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Synergic Circular Economy across European Regions

SCREEN

Deliverable D2.2

LOCAL ANALYSIS

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Executive summary

This document presents the results of the local analysis of regional data collected through the mapping tool and the agreed methodology defined in T2.1. The regions participating to SCREEN sent data on their smart specialisation strategies with specific focus on the areas and sectors to be prioritised for the diffusion of circular economy. The document contains a descriptive local analysis of the data produced by each region and collected during the first 3 months of the project activity. The analysis takes into consideration the data received, which in most cases cover only the area suggested as compulsory by D2.1: focus sectors, R&D capabilities, education capabilities, and emerging ideas.

The local analysis is guided by the data structure of the SCREEN mapping tool and of the related methodology. Under the condition of availability of data, for each region, the analysis describes: (i) the smart specialisation strategy focus areas together with the actual situation and an outlook as reported by the swot analysis performed by each region, (ii) the regional capabilities with reference to actual and potential circular economy applications and symbiosis, and (iii) considerations on the circularity potential of each region, formulated on the basis of the data with capabilities, potential and emerging ideas, and on the information – when available – on the amount of waste and resources available in the region.

During data collection (performed in T 2.1) and local analysis (performed in T 2.2 and described in this deliverable) regions had difficulties in: finding the requested data, finding the data at the needed level of granularity, and finding a precise match between the smart specialisation strategy areas and the focus sectors. These aspects raise implications for policy makers for the “stimuli” of circular economy:

- Punctual and up-to-date data on waste produced by each sector are not always available within regions. The availability of data on waste produced, and waste processes – possibly including the geo-reference dimension – would dramatically help in the effectiveness of match making approaches to identify a possible symbiosis across value chains;
- Economic data on sectors is not always available within region, with specific reference to gross value-added data. The availability of this data would help assess the impact of circular economy approaches by allowing to estimate variations in value added and in year turnover with potential variation of inputs due to reuse of waste. The availability of social accountability matrices would be of help in such analysis;
- Confronting circular economy across different region presents challenges in terms of the potential differences in the way circular economy is stimulated or developed. The local analysis contributed to identify regions in which circular economy is treated as an application internal to one industry, while other regions where focus on the development of circular economy is cross-sectorial or even horizontal. To this regard,

assessment criteria referred to specific industries are possibly not applicable to cross-sectorial and horizontal approaches.

We tried to overcome, to the largest possible extent, the limitations provided by the lack of data by referring to theoretical understanding of models of circular economy which provides ground for interpreting interrelated data. The deliverable describes both the methodology adopted for the analysis, and the operationalisation steps followed to interpret and present data from the mapping tool.

Local analysis

Within the SCREEN WP2, and according to the project plan, the local analysis is the intermediate task (T 2.2). The task is targeted at delivering the first analysis of the circularity potential of the economic fabric in each region. The local analysis is based on the data produced by the partnering regions following the common methodology and the mapping tool designed in T 2.1.

The contents of this deliverable are based on the data collected through the regions participating in the SCREEN project consortium. Through the SCREEN mapping tool designed in T 2.1 each region provided data on the Smart Specialisation Strategy, and on the focus sectors and capabilities for the development of the circular economy within their local economic territory.

The deliverable presents for each participating region a descriptive analysis of the aggregate of the data collected. The local analysis highlights the regional capabilities in terms of actual and potential innovation, potential stimuli or constraints to the development of circular economy, and an overall consideration of the circularity potential of each region.

Methodological notes

The data collected with the SCREEN mapping tool, as described in D2.1, covered the following areas:

1. Step 1– Smart Specialisation Strategy (RIS 3), Strategic areas, and Swot Analysis: regions were required to specify the areas of specialisation referred to circular economy topics, and provide a SWOT analysis for each area of specialisation identified;
2. Step 2 – Focus sectors and companies: regions were asked to identify the focus sectors for the development of circular economy providing a broad overview of the industrial situation in the specific sectors, and to identify companies active on the regional territory whose activity is pertinent to circular economy and is considered a best practice;
3. Step 3 – Research and Development and Innovation capabilities: regions were required to provide data on the different domains of projects ideas, R&D capabilities, innovation capabilities, and education capabilities. These pieces of information provide a general overview of the active and funded projects on circular economy, the R&D and education capabilities related to the services offered by universities and research institutions active over the territorial region;
4. Step 4 – Emerging ideas: to provide a brief map of the emerging innovation ideas pertinent to circular economy to be prioritized by the region;
5. Step 5 – Existing circular economy legislation: a map of the existing sector-specific legislation, regulation and policies pertinent to circular economy;
6. Step 6 – Existing funding instruments: a map of the existing portfolio of investment instruments for the development of circular economy.

According to D 2.1, and on the basis of common agreement with project partners, items 1, 2, 3 were compulsory. Item 4 was considered voluntary but strongly recommended, and Item 5 and 6

were instead fully voluntary. Table 1 provides a brief overview of the data collected from each partner.

	Step 1		Step 2		Step 3				Step 4	Step 5	Step 6
Region	RIS 3	Swot Analysis	Focus Sectors	Companies	Project Ideas	R&D	Innovation	Education	Emerging ideas	Legislation	Funding instrument
Lazio	✓	✓	✓	✓	✓	✓		✓	8		
Lombardia	✓	✓	✓	✓	✓	✓	✓	✓	7		
Navarra	✓	✓	✓	✓	✓	✓	✓	✓	6	✓	6
Tampere	✓	✓	✓	✓	✓	✓	✓	✓	21		
Centro	✓	✓	✓	✓	✓	✓	✓				
La Reunion	✓	✓	✓	✓	✓	✓	✓	✓	7		
Scotland	✓	✓	✓	✓	✓	✓	✓	✓	3	✓	
Crete	✓	✓	✓	✓	✓	✓	✓	✓	17		
Fryslân	✓	✓	✓	✓		✓	✓	✓	10		1

Table 1. Map of the data collected from each participating region

Faced with the needs to minimise the impact of missing data in the local analysis, in the deliverable we used a meta-model of circular economy as a theoretical blueprint for the interpretation of the data available, and for the descriptive analysis of the circularity potential[1].According to this meta-model (see Figure 1 for a graphical description of the meta-model), circular economy applications stem out of organisational innovation actions of the type of: (i) business models[2, 3], (ii) processes[4], and (iii) products[3–5]. These innovation actions are stimulated by fiscal and financial stimuli, and are influenced – and influence in turn – by consumer behaviour[6–8]. Organisational innovation leads to reduced resources, and reuse of waste. The reuse of waste and the organisational innovation enable in turn inter-organisational symbiosis, which is a form commonly reported by the literature for stimulating circular economy. Finally, organisational innovation and reuse of waste happens within the limits of regulation which is in the position both to foster and to hamper innovation[9, 10]. The reuse and reduction of waste, innovation potential, inter-organisational symbiosis, societal awareness, stimuli and regulation are interrelated dimensions of circular economy according to the view here described. Having this statement in mind allows for a relational analysis of the data collected with the mapping tool for the identification of the regional potential of circularity.

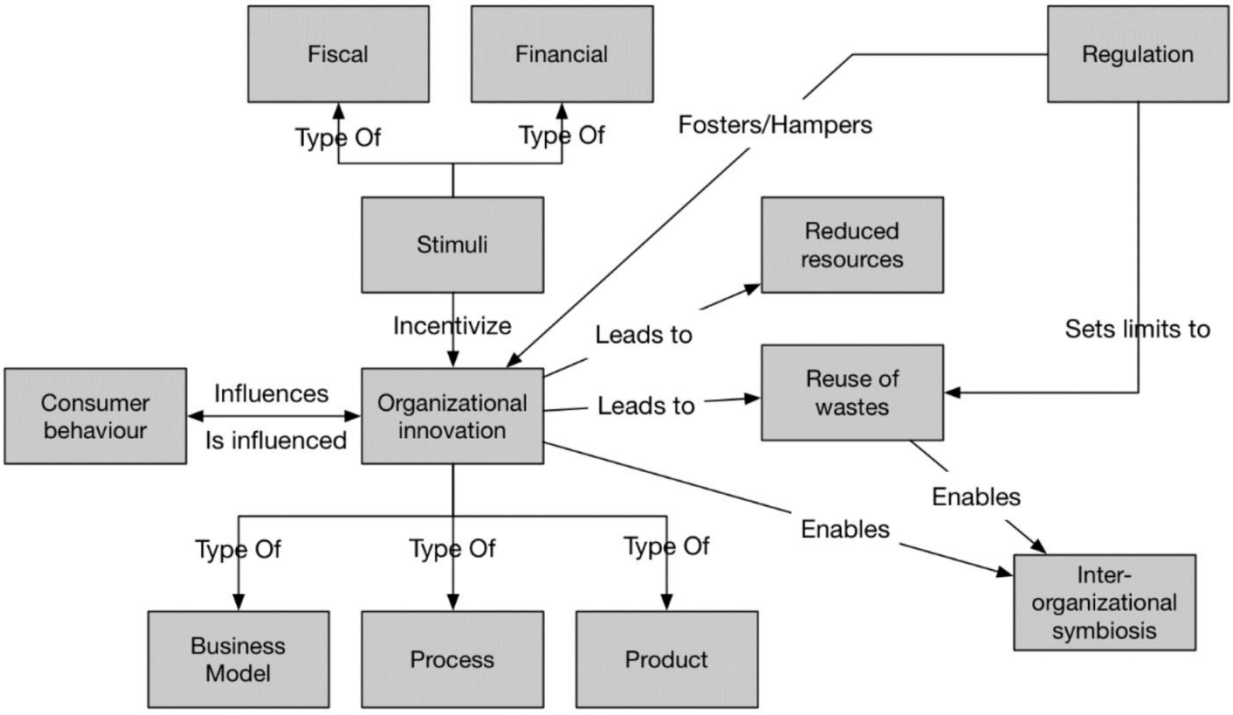


Figure 1. Meta-model of inter-organisational cooperation for circular economy

A relational view of the mapping tool data

The data collected with the mapping tool represent a snapshot of the circular economy interest of the different regions. If interpreted following the relational nature of the different entities

according to the theoretical understanding of the circular economy, the model could provide further insights into the regions and the local analysis.

The data collected with the SCREEN mapping tool will be used in this local analysis to depict a circularity potential of each region by:

- Providing a description of the strategic position of the region within the S3, with specific reference to the priority focus sectors circular economy applications;
- Defining the regional capability of stimulating circular economy by using the different capabilities reported by the region (companies, innovation, education, R&D), and the stimuli and regulation to infer the elements of the meta-model shown in Figure 1;
- Identifying the potential size of the circularity in the economic region through economic data on priority sectors, on waste produced and recycled, and on resources available in the region.

The data collected with the mapping tool have been analysed as follows for performing the local analysis:

- Steps 1.1 and 1.2 (RIS3 and SWOT analysis): data provided with these forms represent a snapshot of the economic situation of the priority sectors within the specific region. The information provided here shed light on the existence of potential trends opportunities in the sectors of interest, risks and barriers;
- Step 2.1 (focus sectors): data on focus sectors, when available, provide immediate information on the circularity potential by looking at the amount of resources (waste) recoverable in the region. At the same time, they show the priorities of regions for the development of circular economy;
- Step 3.1 (companies): data on companies are analysed to reveal potential symbiosis. Knowing that companies run organisational innovation projects lead to the implementation of circular economy applications, company data can possibly be a source of potential symbiosis (by looking at needed inputs or produced outputs) or actual symbiosis (by looking at a potential exchange of inputs and outputs among different companies within the same region). Outputs of companies also provide further information on resources available in the region;
- Step 3 (capabilities): data on capabilities are analysed to reveal intended areas of future innovation active in the region. The data collected in this step provide information both on innovation ideas concerning the application of circular economy, which might also target symbiosis, and on potential targeted sectors other than the focus ones specified in Step 2.1;
- Steps 3.1, 3.2, and 3.3 (R&D capabilities, innovation capabilities, and education capabilities): specific data on the different dimensions of capabilities provide further information on the areas of innovation within the region. Data on R&D capabilities show the potential of innovation in specific application domains. Innovation capabilities show the actual potential of processing resources in pilot plants, facilities active on the region, or enabling technologies that can be exploited by circular economy applications. Education capabilities

provide instead information on the potential to build human and knowledge capital and potentially stimulate responsible consumer behaviour in the region;

- Step 4 (emerging ideas): data on emerging ideas are analysed to reveal potential future symbiosis, to identify further sectors which could be involved in circular economy applications in relation to those indicated in Step 2.1, and to spot for synergies between innovation and capabilities within the region;
- Step 5 and 6 (existing circular economy legislation and funding instruments): data on existing legislation and funding on circular economy are analysed to reveal potential stimuli or constraints for the development of circular economy within the region.

For each region the circularity potential is summarised by key data as shown in Table 2. The table shows how the data of the mapping tool relate to the visualisation of the circularity potential.

Scope	Source	Description
Available resources	Step 2.1 (waste) Step 2.2 (companies)	Types and amount (if data is available) of waste resources to be used as input for circular economy applications available in the region Types of outputs produced by companies
Societal awareness of circular economy	Step 1.2 (SWOT analysis) Step 3.3 (education capabilities)	Potential opportunities and treats against the development of circular economy Actual and prospected societal behaviour towards circular economy
Stimuli	Step 6 (funding instruments)	Existing local (Regional or national) and international (EU) stimuli for circular economy innovation
Regulation	Step 5 (existing legislation)	National or regional level (existing or under development) affecting circular economy application within the region
Inter organisational symbiosis	Step 2.1 (focus sectors) Step 2.2 (companies) Step 4 (emerging ideas)	Local regional or national symbiosis: - Actual symbiosis, - Potential symbiosis or contact points between different industries
Innovation potential	Step 3.1 (R&D capital) Step 3.2 (Innovation capabilities) Step 3.3 (Educational capabilities)	Innovation potential the region can exploit in terms of circular economy applications (e.g. waste reuse, waste reduction, energy efficiency)

Table 2. Circularity potential of circular economy

Use of data from the mapping tool for the analysis

Table 2 shows how the data of the mapping tool are used to describe the circularity potential. Given that the mapping tool collects mostly qualitative data, the relationship shown is not necessarily strict. The steps indicated in Table 2 are those in which regions would most commonly find the needed information – if available – to assess the different dimensions. However, it is possible that further information is available in other sections of the mapping tool. For this reason, this section describes the process used to go through the data collected to identify the information needed for the local analysis of the regions shown in this deliverable. The same procedure can be repeated by any further region which would like to perform a local analysis on the basis of the data collected through the mapping tool.

Available resources

This dimension assesses the presence of waste or by-products in the region that can be exploited in circular economy applications. The main source of information is the "Step 2.1 – Economic data" of the mapping tool, in which regions are requested to report the amount of waste produced in the focus sectors. When available, the data in Step 2.1 informs also on the share of those waste that is currently recycled, incinerated, and land-filled. These can be helpful to estimate the presence of regional hotspots in terms of available unexploited resources that could be used within a circular economy strategy.

A further data source for available resources in the region is the data on companies (Step 2.2), more specifically the outputs produced by the companies active in the region.

Occasionally regions might report specific information on the availability of resources in the SWOT analysis, which is the last source of information for this dimension.

Societal awareness of circular economy

This dimension assesses the level of awareness of stakeholders (citizens, companies, institutions) about sustainability and the opportunities offered by circular economy within the region. The main source of information is in this case the SWOT analysis in which the region critically evaluates its position towards circular economy from different perspectives (economic, social, environmental and regulatory). However, it is not granted that such information will be available on the SWOT analysis, as regions are free to define it.

A further source of data which can be used to express considerations on the societal awareness of circular economy is the education capabilities (Step 3.3). The courses offered by universities in the territory have a potential to enhance he human and knowledge capital in the region and could indirectly contribute to raise the awareness in the region about circular economy, especially when

the courses cover deals not only with technical skills, but also managerial, social responsibility skills and bring about sociological implications of sustainability.

Stimuli

This dimension assesses the existence of fiscal or financial stimuli to sustain innovation projects by companies active in the region. The main data source for assessing this dimension is the data on funding instruments (step 6) of the mapping tool.

Regulation

This dimension assesses the existence of regulation – either at regional, national, or international level, and either existing or currently planning – which could foster, or hamper, the development of circular economy. The data source for assessing this dimension is the data on existing legislation (step 5) of the mapping tool.

Inter-organisational symbiosis

This dimension assesses the existence of actual or potential forms of symbiosis among different companies or industries in the region. According to the circular economy paradigm, a symbiosis enables the contact between three different subjects, sharing at least two different resources. However, for the need of the local analysis, and to have an idea of the connections already existing among companies and industries which could potentially contribute to generate a symbiosis, it is suggested to report also dyadic relationships. The mapping tool does not explicitly ask regions to report symbiosis, however the information available on the tool can be used to spot either actual or potential forms of symbiosis.

A first data source for identifying symbiosis is the data on focus sector (step 2.1), and more specifically the data on waste. To identify potential connections among existing industries – being data available and encompassing all the necessary dimensions – it is necessary to relate waste with input required by the different industries.

A second data source for identifying symbiosis is the data on input and output of companies (step 2.2). Potential connections or symbiosis among companies could be identified by relating outputs of one company with inputs of another company.

A third data source for identifying symbiosis is the data on emerging ideas (step 4). Potential connections or symbiosis among industries could be identified by the description of the emergent ideas, the target sectors, and target materials. The connections or symbiosis spotted this way are most probably potential, as they will be actual only when the emerging idea is put in practice. Other sources of potential symbiosis can be found by confronting data on emerging ideas with data on innovation capabilities (step 3.2) in the region. These connections or symbiosis are still most probably potential.

This information on symbiosis is not available in the mapping tool, such relational analysis can be performed with domain experts who have knowledge on the kinds of materials needed and produced by the different industries.

Innovation potential

This dimension assesses the potential of the region in sustaining innovation processes or technologies which can be exploited within a circular economy strategy. The innovation potential is assessed by the exploitation of different capabilities in the region. The data to assess these dimensions can be found in the R&D capabilities (step 3.1), innovation capabilities (step 3.2), and educational capabilities (step 3.3). The main data source is that on innovation capabilities in which regions report different pilot plants and facilities active on the region, which can be used for circular economy strategies. For the local analysis the capabilities can be described across different application domains and enabling technologies.

The data on R&D capabilities and educational capabilities complement the data on innovation capabilities can provide information on research and innovation capabilities on specific technologies or materials, and on innovation stimulated by knowledge and human capital with specific skills on circular economy.

Implications from the data collection process

The data collection effort involved partners in an iterative process composed of several steps.

First, the project consortium agreed on the mapping tool and on the common methodology, and T 2.1 leader designed and released the necessary supporting artefacts (see D 2.1 for a reference). Soon after that, each SCREEN partner region was called to fill in the mapping tool according to the local situation in each region. The tool fill-in process was guided by WP 2 leader with three virtual meetings during which regions had the opportunity to manifest their difficulties in the data collection, or to ask for clarifications concerning how data had to be collected or how the mapping tool had to be used.

The first aggregation point of all the data collected was during the Rome meeting held in March 16^{th} – 17^{th} 2017.

During the process of data collection, regions reported some difficulties in providing data. Moreover, during the process of performing the descriptive analysis for this deliverable regions reported two main problems with the data collection: (i) the availability of data, and (ii) the granularity of data.

Concerning the availability of data, the mapping tool and the agreed methodology asked regions to provide data on the areas of their smart specialisation strategy they would prioritise for the development of circular economy. Regions were asked to provide their specialisation areas, to provide a SWOT analysis of the areas within the region, and to indicate the focus sectors for the specialisation areas. For each focus sector the agreed methodology asked regions to provide data on:

- Number of employees;
- Year turnover;
- Gross value added;
- Number of companies in the data;
- Volume of waste generated;
- Share of waste recycled;
- Share of waste incinerated;
- Share of waste land-filled.

Regions reported difficulties in terms of data availability, and data granularity. First, it has not been possible for all the regions to provide detailed data on waste and on their treatment. Indeed, not all regions probably possess up-to-date data on waste produced by the focus sectors, and on how this waste are treated. Secondly, not all the regions possess detailed up-to-date economic data on turnover and – mostly – gross value added by the different sectors in the region.

The availability of data on waste is important for assessing the circularity potential in the reuse and recycle of waste. Furthermore, if the data would include also the geographical dimension of the waste, then the complete dataset would be of help for simulating and assessing economic feasibility of industrial symbiosis, also including logistics aspects.

The availability of economic data helps assess the impact on specific sector of specific circular economy applications, making it possible to estimate variations in turnover and gross value added because of specific circular economy applications. The availability of social networking matrices – which were not available in all regions – could contribute to make these analyses possible.

Finally, a second difficulty with the data collected encountered during the local analysis concerns the different approaches of the different regions to circular economy. While some regions have a clear-cut focus in their specialisation strategy to specific industries, other instead accompany focus factors with a cross-sectorial or horizontal focus to circular economy. As a matter of fact, similar circular economy applications – for instance the production of energy from renewable resources – are by some regions prioritised within the energy or the agriculture industry, while by others are indicated in cross-sectorial focus areas like environment, or green economy.

Analysed regions

In total nine regions participated to the data collection process. This deliverable presents the results of the local analysis for the following regions:

- La Reunion;
- Região Centro;
- Tampere;
- Navarra;
- Fryslân;
- Scotland;
- Lombardy;
- Lazio;
- Crete;
- Lodzkie.

The reminder of this document is structured in sub-sections, each one containing the report for each specific region. Each section is devoted to the local analysis of one region according to the following common structure:

- Brief overview of the data provided by the region;
- Description of the strategic positioning of the region and of its chosen priority sectors;
- Regional capabilities exploitable by circular economy applications and prospected innovation;
- Circularity potential of the region.

La Reunion

Table 3 summarises the data provided through the mapping tool by La Reunion for the local analysis.

Table 3. La Reunion: overview of collected data

Steps (mapping tool)	Overview of data provided
RIS 3 Strategic Areas (step 1.1)	Three areas of specialisation: - Tropical Bio-economy - Experiential ecotourism - Resilient – low-carbon – economy
SWOT Analysis (step 1.2)	A general SWOT Analysis without a specific reference to the strategic areas specified in step 1.1
Focus Sectors (step 2.1)	The Region presents a list 13priority: - Crop and animal production - Forestry and logging - Fishing and aquaculture - Manufacture of food products - Manufacture of beverages - Accommodation - Food and beverage service activities - Construction of buildings - Architectural and engineering activities - Electricity, gas, steam, and air conditioning supply - Water collection, treatment and supply - Waste collection, treatment and disposal activities - Services to building and landscape activities
Focus Sectors: Companies (step 2.2)	12 firms
Capabilities view (step 3)	10 projects, 2 of which funded by EU resources, 7 funded by national funding, one without further specifications.
R&D Capabilities (step 3.1)	Two laboratories and one joint research centre all belonging to the University of Reunion Island
Innovation Capabilities(step 3.2)	No data available
Education Capabilities (step 3.3)	Three courses offered by the University of Reunion Island, one at the bachelor level and two at the master level.
Emerging Ideas (step 4)	Seven different emerging ideas
Existing Circular Economy Legislation (step 5)	No data available
Existing Funding Instruments (step 6)	No data available

S3 and focus sectors

Unlike the other SCREEN partner regions, La Réunion is not located within the European continent, and its geographical position offers strategic opportunities for the European markets due to the opportunities of globalisation offered by the neighbour Asian countries.

In its smart specialisation strategy, the region sets three key specialisation areas pertinent to the development of circular economy: tropical bio-economy, experiential ecotourism, and resilient and low-carbon economy.

The tropical bio-economy area focuses on the renewal of praxes in the agriculture and in the industry. The objective is to combine the capability of satisfying the changing customers' needs, with the preservation of the natural eco-systems. In the past, actions on the agricultural industry contributed to the development and diffusion of irrigation and mechanisation systems. Consequently, the agricultural sector is now capable of satisfying about 70% of the regional needs of fruits and vegetables. On the animal breeding side, instead, the region still depends on imports. Within this landscape, the area of specialisation aims at developing bio-economic solutions for the territory. The region reports a turnover of 409 B Euro for the sector (crop & animal production, hunting & related service activities), with 7,650 active firms, employing 7% of the total workforce.

The experiential eco-tourism area is peculiar to the region for the relevance of the tourism industry and the need of further development, and for the necessity to preserve biodiversity and natural and marine resources. The region aims at increasing the mix of touristic services offered in a sustainable way with actions on buildings, auto-consumptions systems, integrated waste management, and outdoor activities compliant with the rhythms of the eco-systems.
Tourism sums up to 8% of the regional GDP. It has a strong economic development potential; hence tourism is central to regional development policies. The region reports two priority sectors in this area employing in total 18% of the workforce, with about 3,000 active companies, and a turnover of about 560 Euro billions.

Finally, within the area of low-carbon economy, the region promotes a shift towards an economic model without carbon emissions. This is done through a set of actions on: eco-housing integrating decarbonised energy production solutions, self-production and renewable energy solutions for decentralised zones, development of urban model solutions fitting with the constraints of the tropical island contexts, and the transition towards industrial ecology.

Regional capabilities and prospected innovation

In the swot analysis towards the position to circular economy La Reunion declares both commitments to stimulate sustainable development, and a long-lasting experience on the adoption

of circular economy in the agro-industry. At the same time – also confirmed by the data showing small amounts of waste for the priority sectors – the region declares difficulties in implementing large scale circular economy applications due to the lack of resources, the size of the region and its geographical position, and to the difficulty of reaching a critical mass.

In spite of these limitations, the region possesses both R&D and educational capabilities on circular economy.

The R&D capabilities belong to the University of Reunion Island. The region reports three research facilities with capabilities exploitable on circular economy:

- A laboratory of physics, mathematical engineering for energy and the environment: with R&D capabilities on energy efficiency and sustainable energy;
- A laboratory for energy, electricity and processes: with R&D capabilities on renewable energy sources;
- A joint research unit for food quality: with R&D competences on food quality assessments, methods for quality assurance of foods, and sustainability of food processing.

The R&D capabilities of the region are focused on the domain of energy efficiency and renewable energy, and on food quality and food treatment. According to the data provided, there are no pilot plants exploitable in circular economy applications.

Concerning education capabilities, the University of Reunion Island offers three courses – one bachelor and two masters' – which are reported to show contact points with the circular economy application. The bachelor course is targeted to biological engineering and takes a technological perspective with a curriculum on environmental engineering. The two masters' courses are – in turn – targeted to the use and re-use of natural resources, and to the biodiversity of tropical systems. Under this perspective the region has potential to deliver human capital skilled on technologies for managing the environment, for using and re-using natural resources, and for promoting biodiversity.

The areas of innovation are targeted to the sectors of:

- Energy (electricity and gas);
- Waste collection, treatment, and disposal;
- Natural resources (forestry, fishing, and aquaculture).

The region reported seven emerging ideas all focusing on the recovery of energy and resources from waste. The reported emerging ideas target two sides: the connection between the waste collection and energy production, and innovations in the agriculture and in related industries.

One trajectory of research follows an environmentally sustainable approach in the field of energy production. Several ideas reported by the region involve different technologies for producing energy starting from waste. In order to feed these prospected initiatives, the region also aims at

promoting different strategies for waste management involving collection, reuse, and recycle, with the objective of increasing the urban local capacity to treat the waste there produced.

Another trajectory of research instead focuses on innovations in the agriculture industry and in its related sectors. The reported ideas aim at valorising residuals of agricultural production to be used as nutrients or cultivar for further agricultural production, or to extract high added value molecules that can be exploited in different industries.

The region also reports ten projects, two funded by EU, and seven by national funds (no funding source provided for one project). Four of the ten given projects focus on different forms of energy production starting from waste or biomasses. Two projects focus on the avoidance of pollutants in production processes. Two projects aim at replacing use of wood with more sustainable alternatives. Two projects focus instead on waste management and also explore new managerial approaches for managing wastes in urban contexts.

The region indicated 12 companies which cover all the positions in the circular value chain excluding the collection of resources and disposal. The companies cover most of the application domain of circular economy, excluding maintenance, repair, and water treatment. The companies possess different technological capabilities. A large number of them specialise on the production of steam and gas from different kinds of residuals of natural resources.

Circularity potential

According to the data provided by the region, in La Reunion the following sectors produce waste which could be used for circular economy strategies.

- Crop and animal production, hunting and related service activities;
- Manufacture of food and beverages: reused as glass cans, biogas, fertilizers, and pet food;
- Construction of buildings: waste reused for the construction industry;
- Water collection, treatment and supply: reused for producing electricity and biogas;
- Waste collection, treatment disposal activities, materials recovery: reused for producing electricity and biogas;
- Services to buildings and landscape activities: waste reused for the construction industry.

There appears to be no visible synergies among the companies whose data the region reported with the mapping tools. Several of the companies active in the region are already working on environmentally sustainable production of energy from different kinds of waste or biological resources.

On the side of regulation, La Réunion reported specific difficulties due to its geographical location. In the SWOT analysis, the region indicates to suffer the competition of neighbour countries without an environmental regulation. Such disparity of regulatory framework is a potential barrier against

the development of circular economy in the region, as environmentally sustainable business models in one of the key industries for the island – tourism – are challenged by neighbour competitors on the same industries active in the region which do not take into consideration the cost of the environment in their value proposition.

The small size of the region, together with its island characteristic, poses challenges towards effective recycle of resources, specifically waste. This is due to the lack of a critical mass, a low capacity of reuse, and physical barriers for moving resources from or to neighbour regions. As a matter of results lots of waste are reported to be not alternatively used. The region is committed towards the reduction of the amount of urban waste, and the adoption of an integrated waste management approach.

The capabilities reported by the region suggest the existence of potential and actual symbiosis between the agricultural sector, chemical, and the marine ecosystem, agriculture and fuel production.

The region also promotes an innovative social inclusion project which favours employment through the increase in value of waste wood.

Table 4 summarises the circularity potential of the La Réunion region.

Table 4. La Réunion: summary of the circularity potential

Area	Description
Available resources	Waste from agriculture, urban activities, and construction industry
Societal awareness	Potential training of human capital with technical skills on bioengineering, biodiversity, and use and reuse of natural resources
Stimuli	No funding instruments reported
Regulation	Potential difficulties of the different regulatory framework – not environmentally sustainable – in use in neighbour countries
Symbiosis	No existing synergies Several dual forms of exploitation of waste for the production of energy and biogas from waste, and from the valorisation of agricultural waste The region has potential to develop synergies starting from the agricultural industry towards high value sectors (green chemistry)
Innovation potential	Sustainable and renewable energy production Integrated waste management Extraction of high value molecules from agricultural waste

Região Centro

Table 5summarises the data provided with the mapping tool by La Reunion for the local analysis.

Table 5. Centro: overview of collected data

Steps (mapping tool)	Overview of data provided
RIS 3 Strategic Areas (step 1.1)	Seven areas of specialisation - Agro-business - Forestry - Sea - ICT - Materials - Biotechnology - Tourism
SWOT Analysis (step 1.2)	A complete SWOT analysis focusing on the environmental, economic, social, and regulatory aspects
Focus Sectors (step 2.1)	Several sectors belonging to the following NACE macro-codes: - Agriculture, farming of animals, hunting and forestry - Mining and quarrying - Manufacturing - Electricity, gas, steam, cold and hot water and cold air - Water collection, treatment and distribution; sewerage, waste management and remediation activities - Construction - Wholesale and retail trade; repair or motor vehicles and motorcycles - Transportation and storage - Accommodation and food service activities - Administrative and support service activities - Other service activities
Focus Sectors: Companies (step 2.2)	22 firms
Capabilities view (step 3)	15 projects all funded by the EU
R&D Capabilities (step 3.1)	Three University and two Polytechnics
Innovation Capabilities (step 3.2)	Ten facilities
Education Capabilities (step 3.3)	Five PhD courses and six master's courses
Emerging Ideas (step 4)	No data available
Existing Circular Economy Legislation (step 5)	National Action Plan for Circular Economy – Potential plan under analysis
Existing Funding Instruments (step 6)	One action plan named PT2020

S3 and focus sectors

The region Centro reports seven key areas of the S3 strategy which are put together by three common areas of specialisation. For each of the key areas and the specialisation areas the region describes different objectives set by the specialisation strategy which are relevant for the circular economy in the region. The seven key areas are: agri-business, forestry, sea, ICT, materials, biotechnology, and tourism. The three specialisation areas are: the exploitation of natural resources, the development of sustainable industrial solutions, and the territorial innovation. Out of the three specialisation areas, the one most frequently cited by the RIS is the exploitation of natural resources, which leverages on the environmental and climatic conditions of the region, which foster the development of a diversified amount of natural resources.

The interrelation among the different strategic areas and the description of the goals is articulated and visually represented in Figure 2 (in the infographic the size of the flows indicates only the number of times the items are referenced in the mapping tool). The graphics shows that, besides tourism which is isolated, all the other areas appear to be interrelated, and this is a potential favourable condition for the establishment of symbiosis across different specialisation areas within the region.

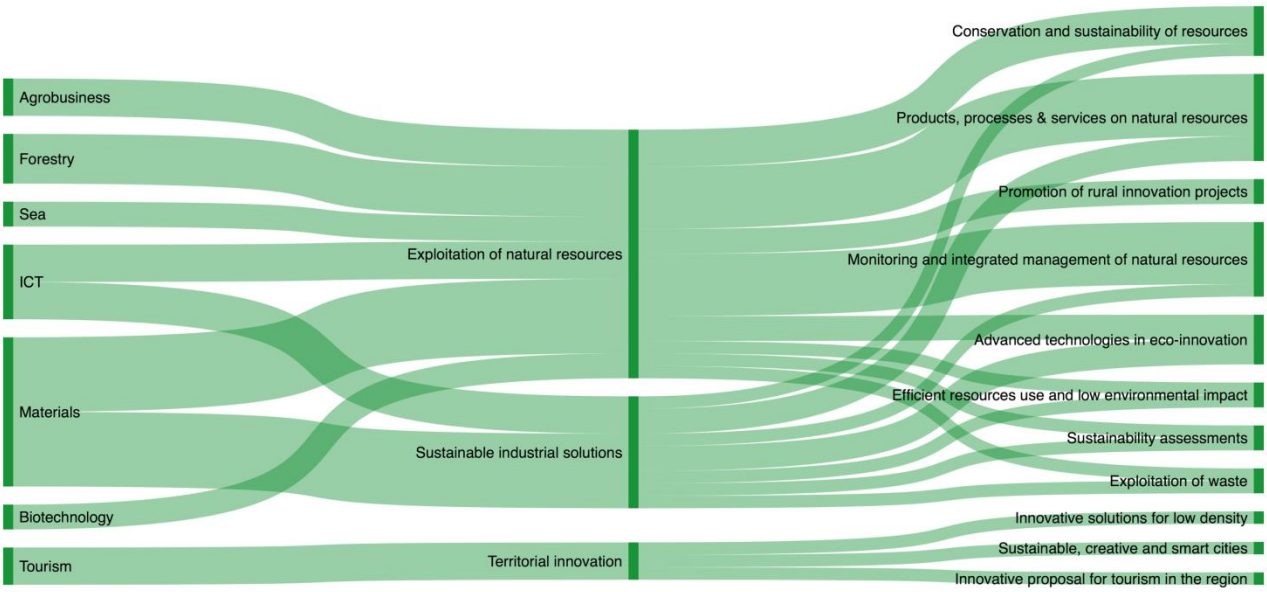


Figure 2. Interactions among the specialisation areas reported by the region in the RIS 3 strategy

The Centro smart specialisation strategy declares a high potential for the future development of agribusiness. The region can count on favourable climatic conditions, and on an economy with several business activities in the value chains of wine, olive, fruits, vegetable growing productions, breeding, and food transformation. The agribusiness develops in the region of Centro across three different domains: crop and animal production (the most relevant both in terms of number of employees and year turnover), forestry and logging, and fishing and aquaculture). On average the

agribusiness concentrates in the region 30% of employees working in the industry at the national level.

The Centro region has 279 Km of Atlantic coastlines (23% of the total coastline of Portugal). The region possesses an active sea industry connected to the exploitation of natural and marine resources. The fishing industry represents about 20% of the regional gross value added, it employees 24% of the workforce and plays a central role in salt works and in aquaculture (about 30% of the national fishing industry). The fishing and aquaculture sector employ about 2,300 personnel units, in about 1,100 businesses with a turnover of 160 Euro millions.

The biotechnology specialisation area focuses on the conservation, sustainability, monitoring, and integrated management of the natural endogenous resources. The area of specialisation promotes initiatives to manage existing natural resources, to increase sustainability of natural resources, to disseminate the importance of biodiversity, and to fight threats to preservation of natural resources.

The tourism industry – though potentially relevant – lags below the country average for presence of infrastructures and utilisation rate. The industry can count on geographically distributed resources with some sites listed in the UN world heritage. In the region, there are about 17,500 businesses, employing about 29,600 personnel units, summing up to 7% of the regional employees. The annual turnover of the industry sums up to 1,21 Euro billions – equal to 20% of the regional turnover, and with 470 Euro millions of gross value-added.

The ICT sector generates a turnover of about 300 Euro millions. The industry is sustained by the universities and research centres that invest in national and international partnerships. The ICT industry in the region covers all the domains, from hardware development, to digital services & application development.

Finally, the material industry shows the most complete value chain in terms of technologies, services, impact on direct and indirect employment, and communication and education programmes. This specialisation area sums up to 16% of the regional gross value added. The region has a strong tradition on industrialisation. The industry has a great propensity for exports, R&D capabilities and clusters within the region push the development and the technology transfer of the industry, sustaining employability. The most important value chains within the industry are that of ceramics, rocks and minerals, wood, cork, and leather.

The data on focus sectors provided by the region are not complete for all the dimensions and for all the sub-sectors, especially for the amount of waste generated and the percentage of waste recycled, incinerated, and land-filled. On the basis of the data available we compute an average percentage of waste recycled for the 11 focus sectors indicated by the region. Table 6 shows the

main economic data (number of employees, turnover, gross value added, number of companies) along with the percentage of waste recycled in the industry. But for the agriculture, mining and quarrying, and construction industries – for which the region provided actual data – the others are the result of the average calculation we performed on the data provided on the sub sectors (not reported here for reasons of length). Not for all the sub-sectors the region had data available, hence the average is not the actual average of the industry. These figures are indicated in Table 6 with a * symbol on a side.

Table 6. Economic data on focus sectors (Centro)

NACE Code	Employees n.	Turnover B€	Gross Val Add B€	Companies n.	% recycled
Agriculture, farming of animals, hunting and forestry	19,095	1.98	0.40	31,318	12%
Mining and quarrying	2,583	0.21	0.08	405	32%
Manufacturing	157,032	18.95	4.47	16,387	31% *
Electricity, gas, steam, cold and hot water and cold air	454	0.78	0.46	238	26% *
Water collection, treatment and distribution; sewerage, waste management and remediation activities	4,960	0.66	0.26	326	32% *
Construction	49,321	3.16	0.91	22,524	41%
Wholesale and retail trade; repair of motor vehicles and motorcycles	103,694	19.87	2.29	52,476	-
Transportation and storage	27,033	2.26	0.81	4,898	-
Accommodation and food service activities	29,647	1.21	0.47	17,555	-
Administrative and support service activities	13,831	0.62	0.32	25,713	-
Other service activities	6,747	0.22	0.09	11,033	-

The table shows that waste recycling varies between 12% and 41%. In some industries – like agriculture for instance – there are potential hotspots of waste not being recycled which could be used in circular economy applications.

The region lists also 22 companies active in the reported sectors. Some of the companies are active on industry different than those listed in the focus sectors. The sectors touched in these cases are that of manage and consultancy, and consultancy related to computer programming and architectural and engineering activities.

The SWOT analysis reports favourable climatic and environmental conditions which stimulate specific industries and research and technological development. Given this relevance of the natural resources – also acknowledged in the specialisation areas of the RIS 3 strategy – the awareness on potential consequences of climate change is high. Sustainability in resource management is reported by the region as potentially improvable.

The region also shows the presence of important regional clusters, and of dynamic businesses. Research institutions nurture and sustain innovation. However, the region reports significant inter regional inhomogeneity, with different dynamics. The region reports resistance to cooperation and networking among industries, and resistance to new ideas by the industry. Access to funding is also indicated as an issue, with difficulties in mobilising the needed funds, and difficulties in obtaining financing.

Regional capabilities and prospected innovation

The Centro region indicated 22 companies with capabilities pertinent to the circular economy domain. The companies cover all the positions in the circular value chain, and all the application domain if we exclude water treatment. The companies offer quite diversified enabling technologies. Part of the technological capabilities of companies focus on the use of waste and biomass for the generation of energy and recovery of heat. The technological capabilities include also both aquaponic test sites, and machine learning and artificial intelligence.

The Centro region indicates three universities and two polytechnics, with about 450 researchers in nine departments as R&D capabilities. These R&D capabilities cover several application domains covering: environmental and natural resources management and exploitation, waste transformation, biomass and energy, nanomaterials and micro-manufacturing, advanced manufacturing systems, maritime and terrestrial ecosystems and biology, materials processes and transformation (with a specific focus on steel and composite structures), ICT infrastructures (both information systems and network) design and operation, socio-environmental governance and sustainability, emerging and green technologies, sustainable manufacturing. The R&D capabilities focus on more specialised set of enabling technologies:

- Water and waste-water treatment technologies;
- Testing of structures and materials;
- Metal processing including both chemical and physical transformation processes;
- ICT infrastructures and applications (including simulations, virtual reality, and additive manufacturing).

Four out of the institutions have also education capabilities at advanced level (master's and PhD courses). The courses offered cover the following areas:

- Architecture and urbanism: one PhD course on landscape architecture and urban ecology;
- Biology and biochemistry: one PhD course on biology and ecology of global changes;
- Civil construction and civil engineering: two master courses on sustainable construction and acoustic and energy efficiency for sustainable construction;
- Earth science: one PhD course on marine and environmental sciences;

- Electricity and energy: two master courses and one PhD course respectively on energy and environmental engineering and energy for sustainability (masters'), and sustainable energy systems (PhD);
- Environmental protection technology: two master courses and one PhD course respectively on environmental studies and sustainable energy systems (masters'), and climate change and energy systems (PhD).

In total the region attracted 169 M Euros of EU grants for research and innovation and has a regional expenditure on R&D up to 439 M Euros. The region reports 15 EU funded research projects, ten funded by H2020 calls, five funded by other EU sources. The research projects tackle the following domains:

- Waste management (four projects): including both urban waste, mining waste, and waste water;
- Agriculture (one project) on sustainability of crop production;
- Sustainable and renewable energy (four projects): including both bio-based economy applications for fuel production, and energy efficiency;
- Sustainable building (two projects);
- Smart manufacturing (one project);
- Collaboration and communication (two projects).

The project listed by the Centro region show connections between the agricultural and the energy production industry. Two projects focus instead on the societal awareness towards sustainability and circular economy. More specifically the two projects aim at stimulating cooperation for reuse of materials, and target to improve the visibility of environmental impacts products and services to the final customer and to stakeholders in general.

The region reported no emerging ideas for prospected future paths of innovation.

Among the capabilities the region reports ten facilities active on the territory working with different enabling technologies and supporting different activities and services. The facilities in the region support different activities:

1. Business model innovation and start-up incubation;
2. Computer simulations;
3. Design, prototype, testing, and development of products;
4. Energy efficiency of automation systems;
5. Physical and chemical processes for biology and micro-biology;
6. Wood and paper transformation technologies.

The services offered do not cover the complete application domain. There are not facilities active on recycling, water treatment, and energy recovery. Most of the activities are concentrated on refurbishment and feedstock

Finally, concerning stimuli to circular economy development, the region reports a prospected national regulation on circular economy (national action plan for circular economy) The region also specifies 19 funding opportunities pertinent to circular economy, under the PT 2020 action plan. Eight out of these funding opportunities focus on different forms of energy efficiency, and four on the adaptation to climate change. The other funding opportunities cover other different domains of sustainability (conservation of nature, coastal protection, intelligent distribution systems, incentives to SMEs).

Circularity Potential

The Centro region possesses a heterogeneous circularity potential. Table 7 summarises the circularity potential of the region. The reported data on focus sectors show the presence of waste in different industries for which recycling can be improved. The outputs of the companies active in the region reported with the data also suggest the availability of further resources on the region that can be exploited by circular economy applications.

According to the reported data the region has several examples of symbiosis between the agriculture industry and the energy production industry. It is also active in stimulating cooperation among different subjects to foster resources and waste exchange, and to improve the visibility of environmental impacts of production and processes to external stakeholders. These societal awareness initiatives have potential in stimulating general attention towards circular economy, which leverages on increasing the awareness of the consequences of the ongoing climate change process. At the same time such initiatives targeted to foster collaboration are needed to overpass the obstacles in terms of resistance to cooperation, reported as a weak point in the SWOT analysis.

The strong presence of regional clusters has a potential for stimulating the emergence of symbiosis. However, the region reports internal diversity and a resistance to networking and cooperation. In general, the economy of the region is affected by the competition of low cost products and by the international crisis which intensified resistances to cooperation.

The region has the potential to contribute in symbiosis by offering different capabilities on the domains of refurbish and feedstock recovery (as a core), and remanufacturing, maintenance, and reuse of materials and resources.

Table 7. Region Centro: summary of the circularity potential

Area	Description
Available resources	Waste from the agriculture sector, mining and quarrying, manufacturing, energy production, water treatment and distribution, constructions Other potential resources from output of listed companies namely: - Feedstock and livestock

Area	Description
	- Metals - Flooring equipment - Biodegradable leather - Building materials - Bioactive oils - Ceramic materials - Aggregated crushed materials
Societal awareness	Climate change awareness Innovation initiatives to foster collaboration and visibility of environmental impacts of production processes to external stakeholders
Stimuli	Several funding sources under the PT 2020 program
Regulation	Prospected national regulation under analysis
Symbiosis	Several applications combining agriculture and energy production
Innovation potential	Waste management Waste water treatment Materials testing Sustainable building Sustainable agriculture Monitoring and management of processes through ICT

Tampere

The Table 8 summarises the data collected for the local analysis of the Tampere region.

Table 8. Tampere: overview of collected data

Steps (mapping tool)	Overview of data provided
RIS 3 Strategic Areas (step 1.1)	Two core areas of specialisation: - Smart Tampere region; - Sustainable Tampere region.
SWOT Analysis (step 1.2)	Complete analysis focusing on the economic, social, environmental, and regulatory areas
Focus Sectors (step 2.1)	The region identifies four focus factors: - Manufacture of paper, paper products, printing and reproduction of recorded media - Manufacture of computers, electronics, electronical equipment, machinery, motor vehicles and other transport equipment - Water, waste and energy - Construction, civil engineering and specialised construction activities For all sectors the region provides economic data and the volume of waste generated. Data on recycling is available only for the overall industry level
Focus Sectors: Companies (step 2.2)	54 firms
Capabilities view (step 3)	92 projects of which: 42 funded by UE programs, 42 funded by national programs, one funded by regional programs, and seven funded by other resources
R&D Capabilities (step 3.1)	The region reports eight institutions among universities and research centres employing about 700 researchers
Innovation Capabilities(step 3.2)	Complete data about 18 facilities with different technology capabilities
Education Capabilities (step 3.3)	Three universities in the region offer courses at different level: 48 bachelor , 61 master's , and four PHD
Emerging Ideas (step 4)	29 prospected emerging ideas with description of the target product and the expected impact
Existing Circular Economy Legislation (step 5)	No data
Existing Funding Instruments (step 6)	No data

S3 and focus sectors

In its smart specialisation strategy, Tampere region sets two main areas, broken down into four sub areas of specialisation. The first area is named Smart Tampere region, and it is specialised in the sub areas of high level of expertise as a success factor, and structural change in manufacturing industry as a driver of growth. The second area is named Sustainable Tampere region, and it is specialised in smart and green growth as driver of regional development, and bio-economy as a growth sector especially in non urban areas.

In the Smart Tampere domain, the region is concerned with the development of a high level of expertise on a mix of technologies capable of stimulating different areas of innovation: advanced manufacturing, wellbeing, health, optics and photonics, signal processing, intelligent transport systems, renewable energy, and sustainable, intelligent, and efficient constructions. The second focus area of the Smart Tampere objective aims at producing prospected structural changes to the manufacturing industry, specifically through the diffusion of advanced manufacturing.

In the sustainable Tampere area, the region is instead concerned with smart and green growth as a driver for regional development, and bio-economy as a growth factor, especially in non-urban areas. These two focus areas together aim at improving the sustainability of natural resources, of processes, and of energy production.

The priority focus sectors reported by the region are:

- Manufacturing of paper, paper products, printing and reproduction of recorded media: with 209 companies active in the region, employing 4,012 persons, and producing an annual turnover of 2,33 B Euros with a gross value added of 0,46 B Euros;
- Manufacture of computers, electronics, electronical equipment, machinery, motor vehicles and other transport equipment: with 394 companies active in the region, employing 10,976 persons, and producing an annual turnover of 4,02 B Euros with a gross value added of 1,07 B Euros;
- Water, waste and energy: with 282 companies active in the region employing 1,409 persons, and producing an annual turnover of 1,14 B Euros with a gross value added of 0,47 B Euros;
- Construction, civil engineering and specialised construction activities: with 3858 companies active in the region employing 12,731 persons and producing an annual turnover of 2,57 B Euros with a growth value added of 0,97 B Euros.

The four sectors are reported to produce about 23% of the waste generated by the industry total in the region. Out of the waste produced by the industry total 41% is recycled and 47% is disposed in landfills. The region is performing well on waste recycle, with a potential to be still exploited.

The SWOT analysis of the region describes a region with a strong manufacturing industry, a nature rich of forest and diverse resources capable of sustaining the development of bio-economy –

currently under-utilised – and a good level of ICT know how that – through services development – can sustain circular economy development. The region shows the presence of different businesses with good potential for symbiosis. The regional culture promotes values such as security, equality, openness and trust. People are on average highly educated. There are good cooperation levels between the public and the research. Finally, Finland has a strict environmental legislation which people tend to respect.

However, the large companies are mainly global international companies, and have less bonds with the region. The rest of the businesses have a low tradition in cooperation, and lag behind European networks and large companies at the international level. At the same time, the rest of the businesses are fragmented and of small size. All these circumstances reduce the possibilities for developing industrial symbiosis and slows down the development of circular economy.

Still in terms of weaknesses, the geographical position of the region – and that of the country – poses further obstacles to the economy. First of all, the cold climate restricts the duration of production seasons for agriculture. Secondly, logistical distances among businesses are significant.

From the administrative perspective, the region reports long terms for decision making, with a bureaucratic approach to regulation, which also has consequences on the development of circular economy. Regulation tends to be centralized and not to match regional needs. It is developed with the principle of partial optimisation and lacks the holistic perspective. The region reports that current regulation on energy production and waste recycling slows down circular economy adoption. Furthermore, there is currently a level of uncertainty on the outcome of the future regional administration renewal process.

The region feels the treats of the decline of the productive manufacturing, and of the potential loss of know-how on ICT as services are bought from outside the region and not developed internally.

Regional capabilities and prospected innovation

The region reports three different universities and four private research centres active in Tampere which have R&D capabilities exploitable in circular economy. The R&D capabilities offered by these institutions spans across several domains. Six different facilities cover different areas of engineering (mechanical and industrial, civic, bio, biomedical, and construction engineering), three the areas of management – including also information management – and then one in turn for political science studies, natural resources, new polymers, and local food.

The education capabilities are offered by three universities that cover all the three levels of education: bachelor (48 courses), master (61 courses), and PhD (five courses). Though the data is not available for all courses, the region reports that these courses enrol in total about 3,400 students per year. The courses are offered in different areas of engineering, information

management, corporate social responsibility, environmental technology and management, biotechnology, energy, health and global development. Table 9 lists the number of students enrolled at the different levels across the courses over the different domains. Missing data in terms of number of students employed (indicated by the * character next to the education domain) indicate the existence of an education capabilities without a reference to the number of students involved. The regions possess a really diversified offer of educational capabilities – with a strong focus on mechanical and industrial engineering, and industrial and information management – which can contribute to strengthen the knowledge and human capital in the region.

Table 9. Breakdown of education domains in Tampere region

Education domains	Bachelor	Master's	PhD	Total
Architecture*				
Automation and Hydraulics*				
Bioproduct and Process Engineering	240			240
Civil Engineering		40		40
Common core studies*				
Energy and environmental engineering	420			420
Energy and environmental technology		100		100
Energy and environmental technology, bioproducts and biorefining		30		30
Environment and society*				
Environmental technology	195	35		230
Environmental technology/bioengineering		60	25	85
Health and global development*				
Industrial and information management	200	380		580
Materials science	100	330	40	470
Mechanical engineering and industrial systems	200	1010		1,210
Responsible business and entrepreneurship*				
Total	**1,355**	**1,985**	**65**	**3,405**

The region lists also 18 different facilities providing capabilities exploitable for circular economy. These facilities offer capabilities across all the application domains and are particularly focused on recycling (both open and closed loop), maintenance, remanufacturing, reuse and water treatment. These capabilities offer enabling technologies and machinery for the recycling of polymers, use of bio-waste as fertilizers, water technologies for water treatment and purification, biomasses, waste management, virtual and augmented reality, automated machinery repair and testing, IT infrastructures.

The region indicated also 54 companies with capabilities exploitable for circular economy. The companies cover all the positions in the value-chain, excluding the gathering of core resources and disposal. They also work in all the application domains of circular economy, excluding refurbish and repair. The companies offer a really diversified set of technological capabilities. Most of them target

the recycling of the following materials: biomass, municipal waste, metal, plastic, rubber, water, fertilisers. Other capabilities concern the incineration processes of different materials, in most cases waste.

From the perspective of innovation on circular economy, the region is quite active. It reports 28 emerging ideas targeting several different products and materials among which the most frequent ones are: bio products, energy, water, composite and textiles. Several ideas point at the definition of digital solutions for business collaboration in circular economy – consistent with the statement of the difficulties in terms of cooperation among companies to foster circular economy – and business model innovations. Several ideas also aim at gaining a better understanding, also at a theoretical level, of products and services. Several emerging ideas are cross-sectorial with a stronger focus on different kinds of manufacturing, and waste collection treatment and disposal (including water). The emerging ideas are targeted mainly to the manufacturing industry – which is also one of the focus sectors identified specified by the region – and on waste collection and treatment second.

Circularity Potential

The regional capabilities, in terms of both actual and prospected innovation for circular economy, are significant. The region has several facilities offering enabling technologies and services exploitable for circular economy. It reports a large number of projects that seeks to explore different applications of circular economy, and which aim at creating synergies among the industries of: waste treatment, water treatment, manufacturing, agriculture, textiles, forestry, energy, sewerage, and civil engineering. The region is also exploiting the use of IT services for monitoring or supporting resources exchange in circular economy applications.

The region is in the position to develop strong knowledge and human capital, and to reinforce the societal awareness of the importance of circular economy.

Though on average resources recycle is around 40%, the region has still potential for using the residual part of non-recycled waste in circular economy applications. According to the outputs described by the company listed, the region also possesses potential resources other than waste produced by the focus sectors which could be exploited in circular economy applications.

While the region does not explicitly report regional funding sources for circular economy projects, Tampere has a strong capability of attracting EU funding for innovation, and reports also project funded by national funds, or Scandinavians supported funds.

As for the regulation side the region Tampere reports a good interconnection among all the different levels of legislation. Environmental legislation is strict, with ambitious targets. However, the regulation is too bureaucratic, and the region reports that regulation on energy production and waste recycling slows down circular economy adoption.

The region is open to new forms of development and cooperation, though at the same time small enterprises have difficulty in cooperating, and the lack of cooperation sets limits to the development of circular economy. There are existing connections across industries, and the diversity of the businesses working in the territory offers even higher potential for new synergies. A potential of an even higher number of synergies is sought by the emerging ideas, several of which build across three different sectors.

Table 10 summarises the circularity potential of the Tampere region.

Table 10. Tampere: summary of the circularity potential

Area	Description
Available resources	Waste from the manufacturing of paper, manufacturing of computers and electronics, water waste and energy, and construction industry According to the output produced by companies reported by the region, resources available in the region include also: - Energy, oil, and bio-energy sources including also green based materials from forests exploitable for energy and fuel production - Fertilizers - Processed materials ready for recycling and recycled minerals - Metals, RAEE waste, and separated municipal waste - Rubber - Polymers - Sludge from waste water
Societal awareness	High educated people with several educational possibilities strengthening the know-how capital in the region Among the emerging ideas the region reports also a training network on the use of natural fibres
Stimuli	No data on funding sources
Regulation	Good connections among the different levels of regulation Regulation is bureaucratic, interpretations are tight, and they slow down the development of CE. The trends are for the development of centralisation of the regulation instead of meeting the regional characteristics
Symbiosis	The region currently exploits different connections among existing industries: - Agri-food and energy - Wood and medical industries - Mineral and ceramics - Urban waste and bio waste production The targeted sectors of the emerging ideas point at several potential symbiosis: - Waste treatment, water treatment, and agriculture - Waste treatment, manufacturing, and materials recovery - Waste treatment, water treatment, and energy

Area	Description
	- Water treatment, manufacturing, and forestry - Water treatment, sewerage, civil engineering - Manufacturing, agriculture, textiles
Innovation potential	Several emerging ideas targeting different products and materials (mainly bio products, energy, water, composites and textile), digital solutions for business collaboration in CE, improved understanding of products and services, business model innovation.

Navarra

Table 11 summarises the data provided with the mapping tool by the Navarra region for the local analysis.

Table 11. Navarra: overview of provided data

Steps (mapping tool)	Overview of data provided
RIS 3 Strategic Areas (step 1.1)	One area of specialisation named renewable energy & natural resources
SWOT Analysis (step 1.2)	The SWOT analysis focuses only on the economic dimension
Focus Sectors (step 2.1)	The Region identifies three macro sectors (without providing nace code): - Renewable energy - Agri-food industries - Automotive industry Data on sectors cover all the dimensions but for the annual turnover, and for the share of waste incinerated
Focus Sectors: Companies (step 2.2)	13 firms
Capabilities view (step 3)	One EU project (FP6)
R&D Capabilities (step 3.1)	Two universities, nine research centres, and a private tech corporations
Innovation Capabilities (step 3.2)	One existing facility
Education Capabilities (step 3.3)	Seventeen different courses at bachelor and master's level offered by two universities
Emerging Ideas (step 4)	6 emerging ideas, with description, target sector/product and the expected impact in economic and environmental areas
Existing Circular Economy Legislation (step 5)	Three different regulations cited
Existing Funding Instruments (step 6)	Six different funding instruments based on the voucher mechanism

S3 and focus sectors

The smart specialisation strategy of the Navarra region focuses on six areas of specialisation, out of which the region reports the renewable energy & natural resources area as pertinent for the development of circular economy. The chosen specialisation area is targeted at consolidating the position of the region in specific sub-domains of renewable energy with the objective of increasing prosperity, quality of life, and sustainability of the economy. In this area of specialisation, the

Navarra region is furthering collaborative approaches between businesses and institutions, the creation of the conditions for establishing business opportunities in renewable energies, the development of circular economy through the reduced consumption of resources, and the management and valorisation of natural resources. The specialisation strategy is divided into five sub-areas:

1. Enhance business and institutional collaboration in order to develop cooperation projects;
2. Increase the production of renewable energies and support energy efficiency as a business opportunity;
3. Develop circular economy actions to reduce consumption of raw materials and energy in relation to the climate change strategy of Navarra;
4. Promote the management and valorisation of natural resources;
5. Enhance talent development in this field.

In its strategy the region of Navarra sets the vision to become world leader in renewable energies with R&D expertise, involving all the actors on the territory in cooperation models, to achieve the goal to reduce regional fossil fuel energy consumption to 0% in 2050.

The region shows a dynamic industrial sector, especially in automotive, agri-food, machinery and equipment, renewable energy, and bio-sanitary technology. The population has a high level of education. Companies show good levels of innovation, and a medium/long term trend of survival. However, the region faces the challenge of a decline in investments in R&D, with the lack of culture from companies to cooperate and work in clusters.

The foreseen opportunity is to overcome this limitation by improving and fostering the cooperation among universities, technological centres, and companies. Another opportunity is seen in the development of circular economy in agri-food, energy efficiency, and waste management and resources. The region is also committed to personally finance R&D, and the region indeed reported also funding sources other than the European funds.

The region sets three focus sectors for the development of the circular economy: (i) renewable energies, (ii) agri-food industries, and (iii) automotive industries. In total these three sectors employ about 38,400 personnel units with a year turnover of 2.8 Euro billion produced by 84 companies. The automotive sector is the largest in terms of employees and number of companies. It is also responsible for almost 95% of the 278,704 tons a year of waste declared for the three industries. At the same time the automotive industry shows a good capability of recycling as 95% of the waste produced are recycled. The agri-food industry is second for the number of employees and it is the most relevant industry among the three declared by the region for the annual turnover. The agri-food industry recycles 42% of the waste produced. For the renewable energy industry, the recycle percentage is instead 28%. The region shows at the same time a good capability of avoiding waste

in some industry, and some hotspots for potential future development of circular economy applications.

Regional capabilities and prospected innovation

The R&D capabilities in the region are possessed by two universities and nine research centres. The R&D institutions work across different domains:

- Mechanical and materials engineering;
- Mechatronic;
- Solar and thermal energy;
- Sustainable production in agri-food;
- Economics and market analysis;
- Sensors development, Internet of Things, and data analysis.

The R&D capabilities also deliver enabling technologies for innovative materials, innovative methods of coating materials, and automation technologies including robotics. The region also offers laboratories for exploring energy efficiency, innovation in agri-food transformation and conservation processes, and biomedical studies.

As for education capabilities there are two universities active on the region offering courses pertinent to circular economy enrolling potentially about 500 students every year (though the figure is partial as number of students is available only for one university). The courses offered cover both the bachelor and the master level, in the areas of: agricultural engineering, industrial engineering, biology, chemistry, and environmental sciences. Most of the courses focus on agricultural engineering.

The region possesses one pilot plant that produces gas from organic wastes through an anaerobic treatment cleaning unit. The gas produced – methane – is used as fuel for public transportation, and the gas is produced from domestic waste.

Concerning prospected innovation, the region shows two different fronts as emerging ideas for further development of the circular economy. On the one hand, a set of initiatives target the creation of networking relationships among businesses to foster collaborations in the sectors of: renewable energies, agri-food industries, functional printing, food processing industry, and automotive. On the other, a separate initiative is targeted to the separate collection of organic waste from agriculture, food processing & manufacturing industry, and municipalities. The waste is managed to reduce costs for disposal, and to valorise it for potential reuse of resources.

Circularity potential

The Navarra region has a clear focus on the potential reuse and valorisation of waste. Under the organisational innovation perspective, the region is committed to innovating the garbage separation in some specific industries, and regarding the organic waste. Such applications are pursued through cooperative business models and cooperative projects. The lack of cooperation culture among businesses is indeed however reported as one potential challenge to the development of circular economy.

In terms of stimuli, the region is in first person committed to support innovation, also in relation to circular economy. The region reports a set of funding instruments targeted to supporting R&D project proposals, funding R&D projects, and hiring research and technological personnel.

The commitment of the region on circular economy is also testified by the presence of a local regulation concerning waste (specifically bio waste), and a long-term integrated plan for waste management for the whole nation. The region also reports a law on waste to be under development.

Actual reuse of waste is exploited in the sector of bio-energy. Organic waste is used to produce methane. In this way the region sustains a symbiosis between the waste management sector and the public transport sector, as the bio-gas produces is used as propellant in public transportation means.

Table 12. Navarra: circularity potential

Area	Description
Available resources	Waste from renewable energy and agri-food industry Few wastes from automotive industry Other materials available from outputs of companies: - Plastic - Metals: copper, tin, silver and metals in general - Textiles - Energy
Societal awareness	Lack of culture for companies to cooperate and work in clusters
Stimuli	Support for the preparation and submission of projects on R&D based on the voucher mechanism Innovation voucher Programs for funding R&D investment projects, or technology investment projects Programs supporting the recruitment of R&D personnel in firms, or for the recruitment of PhD students

Area	Description
Regulation	Existing at the regional level: - Law 07/2013 on bio waste - Waste plan of Navarra 2017 – 2027 Existing at the national level: - Waste management plan Under development at the regional level: - Waste law
Symbiosis	The region currently exploits a connection between the organic waste collection and the public transport industry, through the energy industry, and b generating energy (methane) from waste Among the companies listed by the region there is the possibility of exploiting connections for the exchange of plastics
Innovation potential	Fostering collaboration among business partners Improving waste separation for better potential use

Fryslân

Table 13 summarises the data provided with the mapping tool by the Fryslân region for the local analysis.

Table 13. Fryslân: overview of collected data

Steps (mapping tool)	Overview of collected data
RIS 3 Strategic Areas (step 1.1)	Two areas of specialization: - Water technology - Agri-food & Dairy
SWOT Analysis (step 1.2)	A complete SWOT analysis spanning the economic, environmental, social, and regulatory data
Focus Sectors (step 2.1)	Two priority sectors: - Water collection, treatment and supply - Crop and animal production, hunting and related service activities The companies listed by the region are also active on other industries: - Sewerage (close to water technology) - Manufacture of food products (close to Agri-food) In the emerging ideas the regions seek to involve further industries in prospected innovations: - Construction; - Electricity, gas, steam and air conditioning; - Manufacture of paper and paper products; - Manufacture of chemicals and chemicals products.
Focus Sectors: Companies (step 2.2)	5 firms
Capabilities view (step 3)	No data available
R&D Capabilities (step 3.1)	Five institutions including two universities, two centre of expertise, and one dairy campus
Innovation Capabilities (step 3.2)	Eight existing pilot plants, seven of which specialised on water treatment, and one on recycling (closed loop)
Education Capabilities (step 3.3)	Five education institutions with courses at bachelor, master, MBA level, also non-academic degrees
Emerging Ideas (step 4)	10 projects
Existing Circular Economy Legislation (step 5)	No data available
Existing Funding Instruments (step	One action plan on Water (Noordelijke Innovatie Agenda)

Steps (mapping tool)	Overview of collected data
6)	

S3 and focus sectors

The region Fryslân proposes a smart specialisation strategy focusing on two areas of specialisation: water technologies, and agri-food & dairy.

The area of water technologies is the key specialisation area of the Fryslân region. Fryslân possess a complete value chain in the water technologies industry spanning across education, businesses, and R&D capabilities. This area of specialisation is known also internationally under the name of the "European Hub for Water technology", has a high reputation in Europe. The water technologies sector focuses on water as a resource, on the reuse of water itself, and the reuse of resources extracted from water. The area of specialisation concerns technologies and facilities for water processing and for reuse of resources from water.

The Agri-food diary sector is the second area of specialisation. The objective of the region within this area is to combine innovative business models with environmentally sustainable production. The sector is one amongst the traditional ones in Holland, and specifically in the Fryslân region. It is a strong sector with many active companies. The region has set strategic objective of guiding the development of the sector furthering the development of SMEs working in the food processing industry but building at the same time a bio-based and circular economy.

The region favourably foresees the potential synergies among the two focus sectors, especially considering the natural contact points among them being water an important resource used in agriculture.

The water technologies sector employs about 3,500 persons in Fryslân, with a year turnover of 700 B Euro and a gross value added of 400 Euro billions. The regions report about 110 SMEs working in the water technology sector, eight public water technologies bodies, and 10 water technology related knowledge institutions. The region reports descriptive data on waste produced by the sector. The sector has anyhow a high circularity potential for the reuse of water, nutrients, organic resources, and sludge. Dewatered dried sludge is currently incinerated, while sludge dry matter, or materials containing heavy metals – like PCBs – are disposed in landfill. The descriptive data describes a great potential for the recovery of materials from data, however being quantitative data missing, it is not possible to assess the presence of potential hotspots.

No data is instead available for the agri-food and animal production sector. The industry is also in the position to offer innovative potential to the agricultural sector in industry, and it is seen as potentially symbiotic with the water-technologies industry.

The regional sectors can leverage on a strong market position and a good stock of knowledge with a commitment and productive labour capital. The recovery of resources from water, and the recovery of water as a resource, is an industry with a great potential for fostering circular economy. Hence the water technologies sector is a strength on top of which a strategy for circular economy can be built.

The region reports that the size of companies – mostly SMEs – is an actual constraint to the flourishing of innovation in the region, reducing the chance of businesses running risky investments on innovation for circular economy in the region.

There are innovation initiatives in place, and they take place with specific references to single parts of the value chain. These innovation opportunities are faced by two hurdles. On the one side, the infrastructures in place in the water sector are old, and the sector is potentially resistant to disruptive innovation. On the other, the regulation and the fiscal legislation on the water technology effectively protect the traditional way of organising the water industry, but represent threats to innovation, acting as normative barriers undermining the introduction of new technologies to the market.

The region has a relatively high unemployment rate, and investments in circular economy are seen as opportunities to reduce it. However, there is a current gap between a highly educated and skilled professionals, and lower educated craftsmen. This is seen as a general challenge to a shift from an economy based on production to an economy based on services.

On the broader societal side, the region reports the challenges of the absence of incentives to the population to stimulate more efficient and sustainable use of water, or water saving, behaviour. There is currently no regulation on efficient use of water.

Regional capabilities and prospected innovation

As anticipated in the strategic positioning, the R&D capabilities of the region are possessed by five institutions, and are focused on water technology, chemicals, energy and dairy, on the one side, and agriculture, food, and bio-chemicals on the other. Most of the R&D potential is polarised on the technologies related to sustainable use of water, reduction of water usage, waste water treatment, removal of pollutants/pathogens from water, and reuse of resources and materials from water.

The region reports also eight pilot plants active. Seven of these plants work in the water treatment domain and possess different kinds of enabling technologies (from water collection and treatment to desalination, sensors solutions, and drinking water infrastructures). These pilot plants support innovation processes ranked on the TRL with levels between 3 and 5. They are accessible to SMEs and support the entire cycle of activities of innovation: development, testing, validation, technical

and innovation support, and business model validation. The last pilot plant is instead targeted to the recycling (closed loop) in the agri-food industry. It is accessible to SMEs and support innovation processes ranked on the TRL with levels between 3 and 6.

Finally, concerning prospected innovation, the region reports ten emerging ideas most of which are in the water collection, treatment and supply side. The emerging ideas aims to involve further sectors in circular economy, other than those listed at the strategic level:

- Construction;
- Electricity, gas, steam and air conditioning;
- Manufacture of paper and paper products;
- Manufacture of chemicals and chemicals products.

All the emerging ideas but one target on the reuse and recycle of materials from waste water. The different materials are sought to input different connections with other sectors. The materials that the region seeks to recover from water are:

- Cellulose;
- Humid acid;
- Nutrients;
- Plastics and bio-plastics;
- Biogas;
- Heat;
- Phosphate;
- Clean water.

On the educational capability level, there are two universities, three centres of expertise and innovation, and a water campus offering eleven courses on water technologies (six courses), agriculture (three courses), environment (one course), and economics and marketing). The educational capabilities cover both the bachelor, master's, MBA and other (non-academic degrees) levels.

Circularity potential

The Fryslân region has a circularity potential strongly focused on water treatment. The agri-food industry is seen as a first synergic industry with a great potential of creating symbiosis among them. Coherently with this strategic positioning, the region possesses several R&D capabilities and pilot plants, and presents emerging research ideas, for the reuse of nutrients, materials, and energy from water and wastewater.

Still in terms of waste reduction, the region has R&D capabilities for the reduction of water in industrial processes, and several plants for experimenting and testing water treatment processes and application.

On the stimuli, the region reports the existence of a national fund (Noordelijke Innovative Agenda) financing regional R&D regional programs, under the support of ERDF.

It is also reported that the regulation – fiscal and law – aims at protecting the traditional water treatment industry, acts as a potential disincentive driver towards innovations. Introducing innovation in the industry is seen as difficult. Due to the strengthen of the industry and the tradition of its action, the sector would probably resist disruptive innovation.

Table 14 summarises the circularity potential of the Fryslân region.

Table 14. Fryslân: summary of the circularity potential

Area	Description
Available resources	Water, nutrients, resources (organic, cellulose), sludge, and other materials that can be found in waste water The prospected innovation in the region aim at making the following resources also available: - Cellulose - Humid acid - Nutrients - Plastics and bioplastics - Biogas - Heat - Phosphate - Clean water
Societal awareness	No incentives for water saving compliant consumption
Stimuli	One national fund
Regulation	Regulation on water quality No regulation on water use reduction or water recycling
Symbiosis	Water technologies with agri-food industry Prospected connections and symbiosis are also sought with the sectors of: - Electricity, gas, and steam - Construction - Manufacture of paper
Innovation potential	Several emerging ideas targeted at recovering different materials and nutrients from water and waste water, and targeting also at reducing the amount of water used in production processes

Scotland

Table 15 highlights the data Scotland produced with the mapping tool.

Steps (mapping tool)	Overview of collected data
RIS 3 Strategic Areas (step 1.1)	Three areas of specialisation with sub areas: - Food and drink - Energy and marine energy - Life sciences
SWOT Analysis (step 1.2)	A complete SWOT analysis covering the economic, environmental, social, and regulatory aspects
Focus Sectors (step 2.1)	Eleven sectors without economic and circularity potential data
Focus Sectors: Companies (step 2.2)	46 companies
Capabilities view (step 3)	Six projects, five of which funded by the EU, and one funded by the Scottish funding council (regional level)
R&D Capabilities (step 3.1)	Nine institutions with R&D capabilities
Innovation Capabilities (step 3.2)	Nine pilot plants
Education Capabilities (step 3.3)	Three universities offering eight courses on bachelor, masterand other level
Emerging Ideas (step 4)	Three innovation ideas
Existing Circular Economy Legislation (step 5)	A regional circular economy bill is reported to be under development
Existing Funding Instruments (step 6)	No data available

Table 15. Scotland: overview of collected data

S3 and focus sectors

In its S3 strategy Scotland declares three areas of specialisation (food & drink, energy & marine energy, and life sciences) further broken into two sub-areas. The sub-areas have no interdependences at all (see Figure 3).

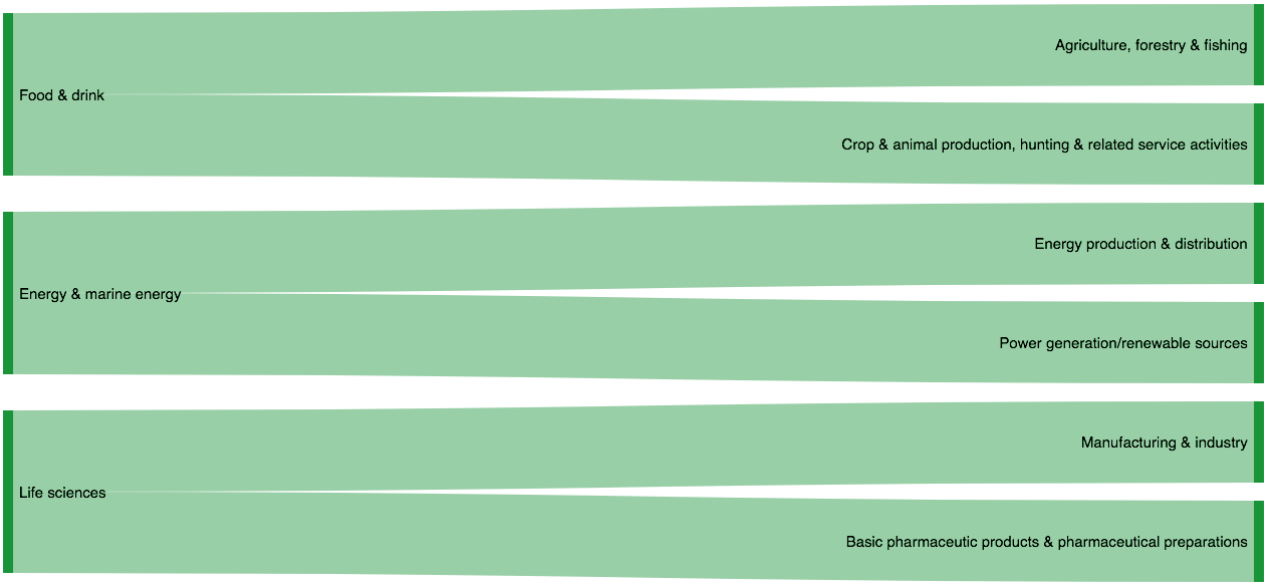


Figure 3. Overview of the specialisation areas

Consequently, the region reports ten different focus sectors, without providing economic and circularity potential data:

- Crop and animal production, hunting and related service activities;
- Forestry and logging;
- Fishing and aquaculture;
- Manufacture of food products;
- Manufacture of beverages;
- Repair and installation of machinery and equipment;
- Extraction of crude petroleum and natural gas;
- Electricity, gas, steam and air conditioning supply;
- Construction of buildings;
- Civil engineering;
- Specialised construction activities.

Scotland is deeply committed to issue policies for the development of circular economy. Scotland reports to have a strong and clear policy framework in which it sets voluntary and ambitious targets to progress towards the completion of a circular economy agenda. The circular economy agenda is furthered by several public bodies and institutions which work with a business-focused mentality to establish actual and working collaborations.

Scotland can count on internationally renowned academic institutions which actively transfer knowledge to the market. Also because of this, the country reports high levels of skills in the workforce. However, the lack of effective links between academic institutions and business is reported to hamper the potential of transferring innovative ideas from the academia to the market.

Scotland also reports the availability of a substantial amount of natural resources in the region (biomass, wind, and hydro- power for energy generation) which could be exploited to create value. The resources and assets identified in the smart specialisation strategy are unevenly distributed across Scotland, and this aspect limits their impact.

The main source of concern, seen also as a potential threat to the economy of Scotland, is the ongoing Brexit process.

Regional capabilities and prospected innovation

Scotland indicates six research projects, three of which focusing on reusing and recovering different materials from plastic waste, marine plastic waste, and electronic waste. The other projects focus on the diffusion of reuse, repair, and remanufacture among companies, on the diffusion of environmental sustainable agricultural productions (through the use of aquaculture), and to the support of business model innovation to companies.

As per R&D capabilities Scotland reports different entities belonging to different universities and research centres. The R&D capabilities are both on management, engineering, sustainability, and geo-science. The capabilities cover the application domain of energy, agriculture, materials and production and recovery, construction, automotive, and chemicals and fuel.

The pilot plants reported by Scotland offer innovation capabilities in remanufacturing, industrial biotechnology, metal processing, fermentation and anaerobic digestion, sustainability in food processing. There are also innovation facilities in the region offering ICT related capabilities, more specifically data science, sensors network, and Internet of Things. All the facilities available in the region are open for access, and in some cases, they are reported to also support innovation projects with funding.

Finally concerning the education potential Scotland has eight courses, one at bachelor level, one at a different (non-academic) level, and the remaining six at master level. The courses cover both technical and managerial domains in the areas of: business and management, engineering, art, education, humanities and social science. It is worth noticing that among the courses available Scotland also reports courses on humanities and social science that together with the other courses available reinforce the human and knowledge capital not only under the technical point of view, but also under the societal perspective.

The industrial capabilities regarding circular economy are diverse. Scotland reports several companies working in different fields, and showing competences related to circular economy. Companies cover all the positions in the circular economy value-chain and combine these positions over different application domains, without possessing all of them. Among the different position production, collection, and disposal are the most present ones among the selected companies.

While for the application domains biochemical feedstock recovery, recycling (open loop), refurbish, repair, and remanufacturing are the ones most frequently available among companies. There are few companies working on reuse, recycling (closed loop) and really few on energy recovery. No companies cover the domains of maintenance and water treatment. Figure 4 summarises the position of the companies across the value chain and the application domains

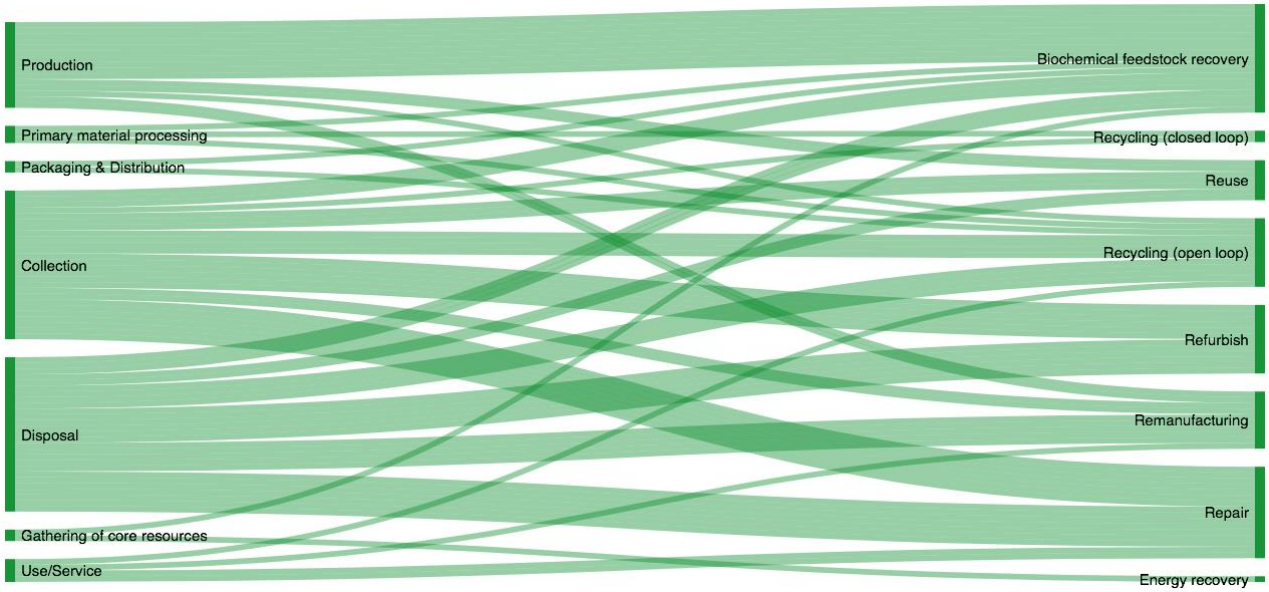


Figure 4. Position in the circular value chain and application domain of circular economy activities of companies in the Scotland region

Circularity potential

The circularity potential of Scotland can count on a large and varied stock of companies with diversified competences on technologies exploitable in a circular economy scenario. The innovation capabilities – as reported by the region – are centred on a set of applications targeted mainly at water as a resource, and at the recovery of different materials (plastics, metals, materials from electronic waste).

Scotland, unique among all the other regions, has an education capabilities which includes circular economy and sustainability also from the point of view of education, and not only on the technical and managerial perspective. The region is committed to improve such position by reinforcing even further these capabilities as one of the emerging ideas focuses on the set-up of a circular economy academy. Under this point of view, the potential to strengthen the human capital, raise the societal awareness of circular economy and promote more sustainable habits.

This is combined with a commitment from the policy side on the further development on circular economy. Scotland reports to discuss a circular economy package law for 2018.

In terms of resources reuse, Scotland focuses on green energy production, and on the recovery of materials and nutrients from electronic waste. Scotland did not report waste data for the focus sectors specified. However, among the outputs of the companies both WEEE, plastics, fuels, and chemicals are materials available over the territory and could be exploited by circular economy applications.

Area	Description
Available resources	No data on waste related to the focus sectors According to the outputs of companies listed by Scotland the following resources are available in the area: - Waste of electric and electronic equipment for recycling - Plastics - Bio based fuels - Bio based chemicals
Societal awareness	Education capabilities on societal aspects of sustainability Prospected academy on circular economy skills
Stimuli	No specific funding reported Some innovation facilities also offer funding support for innovation projects
Regulation	Reginal legislation under development
Symbiosis	Production of energy from agricultural waste Reuse of food waste for agriculture Prospected symbiosis: - Generation of energy from waste plastic
Innovation potential	Production of energy from waste plastic De-manufacturing

Table 16. Summary of the circularity potential

Lombardy

Table 17 shows an overview of the data collected with the mapping tool from the Lombardy region.

Table 17. Lombardy: overview of collected data

Steps (mapping tool)	Overview of collected data
RIS 3 Strategic Areas (step 1.1)	Three areas of specialisation broken down in sub-areas: 1. Advanced manufacturing 2. Environment and energy: green chemistry 3. Agribusiness
SWOT Analysis (step 1.2)	A complete SWOT Analysis focusing on the economic, regulatory, environmental, and social
Focus Sectors (step 2.1)	Five focus sectors with complete data on economics and circularity potential: 1. Discrete manufacturing 2. Continuous manufacturing 3. Construction industry 4. Wastewater management 5. Waste management
Focus Sectors: Companies (step 2.2)	29 companies
Capabilities view (step 3)	Seventeen projects funded, thirteen funded by the EU for a total amount of 71 M Euro, and four founded by the region for a total amount of 8 M Euro
R&D Capabilities (step 3.1)	Several departments from three Universities, one polytechnic, and the National Research Council The institutions host about 540 researchers working in different application domains and offering different enabling technologies related to the focus sectors
Innovation Capabilities (step 3.2)	Six existing facilities with different levels of accessibilities
Education Capabilities (step 3.3)	Five universities offering courses in management, industrial environmental and chemical engineering, and environmental science The courses cover all the levels
Emerging Ideas (step 4)	Eleven emerging ideas with complete data on prospected environmental and economic impact
Existing Circular Economy Legislation (step 5)	No data available
Existing Funding Instruments (step 6)	No data available

S3 and focus sectors

The Lombardy region sets three areas of specialisation in its S3. The areas are further broken down into sub-areas.

The first area of specialisation is that of advanced manufacturing which is focused on the shift towards an environmentally sustainable and smart production systems, covering different aspects of production, from the most technical to the managerial ones. The area is broken down into five sub-areas:

1. Production with innovative processes;
2. Adaptive and evolutive production systems;
3. High-efficiency production systems;
4. Manufacturing for personalised products;
5. Manufacturing systems for environmental sustainability.

The second area of specialisation is on environment and energy with a focus on green chemistry. The areas are quite broad and covers different domains of interest which have contact points with circular economy from the perspective of treatment of natural resources and production of energy. The area is broken down into 9 sub areas:

1. Generation and distributed management of energy;
2. Technological evolution of renewable resources;
3. Energy storage systems;
4. Infrastructure for electrical mobility;
5. Smart lighting;
6. Technologies and materials for the construction industry;
7. Technologies for the management, monitoring and treatment of water, air and waste;
8. Sustainable catalytic processes;
9. Creation of bio-refineries for production of products from no-food and waste biomass;
10. Bio economy of the future.

The third area of specialisation is on agri-business broken down into:

1. Production system for the sustainability of bio-resources;
2. Sustainable ingredients for a competitive agri-food industry;
3. Safe food for a sustainable consumption;
4. Food with high nutritional efficiency.

The region reports five focus sectors as priorities for the development of circular economy. These sectors are:

- Discrete manufacturing;
- Continuous manufacturing;
- Construction industry;

- Wastewater management;
- Waste management.

Out of the focus sectors in general, manufacturing is the most important one in Lombardy. The discrete manufacturing is the most relevant among all the five both in terms of employees (about 480,000 personnel units in the region), year turnover (183,37 B Euros), gross value added (54,58 B Euros), and active companies (about 36,400 companies). The second is continuous manufacturing which employs almost 44,000 people in the region, in 1,239 companies with a year turnover of 21,61 B Euros and a gross value added of 3,04 B Euros. The other three sectors are instead of smaller relevance for the region. In general, the region performs well for the recycling of waste: on average, more than 65% of waste produced by the focus sectors are recycled. The sectors in which recycling is most frequent are that of discrete manufacturing, construction industry, and wastewater management. In all these cases recycling is above 70%, up to 88% or the case of construction industry. There are potential improvements both for the continuous manufacturing and waste management where recycling is around 45%. In particular, 52% of the waste of the continuous manufacturing industry are disposed in landfill, and according to the given definition of the industry, these might contain metals which could be recovered, making the target on this sector a hotspot for the development of circular economy initiatives within the region.

In the swot analysis the region reports a great potential in the exploitation of circular economy, within a favourable environment characterised by high-tech and value-added production, which could help with the rising unemployment, but which is contrasted by the low availability of natural resources, by the saturation of the urban territory, and by the degradation of the natural territory due to continued inaction.

A first asset for the development of circular economy is the concentration of high-tech manufacturing and enabling technologies industries, which have the potential to sustain material and energy-related business. Waste management systems are consolidated and involve all municipal waste. The region possesses many plants for treating urban and industrial waste, and they are sized to satisfy the needs of the region. Both the education, and research capabilities are fully developed, and homogeneously available across the regional territory. Finally, the regional administration shows a strong commitment to support and foster circular economy in Lombardy.

The region also possesses a knowledge and research capital asset, which stimulates the growth of high-tech processes and industries on the territory. The current unemployment rate is seen as an opportunity of a stock of human capital willing to be employed in innovative initiatives.

The region states to need knowledge exchange to share best practices, especially on the side of financial plans and investments in circular economy to support investments in innovation by SMEs.

SMEs composes the largest share of companies in the regional economy, but show a low capacity and tendency of investing in R&D.

The region faces the threats of volatility in prices and availability of raw materials and energy imported from outside the region. Furthermore, the downside of the unemployment rate is the threat of a drain brain and of the loose of competences in human resources to be potentially employed.

The focus sector for circular economy development for Lombardy are in manufacturing, water supply (sewerage, waste management and remediation activities), and construction industry. In total these focus sectors employ 789,860 personnel units, with 242 billion Euros turnover and with 72,194 companies active in the region.

The circularity potential of the region is high, and the data provided are from a database of the environmental directorate general of the Lombardy region. On average, almost 63% of the waste generated by these focus sectors are recycled in the provided focus sector, about 3% is incinerated, and about 12,5% is stored in landfill.

Regional capabilities and prospected innovation

The region indicates 29 companies working in the focus sectors specified, covering all the positions in the circular value chain excluding the gathering of core resources, and all the application domains as shown in Figure 5. The companies possess different technological capabilities on design, transformation, and recycle of different materials. There are also companies specialised in business and management, and on ICT capabilities for additive manufacturing, 3D reconstruction, and high intensity computational tasks. The outputs declared by the companies also testify the availability of different resources at the regional level which could be exploited in circular economy applications.

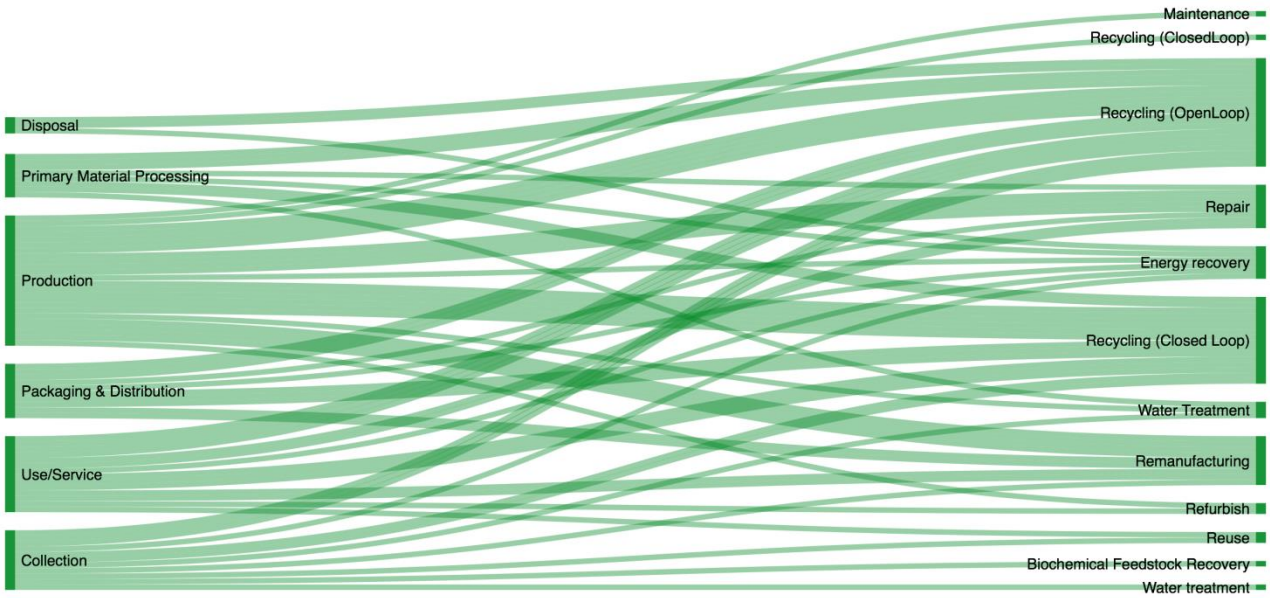


Figure 5. Position in the value chain and application domain of the companies

These companies offer a quite broad set of enabling technologies. A group of technologies are related to processing and reuse of materials like metals, card and cardboard, plastics, natural and artificial fibres. These technologies support both design, test, manufacturing and remanufacturing in various industries among the ones cited in the S3 strategy (mainly construction and manufacturing), but also offer possible connections with textile and high fashion industries for the capabilities of dealing with fibres and using and reusing natural and synthetic components. Besides these technologies the region also possesses technologies for pre-treating, treating, and recycling different kinds of waste, including potentially high value waste like WEEE. Finally, the companies also offer ICT technologies like 3D modelling, computational fluid dynamics, system integration, and 3D printing which could support innovative manufacturing processes.

Concerning R&D capabilities there are three universities, one polytechnic, and the National Council of Research active in the region employing about 540 researchers (though the number is not accurate as data is missing for one university and one department of the National Council of Research).
Three out of these five universities have also research potential related to circular economy. The R&D regional capability is complemented by the National Council of Research (CNR). About 500 researchers work in the selected enabling technology and department. The R&D capabilities are centred on advanced technologies for high efficiency production systems, advanced manufacturing, re-manufacturing and recycling, reduction of emissions, recovery of energy and materials from waste, and for the increase of efficiency of production processes.

Concerning the education capabilities there are five universities active on the region which offer two courses at the bachelor level on environmental science, 17 courses at the master level on engineering (industrial, chemical, information, environmental) and environmental science, and one

PhD course on information engineering. The courses offer the capabilities of enrolling more than 1,100 students every year.

In the region, there are five pilot plants active targeted to the application domains of refurbish, repair, remanufacturing (most of them), and recycling (both open and closed loop). These facilities belong both to public and private research institutions active in the territory. These facilities support different activities in the design, research, optimisation, validation and test of products and processes, including both the technical side, and the business side.

The region indicates 17 R&D projects related to circular economy. The projects target the priority sectors of manufacturing, waste collection and treatment, and construction. The projects cover different domains and are aimed at fostering the capabilities of reusing and recycling different materials from products and production processes in the region, either through demonstrators, new processes, de-construction and re-manufacturing of products, and through pilot plants. There is a strong focus on the reuse of materials from electronic and electric equipment waste, especially printed computer boards, and waste from mechatronic and advanced electrical and electronic devices. Other domains are related to the reuse of materials from the automotive industry; the reuse and recycle of water; the reuse of fibre reinforced composites; and the construction of bio-materials. Quite peculiar, one project initiative aims at fostering industrial symbiosis, specifically targeting the material matching of small and medium enterprises, through a collaborative platform.

The region presents several emerging ideas on circular economy, targeted to the reuse of resources, the substitution of resources, or the identification of new business models to make specific processes or industries more sustainable. In the field of substitution of resources, one project within the region concerns the replacement of polystyrene for impact absorption with cellulose based materials. Being this substitutive material recycled as paper, the project foster at increasing sustainability in packaging (polystyrene is not recyclable), while at the same time simplifying separation of waste.
A couple of projects are related to the recycling of different resources and materials: waste water, extraction of nutrients (phosphorous) from waste water, exhausted and re-usable battery cells, nylon socks. One project initiative also targets – among other goals – at improving the recycling behaviour among the population in a specific industry.

Circularity potential

The Lombardy region shows a high level of awareness of environmental sustainability and a high potential coherently focused on the industries specified by the region as priority for the application of circular economy, and on the related enabling technologies and R&D capabilities.

The level of waste recycling in the region is quite high, especially for waste derived from construction, manufacturing, and water treatment industries. There are areas of improvements for

the waste produced by continuous manufacturing and waste management industry. Furthermore, the capabilities of companies active on the region show the availability of other materials (including high value materials like precious metals, rare earths, and WEEE) that could be exploited in circular economy applications.

The prospected innovation potential of the region is concentrated on processes for manufacturing, de-manufacturing, and reusing materials from products, and on products which are more sustainable. A process-based capability which is complementary to the areas of applications already mentioned is related to the use of ICT for improved efficiency of processes and productions.

Among the reported sectors active for circular economy the region shows potential for exploiting synergies with the textiles and fashion industry which are active on the territory. For the rest, given the fact that recycle, capabilities, and innovation are all focused on the three priority sectors of manufacturing, construction, and waste management, the region could potentially exploit further synergies within these sectors.

Finally, in terms of regulation, the Lombardy region declares a strong commitment in supporting and stimulating circular economy, but also indicates the limited capabilities due to the restricted span of action that is left by the Italian institutional setting to the regional legislation in comparison to the national one. No specific data is given on regional regulation and stimuli for circular economy. From the reported data, the most effective for of stimuli for supporting circular economy are EU funds, followed also by regional funds.

In terms of consumer behaviour, the education capability of the Lombardy region is mainly targeted at the development of skilled profiles on the technologies and on the transformation processes.

18 summarises the circularity potential of the Lombardy region.

Area	Description
Available resources	Waste from the manufacturing (plastic, rubber, and metals), construction, wastewater, and waste management sectors Looking at the outputs of the company the region also has the following materials: • Nylon • Lycra • Chips • Metals, including precious metals • Wastewater • Sludges • Polymers • Energy

Area	Description
	• Plastics • Rare earth • WEEE • Wasted textile fibres
Societal awareness	One emerging idea focuses on the enhanced behaviour of recycling in the population
Stimuli	No data available
Regulation	No data available
Symbiosis	Potential connections among the manufacturing, construction, and waste management industries Potential connections with fashion and textile industries
Innovation potential	The prospected innovation is in the manufacturing, waste collection and treatment, and construction sectors The region also promotes a matchmaking ICT platforms for spotting and developing new symbiosis within industries in the region

Table 18. Lombardy: summary of the circularity potential

Lazio

Table 19 provides an overview of the data collected from the Lazio region with the mapping tool.

Table 19. Lazio: overview of collected data

Steps (mapping tool)	Overview of collected data
RIS 3 Strategic Areas (step 1.1)	Six S3 areas of specialization: aerospace e security, life sciences (pharmaceutical and medical devices), cultural heritage and cultural technologies, digital creative industries, agri-food, green economy (green and smart building, technologies for the generation of renewable energy, ecosystem services and regulation, efficient use of resources treatment and processing of waste, industrial symbiosis)
SWOT Analysis (step 1.2)	A complete SWOT Analysis focused on the economic, regulatory, environmental, and social macro areas
Focus Sectors (step 2.1)	Three focus sectors with economic data but no waste data: - Manufacture - Creative and digital industries - Cultural heritage and cultural technologies
Focus Sectors: Companies (step 2.2)	23 firms
Capabilities view (step 3)	Eight regional funded projects, one national funded research project, and three EU funded research projects
R&D Capabilities (step 3.1)	Four universities and two research centres
Innovation Capabilities (step 3.2)	No data available
Education Capabilities (step 3.3)	Eight universities offering courses in agri-food, agronomy, biology, chemistry, engineering, environmental management, sustainability covering both the levels of bachelor, master's and PhD
Emerging Ideas (step 4)	Eight prospected innovation ideas
Existing Circular Economy Legislation (step 5)	No data available
Existing Funding Instruments (step 6)	No data available

S3 and focus sectors

The Lazio region indicates six areas of specialisation inside the smart specialisation strategy: airspace and security, life sciences, cultural heritage, digital creative industries, agri-food, and green economy. These areas of specialisation are further broken down into specific sub-areas describing the area of applicability of circular economy related activities within the specific are:

- Aerospace and security:

  - Space: technologies for land observation;
  - Aeronautics: ecological production, new and clear engines, efficient air transport operations;
  - Security: climate change applications, and disaster resilience as a consequence of the ongoing climate change process;
- Life sciences:
  - Pharmaceutical: biomaterials, nutrition and nutraceuticals;
  - Medical devices: advances sensors and biosensors for diagnostic;
- Cultural heritage and related technologies: models for dispersion of air pollutants and deposition patterns of pollutants;
- Digital creative industries: technologies for smart green and integrated transport, product design for the use of innovation materials or reuse;
- Agri-food: sustainable agriculture and natural resources management and use, food health and safety, sustainable and competitive bio-based industries;
- Green economy:
  - Green and smart building: construction, heating and cooling, decarbonisation;
  - Renewable energy and smart grids: enhanced storage technologies, modernised grid technologies, electricity from renewable sources for heating and cooling;
  - Ecosystem services and regulation: integrated approaches for security, low-carbon energy, sustainable water management;
  - Efficient use of resources, treatment and processing of waste: sustainable use of agricultural waste, co-products and by-products, eco-innovative processes for waste reuse;
  - Industrial symbiosis: systemic approach for reduction, recycling, and reuse of food waste.

The overview of the S3 strategy reported by the Lazio region is cross-industrial and presents the possibilities of application of technologies and capabilities used in one industry that could be applied to different industries.

The Lazio region hosts an important airspace cluster with 250 companies, ten R&D institutions, five universities, four schools of engineering, twelve departments and about 3,000 among professors, researchers, and experts involved in research, experimentation, and design of airspace technologies. The district produces a turnover of about 5 Billion Euros employing about 30,000 personnel units. The airspace and security sector is characterised by the presence of large companies cooperating with large international groups, active on technology innovation in domains like: electronics, sensors, avionics, components and new materials, satellites and other space applications.

The life science area of specialisation is a complex domain characterised by the presence of high value-added businesses, with strong innovation potential, belonging to different but synergic industries such as: chemical, zoo-technics, pharma industry, agri-food, and environmental sciences. In the Lazio region, this sector is an area of excellence, especially for the pharma industry, with a turnover of about 8 Euro millions, and about 18,000 personnel units and 350 companies (including international, multinational companies, and high value-added SMEs).

Also, the specialisation area of cultural heritage is significant for the Lazio region since the region hosts a technological cluster for cultural heritage. The cluster, created in 2008, aims at strengthening the competitiveness capability and economic development of the regional economy. The cluster is an integrated value chain of all industries working in the domains of valorisation, preservation, and service delivery of cultural heritage and of the related technologies. Among all the Italian region, Lazio is the one possessing the largest share of the cultural heritage and attracts every year about 18,5 Millions of tourists. The area has a turnover of about 11,5 billion Euros and employs about 172,000 personnel units. The area crosses several industries concerning, diagnostics, conservation, restoration, valorisation, and management of cultural heritage. The area also encompasses the creative and digital industries – including ICT and audio-visual. Satellite activities to these industries employ about 120,000 personnel units.

Concerning the agri-food industry the Lazio region shows a highly differentiated landscape with both supply chains of national and international relevance (such as nuts and kiwi production), and by the presence of different forms of vegetable and flower growing. The specialisation area, besides playing a significant role in the regional production, shows a positive trend both in the level of specialisation achieved, and the quantities produced. The industry employs about 17,000 personnel units, with about 3,400 SMEs generating a year turnover of about 6 Euro billions. Despite the quality produced, the industry shows also some chronic difficulties: the reduced size of businesses and their limited capability to enter international markets.

The region declares three main sectors as focus industries for the application of circular economy:

- Manufacturing: which crosses the domains of pharmaceutics, food, and other transport equipment, and which in total employ about 65,000 personnel units in 4,030 companies (circa 85% of which active in the food production), with an annual turnover of 19 B Euros and a gross value added of 1,6 B Euros (though the figure is missing for transport and food production);
- Creative and digital industries: employing about 120,000 personnel units and producing a gross value added of 2,5 B Euros (no data available on turnover and number of companies);
- Cultural heritage and cultural technologies: employing about 170,000 personnel units and producing a gross value added of 11 B Euros (no data available on turnover and number of companies).

The region declared no data on the circularity potential of these sectors (volume of waste and level of recycling).

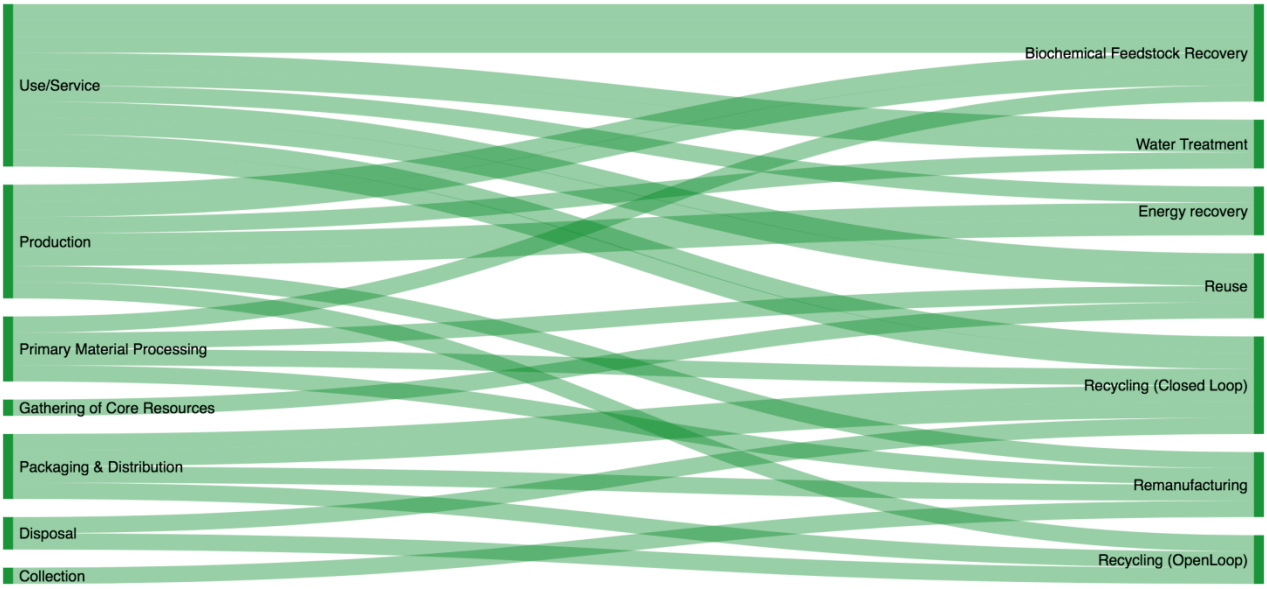
The Lazio region possesses several assets for the development of circular economy. The levels of public spending in R&D is high. The territory can exploit the knowledge assets of high-tech producers, of research infrastructures, and of several technological providers. The Lazio region foresees potential large benefits from the development of circular economy, both in terms of increased sustainability of the industry and of the society, and in terms of economic development, particularly in the agri-food, manufacturing, construction and advanced services industries.

However, the region needs also to contrast some negative tendencies which might jeopardise the achievement of potential benefits of circular economy: the progressive decline of private investments and the progressive decline and the excessive fragmentation of public resources. Both big companies and the financial industry are reported to show a low propensity of investment in circular economy applications, and to prefer more short-term project. The region reports also an insufficient level of cooperation among private companies and the public research institutions in the field of green technologies, and a limited attention of citizens on circular economy and on its consequences. Finally, the region reports difficulties in terms of coordination among the different laws targeting circular economy.

Regional capabilities and prospected innovation

The Lazio region possess several capabilities that can be exploited to foster the diffusion of circular economy. The companies listed by the Lazio region cover all the positions in the circular value chain with a greater focus on Use/Service and Production. They cover only parts of the application domain of circular economy activities (maintenance, refurbish, and repair application domains are absent) with a greater focus on biochemical feedstock recovery and recycling (closed loop). The companies offer different enabling technologies in the field of design, production, testing, and research on products and processes related to the focus sectors. They offer also raw-material and secondary-raw-material processing capabilities (especially on hydrometallurgical processes, cardboard packaging, and ceramic production), and on IT solutions supporting recycling and monitoring of natural resources.

Table 20. Position in the circular value chain (left) with application domain (right) of companies



Among the capabilities the region reports R&D projects aiming at different applications of sustainability. A set of projects deals with the use of bio-materials for the production of polymers, bio-polymers, and bio-fuels. Other projects are instead focused on waste processing, reuse of wastewater, energy savings, and exploitation of renewable energy.

The main R&D capabilities are expressed by three main universities, and inter-university consortium, and a research centre. The research areas are in the domains of: bio-chemistry, green and industrial chemistry, pharma industry, cosmeceutical industry, green energy, sustainability and environmental management, physics, earth science, industry 4.0. The University of Tuscia is specialised on research and innovation in agri-food.

The education capabilities cover all the three levels of education (bachelor, master and PhD). The courses available in the region are offered by eight different universities in the domains of: agri-food, agronomy and forestry, biology, chemistry, engineering, management, and sustainability. Most of the courses (14) are at the bachelor level enrolling about 2,900 students every year. In the level master courses there are about 700 students enrolled every year, and there is only one PhD program available in the region.

The prospected innovation in the region is described by eight emerging ideas targeting waste management, waste water management, energy, pharmaceutics, and specialised construction industry. The projects are all about recycling and reuse of polymers, rubber and plastics, aiming at reducing the impact of urban waste, and finding new ways of creating energy or improving the energy saving or energy efficiency of specific production processes.

Circularity potential

The innovation potential in the Lazio region is heterogeneous. The R&D capabilities, and the businesses active in the regional territory offer different opportunities for innovation. Currently most applications related to circular economy see the pivotal role of the agri-food industry which is feeding materials and resources to other industries (chemistry, pharma/cosmeceutical industry, energy production) in actual symbiosis. The innovation areas most frequently in action in the Lazio region are related to the water treatment, the use of biomasses, and the re-use and extraction of different nutrients and resources from urban and industrial wastes for the chemistry and cosmeceutical industry.
Among the emerging ideas, the region reports further innovation domains related to the reuse of exhausted car tyres, or further improvements to existing practices in water treatment, biomass production, recycling of agri-food waste.

The region reports difficulties at the regulation level. The coordination among the different regulation level for the implementation of policies to foster circular economy is reported to be potentially improved. The region is in first person committed to promote the green public procurement for the public administration.

Concerning the stimuli for circular economy, the region complements EU funding with its own funding. The region reports that, despite a significant level of R&D expenses, public funding is declining, and show increased fragmentation.

Concerning consumer behaviour, the region reports that there is a limited attention to circular economy and sustainability matter by the public.

Table 21 summarises the circularity potential of the Lazio region.

Table 21. Lazio: overview of the circularity potential

Area	Description
Available resources	No data available on waste produced by priority sectors From the outputs of companies, the following resources are available at the regional level: - Polymers - Bio-polymers - High value-added bio materials - Waste water - Waste from sanitaryware productions
Societal awareness	Limited attention of citizens on circular economy and on its consequences
Stimuli	No data available
Regulation	No data available

Area	Description
	The SWOT analysis reports difficulties of coordination among different laws targeting circular economy
Symbiosis	The region currently exploits connections among the following industries: - Agri-food and chemistry - Agri food and pharma/cosmeceutical - Agri-food and energy
Innovation potential	Recycle and reuse of polymers, rubber, and plastics

Crete

The table 23 summarises the data provided with the mapping tool by Crete for the local analysis.

Table 22. Crete: overview of collected data

Steps (mapping tool)	Overview of collected data
RIS 3 Strategic Areas (step 1.1)	Three areas of specialization: - Agro-alimentary - Culture and tourism - Environment
SWOT Analysis (step 1.2)	A general SWOT analysis referred to the strategic areas of specialisation but with no specific reference on any of the areas requested
Focus Sectors (step 2.1)	The Region presents a list 10 sectors in the regional economy with the following details in terms of data: - Employees in the region (2014) - Gross Value Added
Focus Sectors: Companies (step 2.2)	11 firms
Capabilities view (step 3)	A list of 31 projects out of which: - 12 funded by the EU - 3 funded by national sources - 4 shelf-funded - 2 funded by regional sources - 5 self-funded - 4 funded with other – unspecified - sources
R&D Capabilities (step 3.1)	5 departments of the Technological Educational Institute of Crete -TEIC and the Technical University of Crete
Innovation Capabilities (step 3.2)	The data are not consistent
Education Capabilities (step 3.3)	Four Master's level courses and two undergraduate level courses
Emerging Ideas (step 4)	Nine different emerging ideas (four on agri-food sector and five on culture and tourism)
Existing Circular Economy Legislation (step 5)	No data available
Existing Funding Instruments (step 6)	No data available

S3 and focus sectors

The smart specialisation strategy of the Crete region focuses on three areas: agro-alimentary, culture heritage and tourism, and environment.

In the Agro-alimentary area the region indicates two sub areas of specialisation. The first is about the improvement of the competitiveness of food and of agricultural products, including both animal and plants, within international markets. The sub area focuses on a set of applications aiming at innovating cultivation, food processing, and preservation of food, also through smart supply chains, and bio-practices. The second sub-area instead concerns the improvement of value chain cohesion and establishment of interconnections with other chains, specifically aiming at fostering the cooperation between farms and the manufacturing firms.

Within culture heritage, the smart specialisation strategy focuses on the diversification and promotion of tourism. From the point of view of diversification, the strategy focuses on diversifying the tourism product and to consolidate the brand and the name of the island. The objective is to promote an alternative form of tourism supported by more sustainable infrastructures, including transport. On the point of view or promotion instead the strategy aims at increasing the relevance of culture as a competitive element of the tourism product offered by the region.

Finally, from the environment area of specialisation the strategy pursues different domains and objectives related to increased sustainability of the economy. First, the strategy focuses at promoting energy savings through the improvement of materials and construction practices for reducing the amount of resources used by buildings for heating, cooling, and lighting, and by reducing the amount of water used and the waste produced.
Renewable energies are directly promoted through the development and implementation of technologies tailored to the morphological characteristics of the islands, and to the needs of its industry. The strategy also fosters research, development and implementation of new technologies for renewable energy, especially for those exploiting the sea for energy production. Finally, still within this area of specialisation, the region aims at rationalising the management of natural and environmental resources, by seeking innovative management systems for urban and industrial waste treatment.

Though being an island, the Crete regional economy has some important strengths. First of all the presence of internationally acclaimed educational and research potential, which is quite significant in relation to the size of the region, and which shows also the presence of centres of excellence. Second, the equal distribution of ICT resources and infrastructures (broadband network, digital data-centres). Third, the presence of a vital primary sector which is also open to international exports. Finally, the presence of cultural heritage and natural resources, together with a favourable climate condition throughout the year, which sustain a tourism industry, and which can boost the creation of new sustainable developmental activities.

At the same time the region faces the weaknesses of a limited innovative attitude by firms, also not stimulated by a low level of interaction between the industry and the university system. The lack of knowledge-intensive business is also combined with the lack of trained human resources on

technology-intensive and knowledge-intensive sectors, due to the development of different, low-skilled, industries (construction).

The region foresees as opportunity the set-up of national frameworks for the promotion of innovation along with the presence of pilot initiatives for stimulating innovation, as well as the allocation of funds from the European level at regional level. The economic trends currently see low skilled industries in decline with an increasing potential in knowledge-intensive industries. The current trends of tourism is also favouring the development of the sector.

Potential struggles related to the enduring economic turmoil in Greece, and the lack of stability in both the national and international economic environment, are seen as potential threats to the regional economy. At the same time, the region suffers the increased international competition on usual Cretan products, and the emergence of new – perceived by customers as alternative – tourism destinations.

The region declares several focus sectors in the areas of agriculture, and manufacturing. In total these sectors employ 321,323 personnel units, with a turnover of above 22 billion Euros[1].

Concerning the waste produced by the focus sector, the region provides data only on the agriculture sector which produces every year almost 3,6 Millions tons of waste. Only a few portions of these waste is recycled (about 240,000 tons a year). About 475,000 tons a year are incinerated, and about 280,000 tons a year are disposed in landfill.

The relationship between Human Resources in Science and Technology (HRST) in the EU regions reveals high levels of HRST, also characterised by a high degree of R & D intensity, and a high percentage of researchers. In contrast, in Crete (Greece), the share of HRST in the economically active population was low, despite a relatively high proportion of R & D researchers.

The SWOT analysis of the Region focuses on the potential of research and innovation linked to the availability of technological infrastructure and intellectual capital, being present robust research teams. A significant aspect is represented by the potential offered by agri-food, and above all by the potential offered by tourism, by natural and cultural resources that represent an important opportunity for the creation of sustainable practices.

The region is certainly affected by the small size, but above all by the economic uncertainty and its location, which can be read for example in the small size that can have an impact on the entrepreneurial level or in knowledge, with the loss of competitiveness in terms of innovation or of human resources

[1] Data reported in the mapping tool for the focus sectors in the Crete region are partial.

Regional capabilities and prospected innovation

The region reports several companies active on circular economy which possess capabilities mainly related to food processing, transformation, and reuse of nutrients and resources. Among these companies, some possess the capabilities of producing bio-fuel from food and agriculture waste. One company possesses capabilities related to the ICT and electronic industry with the design of printed computer boards.

Concerning the regional capabilities, on the education side the region shows two universities, the Technical University of Crete and Technological Educational Institute of Crete (TEIC), that provide courses at both the bachelor and master level pertinent to circular economy, employing about 270 researchers.
In particular the Technological Educational Institute of Crete offers a focus on agriculture with the domain of waste water and solid, waste management and environment and safety in Economy and Administration where the related department of business administration is focused on Plan for circular economy in consumer and business adoption, and on tourism. The Engineering department and diet and dietetics are focused, respectively, on management of natural resources, materials and environment pollution (and de-pollution), and food quality.
The Technical University of Crete, with its departments, offers training focused on mineral resources, the environment and information technology. The departments focus on the use of row materials in a sustainable approach, in waste management and on opportunities to use sustainable / renewable energy. About 400 students each year enrol in the courses offered by these universities.

A low number of spin-off or start-up companies, also highlighted within SWOT Analysis, shows a limited availability of seed financing for business and venture capital or knowledge intensive business at Regional level.

The regional R&D capabilities are in the areas of: mineral resources engineering, environmental engineering, electronics, informatics, and computer science engineering, business administration, agriculture and natural resources management. These capabilities focus on the domain of waste management, business administration and management, and computer science. The capabilities deliver enabling technologies in the areas of reuse of resources, including energy, from agricultural waste; improvement of food processing and food packaging; improvement of materials, and sustainability of resources use; and internet platforms for supporting tourism in the region.

The region declares a highly diversified innovation capability testified by the presence of several project-based initiatives funded mainly by the European Union, but also self-funded by internal resources. The project initiatives are mainly targeted to six large domains. A great area of innovation capability concerns the extraction of the value potential out of waste from the transformation of the agricultural sector, specifically potentialities referable to the application of

the circular economy concern the exploitation of waste of the olive oil production. Such value potential extractions concern on one side, the use of waste as biomass, or as bio-fuel for the production of renewable energy, biogas, or for the heating needs of public buildings. On the other, side the value potential is in the form of reusing waste of the olive oil production process in the form of animal feed.

A second area of innovation capability concerns the use of residuals and waste of food processing and transformation for the production of animal feed, both from olive oil industry waste, hotel food waste, and juice production waste.

The reuse of water, the treatment of waste water, and the management of water resources, also aiming at preventing marine pollution, are a further are of innovation capability described by the projects reported by the region. Related to water management, waste management, and integrated waste management – including also waste from municipal activities – are innovation areas targeted by projects.

The region also promoted project initiatives related to the increased safety and sustainability in the olive oil industry – through the avoidance of chemicals in fighting olive parasites – and to the education on resources efficiency.

Circularity potential

The Region has a potential for circular economy in the agri-food industry thanks to the strong focus on R&D and the many projects carried out by firms. The data reported for the innovation capabilities show the importance of the EU funds as stimuli for the development of circular economy. At the same time, some projects are declared to be self-funded, so financial stimuli also originate at the regional level.

The data provided show an important focus on the possibility of intervening on the recovery or valorisation of the substances contained in wine and oil, in the citrus peel and in the management of wastewater.

These areas activate a series of potentials for waste management which concern the production of compost (in the case of oil or wine), until the production of bio-fuels or fertilizers in the case of olive oil.

Wastewater management is an important resource to activate circular economy processes, both for oil processing residues, from which active substances can be extracted, and in water treatments, in particular sewerage or treatments for potable water.

The use of tomatoes for the production of puree or the use of citrus peel for making molasse or essential oil.

The region possesses a strong innovation capability in natural resources reuse and recycle, that can facilitate the activation of symbiosis between the food transformation industry, the tourism industry, and the agriculture were waste of food transformation processes or waste of hotels are reused to process feed for animal breeding.

Within the circularity potential the Crete region indicated one project aimed at stimulating education on resource efficiency. The education capabilities are not only targeted to technical profiles, but also to managerial profiles related to sustainability and circular economy. According to this point of view, the region seems to make a formal attempt to raise a sustainability culture across its population which may support the development of circular economy.

Table 23. Crete: circularity potential

Area	Description
Available resources	Waste from agriculture sector, water treatment or sewage In particular some potential resources from agricultural output, listed by companies are: - Organic fertilizer (by Manure) - grape waste - Waste from olive processing: - Citrus peel - Tomatos puree
Societal awareness	Presence of international education and research centre, innovation initiatives. Infrastructure to foster innovation, (broadband networks and digital data centres). Crucial potential derived from agriculture
Stimuli	Several funding sources under EU funding, National or regional funding,
Regulation	No regulation framework to foster circular economy legislation. Avoidance of chemicals in fighting olive plants parasites legislation attentive to the use of chemicals in fighting olive plants parasites.
Symbiosis	The region currently exploits different connections among existing industries: Agri-food and energy (fuel production) Cheese Mineral resources
Innovation potential	Waste management Waste treatment (water or sewerage) Agriculture or breeding waste

Lodzkie

Table 24 provides an overview of the data collected with the mapping tool for the Lodzkie region.

Table 24. Lodzkie: overview of collected data

Steps (mapping tool)	Overview of collected data
RIS 3 Strategic Areas (step 1.1)	Two areas of specialisation: - Innovative agriculture and agri-food industry - Energy Further areas are mentioned in relation to the development strategy of the Lodzkie Region 2020: - Biotechnology - Mechatronics - Nanotechnology and functional materials - Communication and information technology
SWOT Analysis (step 1.2)	No data available
Focus Sectors (step 2.1)	The region declares the following focus sectors: - Manufacture of: textiles, chemicals and chemical products, food, electrical equipment, basic pharmaceutical products and pharmaceutical preparations - Mining of coal and lignite - Electricity, gas, steam and air conditioning supply - Computer programming, consultancy and related activities - The region provided no economic data (number of employees, turnover, gross value added and number of companies) and circularity potential (volume of waste and share of recycle)
Focus Sectors: Companies (step 2.2)	Five companies
Capabilities view (step 3)	No data available
R&D Capabilities (step 3.1)	One university with seven departments enrolling 88 researchers
Innovation Capabilities (step 3.2)	No data available
Education Capabilities (step 3.3)	One university offering courses at all levels (bachelor, master's, PhD, and other types of courses) in different branches of engineering (safety, chemical and biochemical, and environmental)
Emerging Ideas (step 4)	No data available

Steps (mapping tool)	Overview of collected data
Existing Circular Economy Legislation (step 5)	No data available
Existing Funding Instruments (step 6)	No data available

S3 and focus sectors

The Lodzkie region has six specialisation areas in her smart specialisation strategy. Out of them, the region indicated two as priority areas for the development of circular economy: agriculture and energy. Concerning agriculture, the region sees the possibility of applying the existing capabilities to the following target sectors:

- Agriculture;
- Forestry and fishing;
- Agricultural services and identified markets of manufacturing & industry;
- Biotechnology;
- Intelligent, inter-modal, and sustainable urban areas.

Concerning instead the energy specialisation area the region identifies potential target applications in the field of energy production and distribution, energy generation from renewable sources, and sustainable and renewable energy sources.

The region also cites the development strategy for 2020 in which they identify the following priority areas for the application of circular economy: biotechnology, mechatronics, nanotechnology, functional materials, and communication and ICT. The region considers these areas of application as supportive for the development of circular economy in the specialisation areas identified in the S3.

The region indicates four macro sectors as priority for the development of circular economy:

- Manufacture of: textiles, chemicals and chemical products, food, electrical equipment, basic pharmaceutical products and pharmaceutical preparations;
- Mining of coal and lignite;
- Electricity, gas, steam and air conditioning supply;
- Computer programming, consultancy and related activities.

The region provides no economic and circularity potential data but references a EU source about the labour market that identifies these sectors as the most relevant ones for the regional economy.

Regional capabilities and prospected innovation

The region did not provide data on regional capabilities in terms of pilot plants, existing research projects, and emerging ideas are not provided.

The region lists five companies as relevant ones for circular economy. These companies work in the use/service, collection, and disposal position of the circular value chain, and cover the application domains of reuse, recycling (both open and closed loop), and energy recovery. Though not punctually specified, these companies are generally reported to possess capabilities related to the improvement of energy efficiency of facilities, to the production of energy from renewable resources, and to the improvement of recycle and reuse.

The R&D capabilities displayed by the region all belongs to the Lodz University of Technology which has several different departments employing about 90 researchers. The R&D capabilities target different enabling technologies:

- Chemistry;
- Thermodynamics and heat exchange;
- Process modelling, simulation, control, and optimization;
- Computer aided engineering;
- Bioengineering;
- Environmental engineering;
- Production engineering;
- Process safety;
- Renewable energy and energy efficiency.

The same university offers nine courses relevant to circular economy. Five of these courses are at the bachelor level and cover the branches of biochemical, chemical, and environmental engineering. One course is at master level and covers the branch of environmental engineering. One PhD course covers the branch of chemical engineering in environmental protection. Finally, the university offers two further courses classified as “other” per the level of academic degree. These courses are on process safety and engineering, and on chemical engineering (which is prospected). The courses enrol about 670 students every year.

Both R&D and educational capabilities within the region have a strong focus on engineering.

Circularity potential

With data on capabilities and research projects missing, the description of the circularity potential of the Lodzkie region is only limited to the information available. Given the data available the

possibility of inferring information (e.g. identify new resources or potential sectors for symbiosis) is equally limited for the region.

From the smart specialisation strategy, and from the data provided considering companies with capabilities on circular economy, the region has potential for the recovery of energy from waste, and for the reduction of energy used by facilities.

Concerning regulation, the Lodzkie region reports several sources, both at the regional and at the national level. At the regional level the region promoted an environmental plan in 2016. At the national level, Poland adopted a national waste management plan in 2016 following a previous waste act in 2012. The region foresees an incoming regulation on methods for selective collection of waste fractions. However, there are no considerations on the potential effectiveness or shortcomings of this regulation.

Table 25. Lodzkie: overview of the circularity potential

Area	Description
Available resources	No data specifically available According to the specified focus sectors waste of mining, manufacturing (textile, chemicals, food, electrical equipment, and pharmaceutical products) could be available in the region
Societal awareness	No data available
Stimuli	No data available
Regulation	Environmental program for the Lodzkie region 2017 – 2020 with perspective 2024 National management waste plan Waste act Prospected regulation on detailed methods of selective collection of waste Prospected transformation map in the direction of circular economy
Symbiosis	Production of energy from waste
Innovation potential	No data available

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