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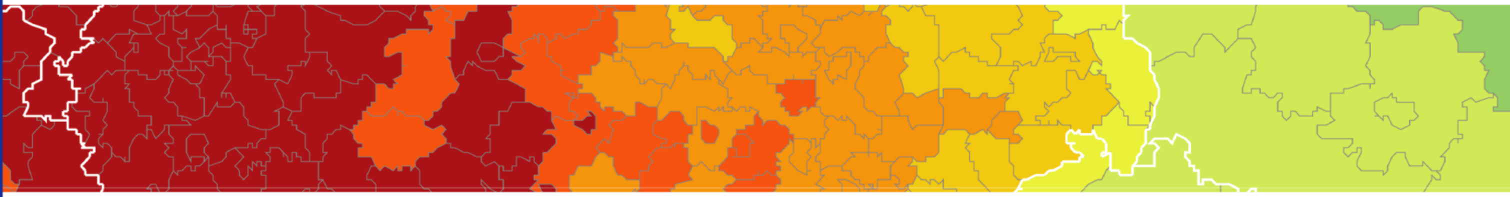

CIRCTER – Circular Economy and Territorial Consequences

Applied Research

Final Report

Annex 4

A sectoral characterization of regional circular economies in Europe

Version 09/05/2019

Final Report

This applied research activity is conducted within the framework of the ESPON 2020 Cooperation Programme, partly financed by the European Regional Development Fund.

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.

This delivery does not necessarily reflect the opinion of the members of the ESPON 2020 Monitoring Committee.

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Contact: info@espon.eu

ISBN: 978-99959-55-70-0

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Abbreviations

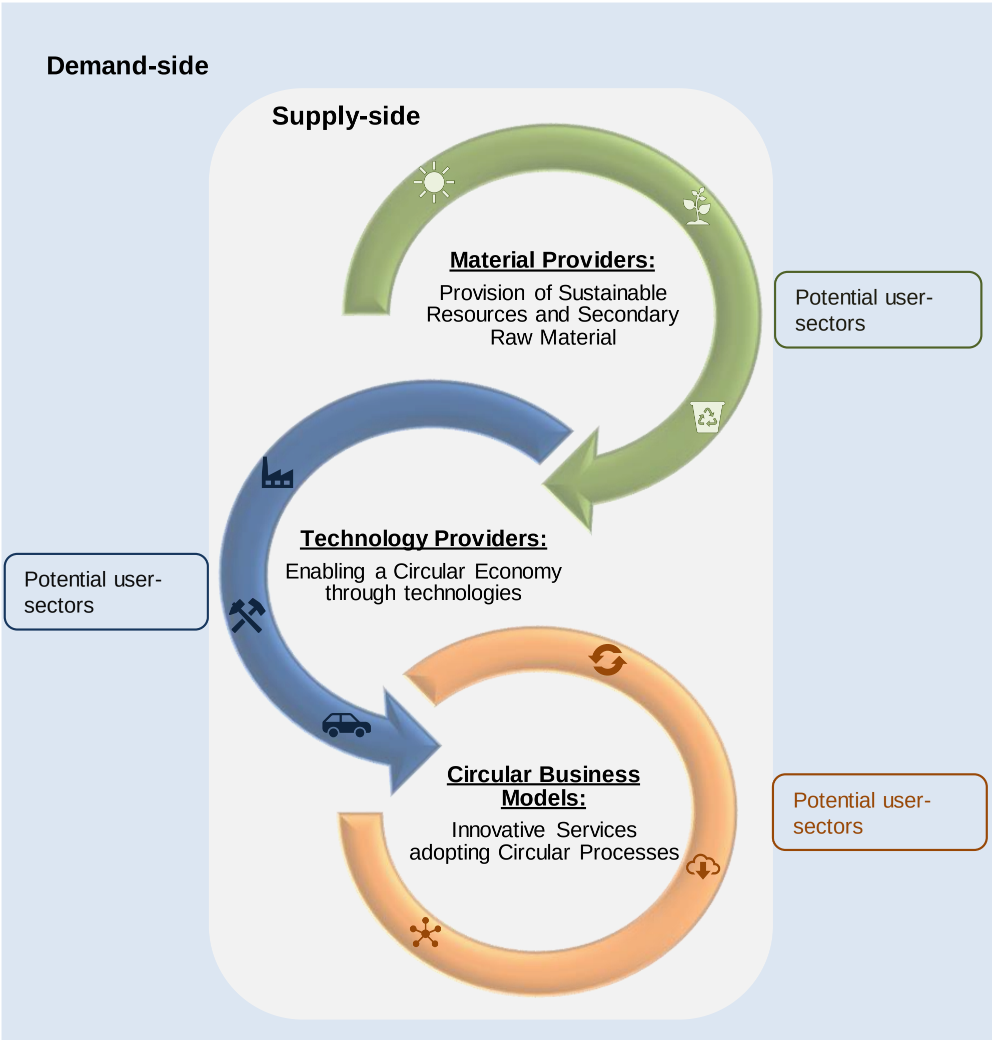
B2B	business-to-business
B2C	Business to Consumer
C2C	Consumer to Consumer
CBM	Circular Business Model
CDC	Caisse des dépôts et consignations
CE	Circular Economy
CEAP	Circular Economy Action Plan
CER	European Remanufacturing Council
CLD	Causal Loop Diagram
DE	Domestic Extraction
DMC	Domestic Material Consumption
DMI	Direct Material Input
EC	European Commission
EEA	European Environmental Agency
EFTA	European Free Trade Area
EMAS	European Monitoring and Audit Scheme
EMF	Ellen MacArthur Foundation
EPR	Extended Producer Responsibility
ERDF	European Regional Development Fund
ESPON	European Territorial Observatory Network
EU	European Union
GDP	Gross Domestic Product
GPP	Green Public Procurement
GWR	Geographically Weighted Regression
JRC	Joint Research Centre
IS	Industrial Symbiosis
LMM	Last Minute Market
MBT	Mechanical-Biological Treatment
MFA	Material Flow Analysis
MS	Member States
MSW	Municipal Solid Waste
NACE	Nomenclature of Economic Activities
NUTS	Nomenclature of Territorial Units for Statistics
OLS	Ordinary Least Squares/Linear Regression
OVAM	Public Waste Agency of Flanders
P2B	Peer-to-business
P2P	Peer-to-peer
PPP	Purchasing Power Parity
PWI	Prognos-Web-Intelligence Tool
RMC	Raw Material Consumption
RMI	Raw Material Input
ResCoM	Resource Conservative Manufacturing
SME	Small and Medium Enterprises
RIS3	Regional Innovation Strategies for Smart Specialisation
ToR	Terms of Reference
WEEE	Waste from Electrical and Electronic Equipment

1 Introduction: A sectoral perspective of a Circular Economy

1.1 Sectoral conceptualisation of a Circular Economy

A circular economy (CE) is restorative and regenerative by design. Companies following these principles as part of their business models aim to maintain the value of materials, components and products as long as possible, while reducing the amount of waste generation. A circular economy increasingly decouples economic activity from the exploitation and dependency on finite resources whilst reducing environmental pressures associated with material use. Looking beyond the take-make-dispose model entails a genuine shift in perspective towards the use of sustainable raw materials and closed material loops by recycling and reusing products and materials. This implies finding novel ways of measuring, aggregating and analysing such economic activities from a sectoral perspective.

Figure 1-1: A conceptual visualisation of the four pillars of a Circular Economy and their respective sectors



Source: Prognos AG, own elaboration 2018

The sectoral definition established in the CIRCTER project captures the direct and indirect effects of identified sectors contributing to a Circular Economy and identifies the value chains involved in the transition from a linear towards a circular economy. The sectoral analysis in this annex is conducted at the regional scale (NUTS 2). The regional scale allows assessing also its territorial implications, be they economic, environmental or social. The CIRCTER sectoral definition of a Circular Economy provides a basis for such an analysis by differentiating between the supply-side and demand-side of the economy (Figure 1-1). The supply side is defined as the provision of materials, technologies and services for a CE. It is represented by the Material Providers, Technology Providers and Circular Business Models. The demand-side is defined as selected industries that adopt or rather demand new circular business processes, products and technologies that drive their uptake. These are referred to as Potential Users. They provide important opportunities for innovative processes and products to be introduced into value chains.

Circular Material Providers, Circular Technology Providers and Circular Business Models are pillars of a Circular Economy which are associated with the supply-side. The Circular Economy definition is aligned with the concept established by the Ellen MacArthur Foundation (2013), where Circular Material Providers represent the biological cycles, and Technology Providers the technical cycles.

Circular Material Providers in a Circular Economy represent mainly the biological cycles but also those essential services that reintroduce wastes as a resource into existing value chains. Simply put, Circular Material Providers form the basic input-side by providing materials for a Circular Economy that are comprised of renewable and recycled materials. Illustrative are the market segments forestry, sustainable agriculture and renewable energy along with the production of high-quality secondary raw materials from wastes, that is the collection and recycling services. Table 2-2 provides an overview of the economic activities that are included in the Cicular Material Providers.

Technology Providers provide technologies and key services that enable cyclical resource flows and more efficient use. They also provide intermediate products representing the technological cycle and, in many ways, enable the implementation of Circular Economy processes through innovative technologies and resource-saving services throughout the value chain. Technology Providers’ contribution to value generation is to recover and restore materials, components and products through the provision of technologies and services that aid the reuse, repair, recycling and remanufacture of durables and turn wastes into resources. In so doing they provide necessary technologies also for the operation of the Ciruclar Material Providers. Circular Technology Providers include the production of consumables from Eco-friendly materials, such as natural fibres, bio-plastics or composite materials, or technologies for the generation of renewable raw materials or energy, as well as installations and machinery for the treatment of material streams. Table 2-3 provides an overview of the economic activities that are included within the Circular Technology Providers.

Table 1-1: The four overarching Circular Business Models

CE Business Model	Description	Contribution to a CE	Examples
Long Life Design	Models focused on delivering long-life-products, supporting design for durability and repair.	▪ Supporting long-life-products through design for repair, refurbishment and remanufacturing – focus on product design. ▪ Essential part of the company's normal design ethos, often linked to the concept of eco-design and geared towards disassembly.	Modular Design, Cradle-to-Cradle Design, Eco-Design
Extending Product and Resource Value	Exploiting residual value of products.	▪ Exploiting the residual value of products. ▪ Collecting and reselling refurbished products and / or components. ▪ Often reffered to as ‚closing the loop'.	Remanufacturing, refurbishment, upcycle, take-back systems
Encourage sufficiency and shifting utilisation patterns	Seeking to reduce end-user consumption and delivering utilities virtually rather than materially	▪ Supporting sufficiency and shifting utilisation patterns – focus on consumers. ▪ Digitising business products and services. ▪ Shift in demand patterns through technology as consumers choose virtual products or services	Pay-per-Service, Re-commerce, reuse cafés
Access, Sharing and Performance Model	Providing the capacity of services to satisfy user needs without needing to own physical products	▪ Manufacturer or service provider retains ownership of the product. ▪ Sharing models seeking to reduce under-utilisation of products, facilitated by digital technology and social platforms.	Car-sharing, Carpooling, tool sharing, office shares

Source: Prognos AG, own elaboration 2018[1]

Transitioning from a linear economy towards a circular economy requires not only a shift in the materials used and technologies provided, but also a systemic change in the way materials, components and products are offered and consumed. Circular Business Models (CBM) facilitate the up-take of circular processes through innovative services and new forms of consumption by connecting businesses to businesses (B2B), businesses to consumers (B2C) and consumers to consumers (C2C). Four overarching Business Model concepts have been identified and are briefly described in the table below (Table 1-1). The CBMs can be categorised as focusing either on consumers or on products but are not mutually exclusive. Primarily focusing on consumers are the Business Models *Access and Performance models*, that provide products as a service, and *Encourage sufficiency and shift utilisation patterns*, that seek to reduce end-user consumption. Targeted at products are the Models *Extending Product and Resource Value* by exploiting the residual value of products, and *Long-Life Design*, focused on a design for durability, repair and material productivity.

Finally, the Potential Users are industries that adopt or rather demand new methods, products and technologies - their needs and choices tend to foretell the needs and choices of the general market. Potential Users represents the demand side in this analysis. Potential Users provide important opportunities for innovative processes and products to be introduced into their own value chains. The primary focus for the analysis of the Potential Users, therefore, is focused on the uptake of Circular Economy processes at the sectoral level.

1 Based on Prendeville, et al. (2015)*: Design for Remanufacturing and Circular Business Models.* Delft University of Technology, NL.

2 Methodology: an overview of models and data sources for the sectoral analysis

The following table summarizes the principle databases, methodological approach, model and level of data used in each of the four pillars.

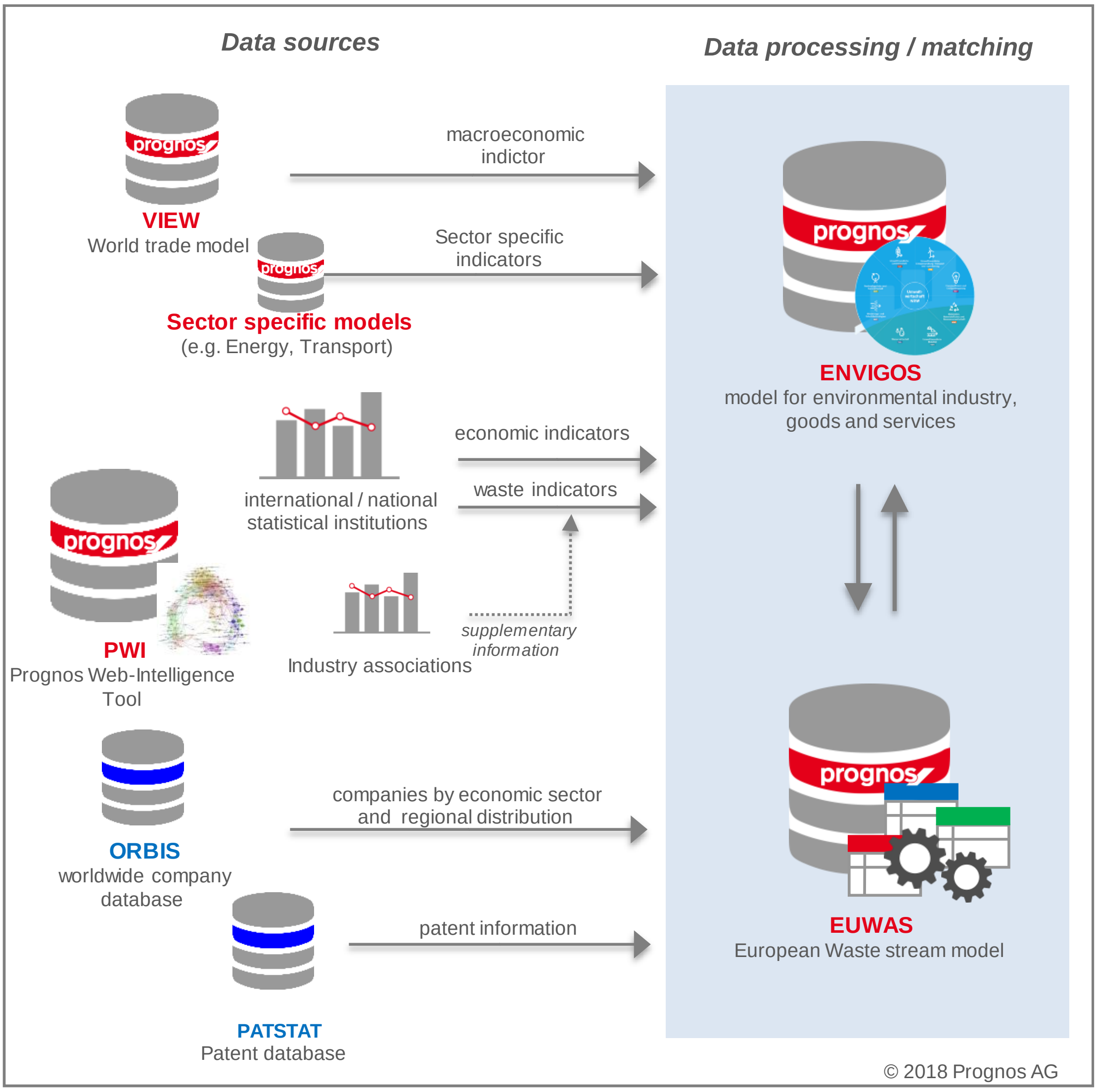
Table 2-1: Data source, methodological approach and output of the four pillars

Pillar	Data source	Description of approach	Regionalisation	Output
Material Providers	Eurostat	Relevant sectors identified according to envigos model at NACE 4-5 level. Shares of identified sectors based upon national characteristics and envigos model.	Basis NUTS 2 NACE 2, regionalised based on employment NUTS 0 NACE 4 Level. For Turnover basis is NUTS 0 NACE 2.	Material Providers NUTS 2 figures for: employment, turnover, local units.
Technology Providers	Eurostat	Relevant sectors identified according to envigos model 4-5 level. Shares of identified sectors based upon envigos model.	Basis NUTS 2 NACE 2, regionalised based on employment NUTS 0 NACE 4 Level. For Turnover basis is NUTS 0 NACE 2.	Technology Providers NUTS 2 figures for: employment, turnover, local units
Circular Business Models	Orbis + Prognos-Web-Intelligence Tool	Relevant terminology identified relating to overarching Circular Business Model categories. Used to identify Companies based on trade description/BvD description on Orbis. Big Data Analysis based on crawling domains of identified companies	Aggregated employment and turnover data of identified companies.	Circular Business Models NUTS 2 figures for: employment and turnover. Thematic strengths of Circular Business Model Categories.
Potential Users	Eurostat, ProdCom, European mineral statistics, BVSE, Orbis	Regional shares for renewable energy and material used by selected key sectors	Basis NUTS 2 NACE 2 (selected key sectors), regionalized based on concentration index using Orbis data (revenues by region)	Regionalised shares for renewable energy and metals used based on Concentration Index calculated using revenues by Orbis

Source: Prognos AG, own elaboration 2018

The sectoral analysis is based on a combination of different models and analytical tools. The chapter provides an overview of the most important models and their interactions, followed by a description of the methodological approaches applied. Results may deviate according to the database source and differences in methodological definitions of indicators. Due to the complexity of the data request, statistical data of Eurostat was chosen. In contrast, the pillars 3 and 4 are based on the Orbis company database with aggregated information at regional level. Due to differences in their methodologies, the data of Eurostat is not directly comparable to that of Orbis.

Figure 2-1: Data sources and methods used for the conceptual model of a Circular Economy



Source: Prognos AG, own elaboration 2018

2.1 Circular Material and Technology Providers:

2.1.1 Sectoral delimitation process

In order to analyse the Circular Material and Technology Providers, economic activities had to be identified based on their contribution to a Circular Economy. Prognos has developed the *envigos©* model, which sets out goods and services that are fundamental to sectors of a Green Economy and thus elements of the Circular Economy. It arranges relevant sectors and goods and anchors them to central data sources structured according to the economic NACE Rev. 2 (2008) classification and various other classifications of goods (e.g. ProdCom).

The *envigos* model provides the basis for the identification of relevant economic sectors that are aligned with the definitions of the Circular Material Providers and Circular Technology Providers. The model works at a very precise level, informing the CIRCTER model at the fourth NACE level (four-digit numerical code, known also as classes) (Prognos 2015 and 2017). The resulting sectoral selection is summarised in the tables below at NACE second level. Respective shares of the identified NACE at second level were derived from the disaggregation of NACE second level to the fourth level, the *envigos* model and national characteristics for selected NACE (see Section 2 for further explanations).

NACE Classification Codes relevant to Circular Material Providers embody respective products and services, based on the definition as set out on Section 2. The table below structures the Material Providers by sector and market segment along with illustrative examples of relevant products and services and the relevant NACE Codes.

Table 2-2: List of the sectors and market segments of the Circular Material Providers with illustrative products and services

Sector	Market segment	Examples of relevant products/services	Classification (NACE, where applicable)
Sustainable Agriculture and Forestry	Organic Farming	Organic agricultural products (e.g. wheat) and livestock (e.g. beef)	Shares* of NACE A01
	Sustainable forestry	Sustainable forestry and logging, forest stocktaking, forestry consulting services, fire-fighting and protection, pest control	Shares* of NACE A02
	Wood materials	Provision of wood-based material from the sawmill, planning and wood impregnation industry and wood-based materials which are a direct product of the sawmill industry, substitution by wood in the construction sector	Shares* of NACE C16
Waste Collection and Recycling Services	Waste collection and treatment	Recovery of sorted materials, collection of recyclable materials	Shares* of NACE E38
	Energy recovery	Landfill gas	Shares* of NACE E35
	Material recovery	Paper/metal recycling within the paper/basic metal manufacturing industry	Shares* of NACE C17, C22, C24, S95
Renewable Energy	Bioenergy, geothermal, solar, hydropower, windpower	Renewable energy provision from bioenergy, hydropower	Shares* of NACE A01, C16, E35
	Network expansion and operation	Electro-installations and powerlines for renewa-ble energy	Shares* of NACE C33, E35, F42, M71

Source: Prognos AG, own elaboration 2018
**Shares refers to a portion and the sums of portions of sectors (NACE) according the methodology outlined below.*

NACE Classification Codes relevant to Circular Technology Providers are also respective of products and services related to the definition of Section 2. The table below structures the Circular Technology Provider by sector and market segment along with illustrative examples of relevant products and services included in the market segment.

Table 2-3: List of the sectors and market segments of the Circular Technology Providers with illustrative products and services

Sector	Market segment	Examples of relevant products/services	Classification (NACE, where applicable)
Agricultural Technology	Sustainable agricultural technologies	Ecological fertilizer, pesticides, energy saving technologies in livestock farming, animal friendly technologies, R&D	Shares* of NACE C10, C13, C20, C33, M72
Eco-friendly Materials	Materials from renewables raw materials	Natural fibres, natural dyes and varnishes, bioplastics, natural fibre-reinforced plastics, composite materials, natural cosmetics and cleaning products	Shares* of NACE A01, C20 and C23
Waste Management Technology	Waste processing technology	Components and instruments for treatment plants, instruments for waste analysis, equipment for agglomeration, pelleting, pressing and mixing of waste	Shares* of NACE C23, C26, C28, C33,
	Containers for waste collection and transport	Waste bins and refuse containers	Shares* of NACE C17, C22, C25
	Other (R&D)	Research, development and analysis, barriers	Shares* of NACE 22, M71, M72
	Waste vehicle technology	Refuse collectors	Shares* of NACE C29
Material and Energy Efficiency Technology	Material-efficient production processes and technologies	Material-efficient processing technologies, information technology, sensors and industrial processing control systems	Shares* of NACE C28, C26, C27, C28, C33, J62
	Installation, repair and consultation services	Installation and consulting services, process control and instrumentation and control technology	Shares* of NACE C33, J62, M71, M72, M74
	Waste heat utilization	Waste heat recovery systems, heat pumps, exhaust heat exchangers	Shares* of NACE C28
	Air pressure and pump systems	Compressed air and pump systems	Shares* of NACE C28
Renewable Energy Technology	Consultation and research	R&D, energy consultation services	Shares* of NACE of M72, M74
	Storage of energy	Electrochemical and mechanical storage of energy technologies	Shares* of NACE of C27, C28

	ICT for energy systems	Information communication technologies for smart grids or meters	Shares* of NACE of C26, J62
	Network technology	Grid technology and measurement	Shares* of NACE of C25, C26, C27
	Energy technology	Technologies for bioenergy, geothermal, solar, hydropower, wind power	Shares* of NACE of C22, C25, C26, C27, C28, C33, F42, F43

Source: Prognos AG (2018)
**Shares refers to a portion and the sums of portions of sectors (NACE) according the methodology outlined below.*

2.1.2 Computation of regionalised data across EU Regions

Following the identification of sectors at NACE classes level (i.e. the fourth level of the NACE classification structure), the regionalisation and disaggregation of data across regions at NUTS 2 level (Nomenclature of Territorial Units for Statistics, 2013) was necessary. Most NUTS-2 statistical data is available at NACE division level (second level of NACE) for the period of 2009/10 - 2015 – however, data is unavailable at levels below. Hence, NACE groups and classes (levels three to four) were calculated for the regional level (NUTS-2). The calculation is based on a Member States' economic structure in terms of their employment, for which statistical data at NACE three to four level are readily available. For Member States without sufficient statistical data, the European average was applied. In cases where there was insufficient national or regional data for NACE-2, no data could be computed and was thus left blank.

Data is available for 274 to 278 out of 292 NUTS 2 regions, depending upon indicator. The result is a consistent CIRCTER database at regional level (NUTS-2) of all relevant NACE groups and classes for the majority of the 28 EU Member States and Iceland, Lichtenstein, Norway, and Switzerland. In individual cases extreme outlier data were excluded from analysis.

The following computations were conducted for the disaggregation and regionalisation of NACE 2 level at NUTS 2 tier to NACE 3-4 level at NUTS 2 tier via NUTS 0 at NACE 3-4 tier to provide the consistent database for the CIRCTER Model at NUTS2 tier NACE 4 level.

Step 1: Share of NACE4 in NACE 2 for Country i based upon number of employees 2014

$$NACE4Share_{Country_i} = \frac{Country_i NACE4_i}{Country_i NACE2_i}$$

Step 2: Share of NACE4 in NACE2 for Region j for year y

$$NACE4_{Region_{jy}} = NACE4Share_{Country_i} * NACE2_{Region_{jy}}$$

Exception 1: In the absence of NUTS 0 tier NACE 4 level, NACE 2 A01 and A02 disaggregation are based upon the NACE2 to NACE4 disaggregation of Germany

$$NACE4Share_{Germany} = \frac{GermanyNACE4}{GermanyNACE2}$$

$$NACE4_{Region_{jy}} = NACE4Share_{Germany} * NACE2_{Region_{jy}}$$

Exception 2: In the absence of turnover NUTS 2 level data, turnover was regionalised based upon employment share of the region in the country before it was disaggregated as in Step 2.

$$TurnoverNACE2_{Region_{jy}} = \frac{EmploymentNACE2_{Region_{jiy}}}{EmploymentNACE2_{Country_{iy}}} * TurnoverNACE2_{Country_{iy}}$$

Where:

- j=region of country i
- i=country
- y=year

Aside of identifying relevant sectors relevant to Material and Technology Providers and linking them to their statistical counterpart, *envigos* provides also the shares of goods and services of said NACE sectors at class level and below. This data allows for an overall economic and sectoral assessment of these Circular Economy activities in the regions. The shares were regionally adjusted for the Circular Material Providers given sufficient disaggregated data at the Member State level. Member State's characteristics for organic farming, renewable energy and waste collection and recycling services were applied to their regions. For the Technology Providers the *envigos* shares were maintained and were not further regionalised based upon national characteristics.

Step 3: Computing the CIRCTER value for employment, turnover and local units with the NUTS 2 tier at NACE 4 level

$$CIRCTER_{k_{jy}}^{All-MP} = \sum \left(NACE4_{Region_{jy}} * envigos_{NACE4_k} \right)$$

k = Classification of the NACE to a market segment and sector

Regional adjustment for Circular Material Providers

$$CIRCTER_{k_{jy}}^{MP} = \sum \left(NACE4_{Region_{jiy}} * Characteristic_{Country_{i_k}} \right)$$

The following table provides an overview of country characteristics.

Table 2-4: National characteristics informing shares for Circular Material Providers

Sector	National characteristics informing shares
Sustainable Agriculture and Forestry	Share of fully converted and under conversion to organic farming in total utilized agricultural area, and average value of percentage of organic bovine and swine farming.
Waste Collection and Recycling Services	Share of waste treatment considered according to amount treated, generated, exported, imported; treated defined as for incineration for energy and recovery, but not backfilling. Including all NACE activities plus households.
Renewable Energy	Share of renewable energy in gross final energy consumption by sector distributed over the types of energy providers according to Gross electricity generation main activities.

Source: Prognos AG, own elaboration 2018

Step 4: Presenting the results per Sector by Circular Material Provider and Technology Provider

$TechnologyProvidersSectors_{jy} = \sum_k (CIRCTER_{k_{jy}}^{All-MP})$, where k equals respective NACE 4 codes listed by sector in table 2 per region per year.

$MaterialProvidersSectors_{jy} = \sum_k (CIRCTER_{k_{jy}}^{All-MP} + CIRCTER_{k_{jy}}^{MP})$, where k equals respective NACE4 codes listed by sector in table 1 per region per year.

2.1.3 Limitations to Circular Material and Technology Providers Database

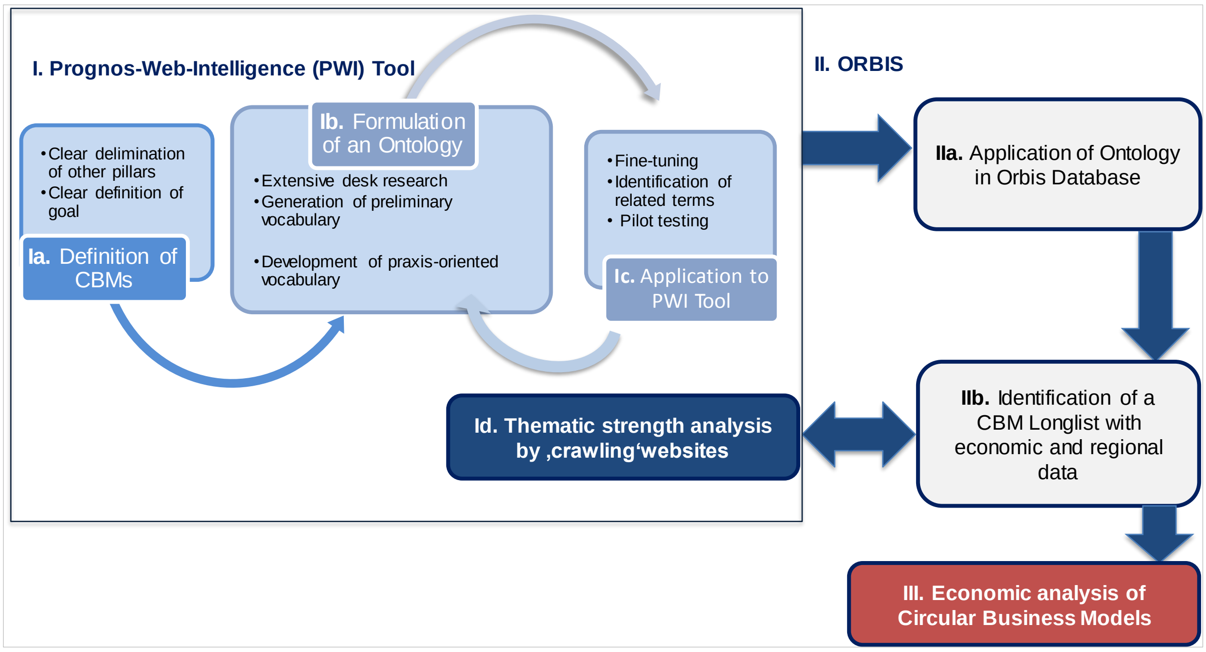
Some important limitations to the database result from the cross-sectoral composition of the Material and Technology Providers and data availability. The sectors NACE A01 and A02 are not provided in the same category at Member State level (NUTS-0) nor are they provided at NACE group level (level four) as the remaining selected NACE codes. At the member state level, the indicator *Total Employment Domestic Concept* was used for the sectors NACE A01 and A02 instead of *Persons Employed*, which was used for all other sectors. The disaggregation of the NACE 2 codes to the NACE 4 code for A01 and A02 was assumed to occur as in the German sectoral bifurcation of A01 and A02, where detailed data is available (Bundesagentur für Arbeit, 2017). In the case of turnover, the indicator A01 *Standard Output* and A02 *Output of Forestry and Connected Secondary Activities* was selected, instead of the indicator *Turnover or Gross Premiums Written*. Instead of *Local Units* for A01, *Farms Number* was used. Due to the absence of equivalent data for A02 at all NUTS levels, no *Local Units* for A02 are included in the database. In addition, for the regionalisation of A02 employment, in the absence of data at NUTS 2 level, data was decomposed according to the share of *woodland in total land cover* of the region in the member state. This was not possible for Norway, due to missing data, so that no forestry activity is included for these regions. Due to limited data availability across Member States and regions, the national allocations of persons employed at NACE 4 level (2014) was used to determine the regional distribution of *Turnover* and *Local Units* over the years. In addition, in the absence of NUTS 2 level turnover data, it was required that the respective data was regionalised solely from the members states' turnover data at NACE two level. Total employment was generated from the persons employed in the economic sectors A01, A02, B-J, L-N and S95. In addition, the database does not provide detail on particular regional characteristics, for example regions which fully source their electricity from renewable energy and have a negligent use of conventional energy, or regions which are specialised in organic or are, by definition of a traditional agriculture, farming organically without having it registered as such. Thus, while the order of magnitude of the size of the Material and Technology Providers are reasonably reliable, the exact number and the change over time need to be treated with some caution, owing to methodological and data limitations[2].

2.2 Circular Business Models (CBM)

2.2.1 Identifying and qualifying actors: the Prognos-Web-Intelligence Tool (PWI)

For Circular Business Models in Europe, both the Orbis database and Prognos-Web-Intelligence (PWI) Tool were used. This unique approach identified and analyses Circular Economy Business Models (CBM) across Europe and provides regionalised economic data, related to the number of units, employment and turnover, as well as a detailed thematic analysis of CBMs (Figure 2-2).

Figure 2-2: Method and tools used to identify Circular Business Models



Source: Prognos AG, own elaboration 2018

[2] The extrapolation process builds upon national and regional data, therefore, calculated trends may be affected by superordinate developments. Secondly, gaps and irregularities in the Eurostat data were methodically closed (only a small percentage of data). Thirdly, and illustratively Figure 3-4, different Eurostat data at different NUTS levels and respectively available indicator lead to different growth rates.

Circular business models (CBMs) have been identified and aggregated according to the type of circular practice they represent. The focus went beyond environmentally friendly businesses: the aim was to identify all businesses that apply circular economy strategies. Whilst many companies actively engaging with a circular economy will also have a focus on their environmental impact, not all efforts towards reducing their environmental footprint can be considered as circular. This tasks' approach on circular business models is guided by established frameworks provided for by other organisations or authors[3] - the result are four overarching categories of circular business models.

They provide a framework through which the different practices can be aggregated. On one hand, the *Long-Life Design Model* and *Extending Product and Resource Value Model* relate to companies which focus on product design and reusability of products, components and resources. On the other hand, *Encouraging Sufficiency and Shifting Utilisation Pattern Model* and *Access, Sharing, and Performance Model* primarily influence consumers in their consumption decisions (Table 1-1).

Each circular economy business activity has its own terms that expresses the issues of value to its business strategy. When a company provides services such as *Reverse Logistics* or *Refurbishment*, it generally aims to exploit residual values of goods through collecting end-of-life products. Businesses that actively seek to prolong their product life-spans may actively speak of *Eco Design*, *Cradle to Cradle* or *Modular Product Design* on their company website or trade description. These activities, the descriptions surrounding them and relationships between words can be aggregated into an Ontology, which puts different search terms in connection to one another to depict a given concept. An Ontology literally translates into '*questionnaire applied to the world-wide-web'*. Extensive desk research of Circular Economy concepts permitted to create an exhaustive Ontology. The search terms were tested and applied to trade descriptions on the ORBIS database to identify relevant businesses across Europe, without focusing solely on environmentally friendly activities. These were then regionalised based on their NUTS 2 location. Aggregated statistical data (in terms of number of units, employment and turnover) were regionalised and display the territorial distribution and economic relevance of CBMs. An additional analytical step, based on a Big-Data analysis with a fine-tuned ontology, allows a look into the specific thematic strengths and relationships of Circular Business Models at EU level.

First step of identifying Circular Business Modes was to apply the search terms of the ontology to an Orbis search strategy. To avoid any double counting with Circular Material and Technological Providers, relevant NACE Codes were excluded from the search strategy and the search

[3] For instance, Ellen MacArthur Foundation, 2018; Prendeville et al., 2015; Rizos, V., Tuokko, K., Behrens, A., 2017

limited to active companies within the EU 28 Member States. The ontology was used to screen the trade descriptions. The output of this search strategy was a set of approximately 9000 companies, covering all Member States. Economic data was retrieved at aggregated regional level (NUTS-2) and respective of their NACE code (4-level digital code). Here, only absolute numbers are given, as the request to provide the share of employment and turnover per total economy is still being processed by the service provider.

Second, using the Prognos Web Intelligence Tool (PWI), the company websites were '*crawled*' to qualify the output and identify thematic strengths. Some domains were not identifiable, which limited the number of company domains to undergo the Big Data analysis – in total, approximately 6000 from a total of 9000 company websites were identified. The *crawling* process allows to determine the frequency at which certain terms and groups of terms appear within the content of a company's website. The output of the analysis is a list of companies with positive detection rates. The frequency analysis allows to display and profile thematic strengths within the different CBMs. The results indicate a dynamic interplay between the four CBM categories, where all models tend to engage to some degree in activities related to a different type of CBM.

2.2.2 Limitations to the identification of companies with Circular Business Models

Due to the novelty of the approach, limitations have been encountered which are outlined thereafter. First, the analysis has so far been conducted in English only – this, however, should have little implication on the identification of companies via Orbis, as trade descriptions, both from the company itself and those given by Bureau van Dijk, are provided for in English. However, the level of details and quality provided for in trade descriptions, submitted to Orbis by the companies themselves, can impact the identification process. Further, the applied search strategy can only identify companies that have referred to the specific CBM search terms in their trade description. Whilst a growing number of companies are actively seeking out circular strategies, some may not be aware that they do contribute to a Circular Economy. Failing to match Circular Economy search terms with a company's trade description means that it unfortunately falls outside of the identified list of companies[4].

To qualify the output and identify thematic strengths, company domains were identified by use of the PWI Tool. Some domains were not identifiable, which limited the number of company domains to undergo the Big Data analysis – in total, approximately 6000 company websites were identified. The domains were then '*crawled'* – this process allows to determine the frequency at which certain terms and groups of terms appear within the content of a company's

[4] Results were also not included that could not be geolocated to a NUTS2 region. The actual employment and turnover figures therefore higher. They are not included in the mapping and for consistency reasons they are also not included in the sums.

website. The output of the analysis is a list of companies with positive detection rates. The frequency analysis allows to display and profile thematic strengths within the different CBMs. Translating the ontology to European national languages would also have an impact on the results of the big data analysis. Specifically, for SMEs and micro-enterprises, which are expected to be major players in CBMs across Europe, which may not have the resources nor need to translate their websites into English (take for instance repair cafés, tool-sharing organisations and second-hand shops, which operate on a very local level). However, whilst these are important limitations to consider, the fact that 9000 companies have been identified across most Member States gives the methodological approach validity. Further fine-tuning the steps will allow to provide a more comprehensive image of the Circular Business Models in European regions.

2.3 Analysing the Potential User side – a CE penetration analysis:

2.3.1 Economic and CE-specific selection process of sectors

Based on the analysis of the economic indicators, the following sectors have been identified as economically relevant for Europe: manufactured metal industry (NACE 24 and 25), automotive industries (NACE 29 and 30), chemical and pharmaceutical industry (NACE 20 and 21), electronics industry (NACE 26 and 27) and the construction sector (NACE 41 to 43).

Figure 2-3: Selection process of relevant sectors for the Potential User analysis

Generic economic selection criteria (based on last avail. Year)

Sectors	Share in employment (2015)	No. of local units (2015)	Sectoral patenting (2012)
Construction sector	33%	3.700.000	1%
ICT sector	13%	964.000	9%
Metal industry	12%	406.000	4%
Food processing industry	12%	329.000	27%
Chemical, Pharma, Plastics	9%	44.100	19%
Manufacturing & engineering	8%	109.000	5%
Electronics industry	7%	99.700	1%
Automotive industry	6%	25.000	1%

CE-specific selection criteria

CE Processes		Relevant sectors where circular economy processes can be applied
Use of less primary resources	Recycling	**Automotive**, textile, **building**, forestry, packaging, **chemical**, raw materials,
	Efficient use of resources	**Building**, plastics, mining & materials, food
	Utilisation of renewable energy sources	**Chemical industry**, food, forestry, defense industry
Maintain highest value of materials & products	Refurbishment, re-manufacturing & re-use	**Automotive**, transport, **consumer electronics**, **building**, furniture
	Product life extension	**Automotive**, **electronics**, household appliances, food, textile, defense
Change utilisation patterns	*Product as a service*	***Consumer electronics**, household appliances, transport, **building**, **automotive***
	Sharing models	***Automotive**, transport, accommodation, clothing*
	Shift in consumption	*Food, publishing, e-commerce*

Selection of relevant sectors:
Automotive industry, chemical industry, metal industry, electronics industry and construction sector

Source: Prognos AG own elaboration, 2018 (based on Rizos, V., Tuokko, K., Behrens, A., 2017)

2.3.2 Calculation of the sectoral penetration rate of a Circular Economy

Data availability

For the estimation of the sectoral penetration rate different available data sources were analysed, additional requests to statistical offices and associations were placed and interviews with relevant stakeholders carried out.

For renewable energy consumption usable data on at least country level were identified with the complete energy balances - annual data [nrg_107a], [nrg_108a] and [nrg_110a] published by Eurostat. Due to the lack of comparable regional data by sector, country data has been analysed and used for the share of renewable energy consumption compared to the total energy consumption (all data in Terajoule for 2016). The sectoral penetration rate (PR) per country was calculated as renewable energy consumption (REC) by the sector compared to the total energy consumption (TEC) by the respective sector:

- $PR_{RE} = \Sigma REC_{SEC} / \Sigma TEC_{SEC}$
- PR_{RE} = *penetration rate for renewable energy consumption*
- REC_{SEC} = *renewable energy consumption by sector*
- TEC_{SEC} = *total energy consumption by sector*

In the alternative a potential regionalisation was calculated as described more in detail further below.

With regard to the penetration rate for secondary materials consumption compared to total materials the most relevant data barriers have not been able to overcome. The original methodological approach chosen was to develop a model-based approach by using material consumption statistics, waste statistics and ProdCom statistics. It was planned to derive a penetration rate at least at country level and for selected defined key secondary raw materials. Thus, an orientation for the regional distribution should be given based on the methodology described further below.

The analysis of the ProdCom data (total volume) by allocation of products to sectors has revealed significant data gaps due to mainly confidentiality reasons as shown in the following table.

Table 2-5: Overview of data gaps in relation to ProdCom by sector*

NACE category	EU 28 volume data gap	Country range	Top-3 share of EU 28 volume	Top-3 share of volume data gap
	[%]	[from – to in %]	[%]	[%]
NACE 20 – 21	30%	8% – 60%	29%	42%
NACE 24	31%	9% - 63%	39%	36%

NACE 25	41%	23% - 64%	42%	43%
NACE 26 - 27	35%	14% - 63%	37%	42%
NACE 29 - 30	35%	19% - 58%	28%	48%

** simplified presentation for values with volumes in kg, except volumes in litre or m³.*
Note: NACE 24 and 25: manufactured metal industry, NACE 29 and 30: automotive industries, NACE 20 and 21: chemical and pharmaceutical industry, NACE 26 and 27: electronics industry, and NACE 41 to 43: the construction sector.
Source: ProdCom data base, volume values for 2016, accessed 2018

In addition, further methodological challenges had to be considered like e.g. data refer to sold volumes only, missing data on the proportion of own-use or different units. All together this led to the accumulation of statistical uncertainties. To avoid the complex issues of intermediate products, in a second step the system boundaries for the penetration rate were planned to limit to direct secondary raw material consumption mainly by manufacture of basic metals, chemical industry and construction sector.

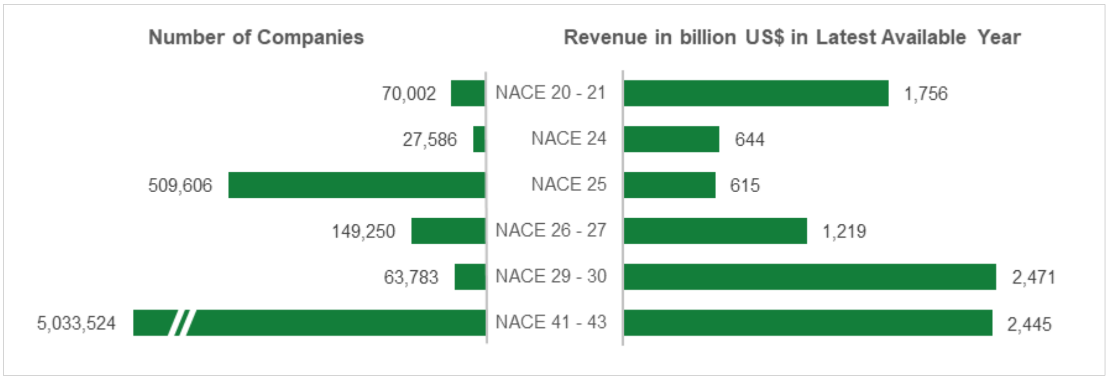
Given the data situation, finally, a robust sectoral quantification could be derived within the framework of this study only for NACE 24 - Manufacture of basic metals by using data on metal production and scrap consumption. For this analysis data on country level were retrieved mainly from European metal statistics and BDSV for iron and steel.

Regionalization

For regionalisation a bottom up approach was selected by using information available from the Orbis database. In Orbis information is currently available for a total of 5.8 million companies, representing revenues of about 9,151 billion US$ for the latest available year (2015 to 2017) active in the key sectors defined above. The allocation to the NACE categories is based on the classification of the companies to their core business activity. Companies core business activities in other NACE categories with smaller economic activities in one of the selected key NACE categories are mostly not covered.

It must be noted, that data from Orbis and Eurostat are not fully comparable due to different methodological approaches. The number of companies in Orbis database is higher mainly due to the fact, that subsidiaries are often listed separately. The methodology used by Orbis for the allocation of NACE categories is not always clear and can be also different. Due to confidentiality reasons, the revenue figures at a detailed level are not fully comparable. Despite some limitations and differences, the comparison of both data sets allows to use Orbis data for further indicative index-based regionalization.

Figure 2-4: Number of Companies and Revenue by NACE category in the EU 28 member states and EFTA states (data availability)*



Source: Orbis database, accessed in 2018
**Note: Manufacture of basic metals (NACE 24) and manufacture of fabricated metal products, except machinery and equipment (NACE 25), automotive industries (NACE 29 and 30), chemical and pharmaceutical industry (NACE 20 and 21), electronics industry (NACE 26 and 27) and the construction sector (NACE 41 to 43)*

For between 94% to 97% of companies a regional allocation was available. It has of course to be noted, that relevant differences between the countries were observed. Larger challenges had to be mastered regarding regional allocation of revenues, where between 10% to 32% could not be allocated to regions directly. Further calculations and model-based assumptions based on data available had to be made. This refers to data available at level of aggregated regions and at country level only.

The potential renewable energy consumption within a country was allocated by the weighted economic significance within the country:

- $\Sigma REC_{SEC\text{-}RE} = \Sigma REC_{SEC\text{-}SUM} * (\Sigma TUR_{SEC\text{-}RE} / \Sigma TUR_{SEC\text{-}C})$
- $\Sigma REC_{SEC\text{-}RE}$ = *potential renewable energy consumption by sector and region*
- $\Sigma REC_{SEC\text{-}C}$ = *renewable energy consumption by sector and country*
- $\Sigma TUR_{SEC\text{-}RE}$ = *turnover generated by sector and region*
- $\Sigma TUR_{SEC\text{-}C}$ = *turnover generated by sector and country*

In order to allow comparison across all regions for the potential regionalisation of country wide data available for the penetration rate by renewable energy and secondary raw material consumption a concentration index based on the adjusted sectoral differences between the regions and Europa was calculated:

- $CI_{RE} = (((\Sigma REC_{SEC\text{-}RE} / \Sigma REC_{SEC\text{-}SUM}) - (\Sigma TEC_{SEC\text{-}RE} / \Sigma TEC_{SEC\text{-}SUM}))\hat{}2)*100{,}000$
- *CI – concentration index*
- $REC_{SEC\text{-}RE}$ – *potential renewable energy consumption by sector and region*

- $REC_{SEC-SUM}$ –*renewable energy consumption by sector across all regions (country level)*
- TEC_{SEC-RE} –*total energy consumption by sector and region*
- $TEC_{SEC-SUM}$ –*total energy consumption by sector across all regions (country level)*

As no regional data were available, a concentration index was produced as an alternative methodology to indirectly estimate the regional shares of use of e.g. secondary raw materials. Methodologically speaking, the index was developed as a the Krugman Spezialisation Index with minor adjustments[5]. This approach is also used for the users introduced in Section 2. The procedure was similar for secondary raw materials as well. It is based on the assumption, that there is at least a general correlation between branche specific regional economic strength (GVA) and the use of secondary raw materials. Of course, due to the very small amount of secondary raw materials used the error rate has not to be underestimated (inversely proportional).

3 Analysis

3.1 Circular Material and Technological Providers: trends across EU Regions

Across all considered regions, Material and Technology Providers represent around 4 percent of the total economy making up almost 5.8 million employed persons and generating a turnover of nearly a trillion Euros in 2015 (940 billion Euros)[6]. Circular Material Providers make up almost 60 percent of employment (57 %) and turnover (59 %) of the combined Material and Technology Providers. However, Circular Technology Providers are developing more dynamically and versatile with an employment growth of 2.6 % between 2010 and 2015. Circular Material Providers

5 The Krugman Specialization Index and its variations indicate the degree of specialisation relative of an economic structure of a single region resembles to the economic structure of the reference level (i.e. the EU in this case). By adding a squared deviation, it gives more weight to large deviations. The multiplication by 100,000 shifts the decimal to the right for legibility. The higher the index, the more the economic structure of one country deviates from the reference group and the more a region is considered to be specialised. For details see FIW -Working Paper, 2010, Measuring of Specialization – The Choice of Indices, Nicole Palan, FIW Working Paper No 62, December 2010 https://www.fiw.ac.at/fileadmin/Documents/Publikationen/Working_Paper/N_062-Palan.pdf

6 With data for Persons Employed in Circular Material and Technology Providers representing 275 out of the 292 regions in EU Member States and EFTA regions (NUTS 2) and the total economy representing 273 regions and the sectors A01, A02, B-J, L-N and S95. Turnover represents 275 regions. These figures do not include companies and sectors covered by the Circular Business Models.

achieved around 1.7 %, as did the total economy (1.7 %)[7]. Sustainable Agriculture and Forestry is the single largest employment sector with 30 percent of the combined Circular Material and Technology Providers. It is followed by the sectors Material and Energy Efficiency Technology (24 %) and Waste Collection and Recycling Services (22 %)[8].

The largest sectors in terms of employment of the Circular Material Providers constitutes Sustainable Agriculture and Forestry (52 %), followed by Waste Collection and Recycling Services (39 %) and Renewable Energy Providers (9 %). The largest sectors of the Circular Technology Providers are Material and Energy Efficiency Technology (57 %), Renewable Energy Technology (31 %), and Waste Management Technology (10 %). Agricultural Technologies and Eco-friendly Materials make up the smallest sectors with 2 percent and 1 percent of employment of the Circular Technology Providers pillar.

The sector Material and Energy Efficiency Technology is the largest turnover generator with 23 percent of all turnover of the Circular Material and Technology Providers. It is closely followed by the sectors Waste Collection and Recycling Services, Sustainable Agriculture and Forestry and Renewable Energy Providers (between 21 % and 19 %). The smallest sectors are Agricultural Technologies and Eco-friendly Materials (each around 1 %).

3.1.1 Territorial employment patterns

Circular Material Providers are more present in predominately rural regions[9], not least due to the dominant role of agricultural and forestry activities in these regions. The territorial distribution of employment of the Circular Material Providers in relation to the regions' total employment (Map 3-1) highlights the important role of sustainable agricultural and forestry activities in the European periphery. In 21 regions, the Circular Material Providers make up more than 5 percent of the total economy. In almost 40 regions more than 30 from 1,000 employees of the total economy are employed in the sector Sustainable Agriculture and Forestry. Many of these are in the European periphery and follows the expected pattern of Europe's economic geography. The sector Waste collection and recycling services also play amongst these circulare economy sectors an above-average role in many European peripheral regions, although less dominating. This circular economy sector contributes with more than 1 percent to the regional employment of almost 80 regions. Northern Europe stands out for its large areas covered in forests (northern Sweden), while some Baltic regions and eastern European regions are marked by higher

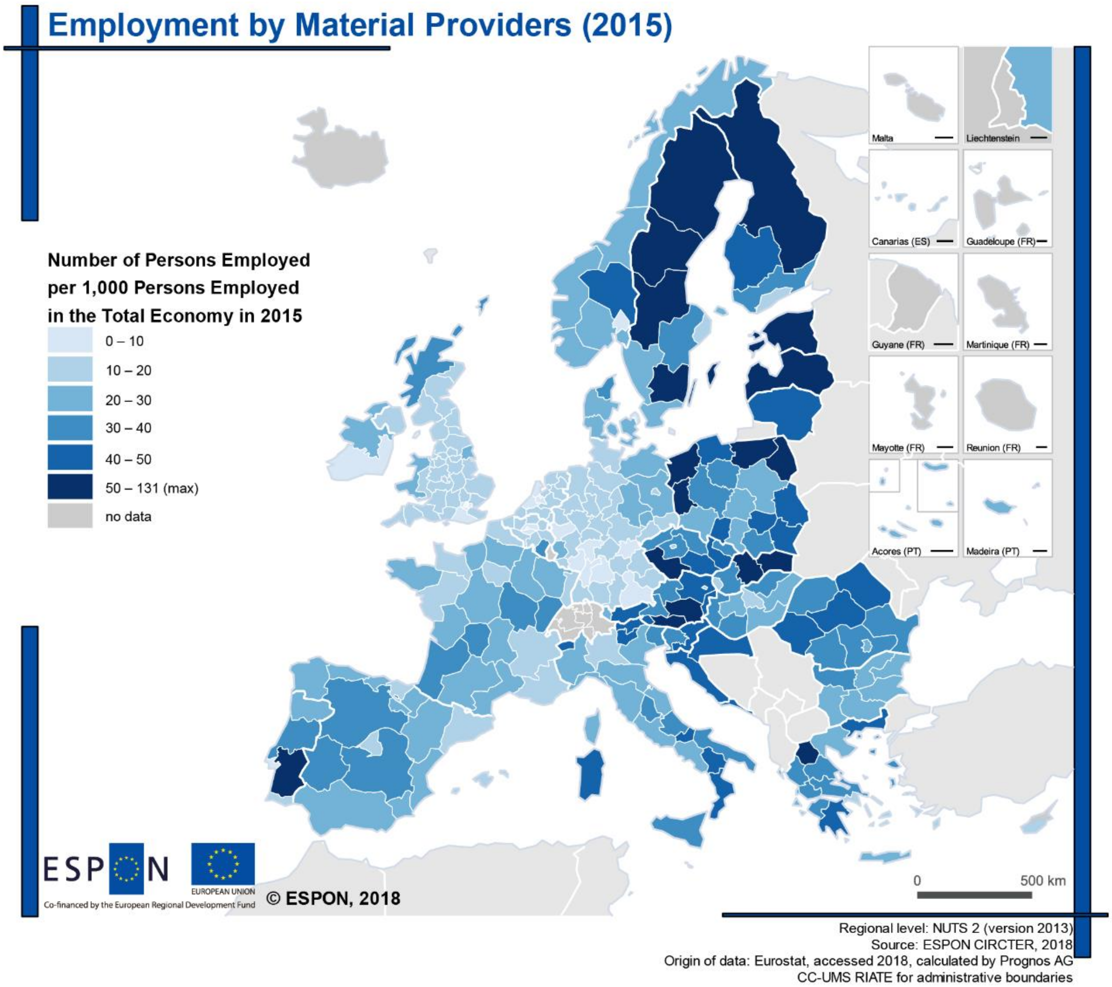
[7] The growth rates are based on data aggregates for Persons Employed in Circular Technology Providers, Circular Material Providers and Total Economy representing the same 267 regions. It excludes the regions of London and Croatia, and Nord-Est of Romania and Zahodna Slovenija.

[8] The distribution shares are based on 272 regions.

[9] According to the three typologies predominately rural, intermediate, and predominately rural adjusted from NUTS 3 level to NUTS 2 level.

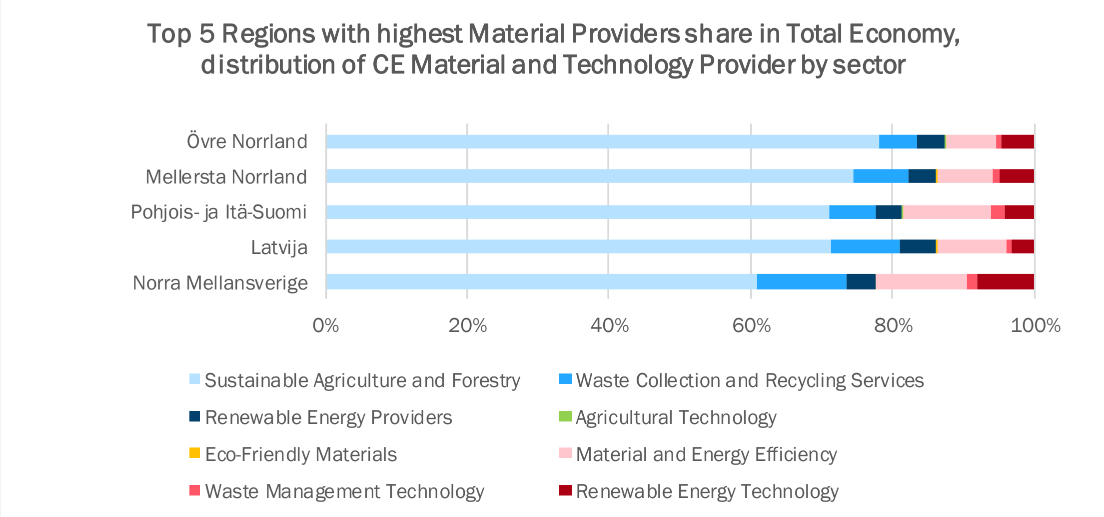
shares in agricultural activities of which some have also high shares in organic farming (Map 3-1). The share in the total economy of these top 5 Circular Material Providers' regions ranges between 7 and 13% (Figure 3-1). The findings underscore that the Circular Material Providers, and therewith Circular Economy activities, already today represent an important contribution to regions' economic structure. In three regions Circular Material and Technology Providers even make up more than 10 % of the total economy.

Map 3-1: Territorial distribution of employment for Circular Material Providers (2015)



Note: Norway excludes persons employed in and turnover from forestry and related activities, due to missing data.

Figure 3-1: Regions with the highest Circular Material Providers share in total economy by sectors



Source: Eurostat, Prognos AG own elaboration 2018
** Norway excludes persons employed in forestry and related activities, due to missing data.*

Circular Technology Providers are more present in predominately urban and intermediate regions. Employment in the Circular Technology Providers of the Circular Economy is comparably lower and located nearer to Europe's industrial centres (Map 3-2). While Circular Technology Providers appear to cluster near industrial centres, several regions stand out for their high shares in the total economy (Figure 3-2). The share of these top 5 Circular Technology Providers' regions is around 3% of the total economy.

Strikingly, their commonality of these selected regions is a large number of persons employed in the repair of fabricated metal products, machinery and equipment. Some harbour towns for example show signs of specialised boat repair and maintenance services. These economic activities are an important contribution to the long-life and efficient use, and possibly improvement, of heavy equipment among other. In Figure 3-2 these activities are captured by the sector Material and Energy Efficiency. Waste Collection and Recycling Services sectors also play an important role, that may benefit from their proximity to industrial processes and urban centres.

Map 3-2: Territorial distribution of employment of Circular Technology Providers (2015)

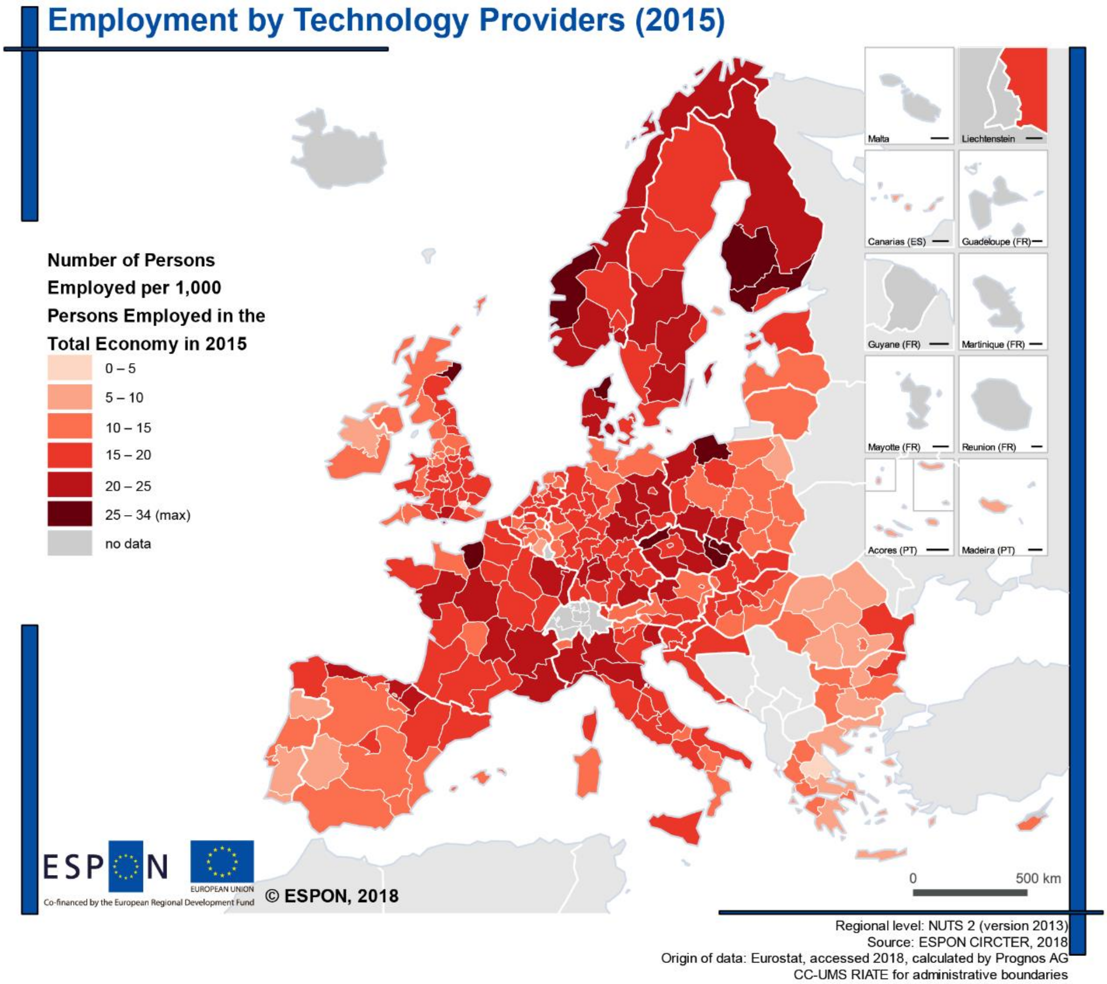
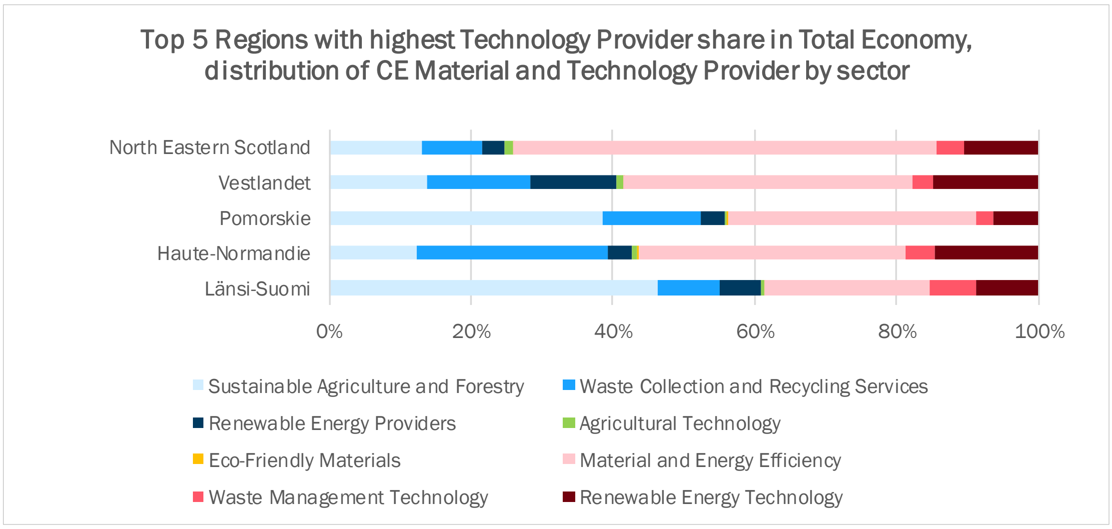


Figure 3-2: Regions with the highest Circular Technology Providers share in the total economy by sectors



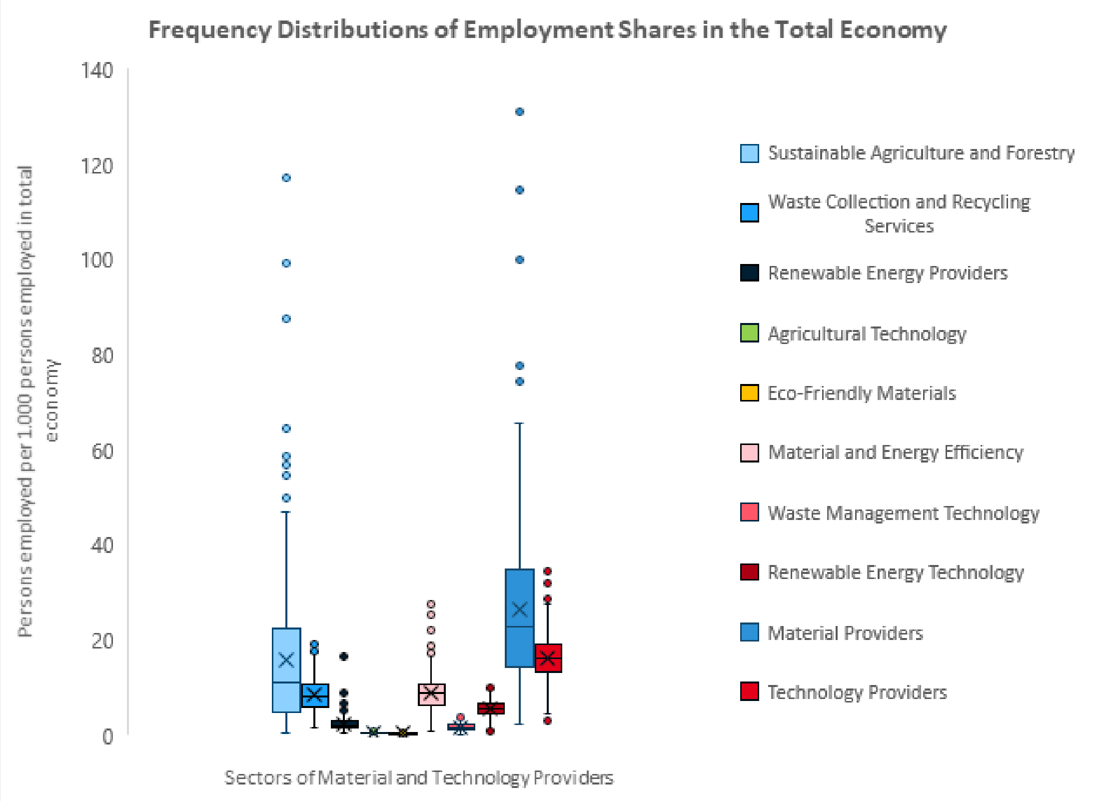
Source: Eurostat, own elaboration Prognos AG 2018

The regional Circular Economy structure reflects a region's overall economy in important ways. The Circular Material and Technology Providers constitute core activities within the linear economy which provide and enable the transition towards a Circular Economy. For example, Waste Collection and Recycling Services tend to remain more proportionate in size to the overall economy than sustainable agriculture and forestry (see Figure 3-3). Waste collection and recycling services are a core economic activity of any economy that is continuously undergoing development to enable greater reuse, recycling and recovery, while efforts are made to reduce wastes. Higher levels of sophistication in recycling allow such services to capitalise on waste streams. At the same time, the secondary resource market is tied to market fluctuations in the primary resource market and is challenged by difficult-to-recycle compounds through the products' design. Proximity to urban and industrial centres provides an input steam of recyclable resources that may allow for greater efficiency and effectiveness. With the implementation of circular strategies across European Regions, one can expect an increase in related services and business activities, such as collection, sorting and treatment services, centred around manufacturing sites and population centres. In more rural areas, agriculture and forestry are important Circular Material Providers, that supply important natural resources. Such regions need to strike a difficult balance between being economic and maintaining an ecological balance.

Another example is employment in the Renewable Energy Providers sector. The employment share in this sector, for example, remains across all regions relatively low except (see Figure 3-3) in few high population density areas such as Cologne, London and Essex. Île de France has a high share of employment in the Renewable Energy Providers sector amongst the French regions. This is likely a result of many energy related jobs being centralised and concentrated in this region, while other regions in France have a markedly lower share. Renewable Energy is also a case in point in how national framework conditions inform the regional energy market[10]. Some of the highest shares of Renewable Energy Providers are found, expectedly, in Sweden and Norway.

[10] IEA (2015): Renewable Energy Medium-Market Report 2015: Market Analysis and Forecasts to 2020. International Energy Agency.

Figure 3-3: Distribution of the Number of Persons Employed per 1,000 Persons Employed in the Total Economy by Material and Technology Providers and their sectors (275 regions)



Source: Eurostat, own elaboration Prognos AG 2018

The territorial distribution of turnover per employee reflects the industrial concentration of economic activities towards the centre of Europe along with the economic strength of member states (Map 3-3 and Map 3-4). Among the Circular Technology Providers, Eco-Friendly Materials has the highest turnover per employee and Renewable Energy Technology the lowest turnover per employee (not depicted). Turnover per employee in the pillar Material Provider is dominated by above-average figures for the provision of renewable energy.

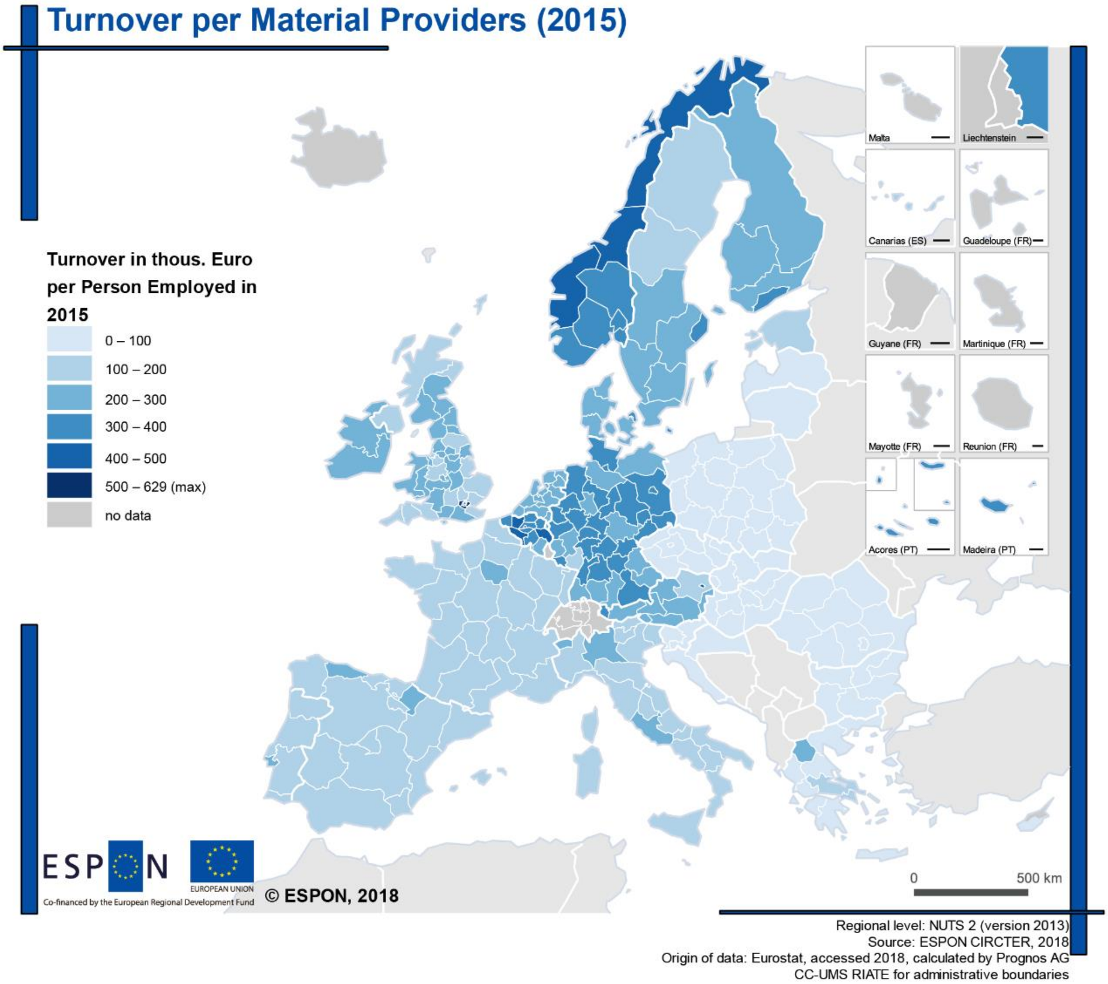
The territorial pattern reflects some commonalities and specialisation. These are inherently linked to existing geographical variation. Specifically, Circular Material Providers are relative to the total economy more prevalent in rural regions. In turn, a higher share of Circular Material Providers employment correlates with lower scores in the Regional Innovation Scoreboard[11] and the Regional Competitiveness Index's[12] sub-indicators Infrastructure and Business Sophistication. The opposite is true for a higher share of Circular Technology Providers, which correlates positively with higher Innovation and Labour Market Efficiency scores, yet barely with

[11] European Commission, Regional Innovation Scoreboard (RIS), http://ec.europa.eu/growth/industry/innovation/facts-figures/regional_en, accessed November 2018.

[12] European Commission, European Regional Competitiveness Index, https://ec.europa.eu/regional_policy/en/information/maps/regional_competitiveness/, accessed December 2018.

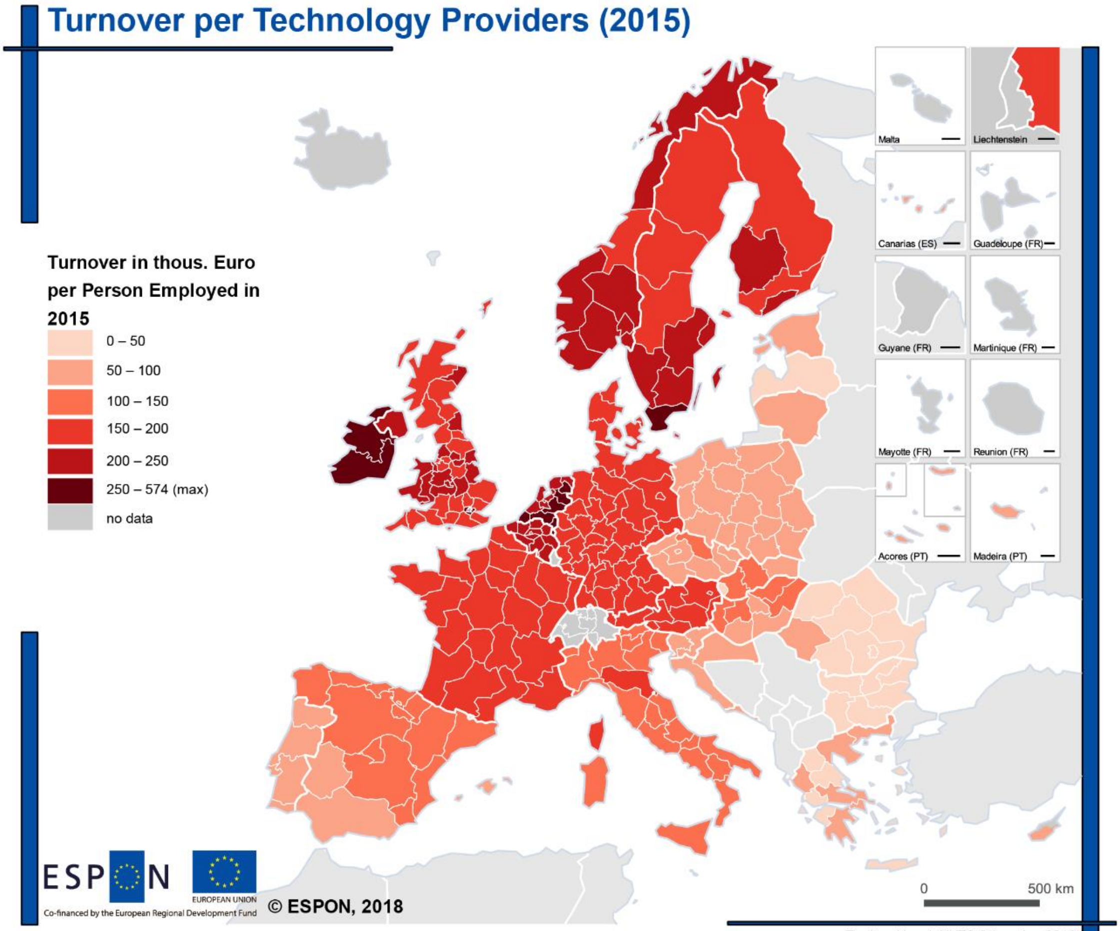
Business Sophistication and Infrastructure. In comparison to Circular Material Providers, the distribution of Circular Technology Providers is, even though more prevalent in urban regions, more abstruse and reflects more varied pull and push factors. These could include the ability of industries to re-locate, locate near existing industrial centres to benefit from proximity and agglomeration effects, or the long-term investment into places through continuous innovation.

Map 3-3:Territorial distribution of turnover for Circular Material Providers (2015)



Note: Norway excludes persons employed in and turnover from forestry and related activities, due to missing data.

Map 3-4: Territorial distribution of turnover for Circular Technology Providers (2015)



Regional level: NUTS 2 (version 2013)
Source: ESPON CIRCTER, 2018
Origin of data: Eurostat, accessed 2018, calculated by Prognos AG
CC-UMS RIATE for administrative boundaries

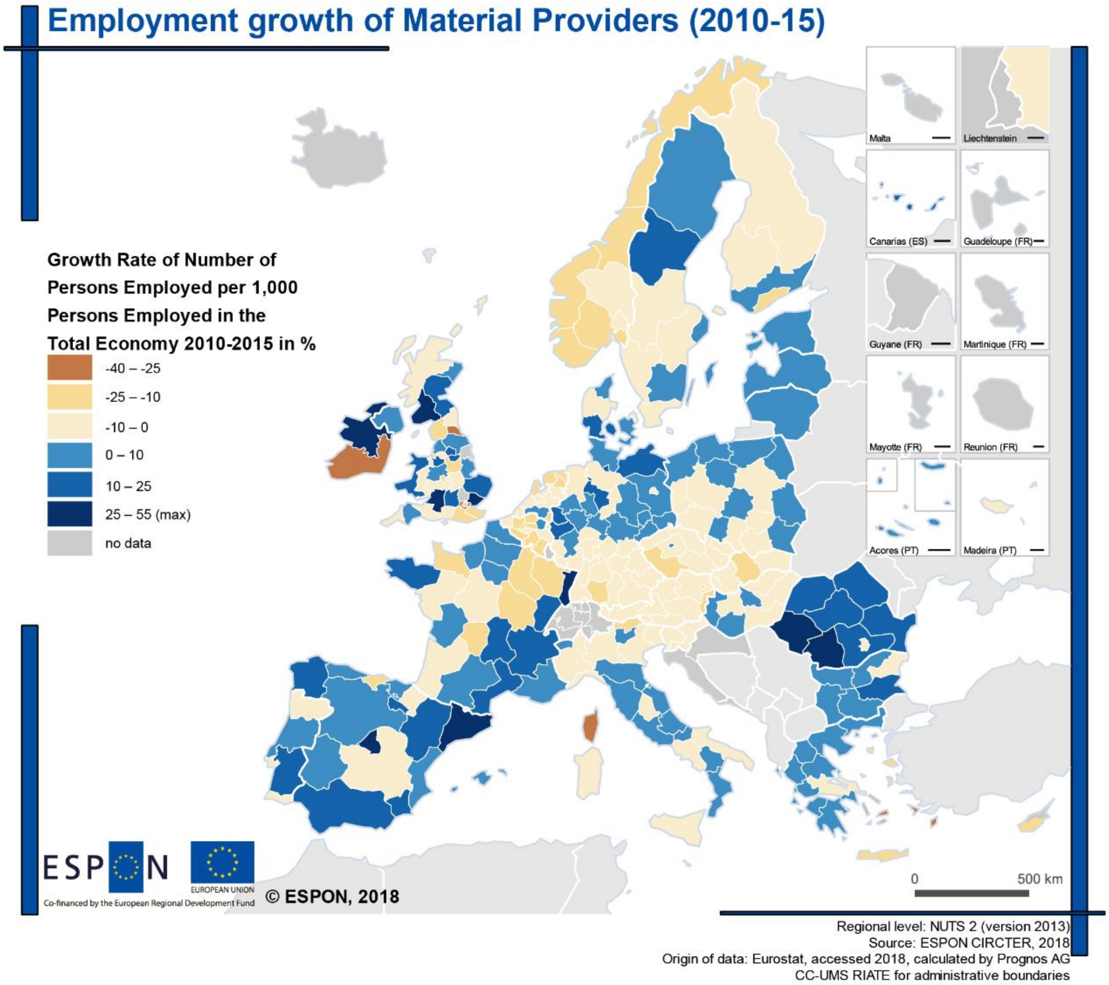
3.1.2 Growth rates suggest the European peripheral are catching up

Map 3-5 and Map 3-6 present those regions in which the Circular Material and Technology Providers share in the total economy grew. This relative employment growth shows a more heterogenous distribution, while many outer regions grew above the average of both, Circular Material and Technology Providers. The maps show many regions’ total economy growing faster than the Circular Material and Technology Providers, so that the share of Circular Material and Technology Providers in the total economy declines. Some of that decline might reflect internal industrial change from which new economic activities are emerging not accounted for by Circular Material and Technology Providers, but through, for example, the Circular Business Models (discussed in 3.2).

Total economy growth correlates strongly with Circular Material and Technology Providers growth, yet, as Map 3-5 and Map 3-6 highlight, to different effect. The employment share of Circular Material and Technology Providers does not notably correlate with either the Regional

Innovation Scoreboard or the Regional Competitiveness Index's sub-indicators[13]. Even though employment by Circular Material and Technology Providers are positively growing (see further below) the growth of the total economy by its sheer size diminishes in many regions their relative expansion in the total economy. Aggregated at national level, Circular Material and Technology Providers are gaining in share in most countries and at the study area level overall (see for comparison Figure 3-4 and Figure 3-5).

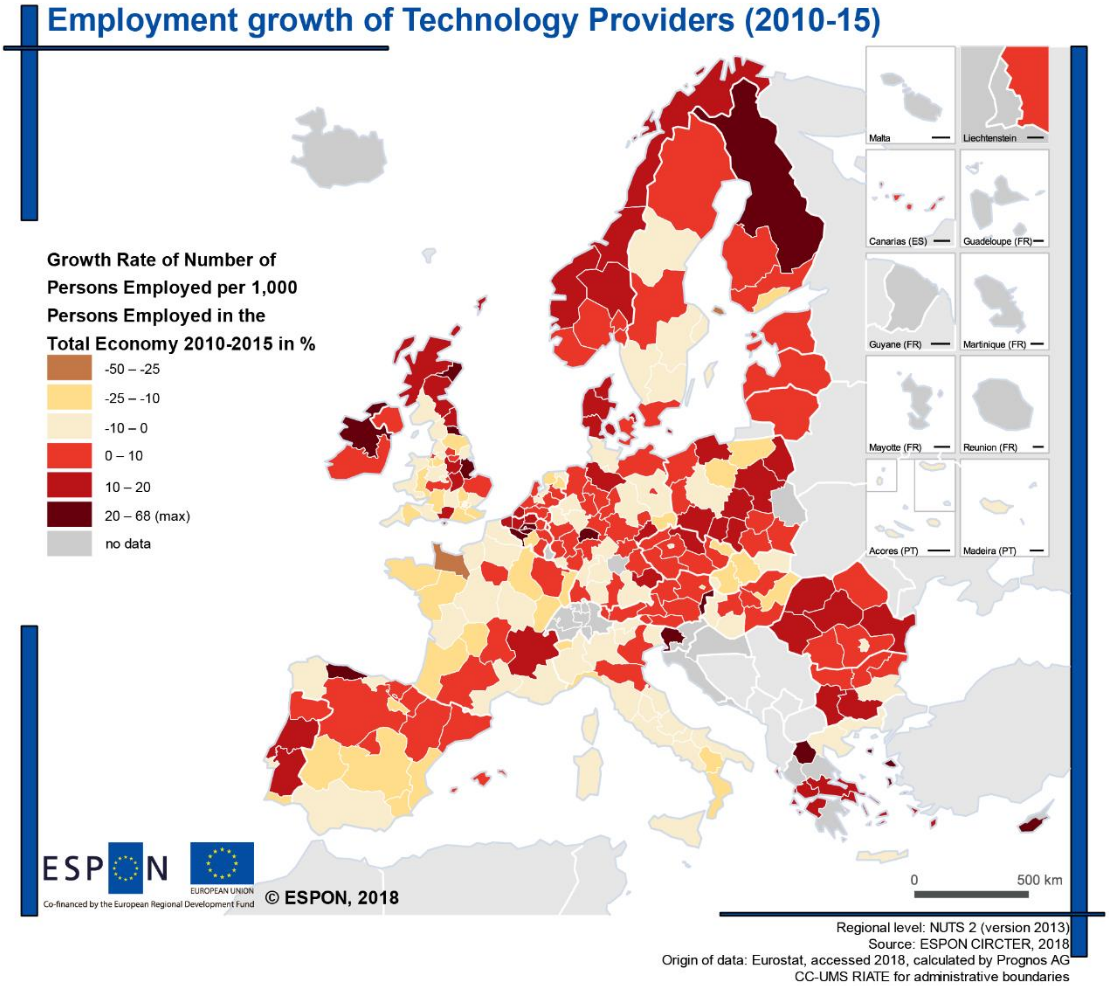
Map 3-5: Territorial distribution of employment growth for Circular Material Providers (2015)



Note: Norway excludes persons employed in forestry and related activities, due to missing data.

[13] For the indicative purpose of this analysis, it was assumed that the values of the Regional Competitiveness Index and Regional Innovation Scoreboard did not significantly change over the observed growth period (2010 - 2015). Therefore, no concern needed to be paid to their reference year.

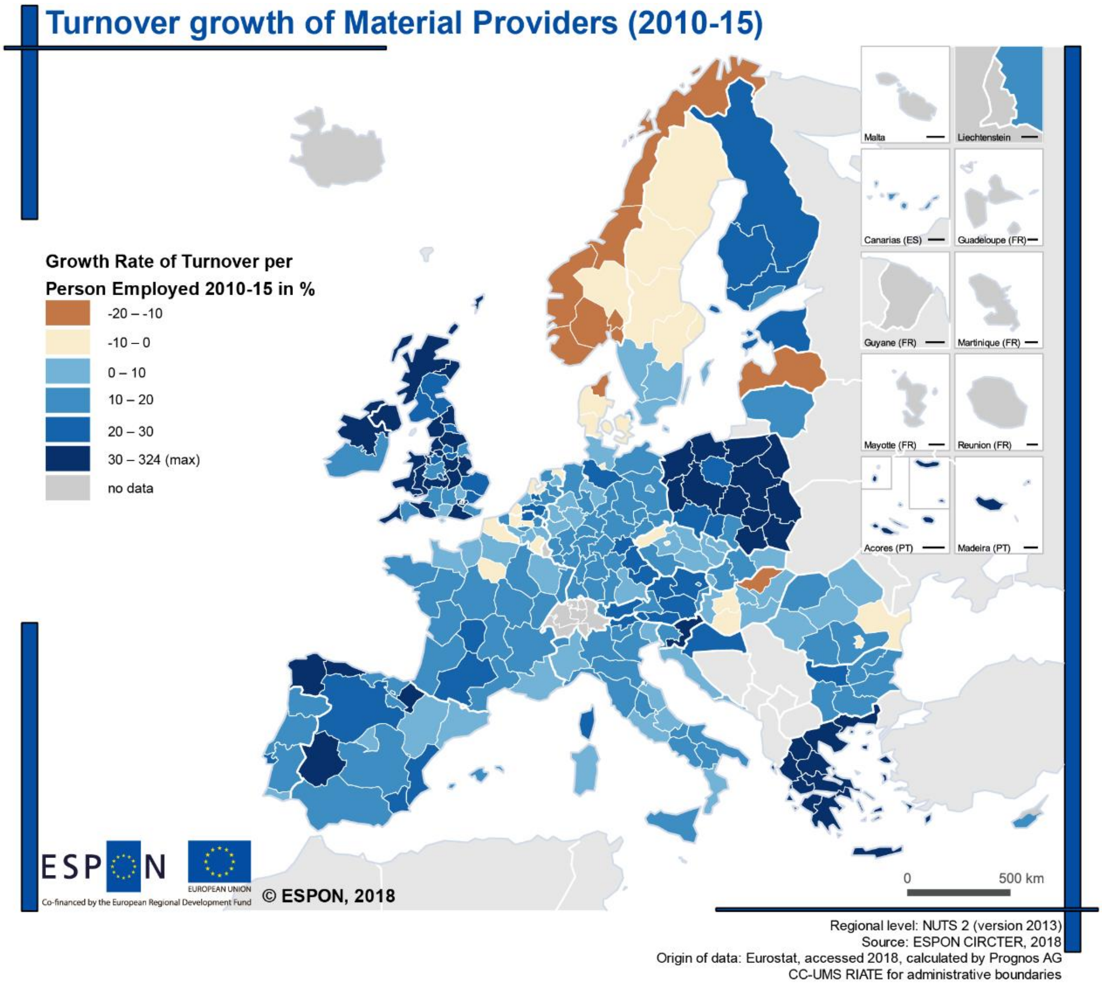
Map 3-6: Territorial distribution of employment growth for Circular Technology Providers (2015)



The positive development is more clearly expressed in the growth rate of turnover per person employed. Turnover growth per Material Provider person employed is particularly strong in the European periphery (Map 3-7). Given their comparably low turnover per person employed, their growth allows them to gain marginal ground against the interior (Map 3-8). Driven especially by employment growth, the development, apart from a few exceptions, provides for an optimistic outlook[14].

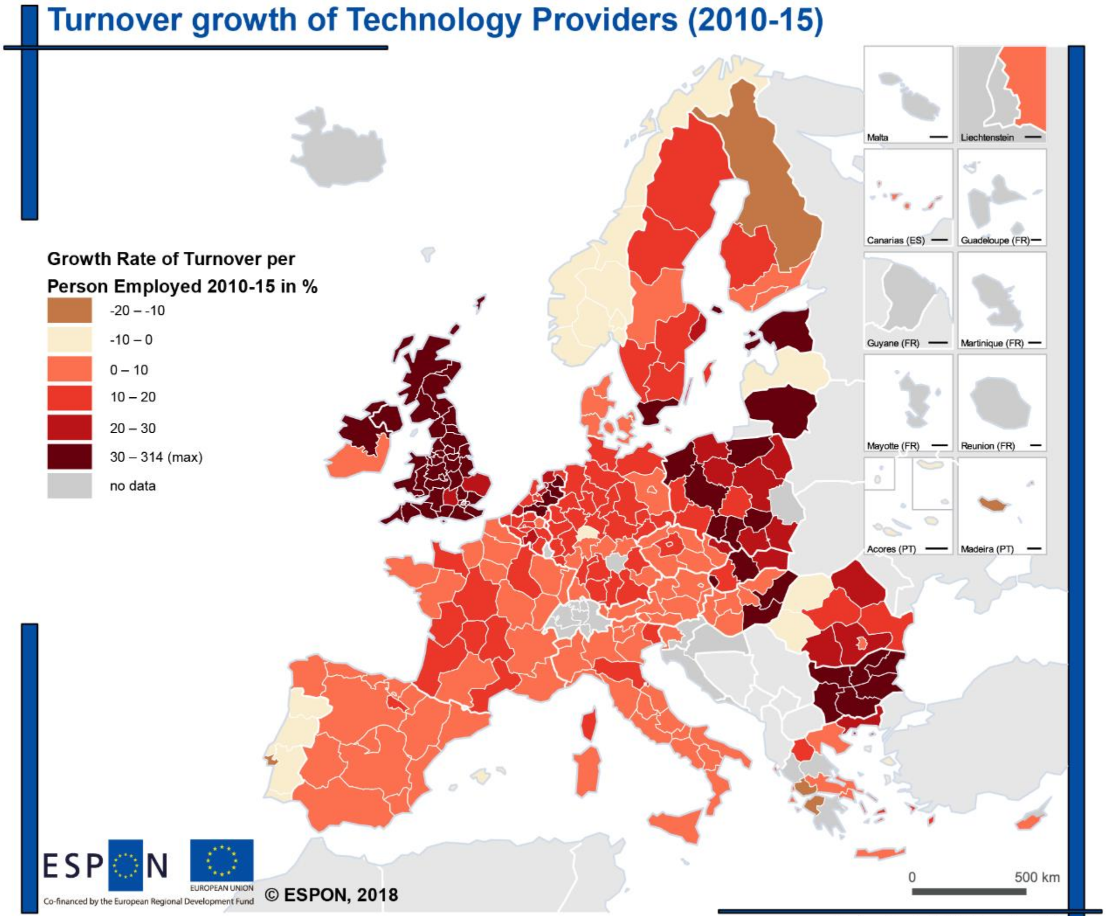
[14] These tendencies are likely to be tied to macro-economic developments including exchange rate fluctuations.

Map 3-7: Territorial distribution of turnover growth for Circular Material Providers (2010-2015)



Note: Norway excludes persons employed in and turnover from forestry and related activities, due to missing data.

Map 3-8: Territorial distribution of turnover growth for Circular Technology Providers (2010-2015)



Regional level: NUTS 2 (version 2013)
Source: ESPON CIRCTER, 2018
Origin of data: Eurostat, accessed 2018, calculated by Prognos AG
CC-UMS RIATE for administrative boundaries

Across the board, all sectors show a positive turnover growth over the 2010–2015 period, despite some shedding employment and some regions showing a downward trend. In the case of the sector Renewable Energy Providers it is likely an expression of the struggles the overall renewable energy market has been experiencing, despite overall growing demand of renewable energy. The solar industry, for example, has experienced international competition and volatile energy prices. According to the IEA (2015), renewable energy generation costs have been declining and economic attractiveness depends strongly on the regulatory framework and market design of countries[15]. Turnover figures for the sectors reflect broadly those trends of the employment structure with two notable exceptions. The renewable energy sector produced a much higher turnover per employed person than sustainable agriculture and forestry. This can be partly explained by the difference in capital expenses, where renewable energy companies must maintain and invest in their grid and plants, while also requiring specialised employees like engineers. Turnover growth rates also highlight the growing popularity of organic farming

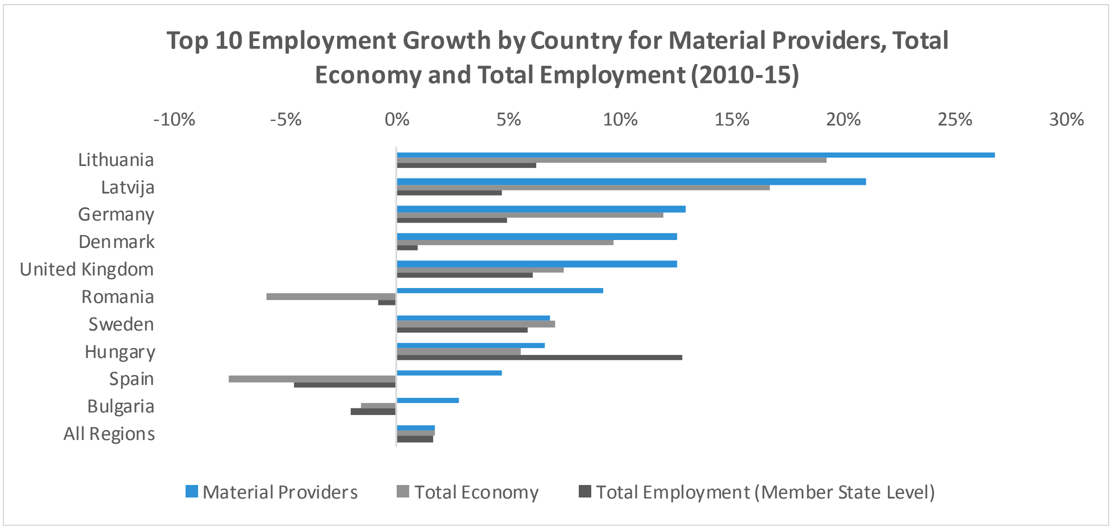
[15] IEA (2015): Renewable Energy Medium-term market report. International Energy Agency Publications [last visited: 06.10.2018]: https://www.iea.org/publications/freepublications/publication/MTRMR2015.pdf

goods and wood as a sustainable resource and construction material. Turnover growth in Material and Energy Efficiency is in line with the rapid employment growth in this sector.

The growth of the eastern regions, in terms of employment in the Circular Material Providers, is especially rapid in Lithuania, Latvjia, Romania and Bulgaria (see Figure 3-4). While Lithuania shows across the board employment growth, Romania provides a mixed picture. Romania shows a sharp decline in agriculture, but a significant increase in forestry and related activities over the observed period, which accounts for the significant growth in Circular Material Providers. This may also reflect macroeconomic fluctuations. Spain's struggling employment market is shown in a strong employment decline over the observed period. Yet, the sector Waste Collection and Recycling Services grew between 2010 and 2015 to more than compensate the otherwise declining trend in the Circular Material Providers segment.

On average these regions' Circular Material and Technology Providers are growing more rapidly than their overall economy. These Circular Economy activities are gaining in employment share and subsequently in relevance in these regions.

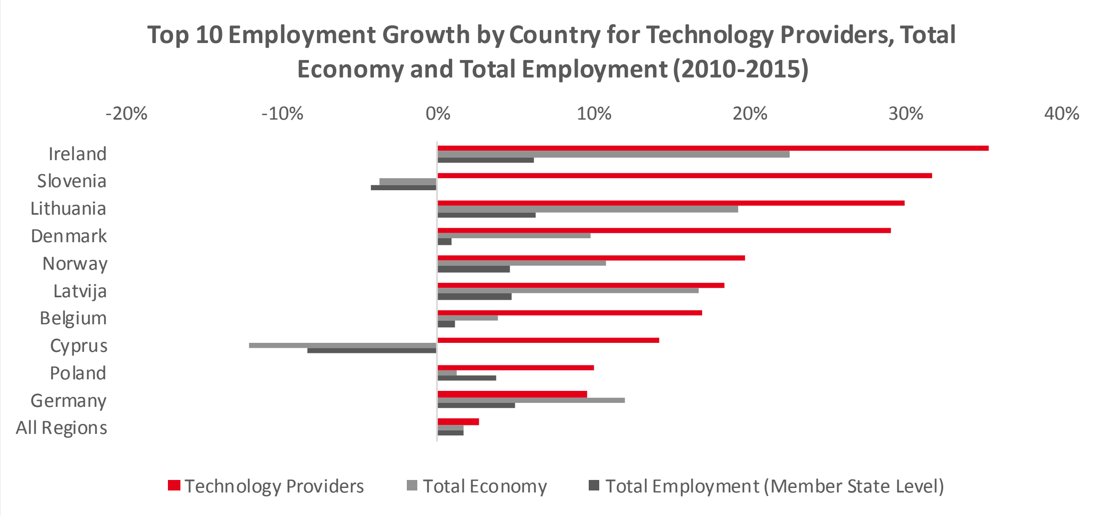
Figure 3-4: Top 10 Countries according to Employment Growth for Circular Material Providers and two different measures of Total Employment (2010-15)



Source: Eurostat, own elaboration Prognos AG 2018;
Note: Growth of the Total Economy refers to the same region aggregates as the Circular Material Providers with data for the sectors A01, A02, B-J, L-N and S95. Total Employment (Member State Level) refers to the entire country's economy employed persons who worked at least one hour for pay or profit. This indicator not only is more holistic but also differs from the persons employed at the regional level.

Slovenia shows a mixed picture with an overall decline, especially driven by agriculture and the construction services (Figure 3-5). Yet at the same time, several sectors important to the Circular Economy have grown. These include, especially the repair and installation of machinery and equipment services, that is part of the Material and Energy Efficiency sector. This is an important trend that can be observed in many regions.

Figure 3-5: Top 10 Countries according to Employment Growth for Circular Material Providers and two different measures of Total Employment (2010-15)

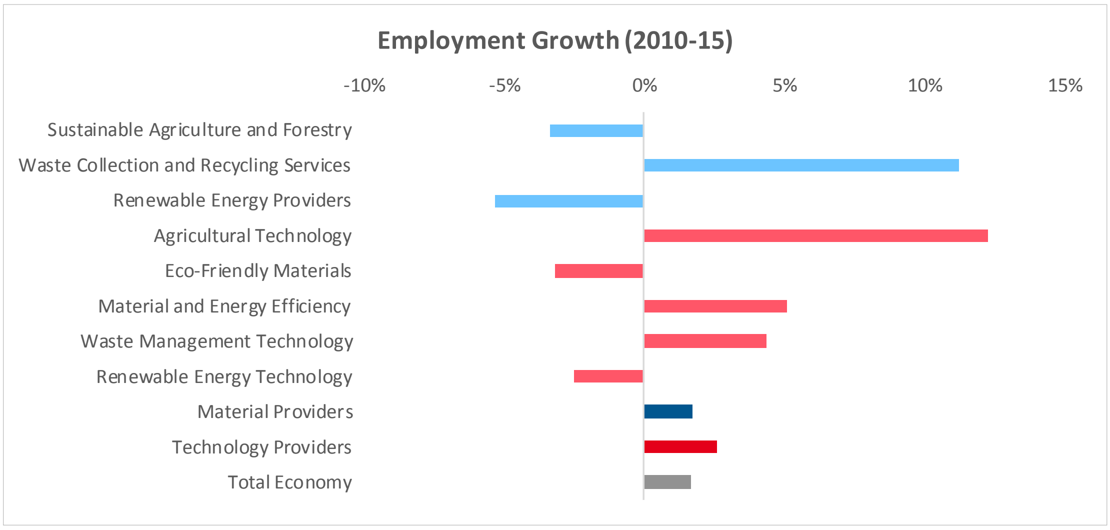


Source: Eurostat, own elaboration Prognos AG 2018
Note: Growth of the Total Economy refers to the same region aggregates as the Technology Providers with data for the sectors A01, A02, B-J, L-N and S95. Total Employment (Member State Level) refers to the entire country's economy employed persons who worked at least one hour for pay or profit. This indicator not only is more holistic but also differs from the persons employed at the regional level.

3.1.3 Cross-sectoral results

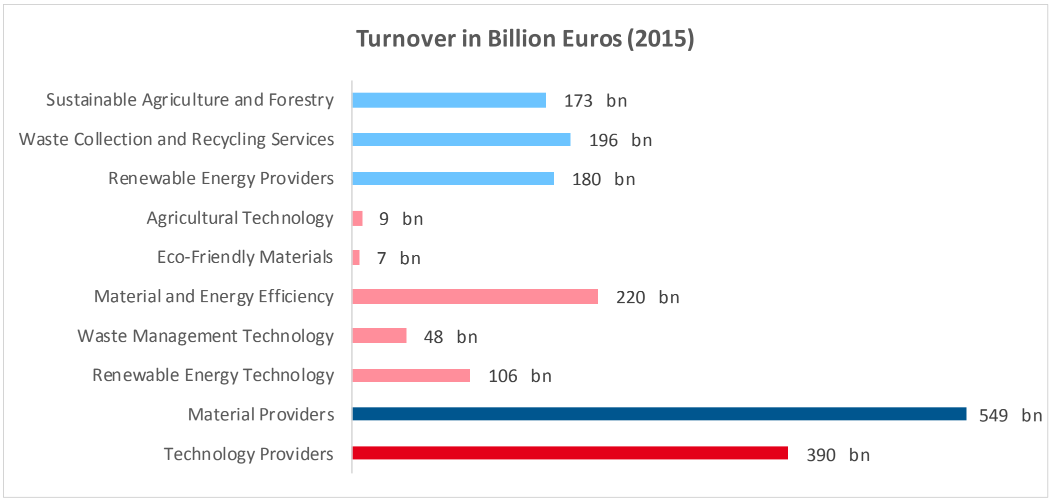
Across all regions, the development of sectors is uneven both at territorial and sectorial level. The greatest gains have been made in the Material and Energy Efficiency sector (growth rates depict the growth rate for the 2010–2015 period across all regions) (Figure 3-6, Figure 3-8), an increasingly important technology segment that allows to reduce wastage of materials and energy but also costs. Agricultural Technologies are greatly benefiting from new means of measuring, controlling and harvesting farmlands. On the other side, organic farming and sustainable forestry and the provision of wood materials remain the largest employment sector in the Circular Material and Technology Providers segment, while experiencing a minor down-turn over the observed period (2010–2015), despite some regions having grown significantly. In contrast hereto, the growth rate of employment in the Waste Management Technology is the same to the total economy, while that of the Waste Collection and Recycling Services is significantly higher. Material and Energy Efficiency technologies are a significant driver for the growth of a Circular Economy, while Waste Management Technology is keeping pace with the need to more efficiently handle wastes from a growing economy. Employment centres for the provision of technologies for material and energy efficiency and waste management can be found especially in regions in Germany and Sweden, but also in France, Spain and Poland.

Figure 3-6: Employment growth for Circular Material and Technology Providers, their sector and the total economy across the same 262 regions between 2010 and 2015



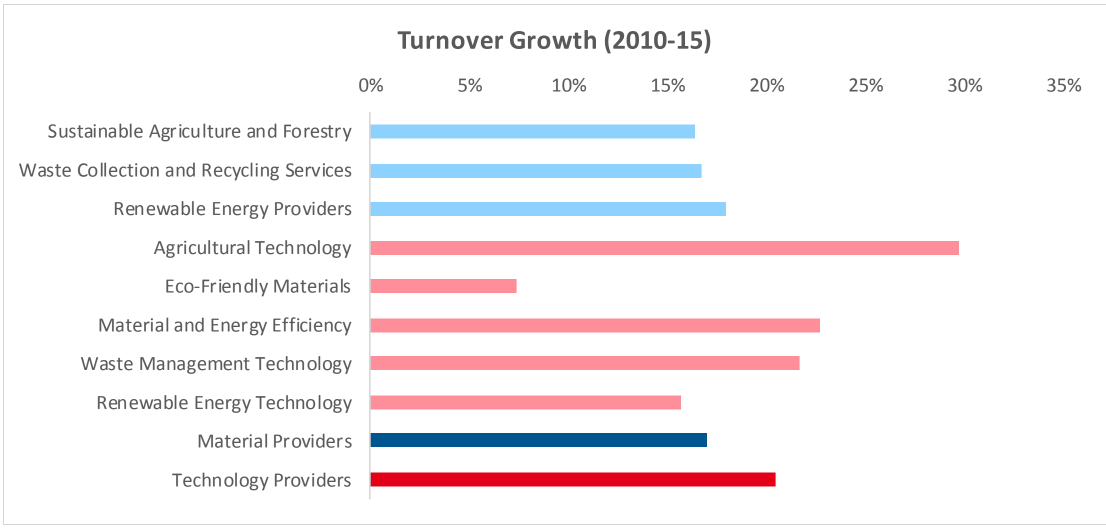
Source: Eurostat, Prognos AG own elaboration 2018

Figure 3-7: Turnover by Circular Material and Technology Providers and their sector across all regions (275 regions of 292) in 2015



Source: Eurostat, Prognos AG own elaboration 2018

Figure 3-8: Turnover growth by Circular Material and Technology Providers, their sector and the total economy across the same 270 regions between 2010 and 2015

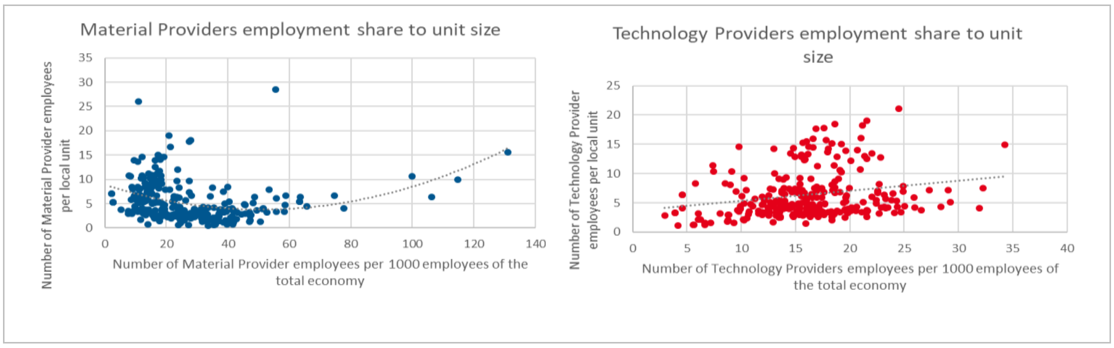


Source: Eurostat, Prognos AG own elaboration 2018

3.1.4 Decentralisation and agglomeration trends of Circular Material and Technology Providers

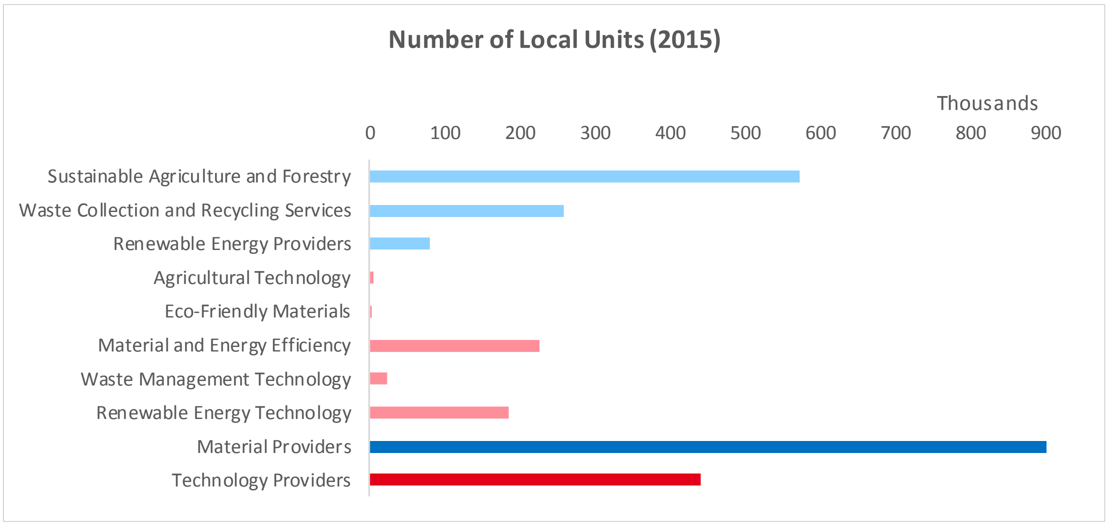
In accordance with the number of persons employed in Sustainable Agriculture and Forestry, this sector is also the largest in terms of the number of Local Units. The unit size (the average number of persons employed per unit across all regions) of this sector is, however, the smallest among the Circular Economy sectors. The gradual consolidation of agriculture is evident in the higher decline (negative growth rate between 2010 and 2015) in the number of local units than in persons employed. For example, where the farm size increases (in terms of output or farmland) the farm number decreases. In contrast, Waste Management Technology and Agricultural Technology have the highest number of persons employed per unit (unit size). Overall the Circular Technology Providers have a higher number of persons employed per unit than the Circular Material Providers. However, in the Material Provider sector Waste Collection and Recycling Services the number of persons employed per unit is higher than in the Circular Technology Provider sector Renewable Energy Technology. The overall higher ratio of Circular Technology Providers reflects probably economic factors such as cost curves and economies of scale. Larger companies are needed in the Circular Technology Providers, reflected in a higher number of employees and turnover per company, than in the Circular Material Providers. One territorial factor clearly plays out: agglomeration. As the employment share of Circular Technology Providers to the overall economy across all regions increases (number of employees in Circular Technology Providers per 1,000 total economy employees), so does the number of employees per unit (Figure 3-9). This is a sign of agglomeration forces operating in the Technology Provider pillar. In contrast, the same analysis for the Circular Material Providers is inconclusive, even though a U-shape trend is notable (figures below)[16].

Figure 3-9: Relationship between employment and local units relative to region's economy size for Circular Material Providers and Technology Providers



Source: Eurostat, own elaboration Prognos AG 2018; Excludes local units for forestry

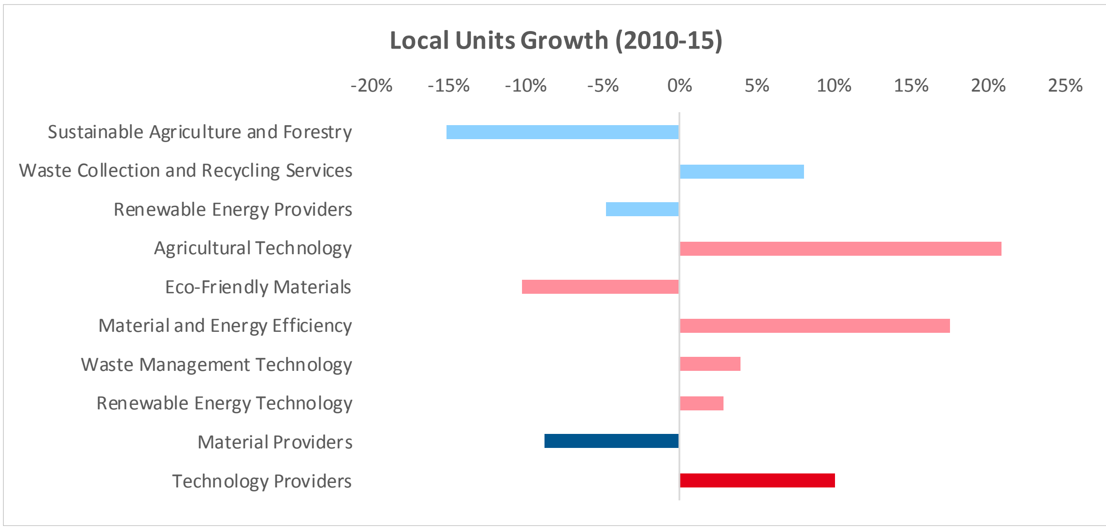
Figure 3-10: Number of local units of Circular Material and Technology Providers and their sector across all regions (268 of 292)



Source: Eurostat, Prognos AG own elaboration 2018; Excludes Local Units for Forestry.

[16] A non-linear statistical analysis is subsequently required for a consistent and efficient analysis.

Figure 3-11: Local units growth of Circular Material and Technology Providers and their sector across all regions (268 of 292)



Source: Eurostat, own elaboration Prognos AG 2018; Excludes Local Units for Forestry

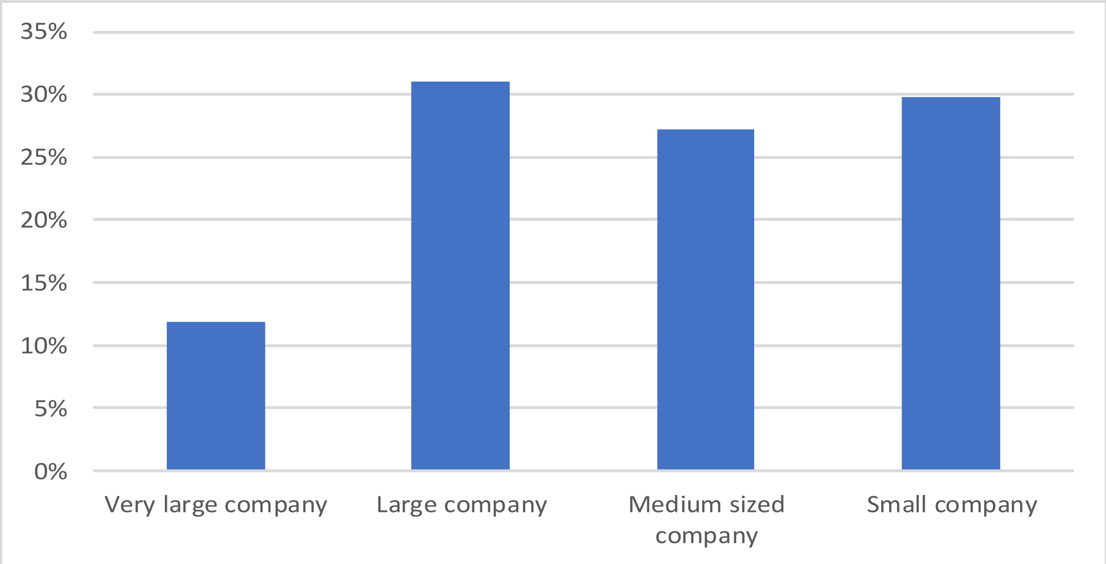
These tendencies around economies of scale are also affirmed when examining the relationship with regions' innovations score. Innovative regions show a higher share of employment in Circular Technology Providers and a higher turnover generation per person employed (see Annex 2, Section 3.3). This trend is the opposite for Circular Material Providers. Circular Material Providers, which per definition are proportionately less technology intensive, are situated more often in less innovative regions.

In summary, Circular Material and Technology Providers already make a significant and growing contribution to regions' economies. Their territorial and sectoral distribution varies across regions. Circular Material Providers play a particularly predominant role in rural regions. Waste collection and recycling services are a key economic sector across most regions. Circular Technology Providers are more concentrated in urban regions. Several regions show a relatively high degree of specialisation in the repair of fabricated metal products, machinery and equipment. Across many states and regions employment in Circular Material and Technology Providers is growing, but not in all. Despite the commonalities, at disaggregated level regions and sectors show differences likely expressing variations in comparative advantages, resource richness, agglomeration forces, labour costs across borders, and regional and national framework conditions. The results of the Circular Material and Technology Providers confirm that territorial factors play a role in their location and relative size[17]. The results suggest proximity and agglomeration or economics of scale effects in place, where Circular Technology Providers and Material Providers tend to follow the respective European patterns of industrial and rural activities. Proximity allows integrating and connecting flows, people and ideas toward greater resource efficiency. Respectively, the sectoral make up at the regional level varies reflecting bespoke local opportunities. The results provide interesting avenues for future research that deserve further investigation, especially regarding value chains, economic location and specialisation.

3.2 Circular Business Models: regional dynamics and thematic strengths

Based on the methodology outlined, over 9,000 companies across Europe were identified as promoting concepts or processes classified under the four Circular Business Models (CBM) (see Figure 3-13). The innovative big data analysis approach has successfully identified CBMs across all Member States. German companies dominate with a share of 0.06%, followed by Great Britain, Ireland, Malta, Luxembourg, Austria and Italy (from 0.02% to 0.01%). All Member States are covered, which shows that CBMs have territorial implications throughout European regions. Additionally, there is a good distribution on company size (based on Orbis definition, see Figure 3-12).

Figure 3-12: Distribution of company size of Circular Business Models identified via Orbis

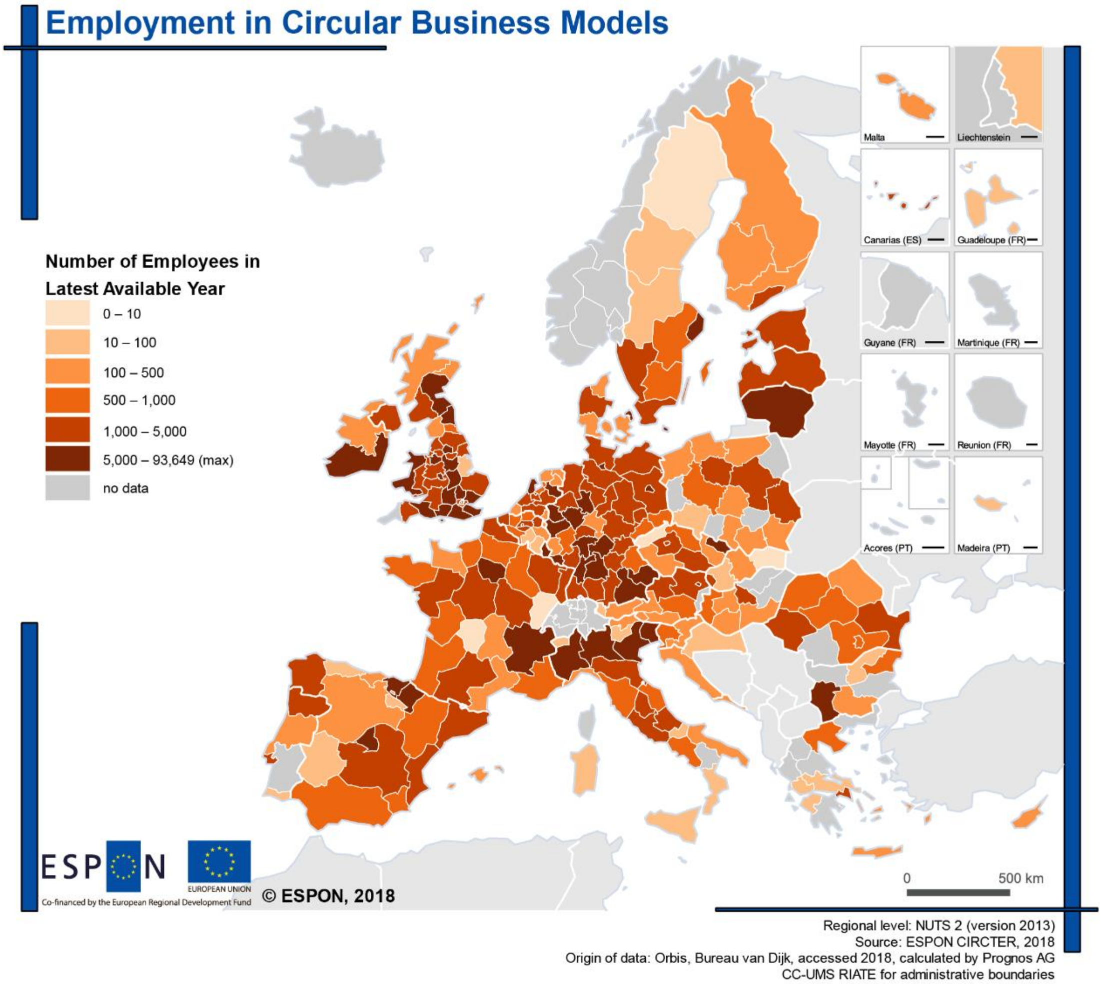


Source: Orbis, Prognos AG own elaboration 2018

[17] In the case of turnover, for example, this is expressed by the effect of varying exchange rates between the Euro and non-Euro countries over the 2010–2015 period.

According to the current assessment, CBMs concentrate in central and western Europe, see Map 3-9 and Map 3-10, with some exceptions in the Scandinavian, Spanish and southern European regions. They accumulate in highly populated regions, such as capitals (see for instance Paris, Rome, Vienna or Greater London) and urban regions (sub-regions of Bavaria and Baden-Württemberg, Catalonia or West Sweden and Lithuania). The tendency to be, in absolute numbers, more present in urban areas overlaps with the observation that Circular Technology Providers are relatively more present in urban regions. It suggests that certain innovative types of circular economy activities flourish especially in urban areas.

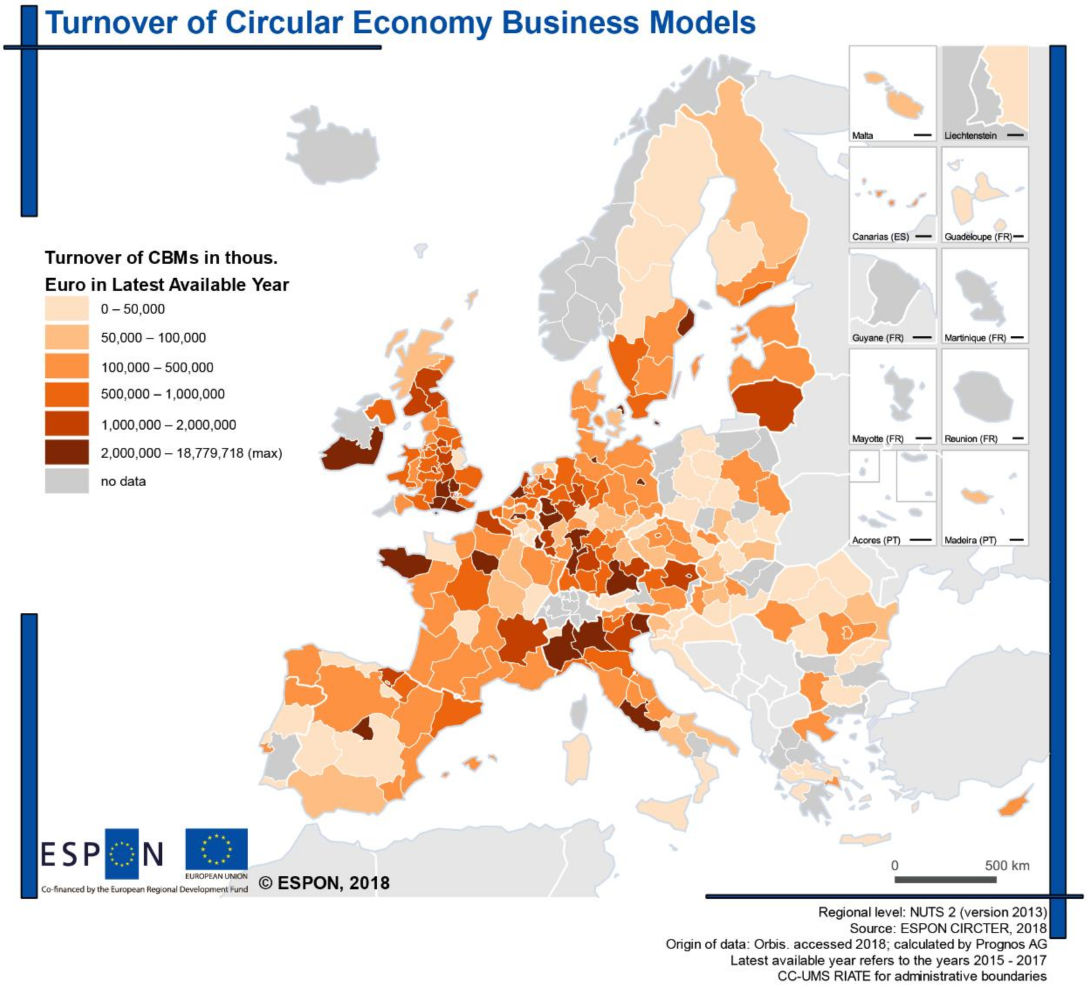
Map 3-9: Number of persons employed in companies associated with Circular Economy Business Models



Generally, the implementation and diffusion of Circular Business Strategies is favoured by agglomerations (both industrial and urban), in proximity of knowledge hubs. Proximity factors provide businesses in industrial agglomerations with benefits due to shared access to information, networks, suppliers, distributors and resources. Urban proximity can promote strategies such as take-back programmes or reverse logistics for a reliable stream of secondary materials.

Knowledge centres, universities or R&D serve as important factors in boosting innovation capacities and can be a decisive factor for the development of disruptive products and / or resource efficient processes. Specialised knowledge of actors within a territory can not only provide a distinct advantage compared to other regions, it can also act as a strong influencer for the design and implementation of effective policies towards a circular economy, informed by the territorial characteristics of a city or region. The end-consumers must be incorporated into circular strategies, as they need to be convinced of the reliability of repurposed products as well as prompted to use circular business models at a peer-to-peer level. Shifting towards a Circular Economy will impact regional employment characteristics. With greater focus on product design and remanufacturing, for instance, an increase in the need for a skilled labour force is expected, with specific competences required in new collection, sorting, and remanufacturing sytems. Remanufacturing sites, transport, storage and distribution activities are likely to increase close to manufacturing sites, as well as near major population centres and transport hubs. The digitisation of services, however, is likely to benefit a greater range of jobs, from local services related to a product or good (customer care services such as return or repair services), though potentially these may follow the current trend towards overseas placement.

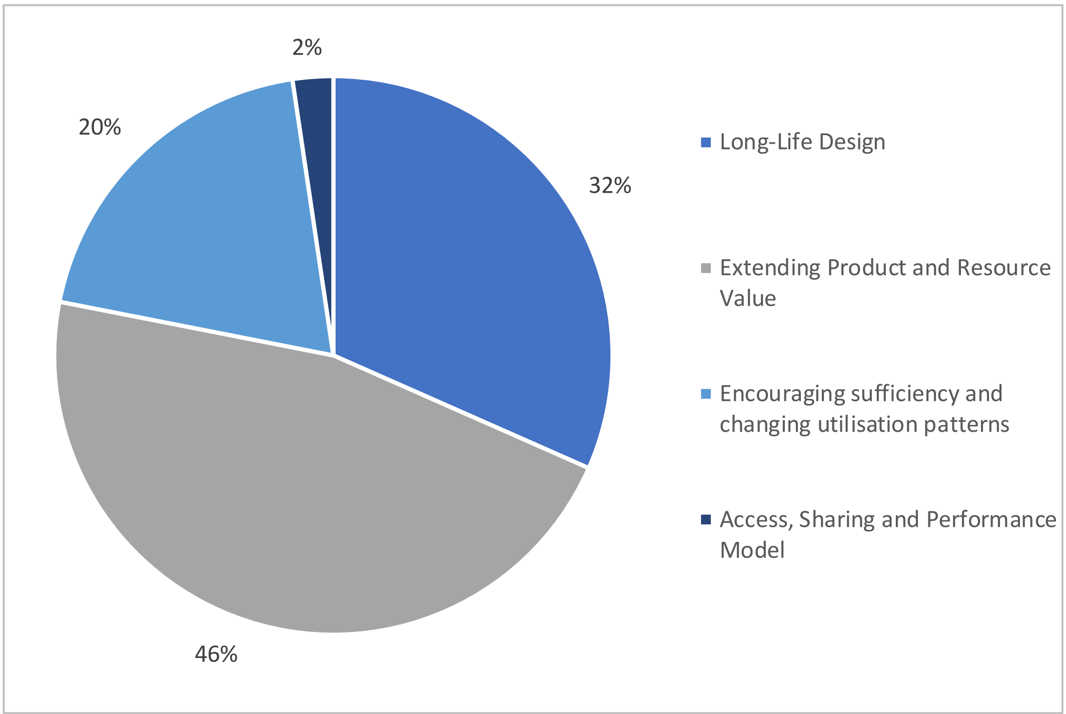
Map 3-10: Turnover in companies associated with Circular Economy Business Models



The analysis of Circular Business Models aims to provide better understanding of the distribution of CBMs across European Regions based on aggregated economic data, which result in the heat maps, and provide an understanding of thematic strengths within each of the four circular strategies. Once a longlist of companies was identified on Orbis, the following step was to identify their websites - of the 9,000 companies, around 6,000 companies had identifiable websites. The search terms applied on Orbis trade descriptions was refined to fit the language used within company websites, for example, refurbishment was fine-tuned to include variations of the words “refurbish”, “refurbished”, “refurbishing”, etc. The output determines the frequency at which search terms appear within the content of a company’s website. This allows to quantify certain patterns across websites. The frequency analysis allows to display and profile thematic strengths within the different CBMs. Based upon the frequency analysis, the results were categorised to the CBMs, while also capturing the overlapping activities belonging to other CBMs. For example, a company providing Eco-Design products (i.e. belonging to the Long-Life Design category) can also be involved in take-back schemes (i.e. Extending Product and Resource Value).

Figure 3-13 displays the distribution of companies within the four identified Circular Business Models. *Long-Life Design, Extending Product and Resource Value* and *Encouraging Sufficiency and Shifting Utilisation Patterns* have a strong occurrence.

Figure 3-13: Share of companies identified through ORBIS for the Long-Life Design (LLD) and Extending Product and Resource Value (EPRV), Encouraging Sufficiency and Shifting Utilisation Patterns (ESSU) and Access, Sharing and Performance Models



Source: Orbis, PWI-Tool Prognos AG own elaboration 2018

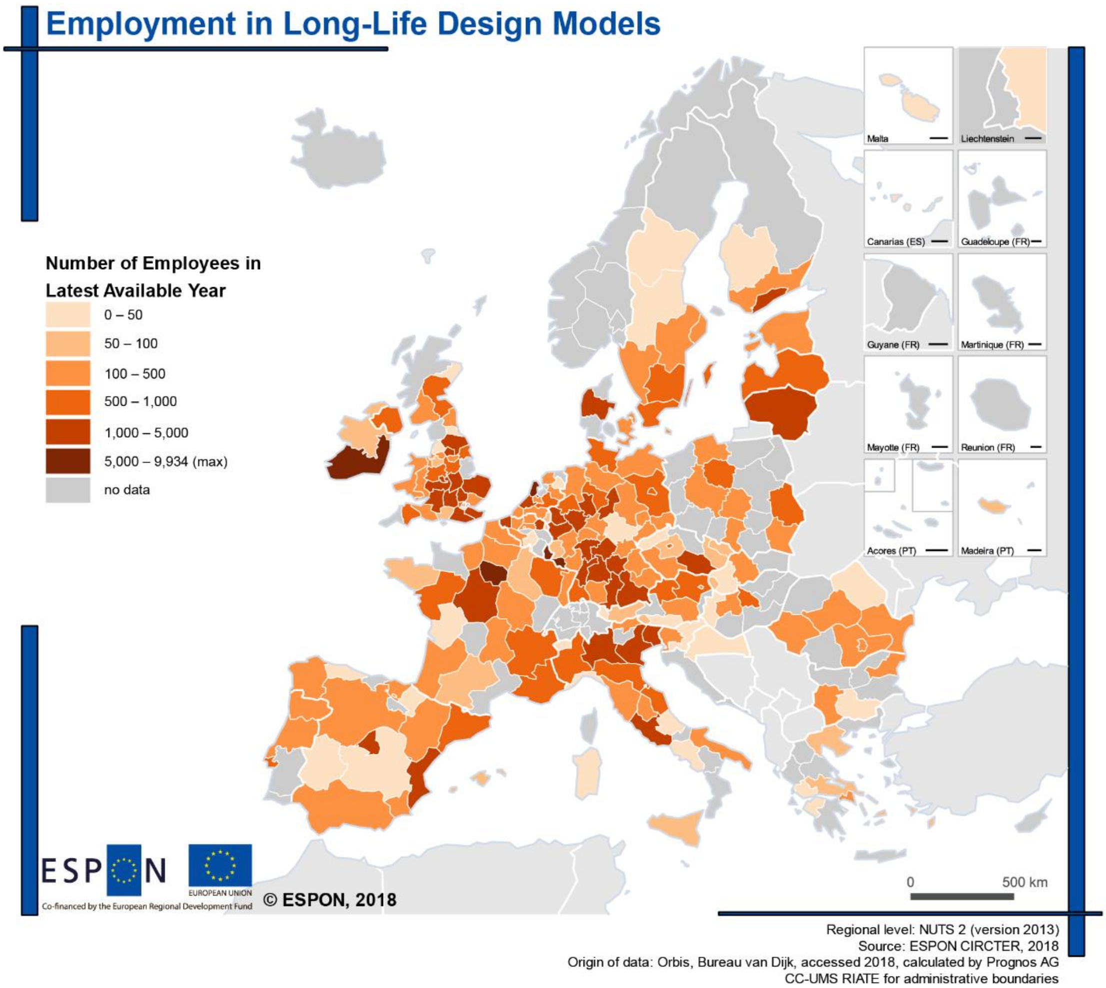
The relatively low result in companies identified under *Access, Sharing and Performance Models* is partly due to the abstract nature of some of the circular strategies: whilst the term '*Car-Sharing'*, '*refurbishment'* or '*remanufacture'* may readily appear in a company's trade description, '*product pooling'*, '*performance-based contracts'* or '*second-hand'* may not. Nonetheless, a more detailed analysis of thematic strengths within all four CBMs has provided for interesting insights that inform the territorial implications of such business strategies. In order to qualify the results, a Big-Data Analysis was conducted. A more fine-tuned set of search terms than that used on the trade descriptions in Orbis were applied to the domain websites of all companies, to replicate the language and word forms adopted (approximately 6000 companies with identifiable websites). The following sub-chapters will show how companies tend to implement several circular strategies at once.

3.2.1 Long-Life Design

Long-Life Design are business strategies with a focus on delivering products designed for longevity through durability and reliability: namely, a product with an optimal design for a lasting life-cycle and aimed at extended and/or long utilisation periods, once in use. It implies manufacturing goods that perform well throughout their life-cycle, aimed to prevent and correct failures easily and oppose gradual (or planned) obsolescence. Cradle-to-Cradle Design and Eco Design are the most prominent examples of such business strategies. Both strategies require consideration of resource (re)cycling during the whole product cycle, informed by social, economic and environmental impacts. A comprehensive set of defined, tested and transparent quality standards are to guide and provide a framework for each individual business based on extensive life-cycle assessments of their product portfolio. Through this procedure, activities such as redesign, reuse, repair, remanufacturing and recycling are induced into the business strategy – cyclical processes are to replace the standard linear approach. Extending the focus from environmental impact to economic and social aspects, *Long-Life Designs* can help to identify new sources of value through repair, reuse and recycling processes, inevitably linking this model to the later discussed *Extending Product and Resource Value*, respectively aimed at identifying such services. To single out businesses with an explicit Long-Life Design strategy, specific search terms such as Eco Design and Cradle-to-Cradle have been applied on the trade descriptions provided by the Orbis database. For the Big Data Analysis, a more fine-tuned Ontology was adopted throughout all four CBMs, attempting to replicate the language and word forms applied on company websites.

Map 3-11 and Map 3-12 illustrate economic data aggregated for economic activities (NACE 2) and location (NUTS 2). The territorial results suggest that Long-Life Design Models are widely used across European regions, such as Noord-Holland, Zuid-Holland, Utrecht and Gelderland, NL; Lombardy, IT; Paris, FR; Ireland, UK; Luxembourg, LU, to name but a few. These outstanding regions all have common characteristics: they tend to be highly industrialised and harbour urban agglomerations with good infrastructure and accessibility between economic actors (industrial, political or societal) and tend to have distinct Circular Economy policy strategies at regional, national or European level.

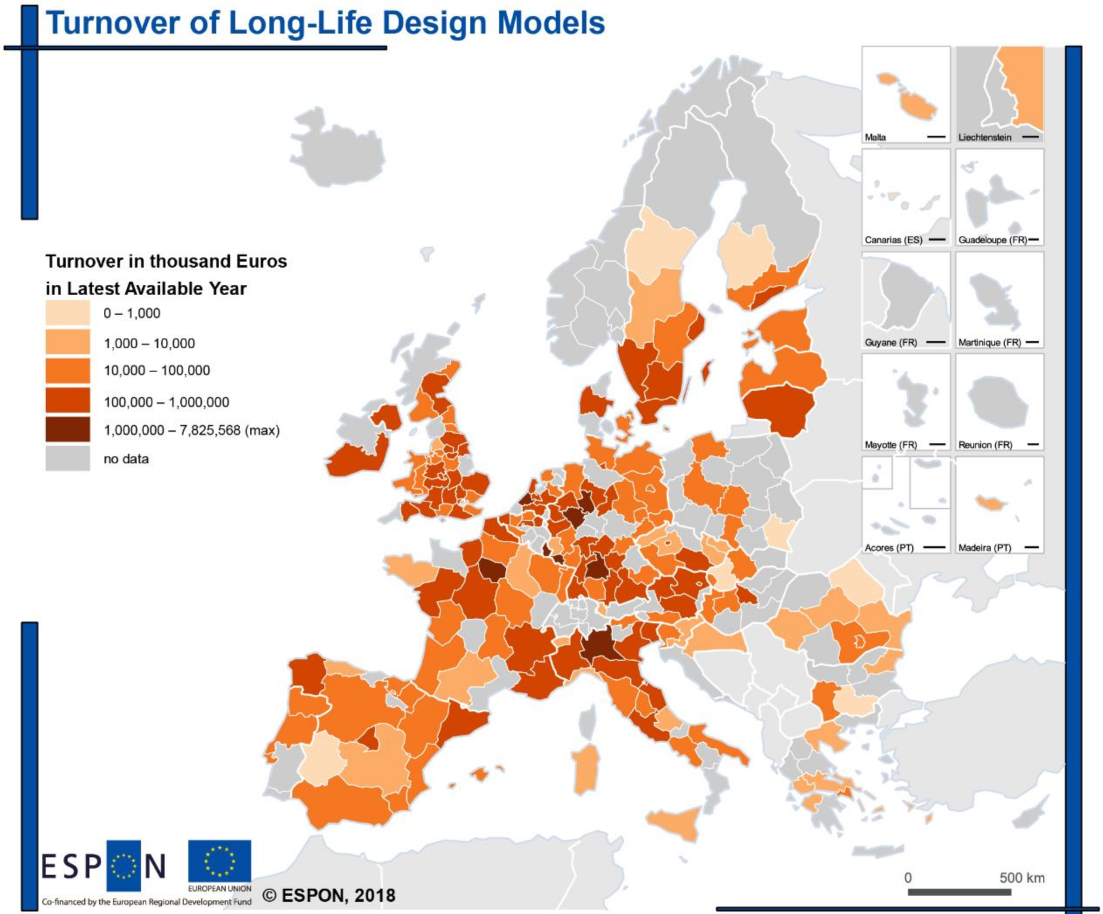
Map 3-11: Territorial distribution of employment in companies identified for Long-Life Design Models



For business strategies that focus on product design and process efficiency, four territorial aspects are of importance (see also Annex 1). Agglomerations, both industrial and urban, provide adequate closeness of agents involved in economic activities. Industrial agglomerations can provide a shared access to information, knowledge and skilled labour-force along the whole value-chain, which can boost innovation capacities. Urban agglomerations provide the necessary social network and market demand. Simultaneously, the proximity of urban centres can encourage business strategies for closed-loop networks, as these rely on economies of scale and accessibility factors (for instance, a take-back programme may only be viable in cities where the availability of stores, shops and drop-off points and adequate transportation options ensure a steady and sufficient stream of product - and thus material - returns). Innovation capacity is influenced by knowledge-factors, the second territorial aspect. The density and characteristics of knowledge hubs (such as universities, R&D or cooperation networks) are decisive actors in the development of disruptive products and resource efficient processes and tend to provide the required skilled labour force. Incorporating the specialised territorial knowledge, they can influence regulations, policy designs and implementation by the public sectors, so long a quality governance and favourable framework conditions allow for effective integration of all stakeholders in the policy debate (territorial aspect 3).

Economy and will help to boost future employability rates end economic growth.

Map 3-12: Territorial distribution of turnover in companies identified as Long-Life Design Models



Regional level: NUTS 2 (version 2013)
Source: ESPON CIRCTER, 2018
Origin of data: Orbis, Bureau van Dijk, accessed 2018, calculated by Prognos AG
CC-UMS RIATE for administrative boundaries

All three aspects shape and are shaped by the Territorial Milieu, which favours a wide stakeholder participation as it '*relates physical resources with local actors'* (see Annex 1). The implementation and diffusion of Circular Business Strategies is favoured by established milieus: policies are informed by and adjusted to territorial aspects, such as structural, industry and skilled labour force requirements. Recycling services may be geographically scattered, reflecting the concentration and availability of waste streams from either industry or households. These areas will also have higher employment rates within related services such es collection, transport, or treatment. Matching its own strengths to business needs a thorough analysis of innovation potentials, infrastructural and labour market requirements. To enable a successful shift towards a Circular Economy, a region will have to address emerging opportunities and market developments comprehensively and coherently – similar to Smart Specialisation Strategies with a specific focus on, or incorporating, a Circular Economy. As an example, one may refer to the comprehensive Circular Economy Strategy of Scotland, where broad stakeholder involvement and a wide consideration of economic aspects fed into the initiative which now is aimed at R&D, SMEs, Governance and skilled labour force. The establishment of the Scottish Institute for Remanufacturing is a concrete step with which the region is addressing specific needs to meet the skills requirement for a Circular To provide further insights into the subjects discussed by Long-Life Design companies, a Big Data Analysis was conducted based on the complete ontology of Circular Business Models. The thematic strengths analysis shows that Eco-Design (23%) and Predictive Maintenance (20%) are the most prominent subjects discussed within the Long-Life Design Models. Generally, companies relate Eco-Design concepts, i.e. they provide a comprehensive examination of their value chain, defining a multi-criteria approach focusing on resource efficiency, use of clean, recyclable and natural materials, improving other environmental impacts (such as noise, smell), and providing an end-of-life strategy. Because aspects of maintenance and repair, reuse, recyclability and recoverability are inherent to Eco Design and Cradle-to-Cradle, the Big Data Analysis results in a more prominent occurrence of circular business strategies relating to *Extending Product and Resource Value*. Predictive Maintenance is a diagnostic strategy which provides information for better product efficiency, meaning that the process uses machinery and product data to derive maintenance information. Rather than reactively providing maintenance and repair services, businesses can proactively maintain the machines and systems in good condition and minimise downtimes, even predict malfunctions and failures. This implies platforms of integrated material databases, a specialist service provided sometimes by other businesses, which have grasped the opportunity to adequately collect, analyse and display the information.

It becomes apparent that appropriate data on the design, pathways and composition is required to determine the potential of a Circular Economy business strategy. Businesses must define how to optimise the resource value of either products and materials, necessitating the analysis of suitability (and optimisation) of a product for reuse, downcycling or recycling. However, this goes far beyond negative environmental impacts of a material / product / process. The focus here lies in the positive value creation of goods for their second life-cycles. Material or Product Passports attempt to provide information on the characteristics of materials or products (which can also be applied onto processes) to put recovery potentials into practice. Buildings as Material Banks, partly funded by Horizon 2020, is an example of a international cooperation between 7 Member States that aim to incorporate a Circular Economy in the building sector through flexible design to promote Urban Mining, based on integrated tools such as a Material Bank / Material Passport[18].

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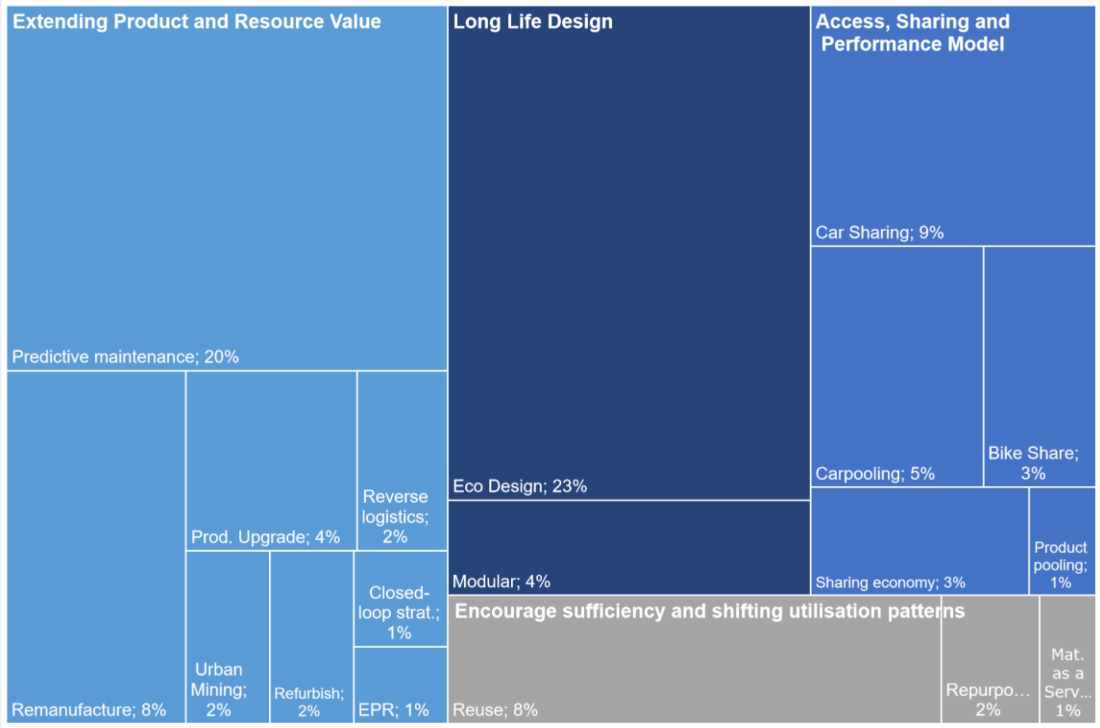
18 For further information on the BAMB Project (Buildings as Material Banks): https://www.bamb2020.eu/about-bamb/

Figure 3-14: Thematic strengths in Europe for the Life-Long Design Models



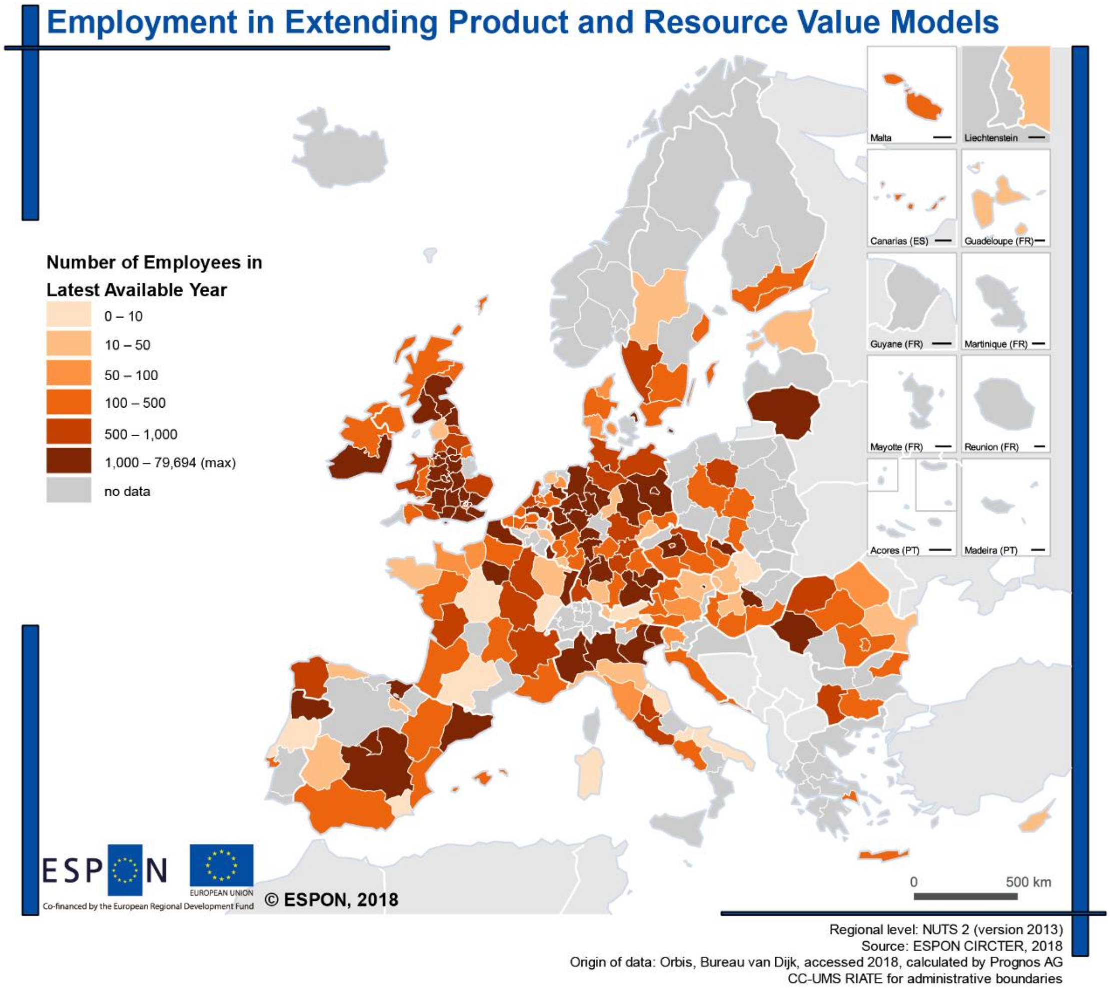
Source: PWI-Big Data Analysis, Prognos AG own elaboration 2018.
Note: Prod. Upgrade= Product Upgrade, 4%; EPR= Extended Producer Responsibility, 1%.; Closed-loop strat. = Closed-loop strategies, 1%; Repurpo… = Repurpose, 2%; Mat. as a Serv…= Material as a Service, 1%;

3.2.2 Extending Product and Resource Value

Extending Product and Resource Value models focus on extending the life-cycle of goods and materials. Through services such as repair, refurbishment and product upgrade, among others, consumers are offered affordable and "good as new" products, thus expanding the product value. As is explained in the methodology, specific terms were identified relating to extended product and resource value strategies. These include *Remanufacture*, *Refurbishment*, *Upcycling*, *Closed-loop Lifecycle Management* or *Reverse Logistics*. These search terms were applied on company trade descriptions for identification via Orbis. For the Big Data Analysis, a more fine-tuned Ontology was adopted throughout all four CBMs, attempting to replicate the language and word forms applied on company websites.

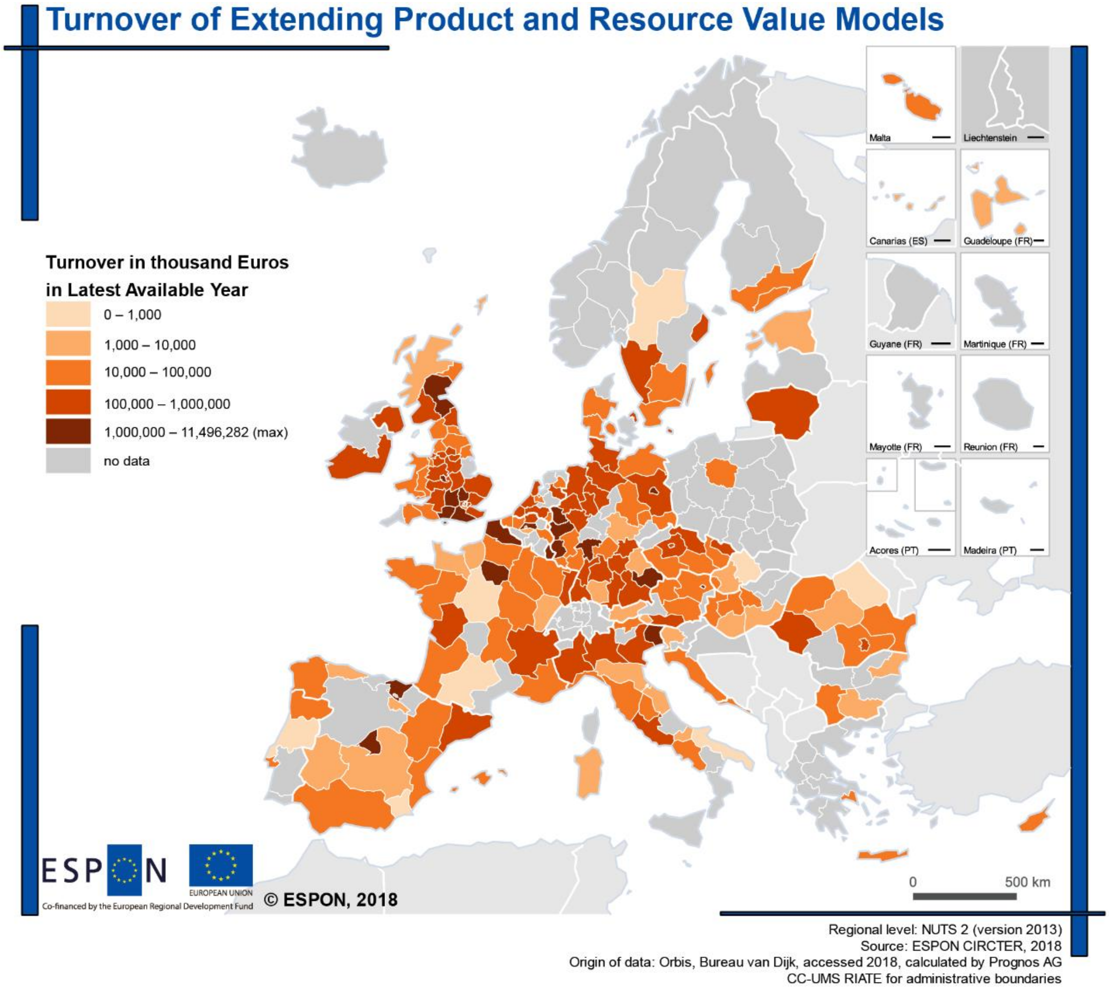
Map 3-13 and Map 3-14 illustrate the employment and turnover data related to companies identified. The territorial distribution of *Extending Product and Resource Value* Models appears to be more present in regions with relatively high population density, as well as higher industry and economic activity. The results indicate the highest concentration in industrial and urban agglomerations: the UK's Counties West Midlands (with its populous cities and knowledge hubs of Birmingham and Coventry), Merseyside (and the UK's second biggest export harbour in Liverpool), and Hampshire (with its important high-tech industry); in Sweden, Västra Götaland County (leading region for industry and transportation in Sweden and the largest port in Scandinavia), Rhône-Alpes in France (with its knowledge hub Grenoble, industry hub in Lyon and research centre in Saint-Étienne) and Bayern, Germany (one of the largest economies in Europe, in particular for automotive and electronics and electrical goods).

Map 3-13:Territorial distribution of employment in companies Extending Product and Resource Value Models



Company and Industry clusters may provide fertile grounds for the development of activities of a Circular Economy, as is elaborated in Annex 1. Collaboration between companies can take place throughout the entire production chains, enabling a shared use of resources, such as by-products, or knowledge spill-overs, as is often seen in industrial parks. Knowledge hubs serve as important factors in providing services associated with, e.g., closed-loop lifecycle management, take-back system and predictive maintenance services. Likewise, consumers and their geographical concentration play a fundamental role in services like reverse logistics, through which products are returned for remanufacture, reuse or recycling. Companies may incentivise returns through take-back programmes in areas of little geographic dispersion. Digital applications have shown to be key facilitators for Circular Economy strategies, providing solutions to technical challenges related to the monitoring, locating, status and quality of products and resource[19]: Some specialist businesses have specialised Reverse Logistics (e.g. Oberbayern, NUTS DE21) providing a tool for B2C and B2B organisation of residual waste collections based on direct communication via apps. Others offer specific services in product returns to prepare them for resale, recapturing unsold products and deliver them to secondary markets.

Map 3-14: Territorial distribution of turnover in companies Extending Product and Resource Value Models

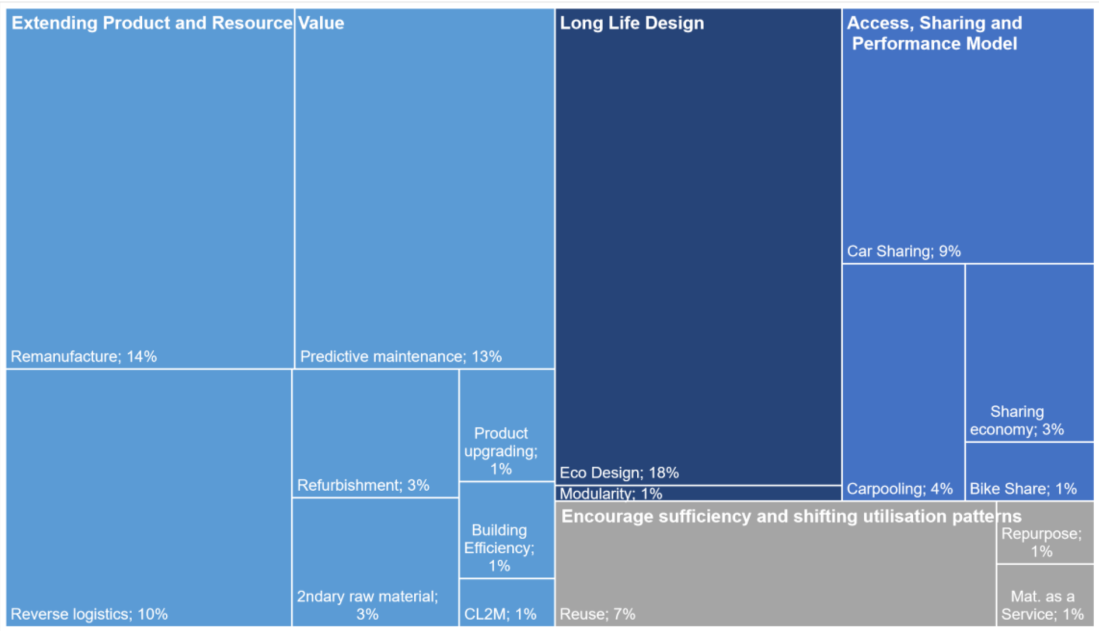


The most frequent themes in Extending Product and Resource Value are *Eco Design* (18%), *remanufacturing* (13%), *predictive maintenance* (13%) and *reverse logistics* (10%). The out-

[19] European Environmental Agency (2017): Circular by design: Products in the circular economy. EEA Report No 6/2017, EU Bookshop. Last visited 04.12.2018. https://www.eea.europa.eu/publications/circular-by-design

comes from the Big-Data Analysis also show that activities for resource and product value extension overlap with Long-Life Design Models, especially so for Eco-Design. These results go hand in hand, as Eco Design sets a framework within which the aim is to achieve longer product life-cycles, based on effective and adequate systems and services in remanufacturing, refurbishment, reuse and recycling (see also sub-chapter above). Circular Economy strategies for material circularity in production and manufacturing chains benefit from larger organizational scales (e.g. industrial symbioses, industrial parcs, etc) as collaborations and knowledge- and innovation capacities are increased, and transportation distances reduced, improving access to material and human input. Such collaborations have a positive impact on a single-firm implementation of strategies related to product design (e.g. Eco Design) and can therefore promote efforts in remanufacturing, reassembly, repair services and so forth. However, they require adequate territorial infrastructure, be it transport, research and/or development centres as well as governance. Digital tools and systems, such as predictive maintenance sensors and platforms, support the tracking of quality and quantity of products and materials and promote circular product life-cycle assessments, which in turn inform product design.

Figure 3-15: Thematic strengths in Europe identified for the Extending Product and Resource Value Models



Note: CL2M = Closed-loop lifecycle management, 1%; Source: Prognos own elaboration, based on PWI-Tool output, 2018.

Companies widely offer product information via e-documentation on online platforms, aimed at employee training offers or specific repair and maintenance aspects to prolong a products life-cycle. Higher concentrations can be found in regions of industry and economic activity such as those outlined above, as well as Centro Region in Portugal, North Rhine-Westphalia in Germany or Lombardy in Italy.

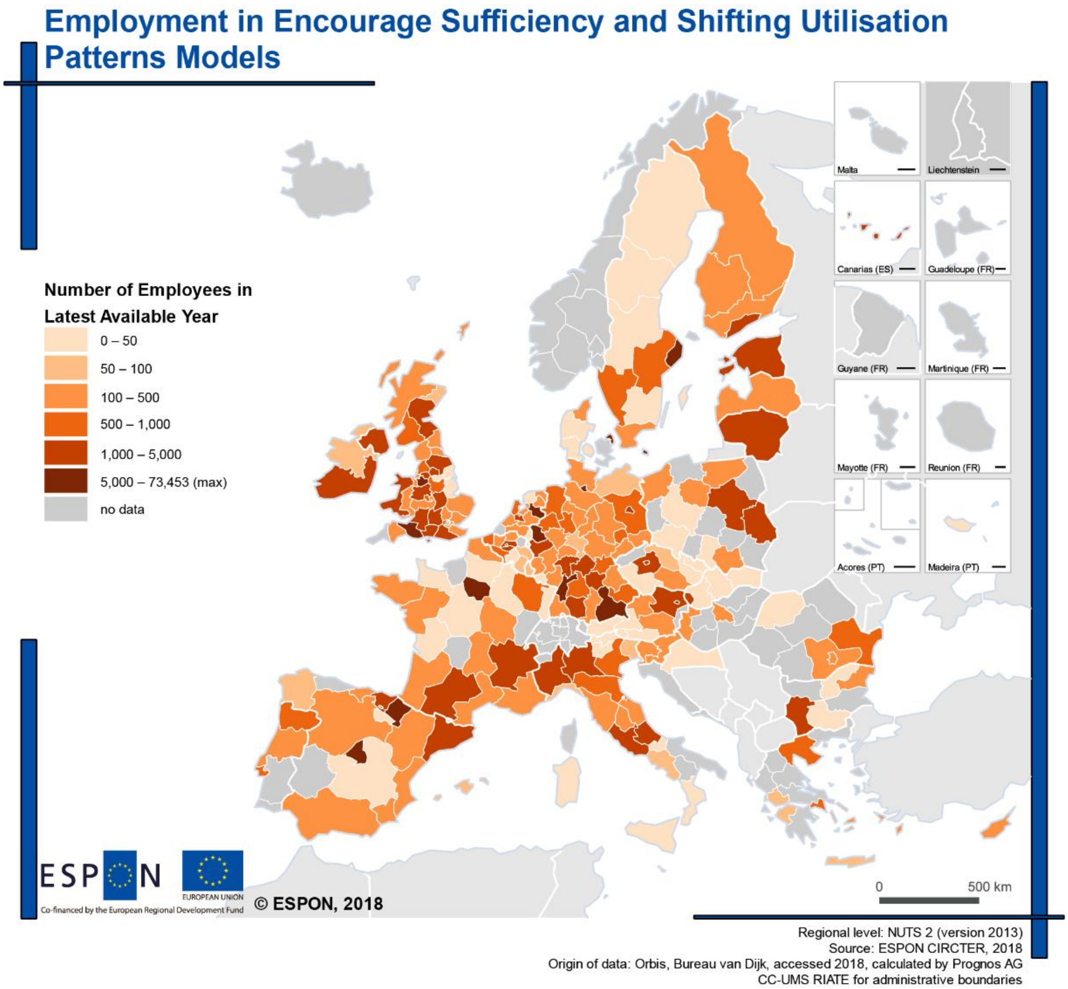
3.2.3 Encourage Sufficiency and Shifting Utilisation Patterns

Encouraging Sufficiency and Shifting Utilisation Patterns stands for a non-consumerist approach aimed at slowing down consumption or delivering utilities virtually rather than materially. Terms were identified relating to strategies including *take-back programmes*, *reuse systems and services*, and *Pay-per-Services* schemes. These search terms were applied on company trade descriptions for identification via Orbis. For the Big Data Analysis, a more fine-tuned Ontology was adopted throughout all four CBMs, attempting to replicate the language and word forms applied on company websites.

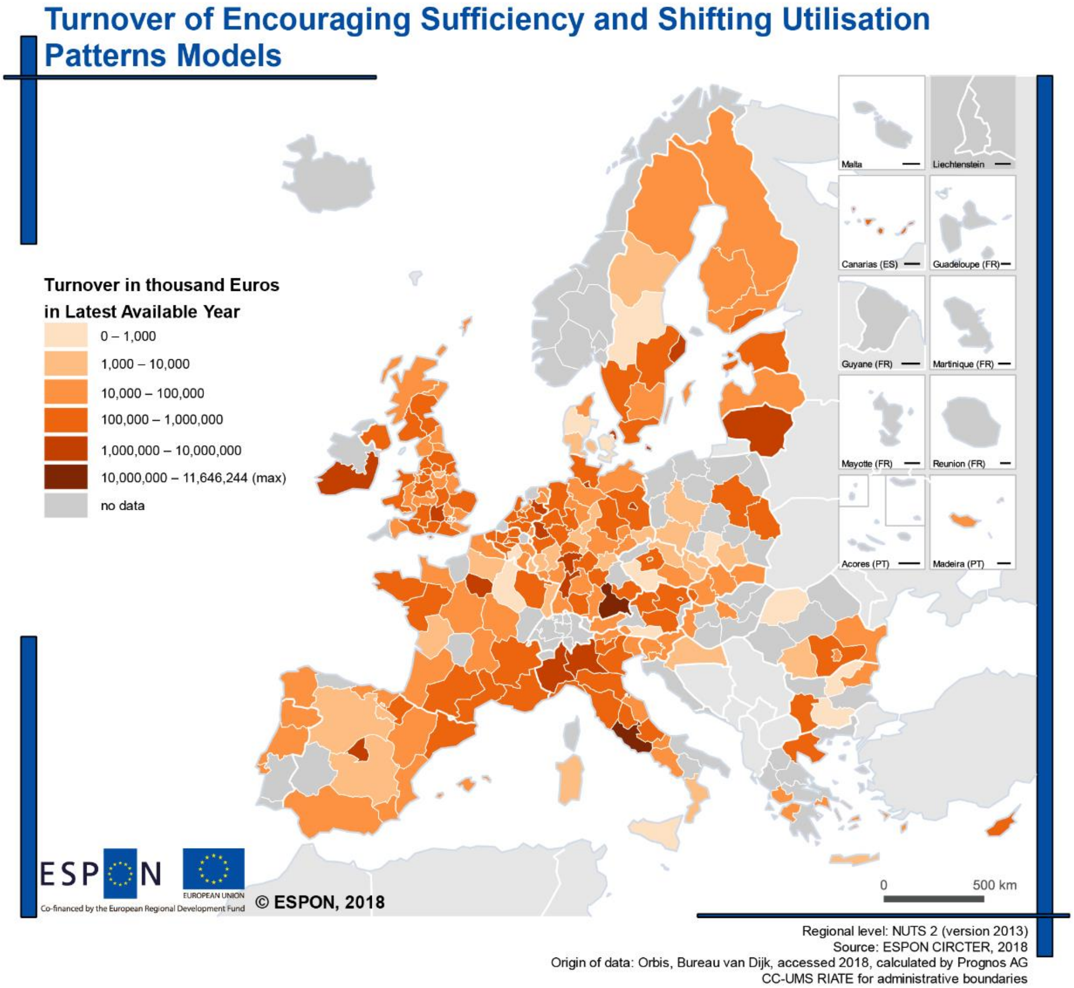
Map 3-15 and Map 3-16, respectively, depict economic data related to companies identified to encourage sufficiency and shift utilisation patterns, at aggregated level relative to the economic activities (NACE 2) and location. Some of the strongest areas appear to be the *Four Motors of Europe* (namely Lombardy, Catalunya, Baden-Württemberg and Auvergne-Rhône Alpes, which have specific working groups that address some circular strategies, such as smart and additive manufacturing), but also Northern Europe (Estonia, Stockholm), Cheshire, Dorset and Somserset (UK) or capitals (Madrid, Paris, Copenhague). As has been apparent throughout the analysis of circular business practices, companies benefit from a clustering of industrial activities due to the accessibility of resources, skilled labour, know-how, and markets.

Encouraging sufficiency and shifting utilisation patterns are both concepts that require a shift in the way individuals and companies consume or offer their products. The focus here lies with companies that offer solutions which aim to reduce end-user consumption through consumption approaches and product design. Whilst the Business category *Long-Life* Design focuses on product designs that aim for durability and repair, the business category here looks to seek out services for durability and upgradability through, for example, take-back programmes and repurposing or reusing its products and materials. The company may also keep ownership of its own products by shifting from the single-transaction sale to a relationship-based model, such as the Pay-per-Service models. Typically, the product manufacturer or retailer is responsible for the installation, maintenance and take-back programme, thus endorsing product and service efficiency. This type of service-based business model makes consumers into long-term partners, with resource efficiency gains for the company, and reduced resource consumption at the level of end-consumers. For such business models to take effect, a certain proximity must ensure. Both maps indicate again that business models tend to concentrate in areas of urban and industrial agglomerations. Proximity of businesses to their customers and agglomeration factors can be a driving force for economies of scale, which in turn is essential in closing material loops, of which activities such as take-back programmes and reuse systems are central contributors. Cities are places where agglomeration, accessibility and knowledge factors accumulate. A large share of resources - be they material or services based, labour force or specific skills - concentrate within the boundaries of cities, pushing for the development of disruptive circular business models. Some nameworthy cities implementing Circular Economy strategies are Amsterdam (NL), Brussels (BE), Maribor (SI) – you may find further information on the latter two in Annex 4.

Map 3-15: Territorial distribution of employment in companies identified for Encourage Sufficiency and Shifting Utilisation Patterns Models

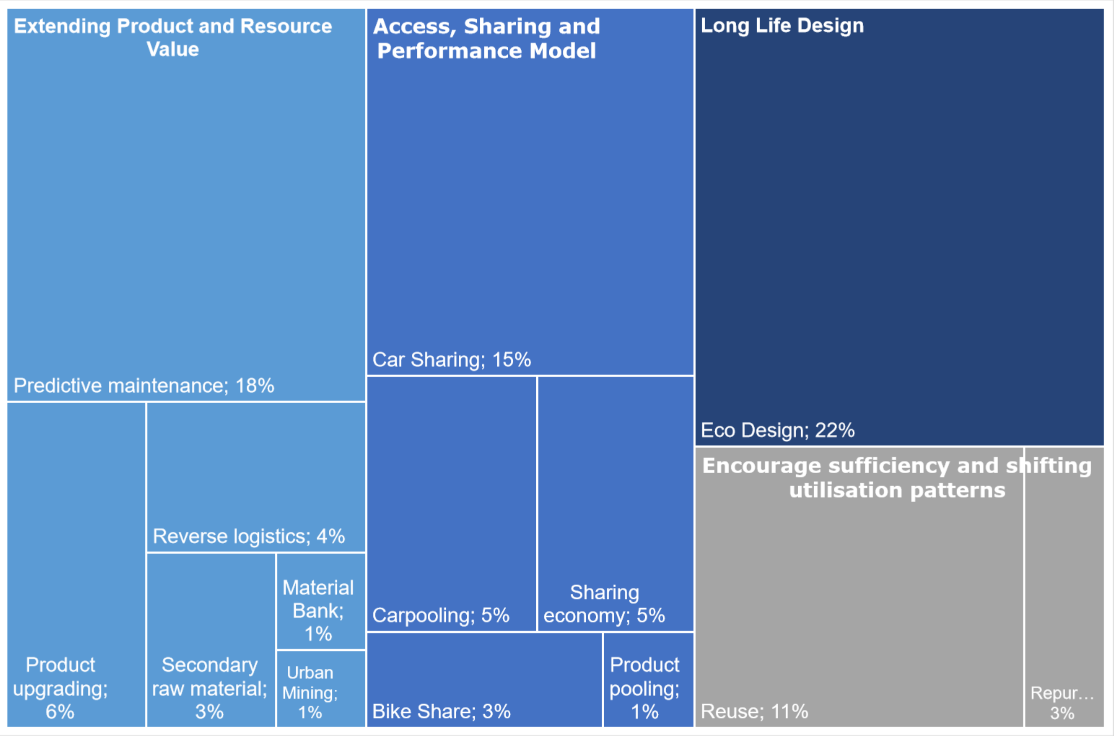


Map 3-16: Territorial distribution of turnover in companies identified as Encourage Sufficiency and Shifting Utilisation Patterns Models



A detailed look into the outcomes of the Big Data Analysis indicate that a sizeable number of companies reflect on Eco Design, either applying the principles as a strategy for the whole production chain or targeting specific product and component aspects. Some may aim to reduce their environmental impact by replacing hazardous materials with bio-based resources, others apply the strategy throughout their production chain: from procurement, to production processes, assembly and installation, maintenance and repair, collection and logistics services. It is indeed the aim of a company to apply Eco Design and Circular Economy principles across its production chain, particularly a life-cycle assessment, to increase its rate of reusing and repurposing products and components. Applying the principles of Eco Design creates transparency over the sources of emissions and material and energy inefficiencies along the production chain and thus informs internal strategies a company can undertake to promote the circularity of its processes.

Figure 3-16: Thematic strengths in Europe identified for Encouraging Sufficiency and Shifting Utilisation Patterns Models



Note: Repur…= Repurpose, 3%
Source: Prognos own elaboration, based on PWI-Tool output, 2018.

For an industry or company, however, geographic dispersion of its products can render efforts to reuse its materials and resources, i.e. closing material loops, difficult. A range of businesses now provide services to facilitate take-back and recycling programmes or reverse logistics, having grasped the opportunity and specialised on collection services, oftentimes combined with specialist reuse or recycling services, to resell refurbished and remanufactured products. The importance of new business models based on services related to product and material collection, recycling and reselling is set to increase if a market for secondary raw materials is to be established. Determinant factors to trigger such strategies are both accessibility and agglomeration. Accessibility provides adequate infrastructure: effective intermodal transportation solutions can trigger economies of scale related to secondary raw material or reverse logistics and take-back programmes. Agglomerations, be they industrial or urban, can ensure a demand for secondary raw materials or second-hand products, whilst reducing the cost of collecting services due to limited geographic dispersion.

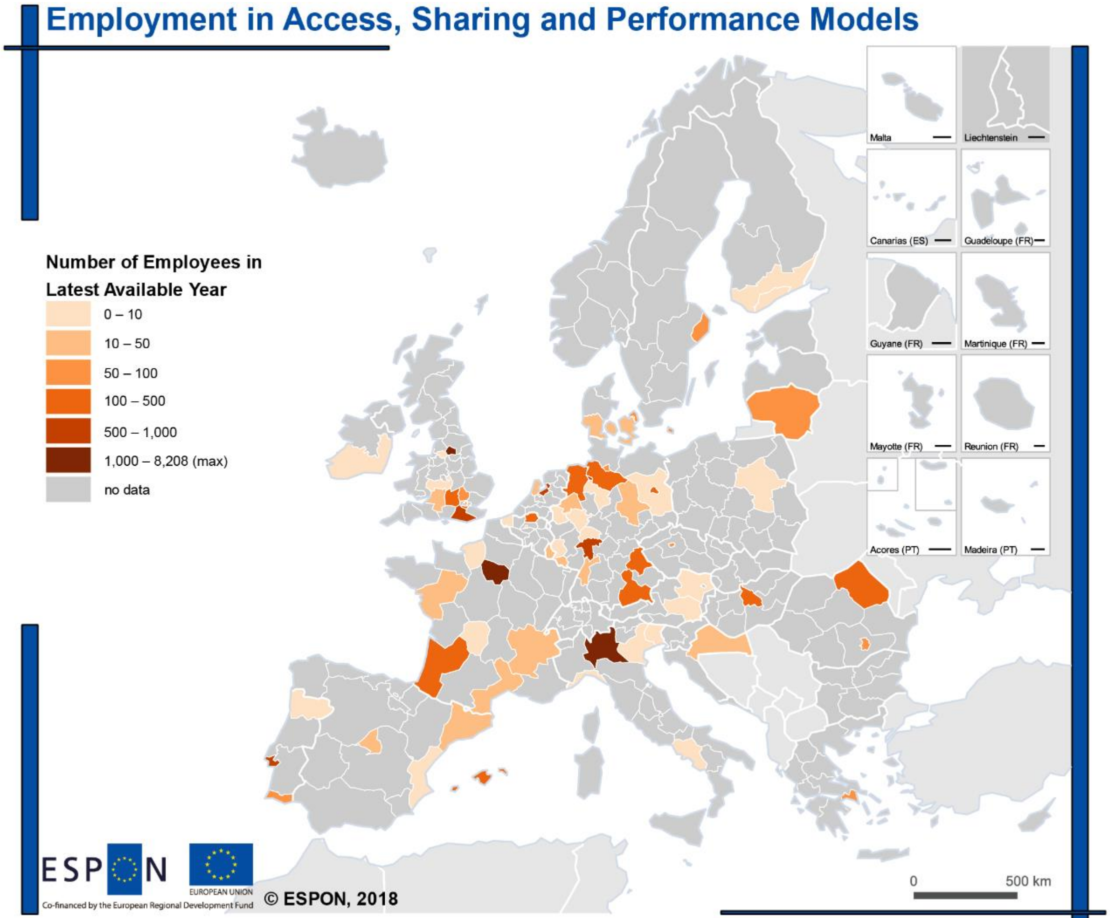
In order to persuade consumers of the reliability of repurposed products, communication becomes an important factor. Indeed, the results indicate that many of the analysed companies provide a customised communication service, usually providing a single contact person. Other ways to ensure trust in the company's products and enhance customer relations are customised maintenance and repair services, online platforms for customer care, fleet/product care, preventive/predictive maintenance and material stock overviews.

3.2.4 Access, Sharing and Performance Models

Access, Sharing and Performance Models are business models which primarily contribute to a change in the utilisation patterns of consumers, by providing for market demands whilst eliminating the need to own physical products. By effacing private ownership of goods and products in favour of servicing, the idea is that access and sharing systems diminish the underutilisation of products and resources at the level of end-consumers. A common and most prominent example of replacing private ownership are Car or Bike Sharing options readily available in many European cities, though recent debates have surfaced regarding the true impact Carsharing options have on consumption patterns (see discussion of this matter on the coming page). Another common model is that of second-hand shops, whether they be textiles, home furniture or electronics. They differ from *Extending Resource and Product Value* as they are aimed at business strategies which incorporate the most inner loops of a Circular Economy – i.e. share and reuse. To identify companies on the Orbis database, search terms such as '*Car Sharing'*, '*Bike Sharing'*, '*Sharing Economy*' or '*Second Hand*' were applied on company trade descriptions. The subtility and abstractness of some of these concepts combined with the heterogenous trade descriptions provided by companies have resulted in a limited, albeit existing data set with which it was possible to attribute some regional and territorial patterns and conduct a thematic strengths analysis.

Map 3-17 and Map 3-18, respectively, depict economic data related to companies identified through the methodology explained above, at aggregated level relative to the economic activities (NACE 2) and location. Whilst the regionalisation shows a dispersed image, it is nonetheless apparent that Access, Sharing and Performance Models concentrate in industrial and urban agglomerations, i.e. regions of high economic activity and available labour force, such as capital and urban regions. Companies benefit from a clustering of industrial activities due to the accessibility of resources, such as materials, skilled labour, know-how, distributors and markets. As is argued in Annex 1, agglomerations, be they industrial or urban, provide a fertile ground for the development of Circular Economy strategies due to the innovative capacity and provision of critical mass for certain market demands. Access and sharing models rely on a sense of community and mutual trust: a common language, culture, traditions or simply face-to-face encounters are important factors encouraging social networks and community driven initiatives. They are particularly favourable for circular economy strategies that build on the concept of sharing and reusing assets, products and resources, or providing services such as repairs at a C2C level.

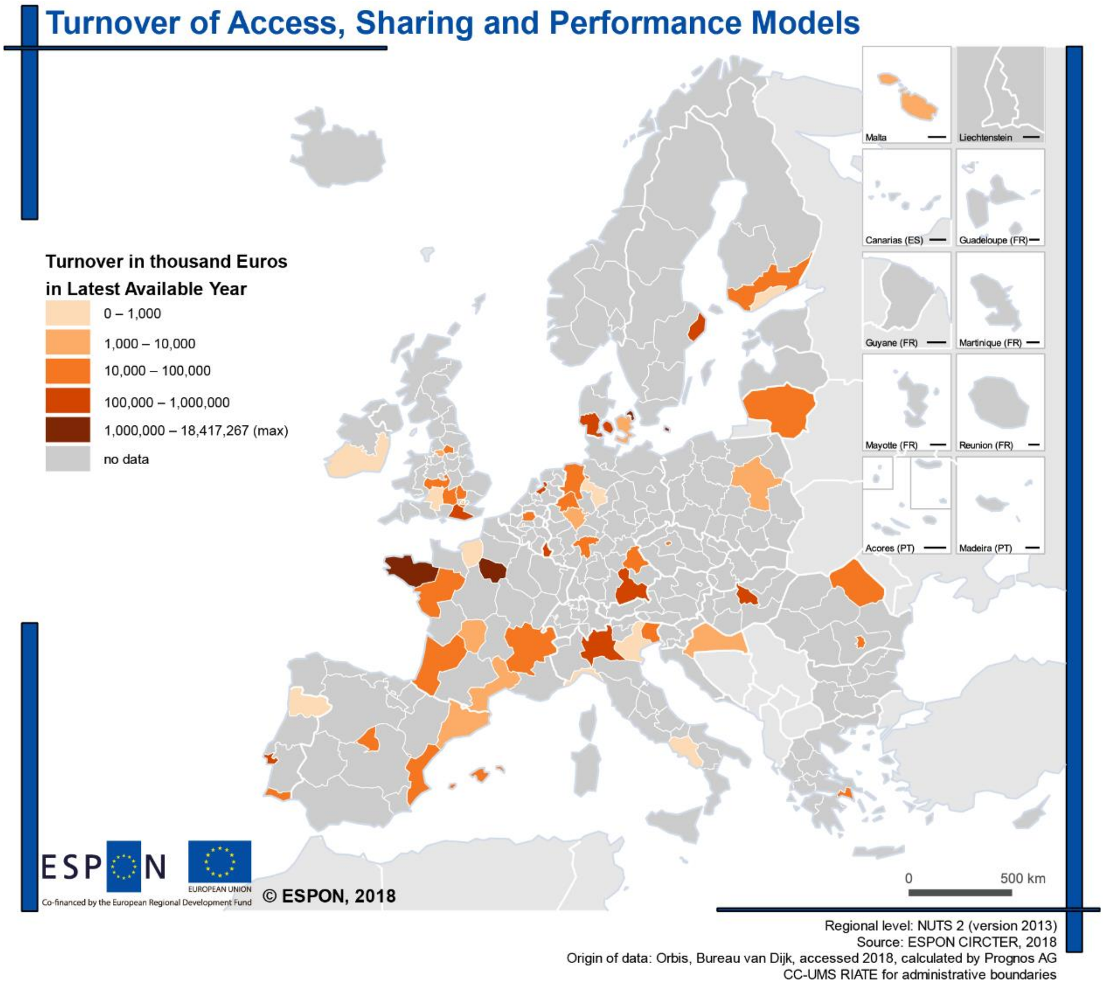
Map 3-17: Territorial distribution of employment of companies applying Access, Sharing and Performance Models



Regional level: NUTS 2 (version 2013)
Source: ESPON CIRCTER, 2018
Origin of data: Orbis, Bureau van Dijk, accessed 2018, calculated by Prognos AG
CC-UMS RIATE for administrative boundaries

A most prominent business model is that of mobility sharing options. To give a more differentiated look at the types of models, Car sharing, Free-Floating Carsharing, Bike sharing, and Carpooling were treated separately. Each of these options provide a differentiated solution to reducing the number of privately-owned cars (Car haring, Free Floating Car sharing and Carpooling) and bikes. Such options require a critical mass of people that will make the provision of mobility sharing services a viable business model. A detailed investigation of the companies providing these options put them in urban or industrial agglomerations, such as Paris (FR), Hannover (DE), and Ost Flanders (BE). Lately, concerns surrounding the true effect of car sharing schemes on reduced number of vehicles on the road and vehicle kilometres driven have arisen. Studies have indicated that customers tend to sell their own vehicles once acquiring a car sharing membership, whilst there is also evidence that this life-style change does not always occur, indeed that some car sharing options can induce an increased use of a car for short-distances[20][21].

Map 3-18: Territorial distribution of turnover of companies applying Access, Sharing and Performance Models



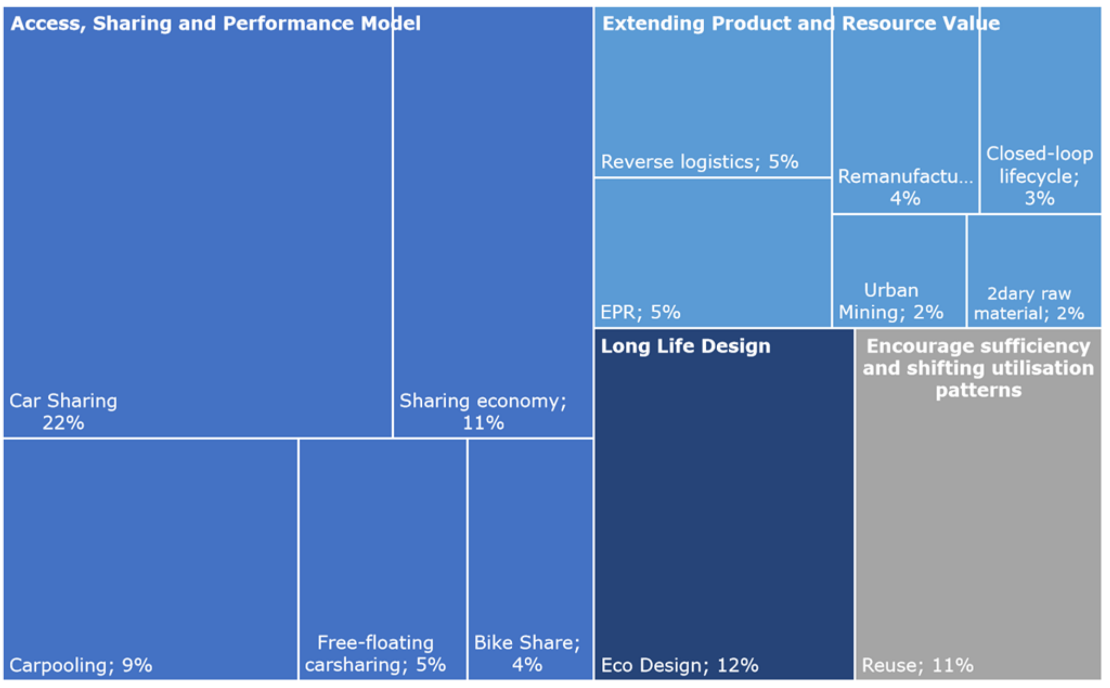
What seems to be of upmost importance is for cities to offer Car Sharing options within a multimodal transport system where neither mobility option competes with the other, but rather offers a combined and efficient transportation system from which the citizen can chose from. As was discussed above, urban agglomerations provide an environment for social interaction and organised social networks and initiatives. The Sharing Economy is a socio-economic concept that is built around the share of physical, human and intellectual resources covering the whole value

[20] Archer, G., and Bondoravá, B. (2017). Does Sharing cars really reduce car use? Transport & Environment [last visited: 06.12.2018] : https://www.transportenvironment.org/sites/te/files/publications/Does-sharing-cars-really-reduce-car-use-June%202017.pdf

[21] EEA (2017): Circular by design: Products in the circular economy. European Environment Agency. [last visited: 06.12.2018]: https://www.eea.europa.eu/publications/circular-by-design

chain of products and services, from design, to production, distribution, trade and consumption. In its most prominent form, it is based on a Peer-to-Peer digital exchange platform, such as the renting platform Fat Lama (East London, UK), but includes also swapping, exchanging, collective purchasing and collaborative consumption. Sharing Economies are by definition place-based, where people, communities, companies or associations are active participants and act collaboratively and cooperatively to produce services and goods, embracing a variety of exchange mechanisms, such as alternative currencies (e.g. the Bristol Pound) and redistribution of assets and resources. They incorporate circular systems or closed loops, through up-cycling or recycling initiatives and embracing sustainable designs (EcoDesign). It explains the linking of Access, Sharing and Performance Models to activities related to Extending Product and Resource Value or Long-Life Design. Companies that aim to reuse and recycle their product streams oftentimes promote circular systems, either internally or with local partners. The existence or intensity of material loops depends much on the accessibility rate, i.e. adequate infrastructure and proximity to consumers (see also Annex 1).

Figure 3-17:Thematic strengths in Europe for the Access, Sharing, and Performance Models



Note: EPR = Extending Product Resource Value;
Source: Prognos own elaboration, based on PWI-Tool output, 2018

3.3 Potential Users: sectoral circularity rates across the EU

3.3.1 Regional distribution of Potential Users

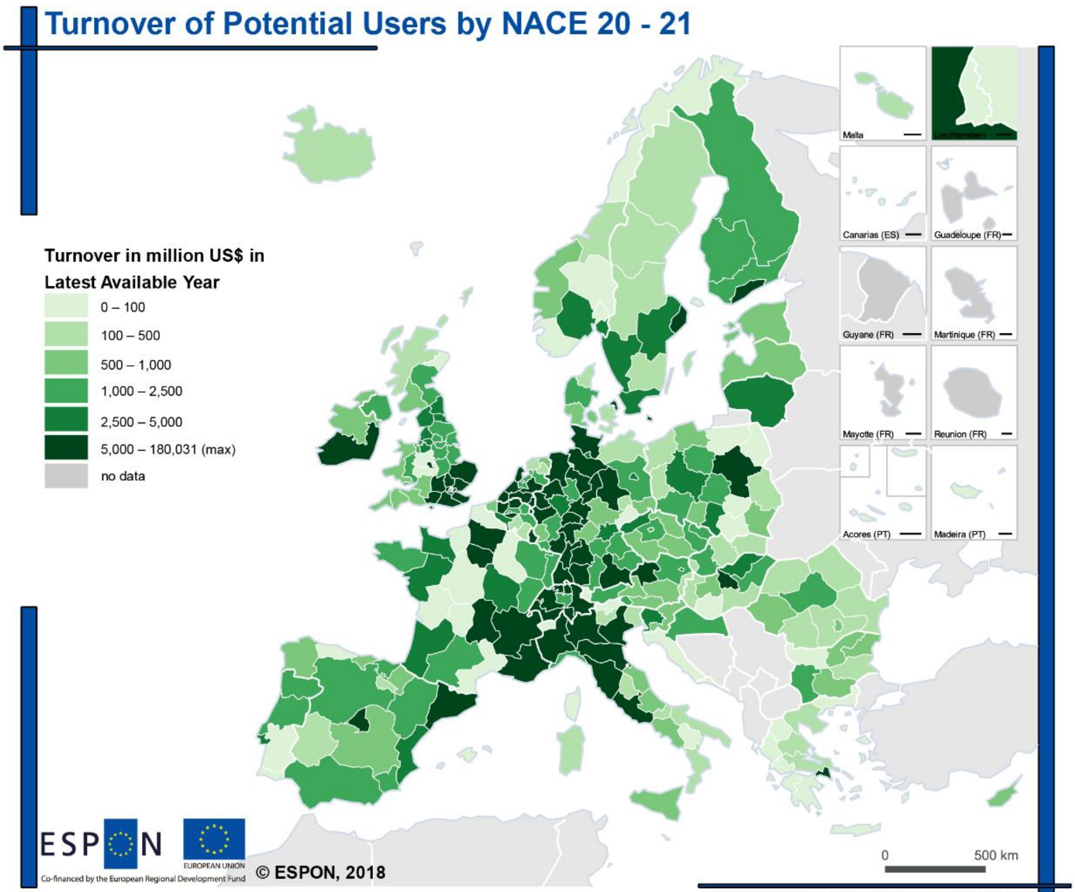
As Potential Users for an exemplary analysis and presentation, the following sectors were selected: Manufacture of basic metals (NACE 24) and Manufacture of fabricated metal products, except machinery and equipment (NACE 25), automotive industries (NACE 29 and 30), chemical and pharmaceutical industry (NACE 20 and 21), electronics industry (NACE 26 and 27) and the construction sector (NACE 41 to 43) as presented in Section 2. The Potential Users within the defined key sectors can be allocated based on their generated revenues as presented in Map 3-19 to Map 3-24 below, allowing for the identification of the sectoral important regions by economic significance. For the analysis information available from the Orbis database was retrieved.

The energy intensive chemical and pharmaceutical industry as Potential User for renewable energy and secondary raw materials like solvents, waste oils, but also plastics – to mention only a few examples – is located regionally mainly in Central Europe, from Germany and Benelux to Switzerland and Italy. A strong position in the sector have also southern regions in UK. In almost 43 regions turnover of more than one million US$ were generated by companies active in the chemical and pharmaceutical industry. Nearly three quarters of the regions are located outside of important industrial regions.

Economically strong regions in the sector manufacture of basic metals were identified mainly in Finland, northern parts of Italy and southern Spain. In the case of Germany and also UK the regionalisation has shown that the economic importance of the country as a whole is based on a relevant regional diversification of the key Potential Users, while in other countries the sector is more concentrated in key regions. In almost 11 regions the generated turnover exceeds 10 million US$. At least half belongs to industrial regions with industrial branches losing importance, the remainder are located mainly outside of industrial regions. The same is true for the manufacture of fabricated metal products, except machinery and equipment showing a more even distribution between a larger number of regions. More sectoral concentrated regions by economic significance of the sector can be found mainly in southern Sweden, northern Italy and France. Key regions with relevant manufacture of fabricated metal products by turnover (>10 million US$) are located mostly in industrial areas, which are characterized by decreasing importance.

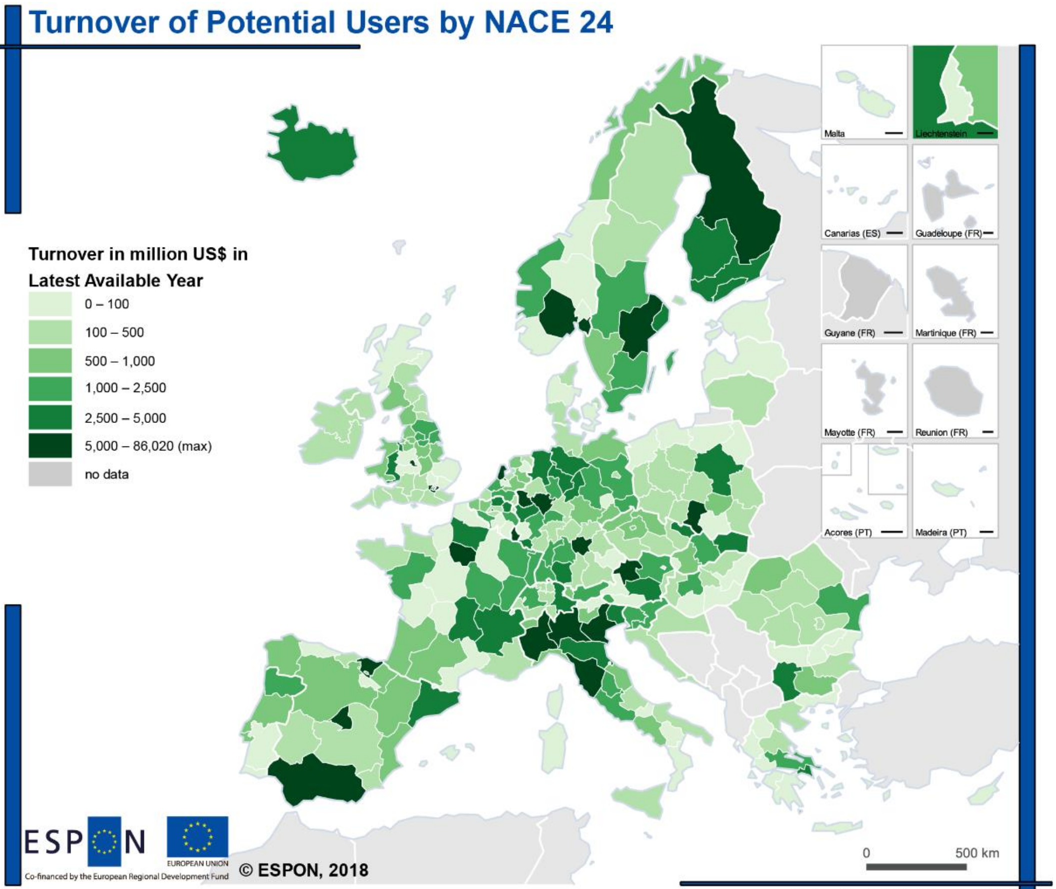
Potential Users in the sector manufacture of electrical and electronical equipment are distributed more evenly comparable to other sectors. While more than half of the most important regions generating annual turnover higher above 10 million US$ (18 regions) belongs to industrial regions, mostly faced with decreasing importance. A comparably larger number of economically relevant regions were identified for the manufacture of motor vehicles and other transport equipment mainly in Germany, Netherlands, France, Italy and Spain. Half of the most important regions with turnover higher than 10 million US$ (in total 42) are located outside of industrial areas, whereas the other half belongs to industrial regions. Seven of them re regions faced with structural changes or increasing importance. The construction sector as potential user for renewable energy and secondary raw materials holds strong regional positions in southern Europe, on an axis from southern France and northern Italy. From the in total 55 regions generating turnover above 10 million US$ in total 71% belongs to non-industrial regions, while the remaining can be allocated to regions loosing economic importance (12) or being faced with structural changes (4).

Map 3-19: Regional Distribution of Revenue of Potential Users by NACE 20-21 (chemical industry) category



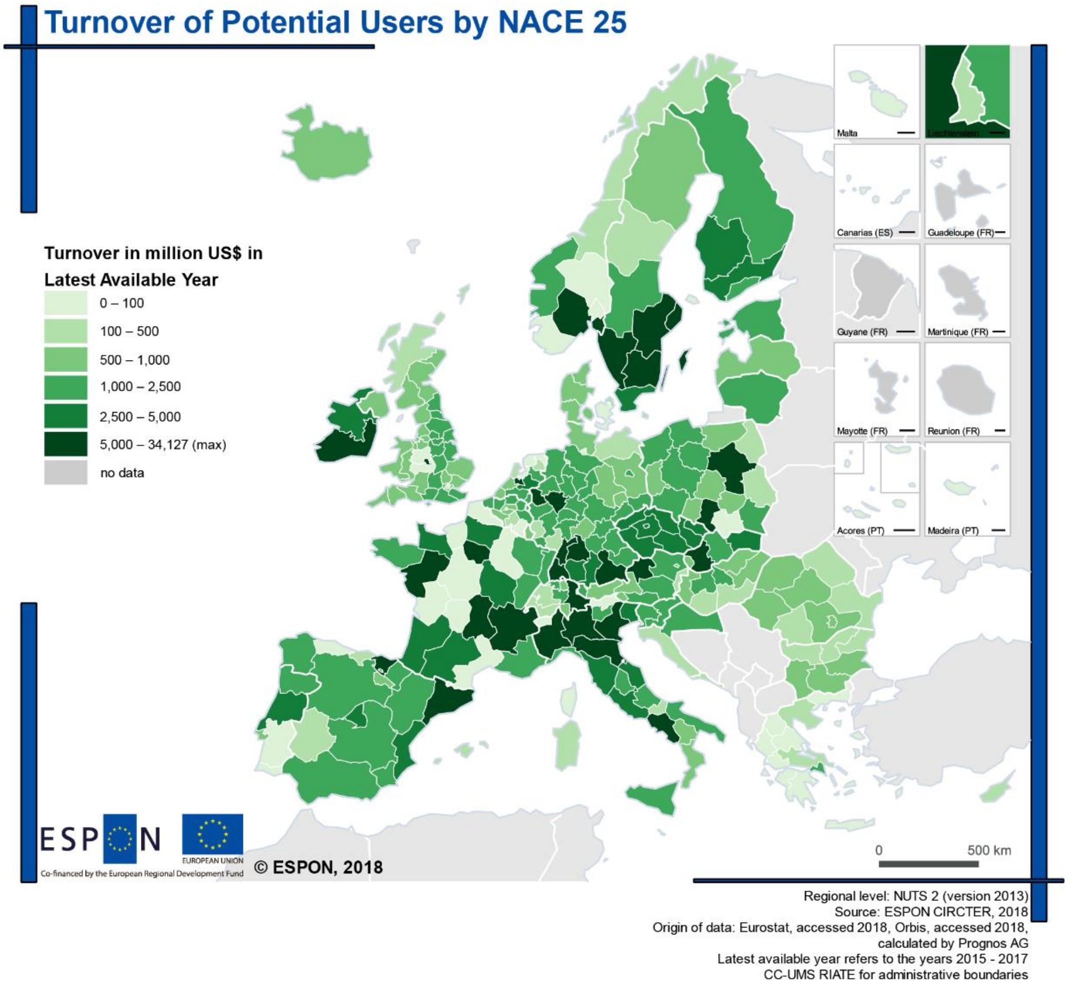
Regional level: NUTS 2 (version 2013)
Source: ESPON CIRCTER, 2018
Origin of data: Eurostat, accessed 2018, Orbis, accessed 2018, calculated by Prognos AG
Latest available year refers to the years 2015 - 2017
CC-UMS RIATE for administrative boundaries

Map 3-20: Regional Distribution of Revenue of Potential Users by NACE 24 (basic metals) category

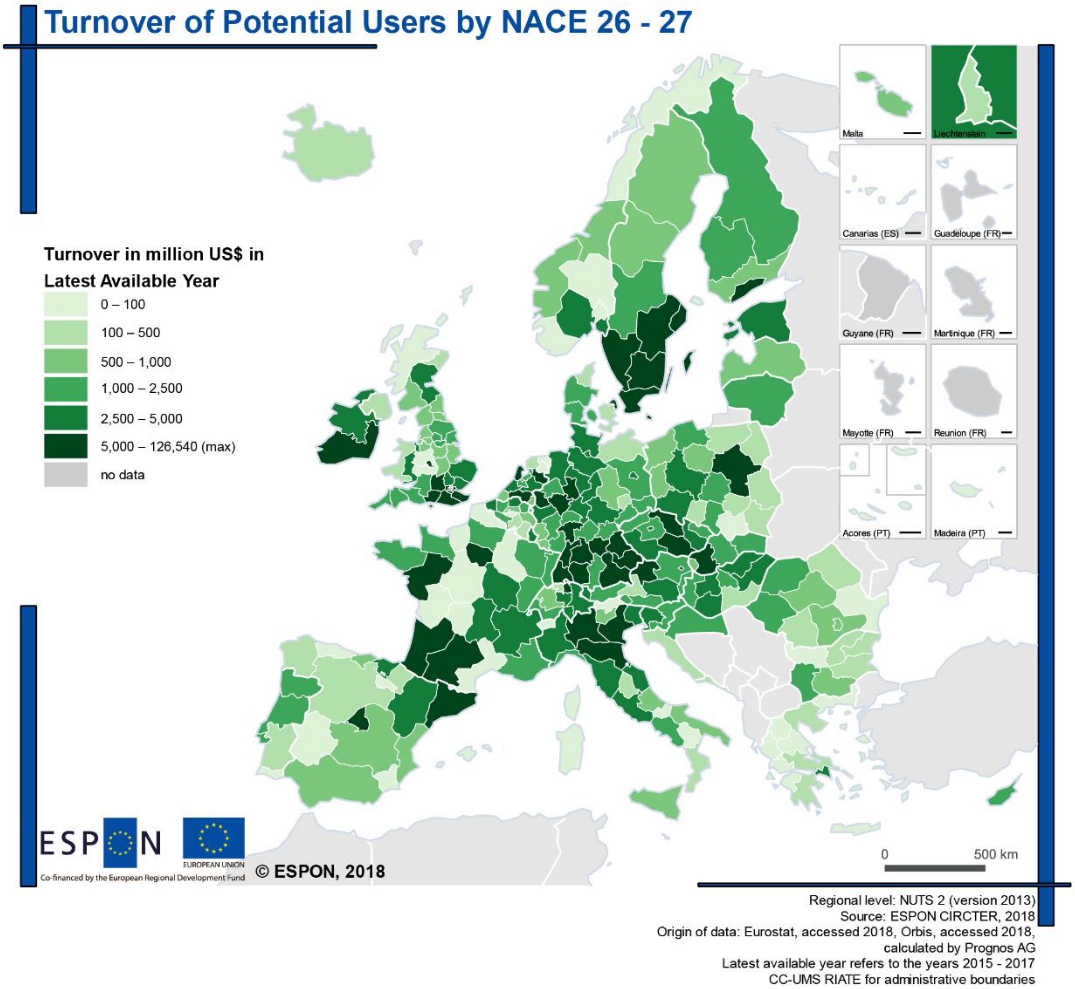


Regional level: NUTS 2 (version 2013)
Source: ESPON CIRCTER, 2018
Origin of data: Eurostat, accessed 2018, Orbis, accessed 2018, calculated by Prognos AG
Latest available year refers to the years 2015 - 2017
CC-UMS RIATE for administrative boundaries

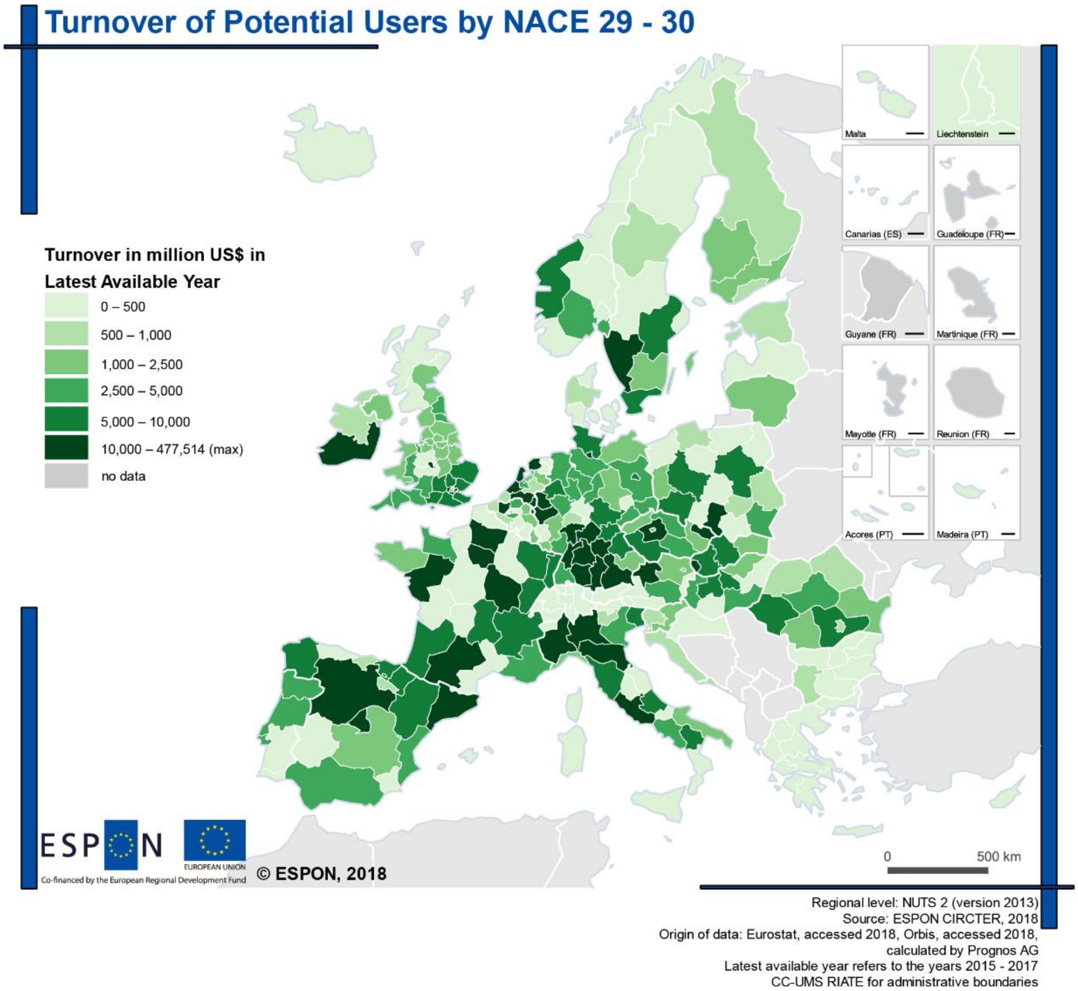
Map 3-21: Regional Distribution of Revenue of Potential Users by NACE 25 (metal products) category



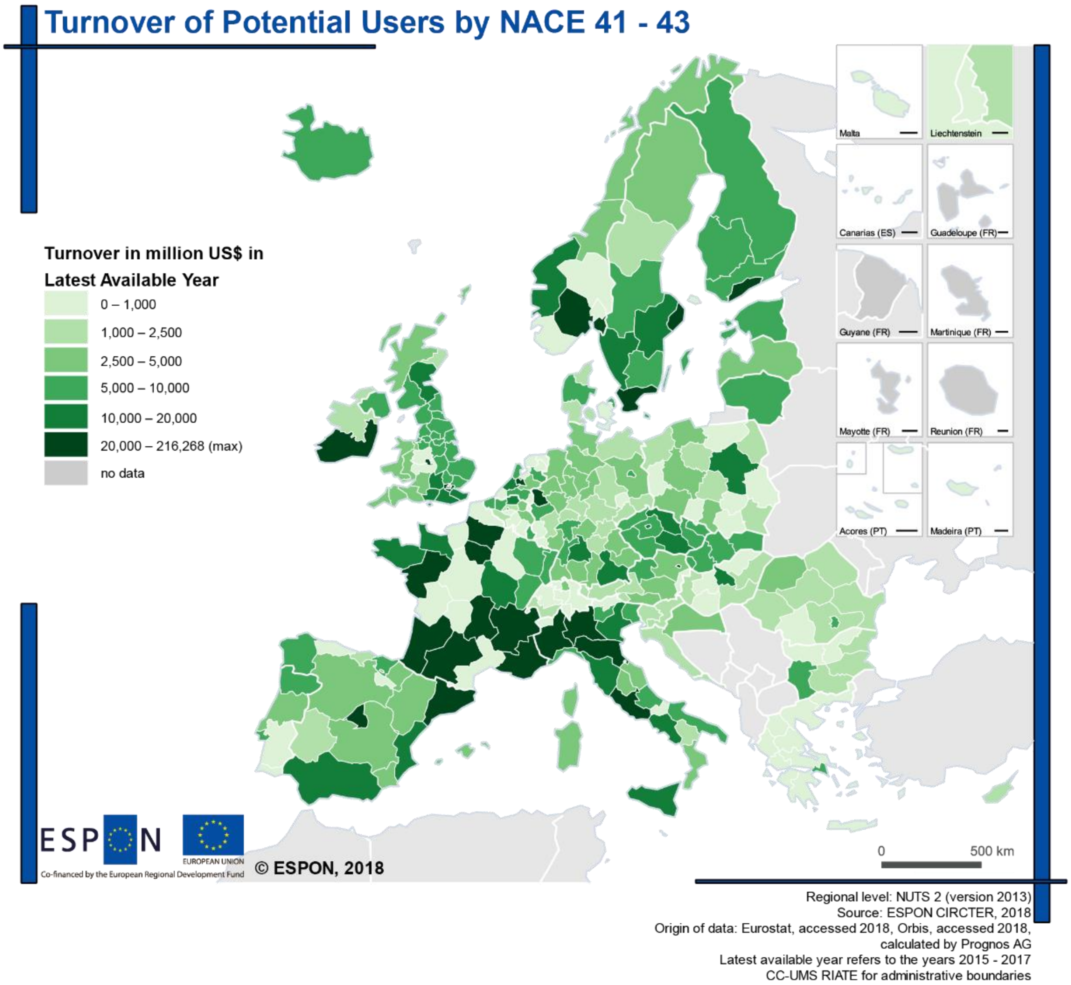
Map 3-22: Regional Distribution of Revenue of Potential Users by NACE 26-27 (computers and electrics) category



Map 3-23: Regional Distribution of Revenue of Potential Users by NACE 29-30 (vehicles, transport, equipment) category



Map 3-24: Regional Distribution of Revenue of Potential Users by NACE 41-43 (construction) category



3.3.2 Use of renewable energy by selected sectors

The share of renewable energy used in the selected sectors is so far in most of the EU member states and EFTA states insignificant, as illustrated by the average shares of renewable energy consumption across all states, when comparing to the total energy consumption, as presented in Table 3-1. In absolute terms most of renewable energy was used by the energy intensive chemical and pharmaceutical industry (20,558 TJ in 2016), followed by manufacture of metal products with 6,836 TJ in 2016. The chemical and pharmaceutical industry have in comparison to the other selected sectors a low use of renewable energy, despite being a relatively high energy intensive sector.

A closer look to single states and the share of renewable energy used by and within single states reveals significant differences as illustrated by the range of shares of renewable energy used by a specific EU member state and EFTA state. As summarized in the following table the current penetration rate in general is comparable low. Also, the regional coverage by number of states, where renewable energy was consumed by the respective sector, leaves room for further improvement.

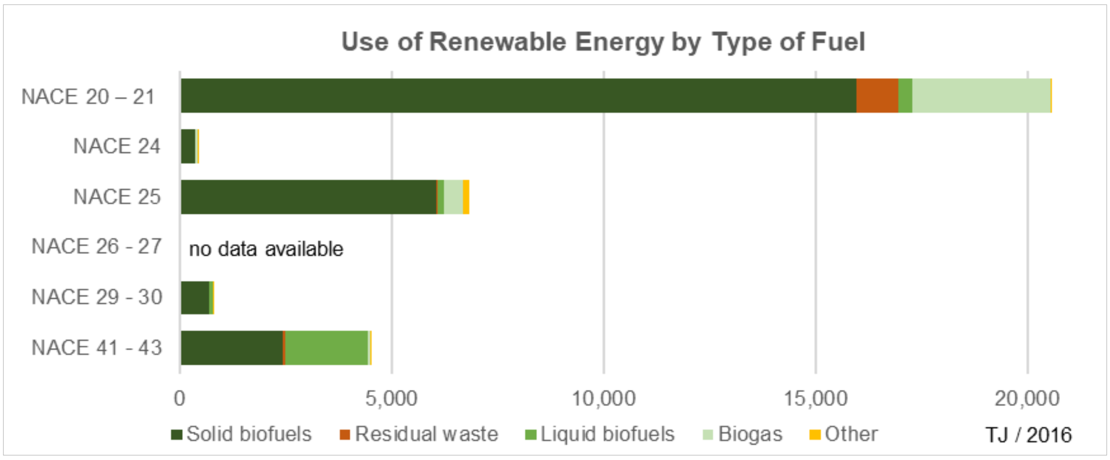
Table 3-1: Overview of renewable energy use by important sectors

NACE category	Total energy consumption across all EU / EFTA states	Renewable energy consumption across all EU / EFTA states	member states consuming renewable energy	Share of renewable energy consumption across all EU / EFTA states	Range of share of renewable energy consumption within a specific state
	[TJ/2016]	[TJ/2016]	[number*]	[%]	[from – to in %]
NACE 20 – 21	2,208,819	20,558	20	0.9%	0.1% - 20.4%
NACE 24	2,619,971	415	15	0.02%	0.001% - 0.7%
NACE 25	792,765	6,836	21	0.9%	0.03% - 15.6%
NACE 26 – 27	n.a.	n.a.	n.a.	n.a.	n.a.
NACE 29 – 30	365,828	798	16	0.2%	0.1% - 6.5%
NACE 41 – 43	311,304	4,503	18	1.4%	0.1% - 8.3%

Source: Eurostat [nrg_110a], accessed 2018, own calculation Prognos AG 2018
Note: NACE 20 and 21: chemical and pharmaceutical industry, NACE 24 and 25: manufactured metal industry, NACE 29 and 30: automotive industries, NACE 26 and 27: electronics industry, and NACE 41 to 43: the construction sector.
** No data available for Lichtenstein and Switzerland*

The selected sectors are using mainly solid biofuels by between 78% and 88 %, except the construction sector (54 %). The construction sector is using to a large extend also liquid biofuels (44%), while this type of fuel is used by other sectors between 1 % and 11 % only. Residual waste is used by the chemical industry (5% of the total renewable energies). Geothermal, solar and tidal energy play a marginal role only between a combined 1 % and 2 % of renewable energy used by metal industries (NACE 24 and 25) and automotive industry (NACE 29 and 30).

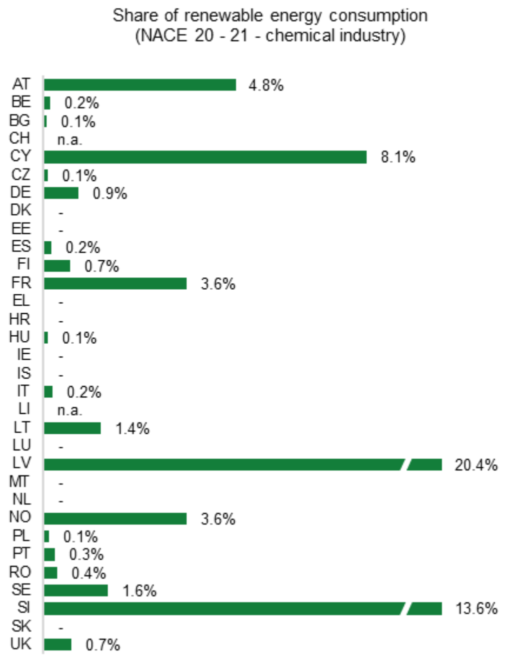
Figure 3-18: Types of renewable energy used by selected sectors



Source: Eurostat [nrg_107a], accessed 2018, own calculation Prognos AG 2018
Note: NACE 20 and 21: chemical and pharmaceutical industry, NACE 24 and 25: manufactured metal industry, NACE 29 and 30: automotive industries, NACE 26 and 27: electronics industry, and NACE 41 to 43: the construction sector.
No data available for Lichtenstein and Switzerland. (Other fuels include geothermal, solar and tidal energy)

The following figures summarizes the penetration rate for renewable energy consumption on country level, calculated as the amount of renewable energy used compared to the total amount of energy consumption in Terajoule. For example, NACE category 20 – 21 (chemical and pharmaceutical industry) Latvia and Slovenia are the frontrunners with shares of 20.4% and 13.6%, respectively. Latvia holds with a share of 15.6% of renewable energy used also a leading position in NACE category 25 (Manufacture of fabricated metal products, except machinery and equipment) followed with a large lead by Denmark with 7.9%.

Figure 3-19:Share of renewable energy consumption NACE 20-21	*Figure 3-20: Share of renewable energy consumption NACE 24*



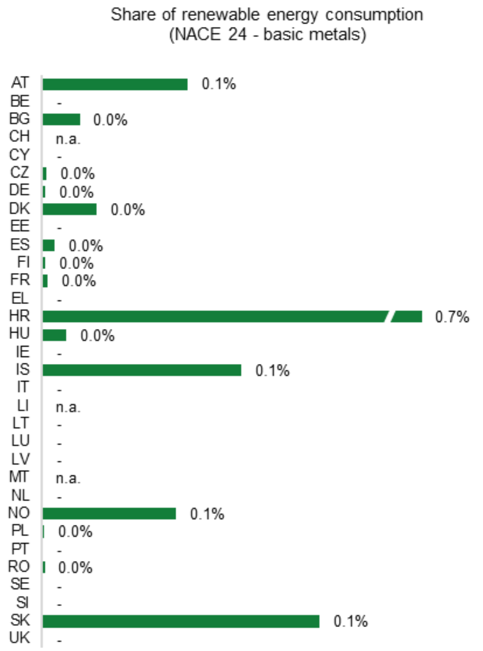
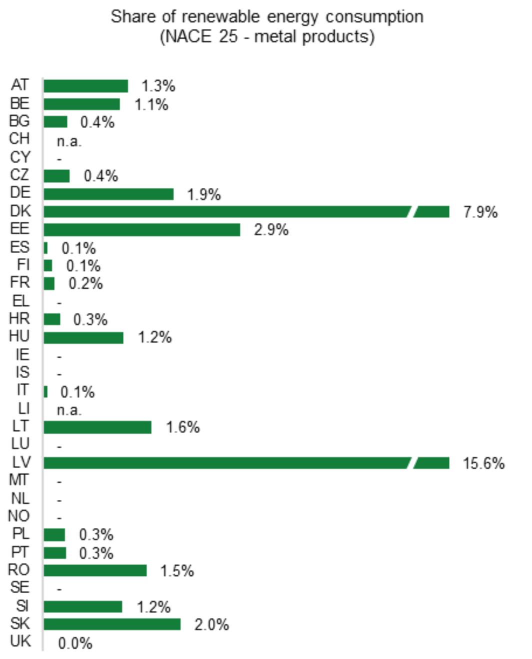


Figure 3-21:Share of renewable energy consumption NACE 25	*Figure 3-22: Share of renewable energy con-sumption NACE 29-30*



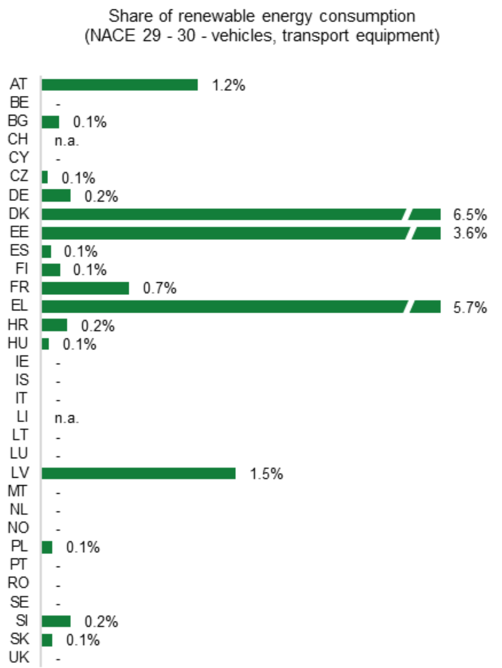
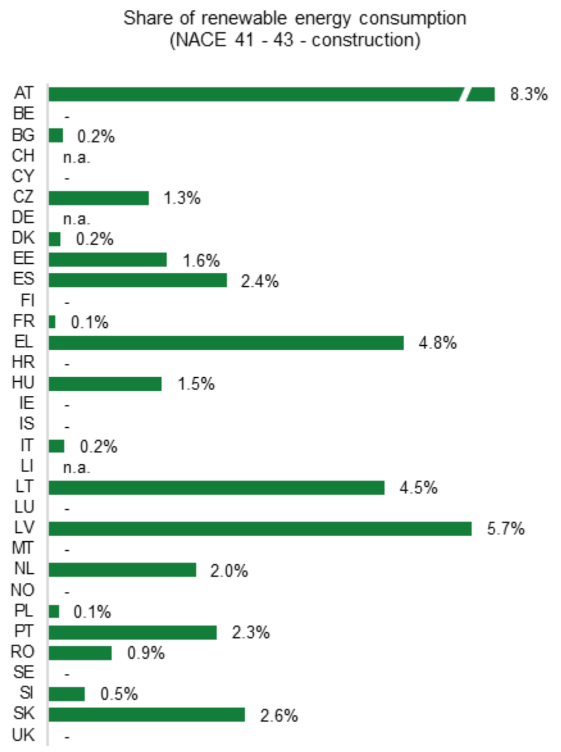


Figure 3-23: Share of renewable energy consumption NACE 41-43



Source: Eurostat [nrg_110a], accessed 2018, own calculation Prognos AG 2018

Note: NACE 20 and 21: chemical and pharmaceutical industry, NACE 24 and 25: manufactured metal industry, NACE 29 and 30: automotive industries, NACE 26 and 27: electronics industry, and NACE 41 to 43: the construction sector.

For the comparison between regions a concentration index (a brief explanation can be found in Section 2) for renewable energy used was calculated based on the adjusted sectoral differences between regions and Europe, allowing to consider both, total amounts of renewable energy used and sector specific regional allocation. Given the aggregated data situation on country level only and the comparable smaller amounts of renewable energy used, figures in Map *3-25* to Map 3-30 below refer to a potential use of renewable energy and not to the real regional allocation. In reality a reasonably uniform distribution by revenue-based concentration of the sector cannot be presumed. The disadvantage of the methodological approach to use revenues as distribution factor is strongly connected to the comparable low shares of renewable energy consumption compared to total energy used by the selected sectors. The likelihood, that only a few companies, but then with higher shares, are consuming renewable energies. These companies may be located in only a few regions within a country. After all this could lead to a simultaneously over- and underestimation of regional contribution to renewable energy use.

The results of the analysis represent a concentration index based on the adjusted sectoral differences between the region and Europe. The focus was here laid down on the comparability between all regions considering the economic strength of the region in the respective sector.

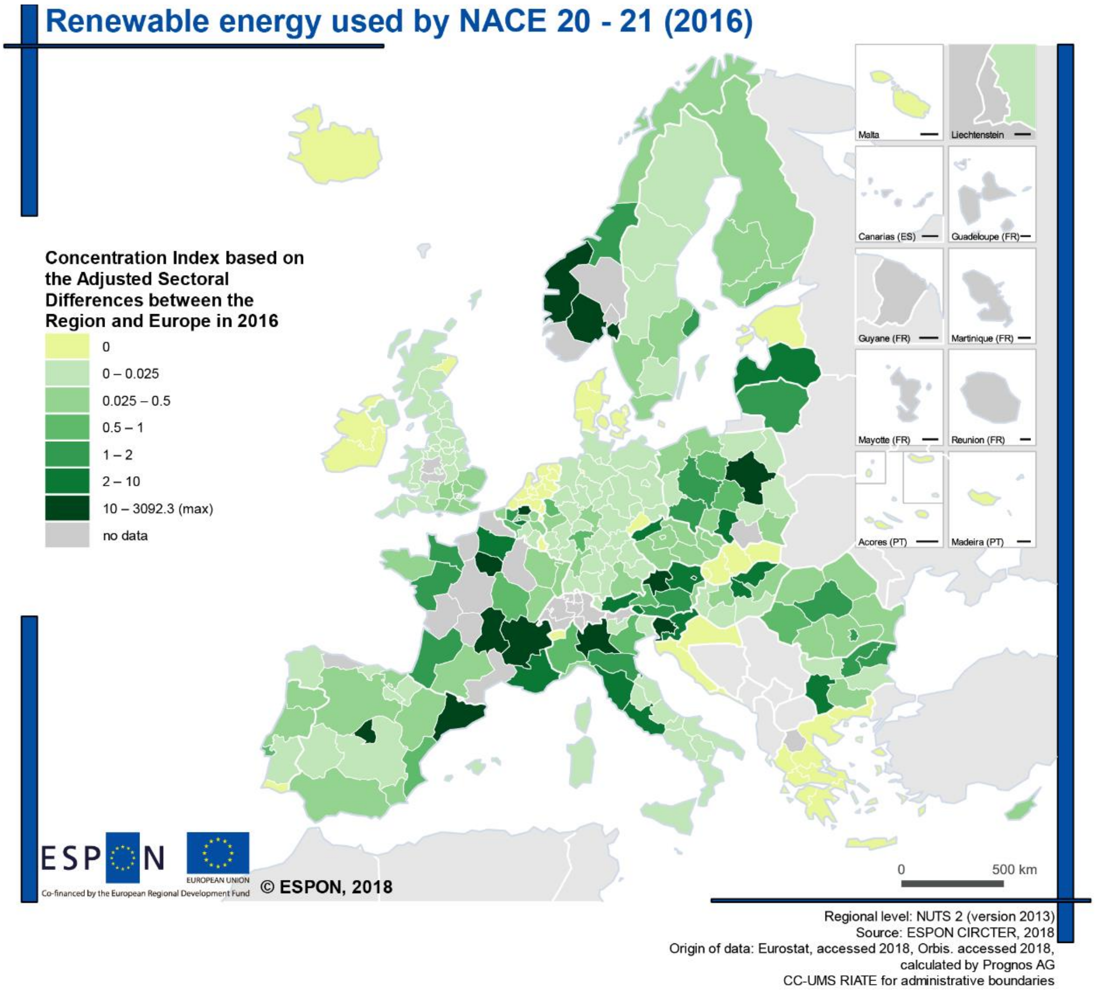
For the chemical and pharmaceutical sector its evident that the European centres of industry in Germany, Belgium and Netherlands are so far using renewable energy to a limited extend only, while mainly the regions Île de France (FR) and Lombardia (IT) can present higher values. Considering the shares of renewable energy, smaller centres of the chemical and pharmaceutical industry, such as in Latvia and Slovenia, have a high penetration rate in relation to their total consumption. This in turn could be (considering the methodological limitations of distribution by revenues already discussed above) an evidence, that the key centres of the sector are not the driving forces in renewable energy consumption.

For the manufacture of basic metals, the penetration rate of renewable energy consumption across all regions is so far rather neglectable. The highest concentration index is in this sector more matching with some of the top centres of the sector, located e.g. in the regions Oberösterreich (AT), Düsseldorf and Arnsberg (DE), Sør-Østlandet (NO) and Île de France (FR). At the very low level of renewable energy consumption by manufacture of basic metals in general mainly the regions in Slovakia attached a greater importance to renewable energy consumption. The penetration rate for renewable energy used by manufacture of fabricated metal products, except machinery and equipment is higher than by manufacture of basic metals. German and Italian regions with a strong market position in this sector must be counted also among the regions with a higher concentration index. From the smaller sector regions by economic significance within Europe mainly Danish regions achieved, compared to other European regions, a higher penetration rate.

The concentration index for the manufacture of motor vehicles and transport equipment shows similar trends like for the chemical and pharmaceutical industry. The most relevant regions in Europe by economic significance are not leading the sector regarding penetration rate for renewable energy, except Île de France (FR). While an overall low average penetration rate of 0.2 % across Europe, relatively smaller regions by economic significance in the sector have a higher concentration index.

For the construction sector, in turn, economically important sectoral regions have a higher concentration index of renewable energy consumption, reflecting also the higher average penetration rate of 1.4% across Europe compared to other user sectors. From the smaller sectoral regions by economic significance mainly the Baltic states Latvia and Lithuania have to be mentioned with a penetration rate of 5.7% and 4.5% respectively. For Germany data is missing.

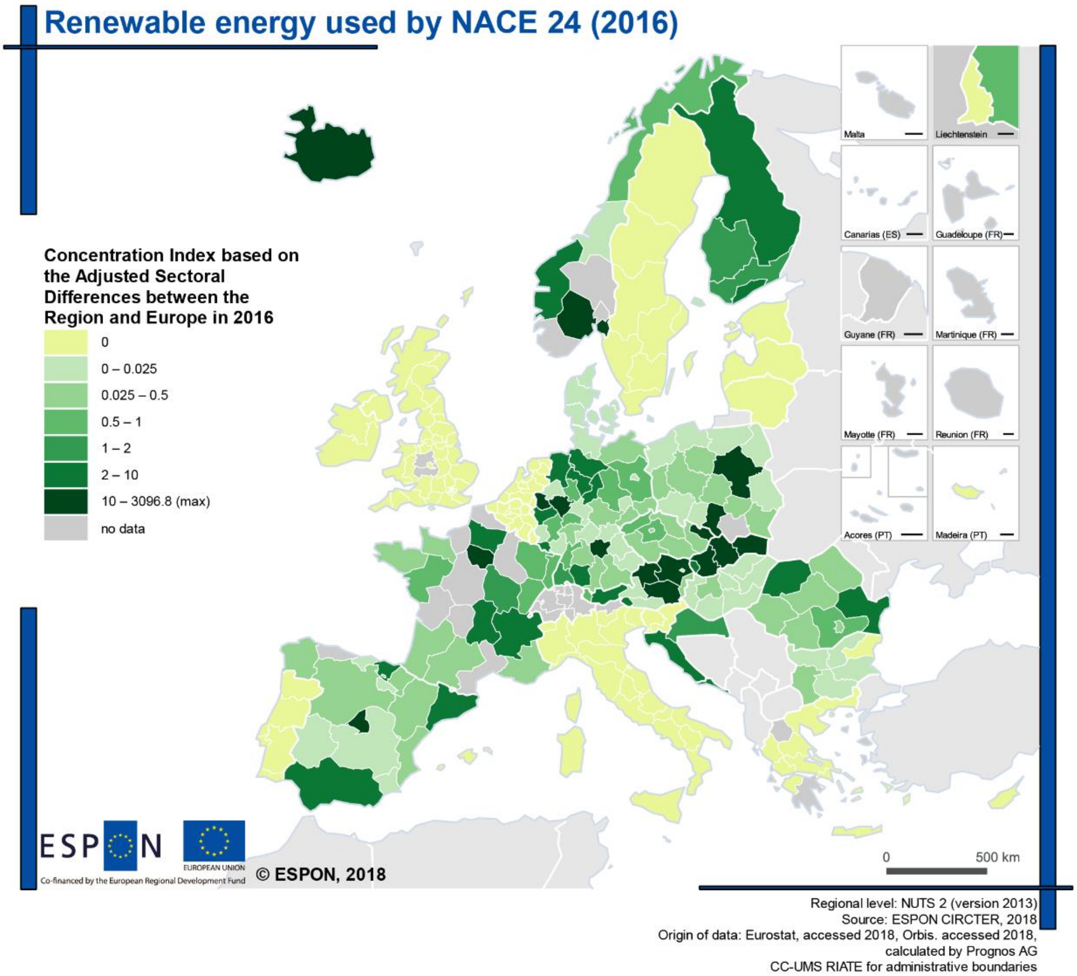
Map 3-25: Regional Distribution of Potential Uses by Potential Share of Renewable energy used and NACE 20-21 (chemical industry) category in 2016



Note: indicative regionalisation of the country specific potential as factual regional distribution is unknown.

Source: Eurostat [nrg_110a], accessed 2018, Orbis database, accessed 2018, own calculation Prognos AG 2018

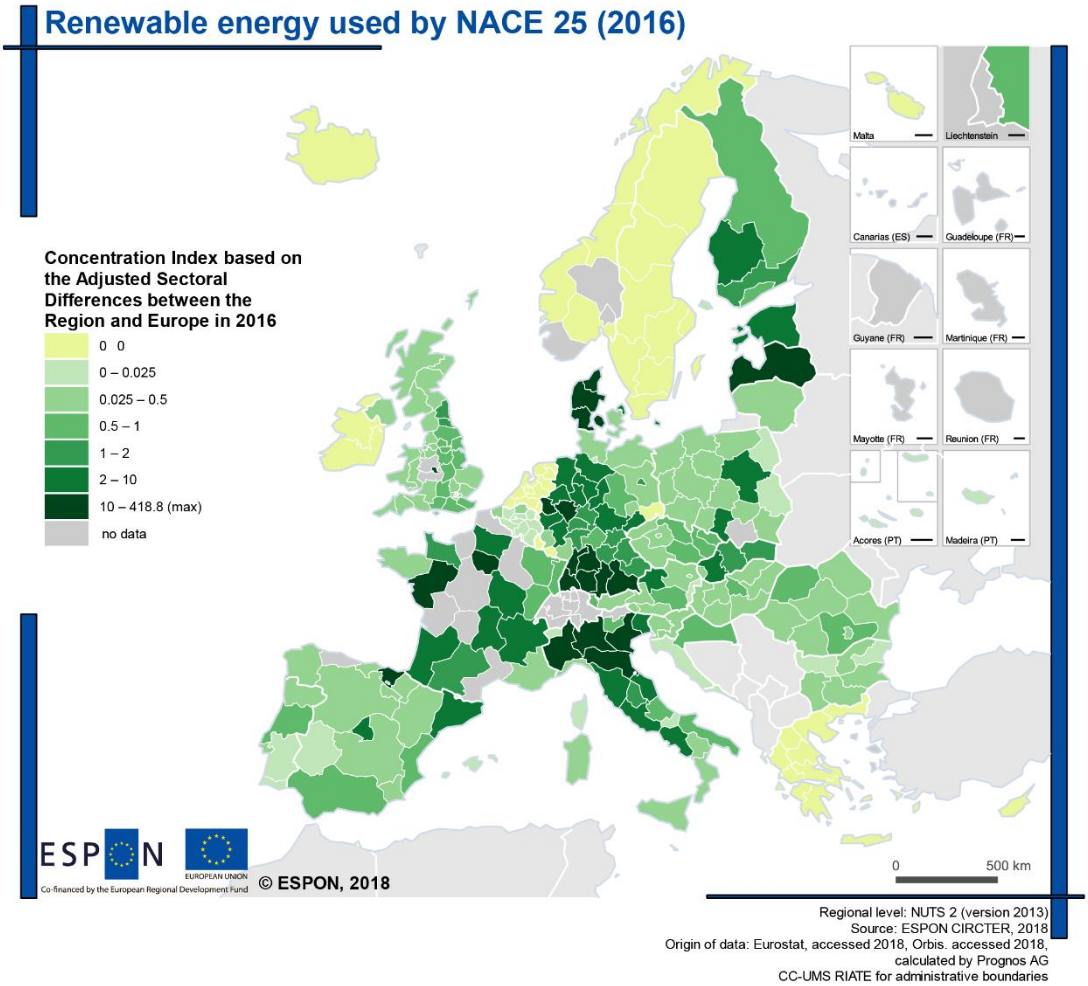
Map 3-26: Regional Distribution of Potential Uses by Potential Share of Renewable energy used and NACE 24 (basic metals) category in 2016



Note: indicative regionalisation of the country specific potential as factual regional distribution is unknown.

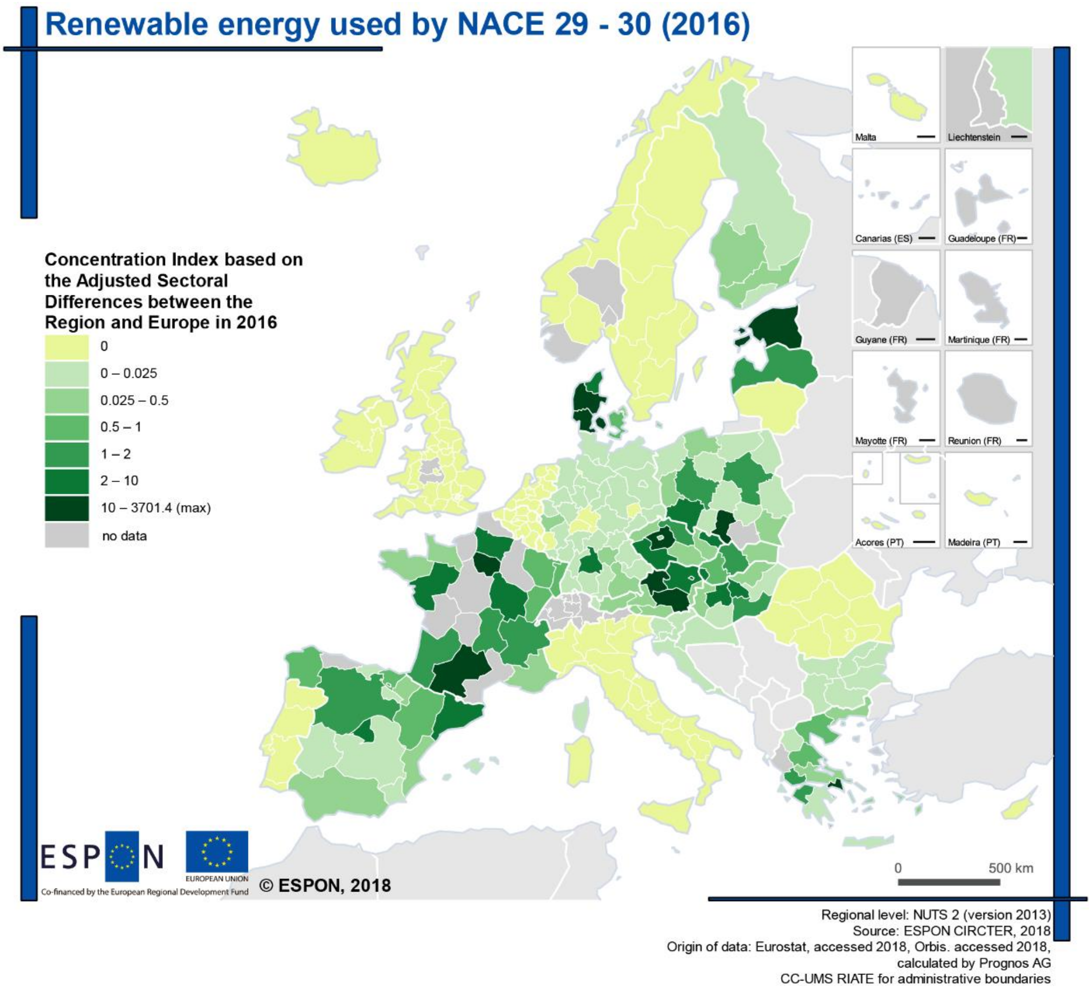
Source: Eurostat [nrg_110a], accessed 2018, Orbis database, accessed 2018, own calculation Prognos AG 2018

Map 3-27: Regional Distribution of Potential Uses by Potential Share of Renewable energy used and NACE 25 (metal products) category in 2016



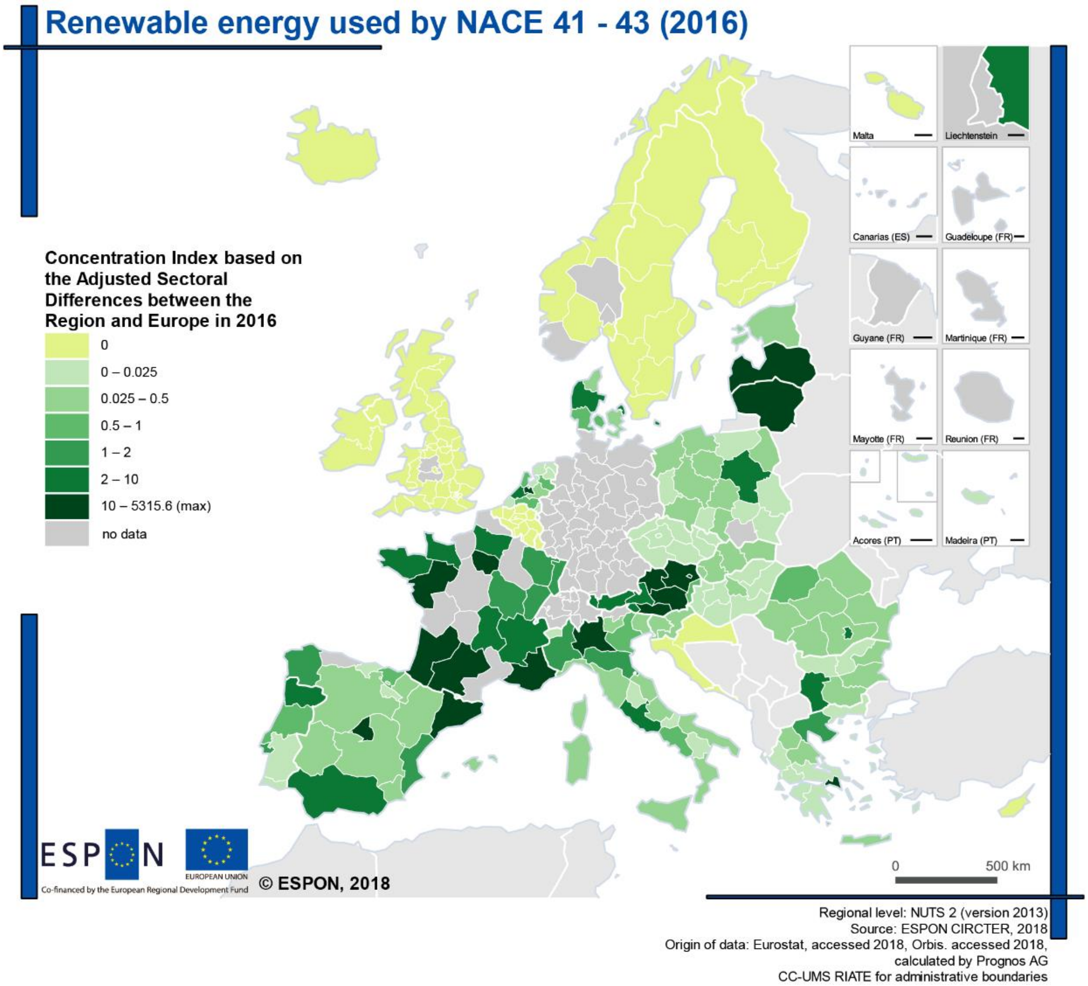
Note: indicative regionalisation of the country specific potential as factual regional distribution is unknown.

Map 3-28: Regional Distribution of Potential Uses by Potential Share of Renewable energy used and NACE 29-30 (vehicles, transport, equipment) category in 2016



Note: indicative regionalisation of the country specific potential as factual regional distribution is unknown.

Map 3-29: Regional Distribution of Potential Uses by Potential Share of Renewable energy used and NACE 41-43 (construction) category in 2016

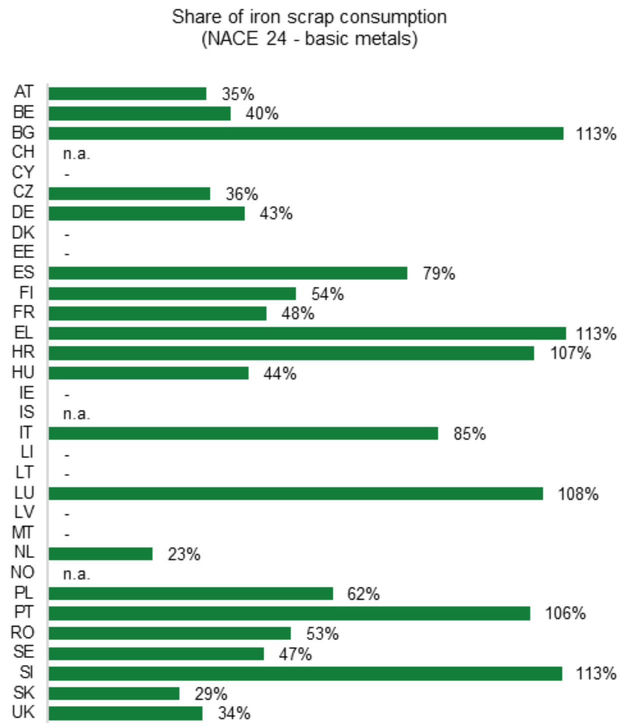


Note: indicative regionalisation of the country specific potential as factual regional distribution is unknown.

3.3.3 Use of secondary raw materials by selected sectors

Given the data situation the concentration index for the use of secondary raw materials could be calculated only for the use of metal scrap by the manufacture of basic metals. Data is available at country level for the share of metal scrap used compared to the crude steel production. The penetration rate varies at country level between 22% for the Netherlands to almost 100% for other countries. Country and regional specific assessment needs of course to consider product-specific aspects, which could limit application possibilities for metal scrap.

Figure 3-24: Share of iron scrap consumption NACE 24



Source: BDSV, 2016; EMS, 2014; Orbis, accessed 2018; own calculation Prognos AG 2018

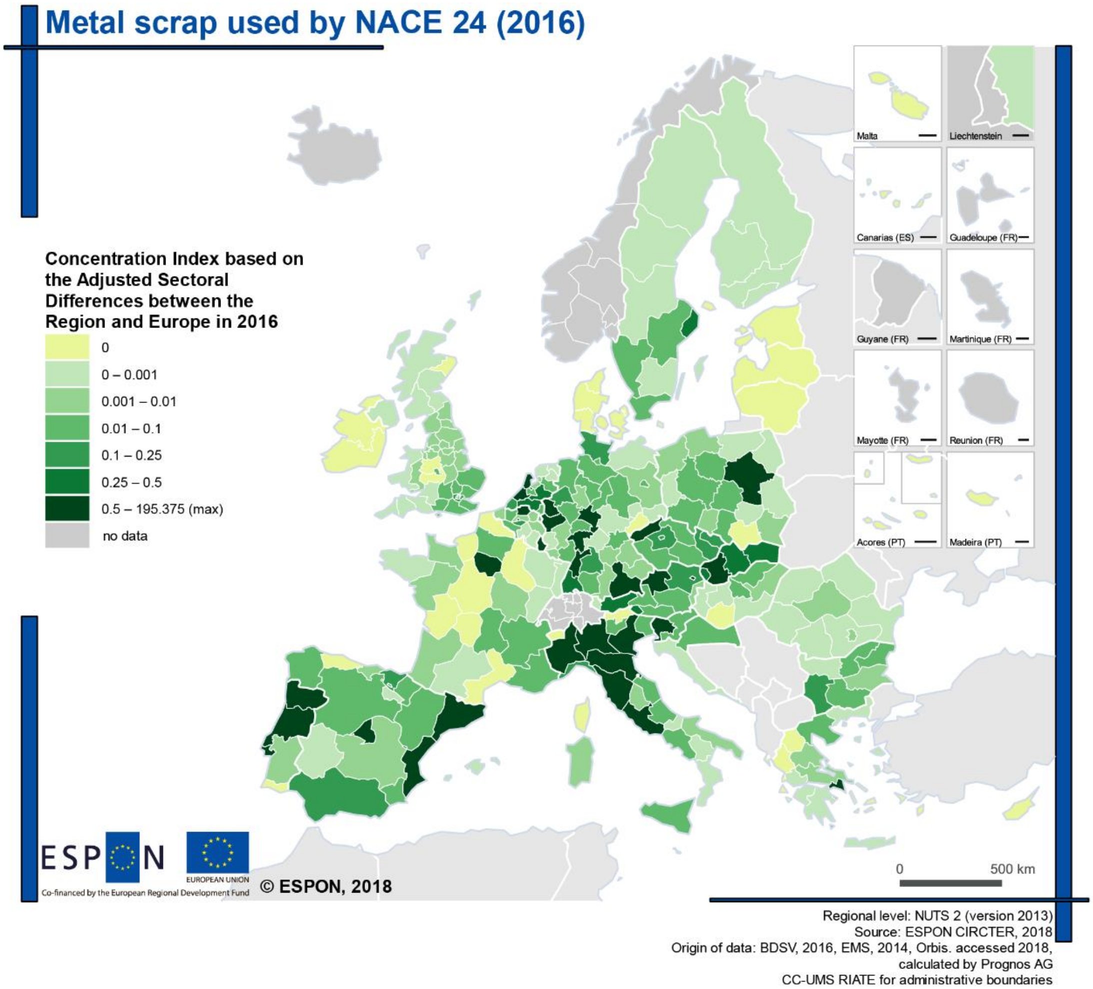
The average penetration rate for metal scrap across all regions amounted in 2016 to 55%.

As is the case for the renewable energy share, also for the consumption of metal scrap it is important to remind that the concentration index is only indicative, an orientation for the potential use of scrap metal and renewable energy.

As no regional data were available, no factual allocation could be derived. For orientation purpose a concentration index was derived and described in greater detail in chapter Analysing the Potential User side – a CE penetration analysis, section “Regionalisation” by weighting the potential metal scrap consumption by economic significance of the respective region measured by turnover. For comparison between all regions adjusted sectoral differences between the regions and Europe was calculated as displayed in the following map. The data basis provides uncertainties. A few large entities could be based in only a few regions, which may skew regional results providing misleading evidence. Even if only indicative, an important result is that significant data gaps have been identified. Their closure provides a pivotal step to identifying trends in the use and uptake of renewable energy and secondary raw materials in the selected sectors and regions.

The regions with the highest potential concentration index include regions with high economic importance in Germany, France, Italy, Spain and The Netherlands as well as economically smaller regions with a higher penetration rate like in Slovakia, Poland and Portugal. Values with "0" refer to countries and regions where no basis metal production industry is located.

Map 3-30: Regional Distribution of Potential Uses by Potential Share of Secondary materials used and NACE 24 (basic metals) category



Note: indicative regionalisation of the country specific potential as factual regional distribution is unknown.

3.4 Conclusions

3.4.1 Main lessons learned from the circular economy sectoral analysis

The sectoral definition established in the CIRCTER project captures the direct and indirect effects of identified sectors contributing to a Circular Economy and identifies the value chains involved in the transition from a linear towards a circular economy. The regional scale allows assessing also its territorial implications, be they economic, environmental or social. Circular Material Providers, Circular Technology Providers and Circular Business Models are the three pillars of a Circular Economy.

Circular Material Providers form the basic input-side by providing materials for a Circular Economy that are comprised of renewable and recycled materials. The territorial distribution of employment of the Material Providers in relation to the regions' total employment highlights the important role of sustainable agricultural and forestry activities in the European periphery. The mapping shows rural regions have a higher share of Material Providers persons employed in the total economy. Rural regions have a stronger agricultural or forestry share and less diversified economies, which result in having overall higher shares of Material Providers in the total economy. European peripheral regions therefore show up more strongly. In 21 regions, the Material Providers make up more than 5 % of the total economy. Waste collection and recycling services are a key economic sector across most regions. The employment share in the Renewable Energy Providers sector remains across all regions relatively low except in few high population density areas.

Circular Technology Providers provide technologies, intermediate products and key services representing the technological cycle that enable cyclical resource flows and more efficient resource use. Technology Providers are more present in predominately urban and intermediate regions. Employment in the Technology Providers of the Circular Economy is located nearer to Europe's industrial centres. While Technology Providers appear to cluster near industrial centres, several regions stand out for their high shares in the total economy. They have in common a large number of persons employed in the repair of fabricated metal products, machinery and equipment services. These economic activities are an important contribution to the long-life and efficient use, and possibly improvement, of heavy equipment. The distribution of Technology Providers reflects, even though more prevalent in urban regions, varied pull and push factors. These could include the ability of industries to re-locate, locate near existing industrial centres to benefit from proximity and agglomeration effects, or the long-term investment into places through continuous innovation.

Circular Business Models facilitate the up-take of circular processes through innovative services and new forms of consumption. Companies operating Circular Business Models concentrate in central and western Europe, with some exceptions in the Scandinavian, Spanish and southern European regions. They accumulate in highly populated regions, such as capitals (see for instance Paris, Rome, Vienna or Greater London) and urban regions (sub-regions of Bavaria and Baden-Württemberg, Catalonia or West Sweden and Lithuania). Proximity factors provide businesses in industrial agglomerations with benefits due to shared access to information, networks, suppliers, distributors and resources. Urban proximity can promote strategies such as take-back programmes or reverse logistics for a reliable stream of secondary materials.

3.4.2 Selected policy messages

<u>Circular Material and Technology Providers already make a significant and growing contribution to regions' economies.</u> Across Europe nearly 4 percent of the total economy is already engaged

in these Circular Economy activities alone (not accounting the new Circular Business Models). These two make up almost 5.8 million employed persons and generate a turnover of nearly a trillion Euros in 2015 (940 billion Euros). In three regions Circular Material and Technology Providers even make up more than 10 % of the total economy. At the European level Circular Material Providers and Technology Providers sectors are showing a growth rate equivalent or higher than the total economy. With dwindling finite resources, growing global demand, technological advancement in the separation and economic provision of secondary raw materials, the overall trajectory, despite economic fluctuations, is set to grow further. Across many states and regions employment in Circular Material and Technology Providers is growing, but not in all.

Circular Material and Technology providers reflect the economic structure of regions. Circular Material Providers play a particularly predominant role in rural regions. Circular Technology Providers are more concentrated in urban regions. Several regions show a relatively high degree of specialisation in the repair of fabricated metal products, machinery and equipment. Despite the commonalities, at disaggregated level regions and sectors show differences likely expressing variations in comparative advantages, resource richness, agglomeration forces, specialisation, labour costs, regional and national framework conditions. The results suggest proximity and agglomeration or economics of scale effects in place, where Circular Technology Providers and Material Providers tend to follow the respective European patterns.

The results provide interesting avenues for future research. Important dimensions of such research can include the investigation into the locational factors, economic barriers and their interaction with the linear economy, as well as regions' position in value chains and competitive specialisation.

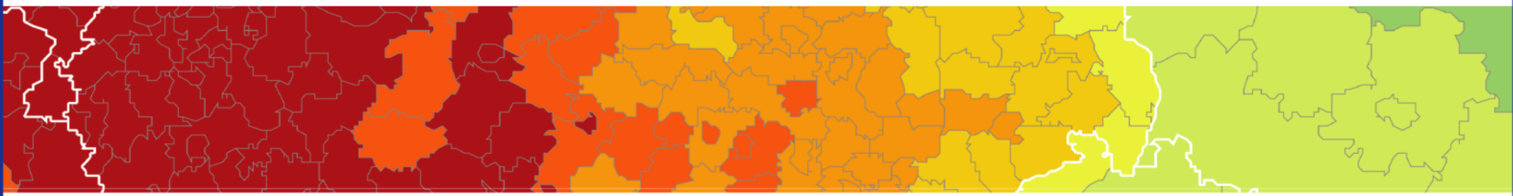
The implementation and diffusion of Circular Business Strategies is favoured by agglomerations (both industrial and urban), knowledge hubs and established territorial milieus. Agglomerations provide circular businesses with the necessary access to resources, knowledge and collaboration as well as a viable demand for circular products and services. Generally, a systemic shift throughout the value chain is at the heart of a comprehensive, circular strategy (such as Eco Design and Cradle-to-Cradle). Collaboration between companies ought to take place throughout the entire value creation chain, enabling a shared use of resources and boosting innovative capacity. Knowledge hubs serve as important sources for boosting innovation capacities. Simultaneously, a shift in consumption patterns can be induced in consumers by shifting towards access, sharing and performance strategies. Urban agglomerations accumulate peer-to-peer strategies between citizens. Based on extensive communication strategies, clarity over circular products and services, and a set of transparent and exhaustive quality criteria for products, consumers can be further integrated in the circular business strategy development.

Provide regions with a systemic approach enabling them to promote a Circular Economy: As cities provide a fertile ground for a circular economy, accumulating positive factors of viable market demand, accessibility, agglomeration factors and a sense of community, they need to be enabled to establish a comprehensive approach to assess and implement potentials for local circular economy strategies. Particularly successful urban agglomerations with regards to Circular Economy implementation have already an explicit Circular Economy Strategy in place (e.g. Amsterdam, Brussels, Maribor). Based on outcomes of regional strengths and structural and economic characteristics (as, for instance, based on the CIRCTER Methodology), European Regions can define specific and comprehensive strategies for the implementation of a Circular Economy.

Initiate and support initiatives and engagement to increase renewable energy and secondary raw material consumption: Currently the renewable energy consumption is regionally mostly at low to insignificant level. Mainly economically prosperous regions are needed to enhance their engagements. Identification and presentation of best practice examples could give an orientation. Additionally, key barriers for implementation should be identified and appropriate measures taken.

Initiate regional specific more detailed analysis on sub-branch level: The applied bottom up approach for the analysis of the penetration rate by renewable energy and/or materials supports sectoral specific results and allows in general for orientation, indicating regional development trends and general recommendations for actions. Given mainly the low share of renewable energy used compared to total energy consumption the used methodology of proportional distribution based on turnover generated for each of the branches in total contains of course limitations. Companies summarized under a branch classification have product specific orientations leading to e.g. different needs for energy or raw materials. To cover these differences, more detailed analysis by relevant sub-branches are necessary. This could be supported by regional case studies, based on the available results of this study.

Initiate discussions and agreements on right indicators and corresponding data collection: Based on the results of a comprehensive research it is evident, that data availability remains a key challenge in general for penetration rate calculations. There is a lack of both, thematic (mainly regarding secondary materials), regional and branch specific data. Regarding circular economy the relevant indicators and necessary data basis should be reconsidered and adjusted.



ESPON 2020 – More information

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The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.