.5% per year to 5.2 billion euros (2015), attributable primarily to turnover reductions in the market segment *Water extraction and preparation, sewage treatment* (-8.4% p.a.).

Important areas of innovation fields in Water and sewage systems and management are modern sewage treatment procedures such as the fourth cleaning stage, phosphorus recovery and ozonation. Advanced membrane and nanotechnologies and ultrafiltration are also extremely significant. A quarter of innovations in Water and sewage systems and management relate to Energy and resource efficiency, where there is still room for improvement, for example with pumps. The submarket's share of green economy patents is 17%.

The global market share fell by 0.5% from 2010 to 2015 to 3.2%; in the same period, the export rate rose by 7.4% to 25.5%. Exports concentrate on EU member states Austria, the Netherlands, Italy and the United Kingdom, as well as non-EU members Turkey, USA and Russia. While exports to Austria are primarily from the market segment *Water and sewage infrastructure*, exports to the USA, Turkey and China are primarily from the market segment *Water extraction and preparation, sewage treatment*.

By degree of specialisation, the most important locations for Water and sewage systems and management are the Ruhr Metropolis at 1.23 (16,600 employed, turnover 1.445 billion euros) and Münsterland at 1.15 (5,700 employed, turnover 582 million euros), while the Cologne/Bonn region is in second place by number of employees (9,800 employees, turnover 870 million euros).

Regarding turnover (+5.5% p.a. 2010–2015 to 1.9 billion euros) and gross value added (+4.2% p.a.), the submarket **Pollution monitoring, mitigation and restoration technologies** gives the best overall picture and is the only submarket in the North Rhine-Westphalia green economy that showed continuous and sustained turnover growth from 2010 to 2015. With a very vigorous growth in turnover of 12% p.a., the market segment *Noise mitigation and clean air technologies* shows the strongest growth rate of all market segments in the North Rhine-Westphalia green economy. The number of employees in the submarket overall has risen by 1.6% p.a. to 10,000 in 2016.

The submarket's share of green economy patent applications is 5%. New solutions in the field of *Noise mitigation and air cleaning technologies* dominate the innovation scene. Outstanding developments include innovative filters made from glass and nanofibres and metal filter textiles. The digital revolution and the increase in energy efficiency are significant factors for new developments in ventilation engineering. In soil remediation, companies from North Rhine-Westphalia contribute to greater precision and better practicability in soil analysis with innovative measurement technologies (LIF and EC sensors).

The export volume rose sharply by 5.2% p.a. although the global market share fell by 2.6% p.a. At 31.4%, the export share remains top among the submarkets, just ahead of Environmentally friendly farming. The market segment *Noise mitigation and air cleaning technologies* is the clear leader for exports. North Rhine-Westphalia long-established expertise as an industrial region is expanded with determination in the field of Pollution monitoring, mitigation and restoration technologies. In this submarket, most North Rhine-Westphalia exports currently go to Turkey. With an export volume of 54 million euros, this exceeds exports to the USA (39 million euros) and China (41 million euros). Also in the top group are western EU countries including the Netherlands (41 million euros), France (34 million euros) and the United Kingdom (34 million euros).

The most important locations for Pollution monitoring, mitigation and restoration technologies are the Ruhr Metropolis with 3,000 employees (2016) and turnover of 474 million euros (2015) and the Cologne/Bonn region (2,300, 444 million euros). By turnover, the Südwestfalen region takes third place with only 600 employees (2016) but turnover of 259 million euros (2015).

In the submarket **Sustainable forest management and wood industry**, North Rhine-Westphalia focuses on the development of new construction materials made from hard and soft woods. Wood is one of the most versatile materials and has outstanding properties. Predominantly

in Niederrhein, Ostwestfalen-Lippe and Münsterland, companies offer new processing forms for the natural raw material. Examples are products made from hardwood and hardwood hybrids, wood composite materials and biogenic construction and insulation materials with a wood base. The development of digital forest management concepts optimises the sustainable management of woodland. In the submarket, employment has an annual growth of 0.3% on the 2010 level of around 22,000 employees. However, with 3,500 employees, the smallest market segment *Sustainable forest management* has generated an annual workforce growth of 2.7% since 2010. Gross value added in the submarket rose by 1.9% p.a. (2010–2015) to 1.6 billion euros.

In North Rhine-Westphalia, the submarket is comparatively innovative with a share of 11% of patent applications in the green economy compared to 7% in Germany as a whole. The export rate remains a stable 19%. The Netherlands is the most important buyer country.

The locations of the submarket are concentrated – just like the North Rhine-Westphalia forests – in the three regions Münsterland, Südwestfalen and Ostwestfalen-Lippe with 4,400, 6,000 and 6,300 employees respectively (2016).

In the smallest submarket **Environmentally friendly farming**, North Rhine-Westphalia is setting standards in digital agricultural engineering. The submarket as a whole has demonstrated high growth rates with the number of employees rising by 2.3% p.a. from 2010 to 2016 to 8,000. With annual growth of 5% (2010–2015), turnover is showing a particularly positive trend. The two market segments *Environmentally friendly technologies for agriculture* and *Environmentally friendly and regional agriculture* were able to make more or less equal gains.

In comparison to the rest of Germany, North Rhine-Westphalia shows above average levels of innovation. More than 20% of patents applied for across Germany in this submarket originate here. These innovations are mostly features of the digital revolution. The focus here is on various sensor-supported technologies, for example to enable the spreading of fertilising according to need. Apart from technical topics, farmers in North Rhine-Westphalia also intensively tackle alternative cultivation methods.

The export rate in the submarket rose to 30.8% and is now just 0.6% behind that of the submarket Pollution monitoring, mitigation and restoration technologies. The Netherlands and France are the two most important importers (85 million euros and 49 million euros respectively, 2016); following in third and fourth places are Poland and Belgium (26 and 24 million euros, 2016).

Like Sustainable forest management, the submarket is concentrated in certain regions: the Cologne/Bonn region with 1,000 employees (2016) and turnover of 84 million euros (2015), Münsterland (1,200 and 308 million euros), Ostwestfalen-Lippe (1,300 and 354 million euros) and Niederrhein (1,400 and 140 million euros). The significantly higher per-head turnover of the submarket in Münsterland and Ostwestfalen-Lippe can be attributed to the strong green agricultural technology sectors in these regions.

1.5 The Green Economy in the Regions

With 10,200 employees (2016) and turnover of 0.8 billion euros (2015), the **Bergische Städtedreieck** region is the smallest green economy region in North Rhine-Westphalia. Around 33% of these employees (2016) fall into the submarket Green mobility - in no other region does a submarket achieve so dominant a position. The highest turnovers are generated by the submarkets Environmentally friendly energy conversion and Energy efficiency and energy conservation (with 193 and 191 million euros respectively of 819 million euros of overall turnover in the green economy). The region also has outstanding expertise in the submarket Materials, material efficiency and resource management, for example in the field of surfaces technology.

With a total of around 106,000 employees, the **Ruhr Metropolis** is the largest green economy region in North Rhine-Westphalia with almost one third (29%) of employees. With turnover of 22.7 billion euros (2015), the region also generates almost one third of the overall turnover in the North Rhine-Westphalia green economy. In the Metropolis region, the submarket Green mobility is particularly strong with 28,000 employees. Almost the same size is the submarket Materials, material efficiency and resource management. The region has outstanding innovative skills, particularly in topics such as materials, energy systems and electromobility.

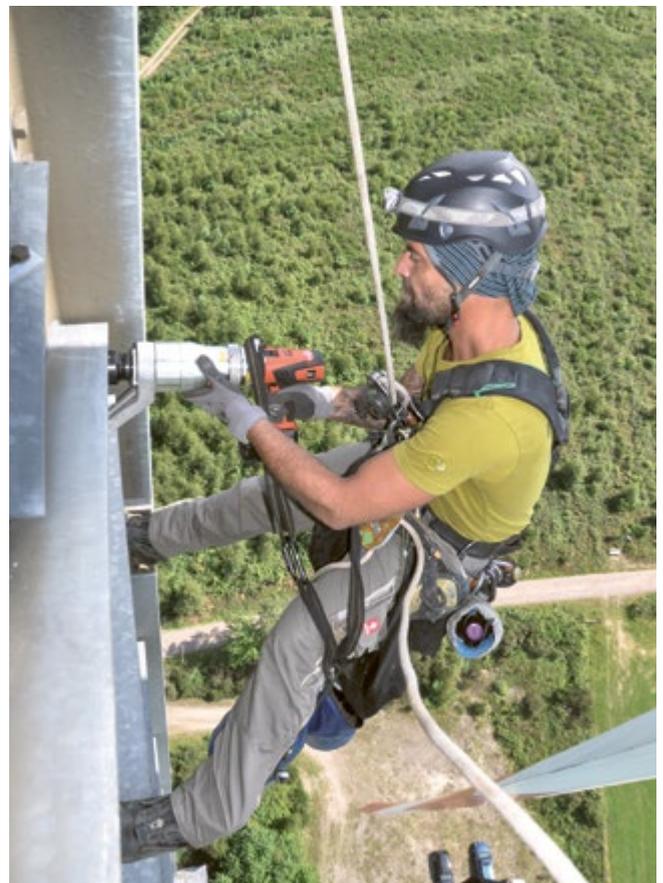
In **Münsterland**, the green economy has shown employment growth of 2.1% p.a. since 2010 with 33,100 employees (2016). The region likewise features a very broad composition with over 3,000 employees in six of the eight submarkets and the region well represented in the remaining two. Innovative skills lie primarily in energy storage research and wind energy. The market segment *Technology for waste management* also achieves a very high degree of specialisation. Furthermore, Münsterland is the home of leading research institutions and companies in the field of environmentally friendly materials, for example renewable primary products and technical textiles. The region demonstrates a high level of specialism in Environmentally friendly farming, with the technology field Green agricultural technologies in particular providing approaches to precision farming systems.

In **Niederrhein**, 31,500 employees are active in the green economy (2016). One third of these employees work in the submarket Materials, material efficiency and resource management, which generates almost 54% of all turnover in the green economy in the region (3.1 of 5.6 billion euros, 2015). Niederrhein is an export leader in North Rhine-Westphalia, for example for its strong railway vehicle sector. Employment in the overriding submarket Green mo-

bility rose between 2010 and 2016 by 7.9%, a record in North Rhine-Westphalia. Another clear focus in the region is the submarket Environmentally friendly farming.

Ostwestfalen-Lippe has 44,200 employees (2016) in the green economy and is therefore the third largest green economy location. As in Münsterland, companies are well represented in all submarkets, in six of them particularly strongly. The region can demonstrate outstanding skills in the submarkets Energy efficiency and energy conservation and Materials, material efficiency and resource management. With around 7,700 and 10,300 employees (2016) respectively, these are the largest green economy submarkets in the region, together generating around 3 billion euros of turnover (2015). Ostwestfalen-Lippe has outstanding expertise, for example in Industry 4.0 and in precision farming.

The **Aachen region** focuses on the two energy oriented submarkets and Green mobility. The submarkets Energy efficiency and energy conservation and Environmentally friendly energy conversion, transportation and storage together amount to around 35% of employees and around



Tools for screw joints on wind energy plant are a speciality of PLARAD (Maschinenfabrik Wagner GmbH & Co. KG) from Much in Rhein-Sieg-Kreis.



From start-up to OEM: Founded in 2010 at RWTH Aachen, the manufacturer of delivery e-vehicles StreetScooter had brought 4,450 e-vehicles onto the streets by September 2017.

45% of turnover in the region's green economy (8,100 of 23,500 employees and 1.2 of 2.8 billion euros of turnover). In the market segment *Intelligent energy systems and grids*, the number of employees rose by 7% annually from 2010 to 2016, which can be attributed to the strength of the research facilities in the region. As indicated by successful outsourcing from the RWTH Aachen, the submarket Green mobility is developing into another significant submarket.

With 22,500 employees (2016) in the green economy, the **Düsseldorf region** takes eighth place in the region but generates a comparatively high 6.6 billion euros of turnover (2015). The highest turnover in the Düsseldorf region is achieved by the submarket Environmentally friendly energy conversion, transportation and storage with 3 billion euros. Within North Rhine-Westphalia, the region boasts particularly high patent density as well as sectoral skills in the ICT field. As regards employment figures, the submarkets Green mobility and Materials, material efficiency and resource management predominate with 26% and 25% of employees respectively.

With nearly 62,000 employees (2016), the **Cologne/Bonn region** is the second largest green economy location in North Rhine-Westphalia. The economically successful region demonstrates cross-sectoral growth of 2.4% p.a. (2010–2016). The largest submarket is Green mobility with 17,200 employees (2016). The highest turnover is attributed to the submarket Materials, material efficiency

and resource management (3.3 billion euros, 2015). The many and varied innovations in the region are features of the market segment *Intelligent traffic management systems and infrastructure* and the technology field Environmentally friendly materials in resource management, as well as new filter technologies in the submarket Pollution monitoring, mitigation and restoration technologies.

In **Südwestfalen**, 9.6% of employees work in the green economy. With 35,300 employees, the region therefore takes first place in North Rhine-Westphalia. Characteristic of Südwestfalen is the submarket Materials, material efficiency and resource management, which generates around 1.4 billion euros of turnover with 28% of employees in the Südwestfalen green economy. Particular skills lie in energy efficient buildings, refuse vehicles and sorting technology for waste management and wood construction materials. The market segment *Sustainable forest management* also shows above average growth (+3.2%) in the number of employees.

The Green Economy Strategy for North Rhine-Westphalia

The Green Economy Report for North Rhine-Westphalia is a central component in the state's green economy strategy. On the basis of detailed data, it analyses comprehensively the situation, opportunities and prospects of the interdisciplinary sector in North Rhine-Westphalia – and present facts and stimuli for the development of the green economy in the state.

Despite its huge economic significance, the green economy is a work in progress. Its companies have yet to develop a consistent sector identity in line with this significance so it does not yet fully exploit the great potential for synergy within interdisciplinary cooperation, joint export trade arrangements or the development of its own start-up culture. North Rhine-Westphalia companies must be supported in opening up the great potential of the green economy for themselves and for North Rhine-Westphalia, expanding this and establishing the green economy as a central growth factor for a modern industrial and service-oriented society.

The first steps along this path have already been taken: the **North Rhine-Westphalia Green Economy Report 2015** analysed for the first time the performance and potential of the local green economy and provided a stimulus to identify initial approaches to strengthen the green economy. Building on this, **nine economic forums and nine location forums** took place between 2015 and 2016 at the most important green economy locations in North Rhine-Westphalia. Around 800 stakeholders from the local and regional economic landscape took part in this consultation process in working groups that tackled the prospects, opportunities and limitations in the regions and submarkets of the green economy.

The North Rhine-Westphalia **Green Economy Masterplan** presented in 2017 built on the first Green Economy Report, brought together the findings of the consultation process and outlined around 100 concrete measures, project ideas and recommendations in the following five fields of action: Innovation promotion, Market development and internationalisation, Consultancy and networking, Specialist staff and Frameworks and standardisation. The focus was on the potential to be found in the further development of sector structures and in particular the individual submarkets of the green economy.

It was with this in mind that the **Kompetenznetzwerk Umweltwirtschaft.NRW (KNUW)** [Green economy competence network] began its work in 2017. Its task is to drive forward the green economy with suitable measures in the fields of innovation promotion, international markets, network expansion and communication, communicating outwardly and providing a network manager for representatives from companies, research, associations and economic developers.

The **North Rhine-Westphalia Green Economy Report 2017** represents a further milestone along this path. The report presents detailed monitoring of the green economy in North Rhine-Westphalia since 2010 and provides information in the key areas of innovation and internationalisation to further develop its potential.



Presentation of around 100 measures in the NRW Green Economy Masterplan in February 2017 in Düsseldorf.

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