



Interreg



EUROPEAN UNION

Danube Transnational Programme
MOVECO

Transnational Report on R&D Activities in the Field of Circular Economy

MOVECO PROJECT

**Mobilising Institutional Learning for Better
Exploitation of Research and Innovation for the
Circular Economy**

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1. Introduction

The EU Action plan for the circular economy recognises innovation as a key facilitator for transition from linear to circular design, production, consumption and transformation of waste to high value added products, which will require new technologies, processes, services and business models, which will shape the future of our economy and society. Together with innovation, research will need to contribute to the required transition supporting the competitiveness and modernisation of the EU industry. The Horizon 2020 Work Programme for 2016-2017 included a major initiative on Industry 2020 in the circular economy, providing funding of over €650 million. This is complemented by the implementation of the Ecoinnovation Action Plan. Funding is also available under the Cohesion Policy, supporting Smart Specialisation Strategies, while additional support for the transition to a circular economy is also planned through LIFE and COSME programmes. It is important that R&D organisations within the DTP are aware of these opportunities and are prepared and capable of tapping them and supporting the economic stakeholder in the region to make the transition. The objective of this overview prepared by the MOVECO partnership is to recognise such R&D organisations within the region and link their activities with the requirements of economic stakeholders faced with new challenges and opportunities presented through the transition towards a circular economy.

2. Research problem statement

2.1 General need for the circular economy transition

In the closed system called planet Earth, it is the time to forget the notion of endless resources as well as limitless pollution capacity of our planet. Our current society measures progress with a unit of GDP and it is known that the resource usage goes almost in parallel with the rise of GDP. In details- for every 1% of GDP increase, 0,4% of increase of resource consumption was recorded. Still, this closed system is slowly coming to a depletion point. Prices are continuing to be volatile, commodities are becoming more expensive (UNEP¹, 2011), fossil fuels are constantly degrading in quality and in quantity (UNEP², 2011), we have either passed or about to pass major oil and coal peaks (Michaux³, 2016). That means we are to decrease our major power providers for progress. We are clearly using our resources unsustainably and we need new solutions; all from energy provision and consumption to substitution and/or decreased usage of (other) resources. CE is a promising model to mitigate these challenges. It may happen with a partial decoupling (decoupling resource usage from the societal prosperity) eventually total decoupling (environmental negative effects and resource usage from the prosperity (Ellen MacArthur Foundation⁴, 2012; UNEP⁵, 2011)).

- Global demand for food is expect to grow by about 70% between 2005 and 2050.
- The US Geological Survey estimates that 80 years of phosphorus reserves remain.
- Only 2% of plastics in the world go back to the original quality.
- Europe currently loses around 600 million tons of waste materials, which could potentially be recycled or reused.

¹ UNEP. (2011). *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth*.

² UNEP. (2011). *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth*.

³ Michaux, S. (2016, 03 02). *THE IMPLICATIONS OF PEAK ENERGY*. Retrieved 04 05, 2017, from circulatenews.org: <http://circulatenews.org/2016/03/implications-of-peak-energy/>

⁴ Ellen MacArthur Foundation. (2012). *Towards the Circular Economy Vol. 1: an economic and business rationale for an accelerated transition*.

⁵ UNEP. (2011). *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth*.

- Total demand for limited resource stocks (biomass, fossil energy, and many metals) is expected to reach 400 percent overuse of Earth's total capacity by 2050.
- 70% of fish we catch, we don't eat.
- At the current rate of production, the global oil reserves is predicted to last for 46,2 years, coal for 188 more years, Natural gas - for 55 more years.
- OECD, air pollution will cause 6 million to 9 million premature deaths annually and cost 1 percent of global GDP by 2060.
- According to the Global Opportunity Report 2016, 32% of CEOs surveyed were familiar with the SDGs, and 23% were planning a response. But awareness further down the management chain was minimal, with only 5% of mid-level managers aware of plans for a company to act on the Goals.

A circular economy is coherent with natural processes, which flow in closed loops and nothing is wasted. Humans are the only beings on the planet, which produce waste and this has intensified with the expansion of the industrial revolution and exasperated with the linear take – make – throw away economic model encouraged by modern consumerism.

Today, only around 40% of the waste produced by EU households is recycled. **This average masks wide variation between Member States and region, with rates as high as 80% in some areas and lower than 5% in others.** A number of sectors face specific challenges in the context of the circular economy, because of the specificities of the products or value chains, their environmental footprint and dependency on material from outside Europe.

Increasing plastic recycling is essential for the transition to a circular economy. The use of plastics in the EU has grown steadily, but less than 25% of the collected plastic waste is recycled and about 50% goes to landfill. Large quantities of plastics end up in oceans.

The EU has prepared a list of critical raw materials which are of high economic importance to the EU and vulnerable to supply disruption. In certain cases, their extraction also causes significant environmental impacts. They are often present in electronic devices. The current very low rate of recycling of these materials means significant environmental opportunities are lost. Increasing the recovery of critical

raw materials is one of the challenges that must be addressed in the move to a more circular economy. The EU action plan recognises that it is essential to improve the recyclability of electronic devices through product design. The Commission is encouraging Member State to promote recycling of critical raw materials in its revised proposals on waste.

2.2 EU Circular economy plan

EU's action plan for a circular economy aspires for a sustainable, low carbon and competitive economy, which is resource efficient. The action plan determines measures to influence production, consumption and waste management and the secondary resource market.

The circular economy is oriented towards reuse, repair and recycling of existing materials and products. It is founded on energy from renewable sources, phase out of hazardous substances, resource efficiency and eco-design to retain economic added value as long as possible. Specifications will be formed within the eco-design directive. The Eco-design Directive (2009/125/EC) implemented through product-specific design regulations, directly applicable in all EU countries together with extended producer responsibility encourages repair, upgradability, technical longevity and recyclability.

EU reference documents on best available techniques (BREF) are designated as measures to improve industrial production processes. Currently, significantly enhanced environmental objectives are being discussed in the EU parliament and council with regard to proposed changes of the waste framework directive (2008/98/ES). These changes could imply stricter demands for industrial wastes with BREF documents as a temporary solution for achieving circular economy targets.

To encourage innovative industrial processes and industrial networking, where production residues (either wastes or by-products) originating in one industrial sector, become a resource for other sectors (industrial symbiosis). The action plan has announced guidance on by-product rules.

Plastics and critical resources, such as rare earth and other precious metals as well as phosphorus are identified priority areas. Special attention is attributed towards

innovation, investment and other horizontal measures and indicators, which will measure progress in these areas.

New legislative waste proposals are included in the circular economy action plan, announced by the EU commission in December 2015. Discussions concerning the proposed changes to the waste directives imply a tendency to enforce stricter measures and a more focused orientation towards closing loops of material flows.

The transition to a circular economy is a systemic change, which affects each phase of the value chain and key sectors.

European Union had published a Circular economy package under which number of documents including the CE action plan for Europe (europa.eu⁶, 2017), revised waste management goals (europa.eu⁷, 2017), the Eco-Innovation Action Plan (europa.eu⁸, 2017) a proposal for a new eco-design working plan (europa.eu⁹, 2016), etc. are shaping the future roadmap towards cleaner European market and more efficient economy. Finances had been started to shift from end-of-pipe to beginning-of-pipe solutions. The goal is to switch economic activities en route for preservation of natural resources and energy independency.

Following this move, member states such as Scotland, the Netherlands, Germany, etc. had brought strategies for the development of the Circular Economy (CE). That makes us conclude that Europe had entered the transition and had started with preparation of its grounds for CE to be widely accepted in everyday life.

Worth mentioning is one conclusion repeated in almost all national strategies as well as in reports by independent research bodies. Countries that are resource export oriented will have a major industrial overhaul burden since EU is planning to cut imports of natural resources by 20% by 2030 (The Government of the Netherlands, 2016), it plans to improve efficiency on food distribution as well as

⁶ europa.eu. (2017). *Circular Economy Strategy*. Retrieved 04 08, 2017, from http://ec.europa.eu/environment/circular-economy/index_en.htm

⁷ europa.eu 2. (2017). Retrieved 04 06, 2017, from Waste policy review: http://ec.europa.eu/environment/waste/target_review.htm

⁸ europa.eu 3. (2017). Retrieved 04 06, 2017, from Eco-Innovation Action Plan: http://ec.europa.eu/environment/ecoap/_en

⁹ europa.eu 4. (2016, 11 30). Retrieved 04 10, 2017, from Communication from the Commission - Ecodesign Working Plan 2016-2019: <http://ec.europa.eu/DocsRoom/documents/20375>

lower imports of high impact foods (e.g. meat). Finally, it plans to reduce its dependency on energy imports.

EU countries (primarily the eastern member states) are recognized to have difficulties in this transition if not prepared for the shift (The Government of the Netherlands, 2016).

The importance of CE implementation is evident. That is why rising question is what the current situation in partners' countries concerning circular economy, on which we could build on strategically is. In other words we could derive two main questions for this research:

1. What is the main institutional framework for the circular economy development?
2. What are the main research and development activities that could serve as enablers for the circular economy transition?

These following pages will present the necessary institutional support through a brief description of key strategic national documents as well as through a short insight in the most important institutions conducting research activities regarding circular economy.

3. Methodological approach

3.1 Description of the developed questionnaire for the mapping of the strategic documents and online form for the R&D mapping

A draft questionnaire was prepared by CCIS and SUA and sent to all the partners so they could provide their suggestions and input. The initial draft was based on the topics covered in the so-called butterfly diagram presenting the main material loops of the circular economy. The final questionnaire requires the following information:

Questionnaire:

This data is collected in the framework of the Interreg Danube project MOVECO. The purpose is to provide information to the business sectors on the expertise available for the transition to the Circular Economy. Thank you for your support.

Country:

Name of the organisation:

Type of organization:

- University / Faculty
- Research centre
- R&D Institute
- R&D company
- Other:

Location (Address):

Number of researchers employed:

Website (to description of the organisation):

Contact:

What are your organisation's main areas of R&D expertise (max. 5 choices – Please provide relevant projects for the selected areas of expertise in the following section)

- Supporting durability and maintenance
- Supporting multi-functionality / multifunctional use of waste/resources
- Supporting repair
- Supporting recyclability
- Supporting remanufacturing
- Increase reuse
- Innovation in packaging
- Innovative material and component recycling
- Electrical and electronic equipment waste treatment
- Eco-design
- Promoting new business models
- Digitalisation for Circular Economy
- Consumer behavior / prosumer behavior
- Other:

Materials you specialise in:

- Paper / cellulose
- Glass
- Metal
- Polymers / Bio-Polymers
- Wood
- Construction materials
- Combined materials
- Other: _____

Please give an estimate of your organisations private funding from industry (contracted R&D services)

- 0 - 25%
- 25% - 50%
- More than 50%

Provide R&D reference projects of your organisation!

Name of the project:

Project duration (year – year):

Keywords (max. 5):

- Collection
- Share
- Maintain
- Prolong
- Reuse
- Redistribute
- Refurbish
- Remanufacture
- Recycle
- Optimize
- Change use patterns
- Location tracking
- Condition assessment
- Asset valuation
- Predictive analysis

Your role in the project:

- Lead partner
- Key R&D partner
- Partner

Website:

Keywords:

- Collection
- Share
- Maintain
- Prolong
- Reuse
- Redistribute
- Refurbish
- Remanufacture

- Recycle
- Optimize
- Change use patterns
- Location tracking
- Condition assessment
- Asset valuation
- Predictive analysis

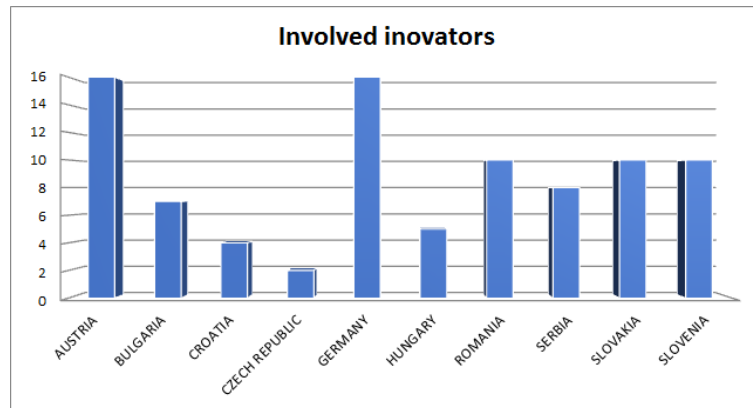
3.2 Methodological approach in partners' countries:

A desk research was performed to identify the national and regional strategic documents, focusing on environmental topics, especially circular economy, waste management and R&D/innovation. Additionally, partners interviewed stakeholders relevant for their national situation. Based on the research and received information they selected the main strategic documents at national and regional level.

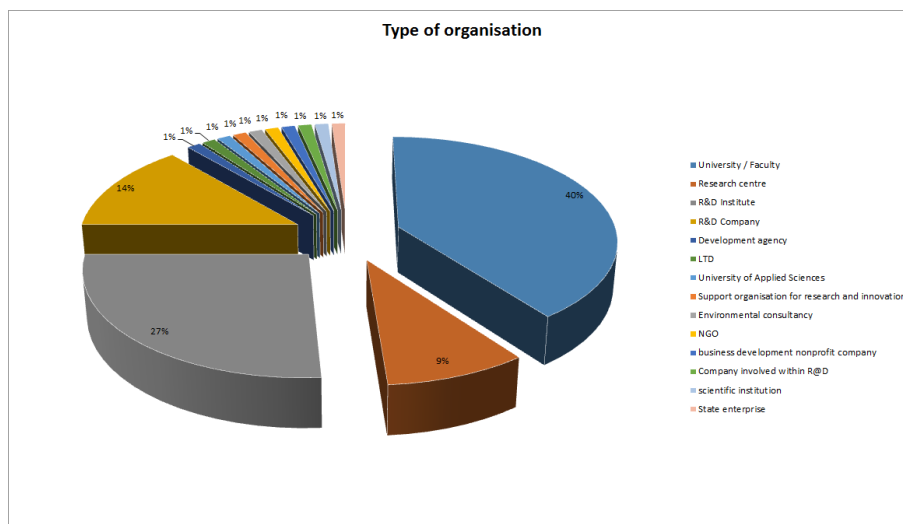
The same method was used to identify R&D organizations and their research projects relevant for the circular economy. The identification included an online research (with searching for keywords such as "Circular Economy", "waste management" and "recycling materials").

The partners' teams also addressed the key institutions dealing with the circular economy - e.g. the Ministries, the Technology Agencies, the Institutes of Circular Economy etc. - to provide information on the main R&D actors, projects and best R&D practices available in the country. The representatives of identified organizations were then approached by email and phone communication to describe the past and current research activities and fill up the questionnaire.

Partners also used different databases, like a Database of the National Research, Development and Innovation Office, Intellectual Property Offices. They survey web sites of the successful projects of funding programmes with national and European co-fundings. Also key note speakers and participants of sectoral conferences and workshops helped to identify potential R&D players.



Graf 1: Number of received feedbacks from innovators/stakeholders



Graf 2: Types of organisations involved in the research

4. Descriptive report

4.1 Global and EU documents

As a basic document can be considered **Agenda 2030**, presented at the UN summit on sustainable development on 25. September 2015, representing a historical agreement achieved by the international community to abolish poverty, minimize inequality, ensure advancement and protect the environment for current and future generations. Agenda 2030 links the three pillars of sustainable development, economic, social and environmental in a balanced manner, intertwining them through the 17 objectives for sustainable development, which must be fulfilled by 2030.

In the **7th Environmental action programme**, the EU has made a commitment to strengthen its attempts to protect EU's natural capital, encourage low carbon growth with efficient use of resources and innovation and protect the human health and wellbeing, while respecting the natural limits of our planet. Special emphasis amongst the priority objectives is attributed towards transforming waste to resources with better prevention, reuses and recycling, abandoning wasteful and harmful practices, such as landfill. The long-term programme vision follows the idea *"To live well, within the environmental limits of our planet by 2050"*. Our wellbeing and healthy environment are based on an innovative, circular economy, where nothing is discarded and natural resources are managed sustainably, biotic diversity is protected, valued and restored in a manner making our society more resilient. Low carbon growth, where growth no longer coincides with use of resources and fosters a safe and sustainable global society.

4.2 Strategies on CE implementation

Following paragraphs present main findings from national reports focusing on the national Circular Economy strategies. More detailed description and information can be found in the national R&D mapping reports and EPR study reports.

Austria

Central pillar of the Austrian CE strategy is the **Austrian Waste Management Act (AWG 2002)** accompanied by the actual version of the Federal Waste Management Plan (2011, draft 2017 already issued). Further there are a large number of options for the legislature to promote the development in the sense of a circulatory economy. This includes, for example, the integration of cycle business models into production lines for innovation and start-ups, the creation of competence and support centers for companies that want to implement cycle business models or the promotion of science and research in the field of design in the field of design Sense of the circulatory economy. In Austria, besides legislation there have been and are several support channels at national level, which have fostered the development of circular economy projects.

Actual planned activities and plans in discussion:

- Integration of cycle business models in conveyor rails for innovation and start-ups.
- Promotion of pilot and lighthouse projects.
- Creation of competence and support centers for companies that want to implement cycle business models.
- Development of criteria catalogs under which conditions a switch to cycle business models is profitable.
- Preferences of services in public contracts.
- Promotion of remanufacturing models by means of take-back commitments or the demand of the expanded producer responsibility.
- Integration of the circulating capacity of product components into the customs and tax system.
- Promotion of science and research in the area of design in the sense of the cycle economy.

Bulgaria

The main documents and plans related to introduce more Circular oriented economy are **National Plan for Waste Management 2014-2020**, **National Development Programme: Bulgaria 2020** and **Innovative Strategy for Smart Specialization 2014-2020**.

Also the following **Operational Programmes (OP)** are considered as one of the instruments for achieving of more circular oriented economy - **OP Innovation and Competitiveness 2014-2020** and **OP Environment 2014-2020**.

Croatia

In Croatia the following national documents and they key objectives are most relevant for the Circular Economy:

- **Strategy for sustainable development of the Republic of Croatia** focusing on Stable economic growth; Equal allocation of social opportunities and Environmental protection.
- **The decision for adoption of the Waste Management Plan of the Republic of Croatia for the period 2017 – 2022** focusing on current state and trends of the waste management in Croatia (origin, structure, categories); goals, measures and priorities for improving waste management system and at last, but not least funding project implementation.
- **Selected environment and nature indicators in Croatia, 2016** covers components of the environment, sector load and integrated and general issues of environmental protection and nature.
- **Methodology for determining composition and quantity of municipal and mixed municipal waste** ocusing on the following:
 - o Factors affecting the average composition and quantity of municipal waste in the Republic of Croatia;
 - o Analysis of the applicability and suitability of the proposed methodology for determining the composition of municipal waste and municipal mixed waste;
 - o The determined composition of mixed municipal waste and municipal waste in the Republic of Croatia;
 - o The methodology for determining the composition of municipal waste or mixed municipal waste;
 - o Method to determine the biodegradable components in certain types of waste;
 - o Proposed methodology of physical - chemical properties and biodegradability of the waste.

Czech Republic

Currently, the Czech Republic has no independent strategy at the national level at its disposal, which would completely cover the circular economy problematic. However, several strategies, plans, and policies do exist, which, through their content, objectives and measures largely address and support the introduction of circular economy.

The identified strategy adopted by the Czech government:

- **Czech Republic 2030** - a strategic framework sets forth long-term priorities of the development of the CR helping to improve life quality both for the current and next generations.
- **The State Environmental Policy of the Czech Republic 2012-2020** - the strategic and implementation part of the policy includes four goals: Safe Environment, Climate Protection, Nature and Land Protection, and Protection and Sustainable Use of Resources.
- **The Waste Management Plan of the Czech Republic for the period 2015-2024** - the document sets goals for waste management and measures for achieving those goals.
- **Czech Republic's Waste Prevention Program for the period 2014-2020** - it is relating not only to the waste management sector, but also to the extraction and processing industries, design, services, and education.
- **National Research, Development and Innovation Policy of the Czech Republic 2016-2020**, which identifies the key areas and research themes that applied research should focus on.

Hungary

- **National Environmental Protection Programme of Hungary** - identifies three strategic objectives i) Improving the environmental conditions of quality of life and health for the human, ii) Protection and sustainable use of natural values and resources and iii) Improving resource economy and efficiency, greening the economy.
- **Hungary's First National Environmental Technology Innovation Strategy** - presents support of investments in energy efficiency and renewable energy and environmental friendly technologies.

- **National Waste Management Plan** - overall objectives of the document are
 - i) Increase the reuse/recycling rates;
 - ii) Reducing the created waste;
 - iii) Establishing and developing the system of selective collection;
 - iv) Separation, repair and reuse of reusable components of waste.

Circular Economy strategy implemented on the Regional/local level in Hungary does not exist.

Germany

Four strategic documents have been identified as very important regarding the implementation of CE on national level.

The **German Resource Efficiency Programme II** recognises the global responsibility as a key focus of the German resource policy. The main objective of the document is to combine ecological necessities with economic opportunities, innovation support and social responsibility.

The study **Germany on the Road to a Circular Economy** emphasises that CE means more than improved waste management. The document presents the concept of CE, its benefits and limits, as well as the institutional system and its actors. Moreover, it highlights the progress of the German waste management towards a CE including the 'inner cycles' (reuse, repair and extending service life) and related obstacles.

The key objectives of the **Resource Management and Municipal Waste Management** are to identify shortcomings of German municipal waste management and setting ecological goals of sustainable waste management in the context with economic opportunities and risks as well as social aspects. Further it aims at promoting harmonised solutions for resource and waste management at EU level.

The **German Sustainable Development Strategy 2016** formulates goals on sustainable development between 2018 and 2030. This includes e.g. ending poverty and hunger, protecting and restoring ecosystems, conserving our oceans and promoting sustainable economic growth. The document refers to the Sustainable Development Goals (SDG) and its corresponding sub goals of the United Nations, namely responsible consumption and production, reduction of

waste, sustainability in public procurement and sustainability reporting of multi-national companies.

Montenegro

In Montenegro are actually no national or regional/local strategies implemented or being drafted on Circular Economy. Some documents that could enable further development of circular economy strategic documents are listed below.

While **Law on Waste management (2011)** is decently developed in order to provide principal boundaries within waste management system, **National plan on WM** builds on with properly set proposals, which are based on geographical, social and economic analysis of the country and suggests modern technologies and emphasizes the importance of the primary selection, while recognizing major gaps in infrastructure and public awareness regarding proper waste management.

Even if the **State Working Plan on Waste Management 2015-2020** does mention circular economy as a preferable direction of future development, it fails to suggest solutions for it.

The **Law on Innovation activities (2016)** regulates organization, conditions and modes of financing for innovation activities (IA) in Montenegro in a way that funding and financing become the main pillar of a dynamic environment developed for the research and development. The goal of innovation activities is to create conditions to modernize industry based on knowledge and innovation so it could be better integrated on international market.

National Strategy for Sustainable Development (2016) recognizes the importance of circular economy, but it puts it under the context of Waste management in definition of the Strategic Goal **4.4: Improve waste management towards circular economy**¹⁰. When it comes to the strategic framework in innovation and research and development, the strategy does emphasize innovation as a future option for industry and business, and underlines the importance of future, as well as the current gap of connection between research, development

¹⁰

<http://www.mrt.gov.me/ResourceManager/FileDownload.aspx?rid=272986&rType=2&file=NSOR%20do%202030%20FINALNA.pdf>

and innovation systems on one side, and business and its needs on the other. However, the strategy does not mention circular economy as a possible direction for future innovative activities, and it fails to mention eco-innovation.

Romania

The **National Competitiveness Strategy 2014-2020** is considered as a main document related to the Cohesion Policy for smart specialisation strategies in Romania. The Key objective of the NCS is to integrate identified challenges into a coherent, medium-term, and supportive vision.

National Strategy for Research, development and Innovation aims at activating public sector demand for innovation. In relation to the CE, document covers topics such as i) preserving the environment is a priority for all; ii) current policies under the massive investments to be made in, iii) depollution and recycling techniques in resource management water and a wetlands; iv) the "smart city" concept provides infrastructure solutions and integrate them for the needs of the population in urban agglomerations.

National Waste Management Strategy 2014-2020 covers objectives related to the waste management efforts in line with the waste hierarchy and encouraging prevention of waste generation and re-use for greater resource efficiency, developing and expanding separate waste collection systems to promote a high quality recycling and development/implementation of recycling technologies and use of raw material from waste. Support for energy recovery from waste, where appropriate, for non-recyclable waste and reduce the amount of waste disposed of by storage are part of the document as well.

The main goal of the National Waste Management Plan and a National Waste Prevention Plan is to develop a general framework conducive to waste management at national level with minimal negative environmental impacts.

Serbia

Even if in Serbia are no directed policy instruments towards the circular economy, an operational integrated system for waste management, packaging waste, pollutants and chemicals as well as for the energy use has been set up. Laws are

constantly being amended with bylaws for the reason of approximation with the newest EU sets of laws and regulations. Important to mention are also following strategies:

- **National Sustainable Development Strategy 2008 - 2017** - the objective is to establish a balance of three key factors of sustainable development: sustainable economic growth and economic and technological progress, sustainable social development as well as environmental protection accompanied with reasonable use of natural resources supported by an adequate institutional framework.
- **Waste Management Strategy 2010-2019** - The targets are related to the recycling of municipal waste, diversion of biodegradable waste from landfills and recycling of packaging waste (paper, PET, glass, metal and wood) as well as disposal of waste on compliant landfills.
- Major objectives of the **Industrial Development Policy and Strategy** are to boost economic activity, employment, competitiveness, export, and balanced regional development. The strategy aims to develop three sectors - automobile and components industry, electronics and information technology, while emphasizing the attraction of direct investments as a crucial development factor.
- **National strategy for sustainable use of natural resources and Goods** defines three key objectives – i) defining direction of efficient resource usage, ii) reduction of negative effects of resource use on the economy and the environment and iii) contribution to the sustainable production and consumption as well as greening the public procurement processes.

Slovakia

On the National level are in Slovakia implemented following strategic documents:

- **Waste management program of the SR for period 2016-2020** – focusing on the minimalisation of the negative effects of the generation and management of waste on human health and the environment. The document also enhances enforcement and compliance with a binding waste management hierarchy with the purpose of increase of waste recycling.

- Environmental policy strategy of the SR to 2030 identifies major environmental problems and sets direction of future measures.
- SR's Waste Prevention Program for the years 2014-2018 does not set specific targets for waste prevention. However, some of the measures are aimed at minimizing the impact of waste on human health and the environment and on reducing the landfill of biodegradable waste.

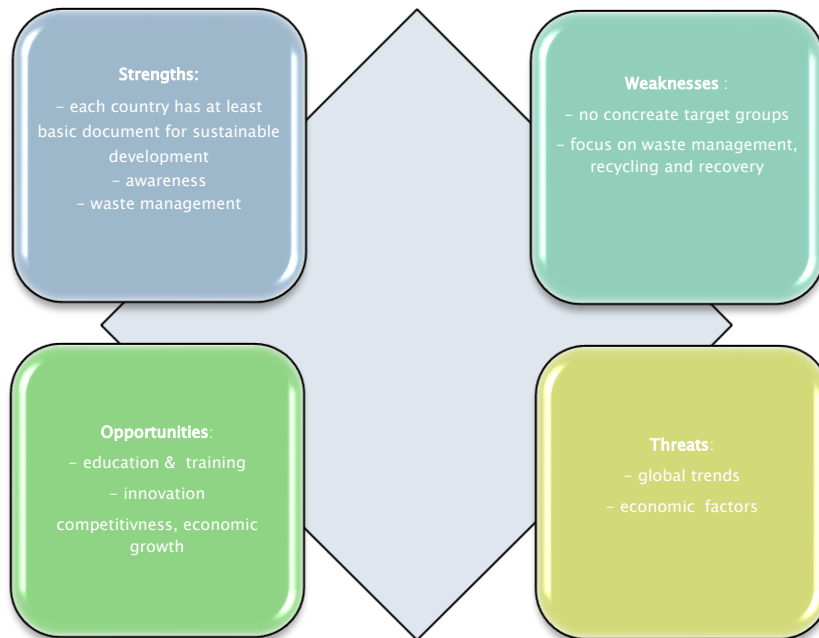
Nowadays on the local standard, there is no accepted strategy for the implementation of Circular economy in Slovak Republic.

Slovenia

The key objectives of the **Slovenia's smart specialization strategy – S4** is sustainable technologies and services for a healthy life on the basis of which Slovenia will become a green, active, healthy and digital region with top-level conditions fostering creativity and innovation focused on the development of medium- and high-level technological solutions in niche areas.

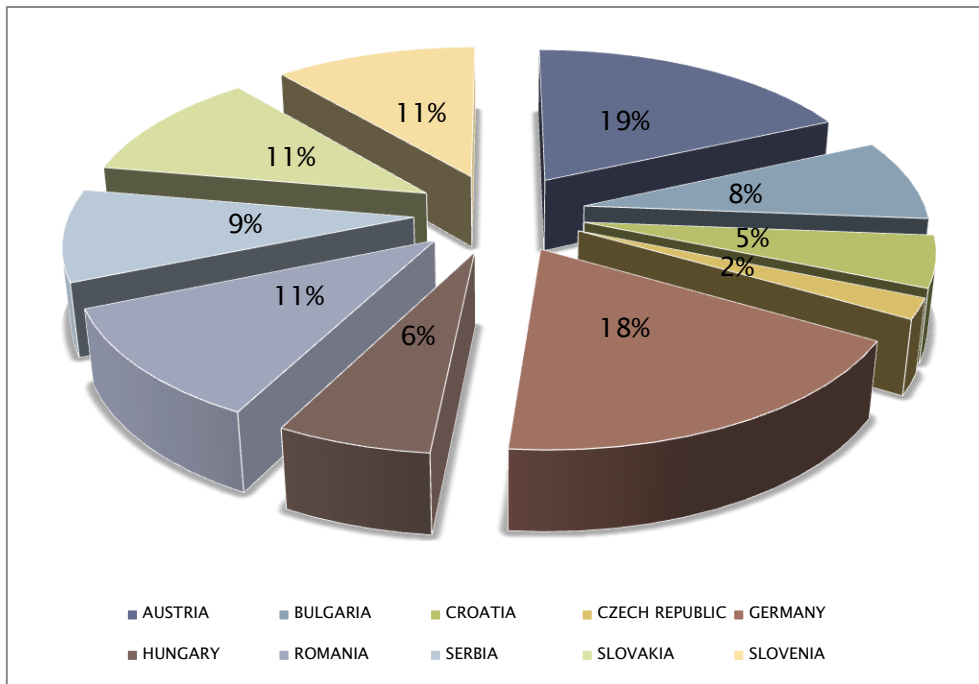
The **Waste management and waste prevention programmes** follows the strategic objectives of European policies, with emphasis on waste prevention, followed by preparation for reuse and recycling before energy recovery of waste.

4.3 SWOT analysis on CE implementation in partners' countries

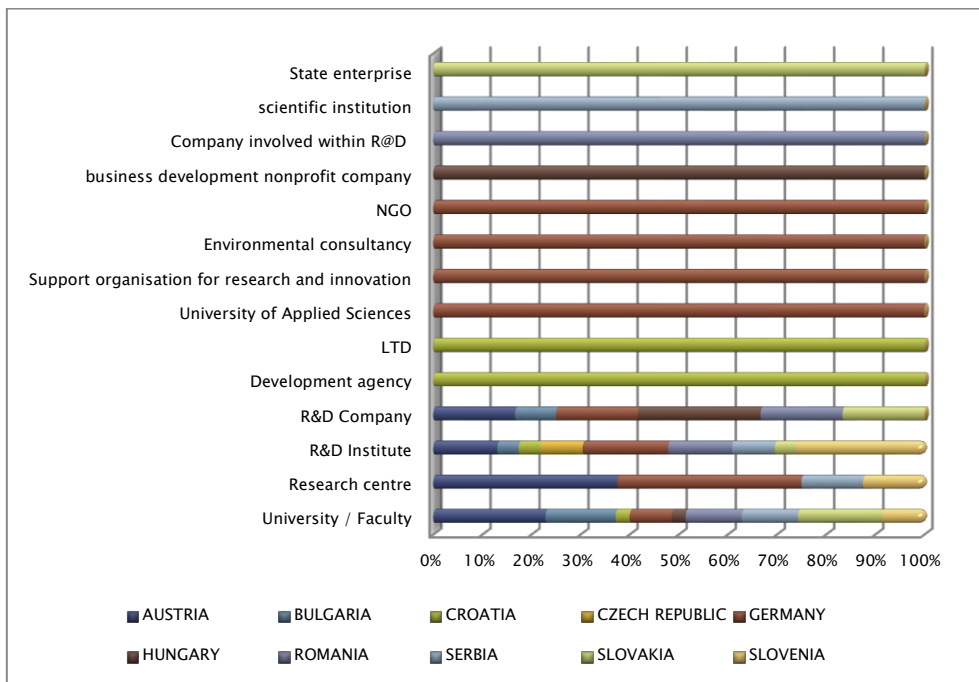


4.4 Mapping of E&D Organisation Supporting the Transition to a Circular Economy

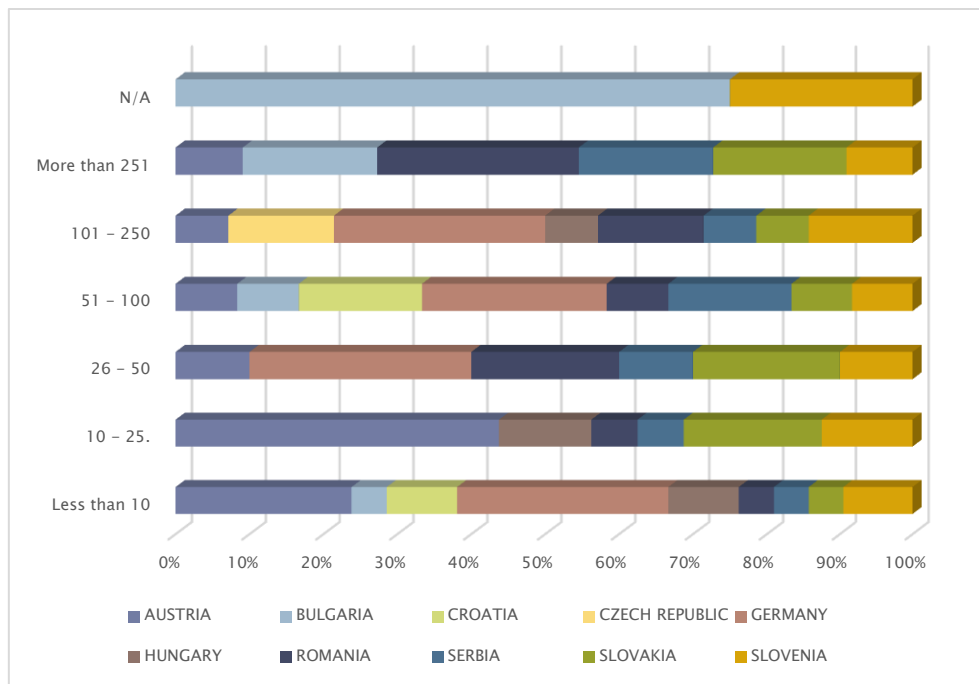
In the process of R&D mapping were involved **88 R&D institutions** across all MOVECO partners' countries. Their detailed description as well overall information about national R&D activities can be found in national reports. These paragraphs present only MOVECO transnational overview on the state of the art in the field of Circular Economy research in MOVECO consortium.



Graf 3: Percentage of involved R&D institutions



Graf 4: Type of involved R&D organisations



Graf 5: Numbers of researchers employed

4.5 Best practices identified: innovative approach and products for CE;

Closed recycling circuit for banner batteries¹¹

Empty car batteries are recycled to 99% and have a higher collection rate than glass or paper. In the past 20 years, the Upper Austrian family company Banner Batterien has collected 15 million spent vehicle batteries together with the Umweltforum Starterbatterien (UFS), where Banner is a founding member, and recycled them throughout Austria.

Revital¹²

Reusable waste products are collected in a controlled manner via selected busses, reprocessed in qualified facilities, and the revitalized products are delivered to the sales offices of the respective ReVital partners. These partners are predominantly employment-promoting organizations.

¹¹ http://www.cleantech-cluster.at/fileadmin/user_upload/Cluster_UC/Partnernews/2016_05_Mai/05_16_PM_Banner_Nachhaltigkeit.pdf

¹² <http://www.revitalistgenial.at/>

ÖLI¹³

In the system "Öli" collected oil is centrally handled in the waste logistics center of the OÖ LAVU AG in Wels and is cleaned and processed in the "Öli washing and conditioning plant", where the oil and grease are heated to 45 ° and the solids, salts and water are separated. Austrian biodiesel refineries produce environmentally friendly biodiesel. One liter of biodiesel is produced from one liter of old cooking oil!

Rosenbauer¹⁴

It is general overhaul of fire-brigade fire engines. Both municipal and foresight vehicles as well as industrial and airport extinguishers can be retrofitted with state-of-the-art fire extinguishing technology. Even individual modernization proposals are possible.

BioRegion Mühlviertel¹⁵

Regional Association for Organic Agriculture, which is increasingly focused on the processing of raw products to produce ready-to-consume products and direct marketing.

Energy from waste water¹⁶

Sewage flows daily in large quantities as a "waste" product through urban sewage networks. This wastewater contains an enormous amount of energy, which can be used to heat or cool buildings.

Trodat stamp¹⁷

The stamp Printy 4.0 consists of up to 65% * post-consumer recycled plastic (4910, 4911, 4912, 4913, 4914, 4915, 4642) - saving valuable resources and up to 49% * CO2. The stamp Printy 4.0 is produced with 100% green electricity!

¹³ http://www.lavu.at/fileadmin/user_upload/redakteure/asz/Downloads/Newsletter/2012_03_Newsletter_OELI_HP_72dpi.pdf

¹⁴ <https://www.rosenbauer.com/index.php?id=4204&L=0®ion=3&cHash=6c474b3db8629f452b7532023029751d>

¹⁵ <http://www.bioregion-muehlviertel.at/index.php/pid.107>

¹⁶ <http://www.wmu-gmbh.com/index.php/therm-liner/thermliner-projekte>

¹⁷ http://www.trodat.net/de-DE/uebertrodat/nachhaltigkeit_umwelt/Pages/Wir-tragen-Verantwortung.aspx

Aqua Diamante¹⁸

The AQUA DIAMANTE-Soda process is based on the activation of the oxygen in the bath water by diamond electrodes. In contrast to classical "salt disinfection", chlorine is not the active substance, but oxygen.

FerroDECONT¹⁹

FerroDECONT GmbH offers solutions for the remediation of contaminated sites and the treatment of heavy industrial and process waters. With the innovative Pump & Treat refurbishment technology, where wastewater containing wastewater is pumped through fluidized bed reactors and thus made harmless, disposal costs can be saved and water can be recycled.

Kirchdorfer Zementwerke²⁰

Replacement of fossil fuels by alternative fuels combined with waste air treatment & energy recovery in the cement industry.

Saubermacher²¹

Saubermacher provides containers in various sizes and designs for the right waste separation and collection. Depending on the waste, different special vehicles of the 680-fleet collection fleet are used, whereby a professional route planning minimizes environmental impacts. The various substances are already collected and transported separately during collection.

Project Bio Ore²²

Recovery of metals from sewage sludge and similar substances by means of hyperaccumulating plants

Regeneracija d.o.o.

In accordance with the world trends, the high environmental awareness of the company is manifested in the positive organization of the production process

¹⁸ <http://www.aquadiamante.com/home/>

¹⁹ <https://www.ferrodecont.at/>

²⁰ <https://www.kirchdorfer-zement.at/umwelt/mensch-und-umwelt-verpflichtetinvestitionen-und-innovationen-mit-dem-fokus-auf-reduktion-von-emissionen/>

²¹ <http://www.saubermacher.at/de/wertschoepfung/>

²² <http://www.alchemia-nova.net/projects/bio-ore-de/>

based on the principles of sustainable development. Project on textile material recycling “EKO – EKO” had two stages: the economy stage (EKOnomija) which has enabled to produce raw materials and resulted in the reduction of the disposal of our waste into the environment and other textile industry waste. The second stage – ecology (EKOlogija) – includes the processing of the total amount of gathered textile waste in the Republic of Croatia.

Agroproteinka d.d.

Agroproteinka d.d. is a company with a 60-year-long tradition in collecting and managing animal by-products, which has been turning to production of renewable energy sources in the last decade. As a part of the global vision of environment protection, in 2008 Agroproteinka started collecting waste edible oil, which is transported to their plants for physical pretreatment. Waste edible oil is a huge resource of renewable energy sources – it is used for obtaining biodiesel, a fuel for diesel engines. As citizens’ awareness grows, and Croatia’s responsibilities as an EU member increase, quantity of recycled oil grows day by day. Agroproteinka sells purified oil on the EU market. In 2017 started a pilot project for collecting waste edible oil, which was launched on 30 selected retail outlets in central Croatia (retail outlets owned by INA d.d.).

Flexibuild

Flexibuild is a certified building material made of two cellulose-based boards and polystyrene between them. It was developed by the private company Flexibuild Technology Ltd. in co-operation with the Faculty of Civil Engineering at the Czech Technical University in Prague. The boards are produced with a special technology that recycles drink cardboard packages containing polyethylene. The material has a high strength, impact resistance, and elasticity and low moisture absorption. It has also an excellent dampening and sound insulating properties. In comparison with other construction materials, the Flexibuild is lighter and therefore easy to manipulate. All these properties make the material ideal for wide use in the construction industry. Due to the base material (industrial and communal waste), it is ecological, healthy and cheaper than other materials with similar use.

GreenFuture

The Czech automaker Škoda Auto Inc. follows its sustainability strategy called GreenFuture. In frame of the strategy, significant reduction is expected in the volume of waste for removal in the Mladá Boleslav plant, including the nearby locations. A design and operational implementation of a new mobile filtration system, which extends the service life of oils from component production process reducing the necessity to buy new ones as a result, can be included among the relevant CE innovations. All Škoda vehicles are at least 85 % reusable and/or recyclable, thus meeting current EU standards. At the same time, all models are homologated in compliance with the recycling requirements.

Ecological Waste Apparatus

AGRO-EKO is a private company focused on manufacturing, development and other services in the environmental area, primarily concentrated on a unique facility for processing biologically degradable waste in enclosed spaces. Its technology is called Ecological Waste Apparatus (EWA). The device uses a method of controlled thermophilic aerobic fermentation to treat a biodegradable waste. Final products can be used as compost for agro-technical use or as biofuel for energetic use, which was successfully tested in Czech heating plants as a substitute for biomass or low-quality coal. EWA gained a European certification (Environmental Technology Verification) for animal by-products treatment.

SmartCity – Bigbelly and Smartbelly systems

Verb Group is a Czech company engaged in the implementation and distribution of smart city technologies and products that revolutionize waste management. Bigbelly is an online closed waste container with a solar panel, which charges a battery driving an electric motor to compact the waste. The Smartbelly is the non-compacting version of waste container. Both systems use real-time data so drivers can collect waste just-in-time. The result is a reduction in waste collections by 80-90%, a reduction in number of bins by 30-70% and an increase in waste volume by 230-530% depending on the city where the containers are installed (Karlovy Vary, Prague, Brno).

PYROMATIC

Pyromatic is a new concept of pyrolysis technology developed by Arrowline Inc. with co-operation of the VŠB - Technical University of Ostrava and other partners.

The technology of pyrolysis waste processing allows to reduce and energy-recover a wide range of waste materials (tires, plastics, biomass, coal, hospital waste, mixtures of wastes, etc.) and to convert waste into usable raw materials. The pyrolysis facility was put into operation in 2009 and is able to process 50-200kg of waste per hour.

Veolia Waste Management CR, Inc.

Veolia is an international company which provides complex services for the Czech market in three areas - water management, power production and supply and waste management. In May 2017, the company announced a new solution for the reuse of melting slag produced in its thermal power plants as a by-product of coal combustion process. In the Ostrava-Třebovice power plant, Veolia produces almost 10 000 tons of the slag per year which is accumulating in landfills. After special processing, the slag has the ideal hardness and density, so it can be used as a replacement for natural materials (sand and silicon oxide which, when inhaled, greatly damages health) used in blasting or shot peening. These two techniques are used to treat surfaces, for instance, in a process of removing old paint from car bodies. Therefore, the slag reuse reduces landfilled waste from plants and can be used as an effective and harmless substitute in industrial surface treatment.

Energocell

Energocell is a glassfoam made of 100% recycled glass that do not need to be selected according to colour. Types of glass waste that could be recycled into glass-foam: plate-glass, packaging glass (glass bottles) and ongoing research gives the hope those hazardous materials such as computer monitor glasses (CRT glass) can be also used.

Glassfoam can be used for isolation of buildings. Other areas of usage are under research.

Agroloop

Agroloop introduces industrialized insect farming in the Central European region. They utilize the Black Soldier Fly larvae`s ability to transform organic waste into a sustainable protein source. This highly efficient natural process has been beneficial for organic farmers on small scale. One of the main focus is to raise awareness to the ecological responsibility that every agricultural stakeholder shares.

REFERTIL

The key objectives of the REFERTIL project are to improve current compost treatment systems and develop zero emission biochar technologies at the industrial scale for safe and economic nutrient recovery processes. Beyond the technological development the REFERTIL project also provides a strong policy support in the revision of the Fertiliser Regulation in Hungary (Reg. EC No. 2003/2003) and possible inclusion of biochar - as organic fertiliser and soil additive. The REFERTIL project will also define the improved compost and biochar quality and safety criteria and standards in the EU28 for safer, better; less costly and more environmental friendly utilization of the EU28 generated 150 M t/y plant/animal biomass waste streams.

Turtle Box GmbH,

The start-up that is located in Munich, rents moving boxes. By this, buying of moving boxes can be avoided. In addition, these boxes are more stable than boxes from cardboard.

RECUP

This is a start-up with the vision of coffee to go without waste. It has an office in Berlin and Munich. The concept is coffee to go in returnable cups with a practical deposit system. The start-up won different awards, e.g. the next organic startup award in 2017. Cafes and stores in the whole of Germany already participate in the system.

ROMBAT - REBAT

SC Rombat SA, producer of lead acid batteries, collects the used batteries (through the distribution stores or directly), with the purpose of their valuation in the REBAT, Copsa Mica, working point. Over 83% of the battery weight is reused in new processes of production. Thanks the fact, that Rombat distributes batteries in more than 3000 stores across Romania, more than 83% of the battery weight is reused in the process of production of new batteries. In addition, progressive upgrading and retooling of the technological flows to reduce the impact of its activities, products and services on the environment.

STERED

The company STERED PR Krajné s.r.o has developed a technology based on textile recycling. Their technology is presented by a complex technological line, which is able to recycle this valuable textile material and to evaluate it to new products. This complex processing line consists of a recycling, evaluating stage and of an output production unit of complete products.

3E MILL a.s.

The company has initiated an unique worldwide patented solution, which produces electricity from water via a floating wheel – the 3E MILL. It is an ecological solution of producing electricity when the influence to the river environment is minimal. It is not necessary to build pound locks and to make back-water level. On the other hand it produces a stable and expectable electricity source from renewable sources.

EVERLASTING

The project develops innovative technologies to improve the reliability, lifetime and safety of Lithium-ion batteries by developing more accurate, and standardized, battery monitoring and management systems. This allows predicting the battery behaviour in all circumstances and over its full lifetime and enables pro-active and effective management of the batteries, which leads to more reliability and safety which enables preventing issues rather than mitigating them. Moreover, by exploiting the interaction between the battery and the vehicle, more accurate range predictions can be made to reduce the range anxiety for the driver and allows the battery to be kept in a safe and optimal operational state to improve the lifetime of the battery (target +20%) and to use the battery to its full capacity in a safe way. This leads to lower overall costs.

Ecocapsule

It is a mobile habitable cell, which is able to generate free electricity and water from its neighbourhood, by its own. It produces electricity from the sun and wind and it collects rain water without connection to the network. In spite of its small dimensions (8 m² of useful area), it is able to comfortably accommodate two person.

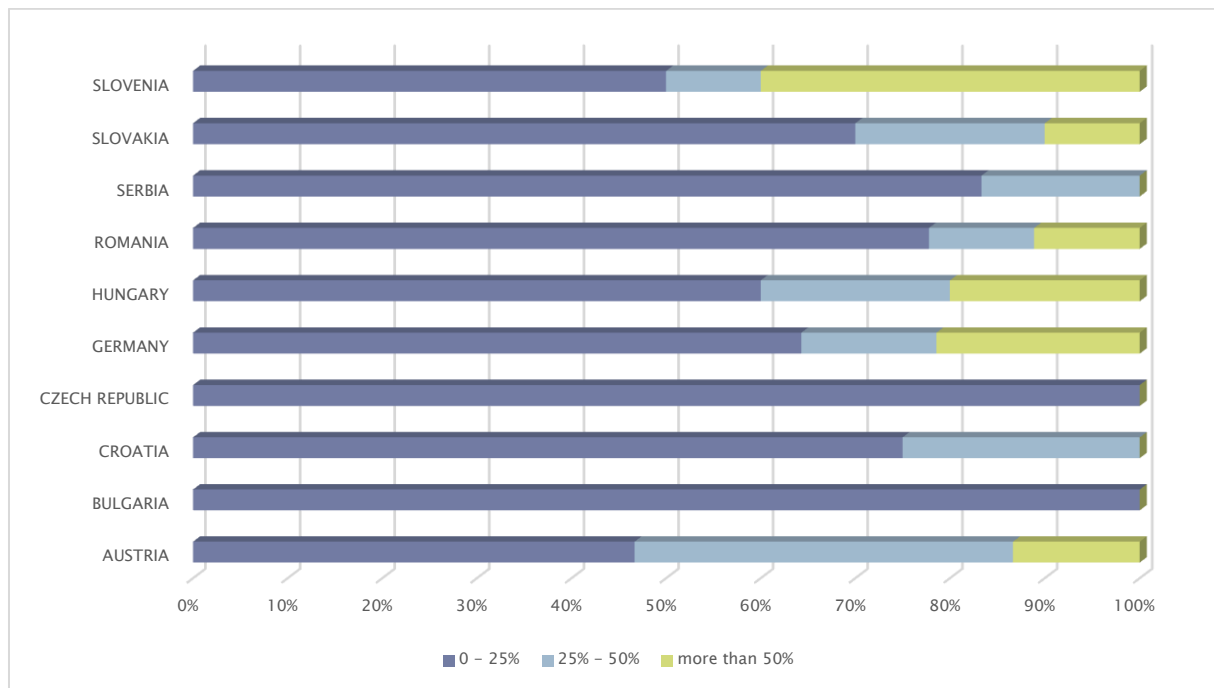
REFILL CASE, s.r.o.

The startup company developed a technology for plastic waste reduction through recyclable inserts that are placed in multi-trip bottles and containers, its recycling and reuse of the plastic casing. The goal is to dramatically reduce the amount of plastic waste via complete system of recycling of the plastic insert; the reduction of the production costs allows lower environmental charge of the nature and of the environment.

4.6 Analysis

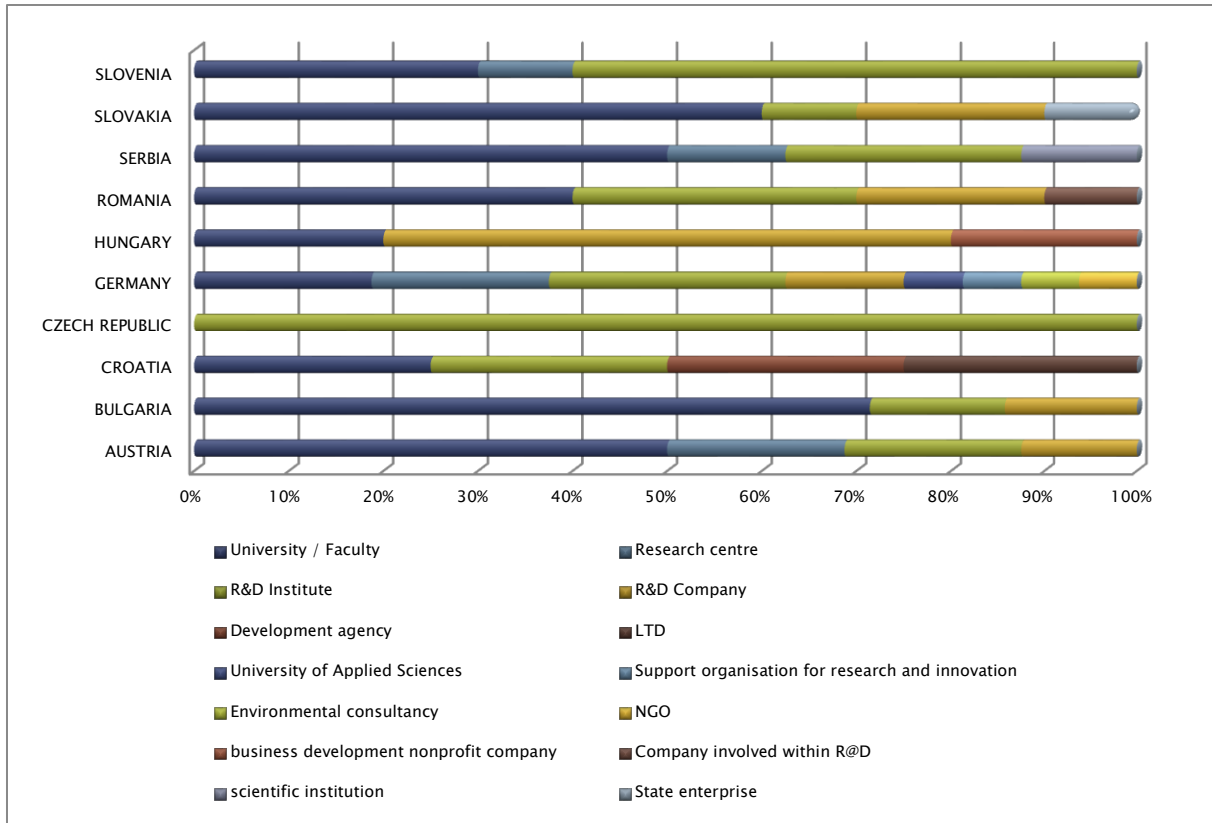
In general, all partners had problems to find detailed information of the R&D dedicated to circular economy and the coverage of circular Economy within the R&D scene could be found. **From this point of view, information presented in this report cannot be considered as evidentiary.**

Overall, all countries increased its expenditures on R&D and crucial part of financing is covered from public sources. However, the reason can be find in intensity of drawing funds from the EU, which still forms a substantial part of R&D funding. The private sector's total funding ratio is on the Graf 6.



Graf 6: Estimate of organisations private funding from industry

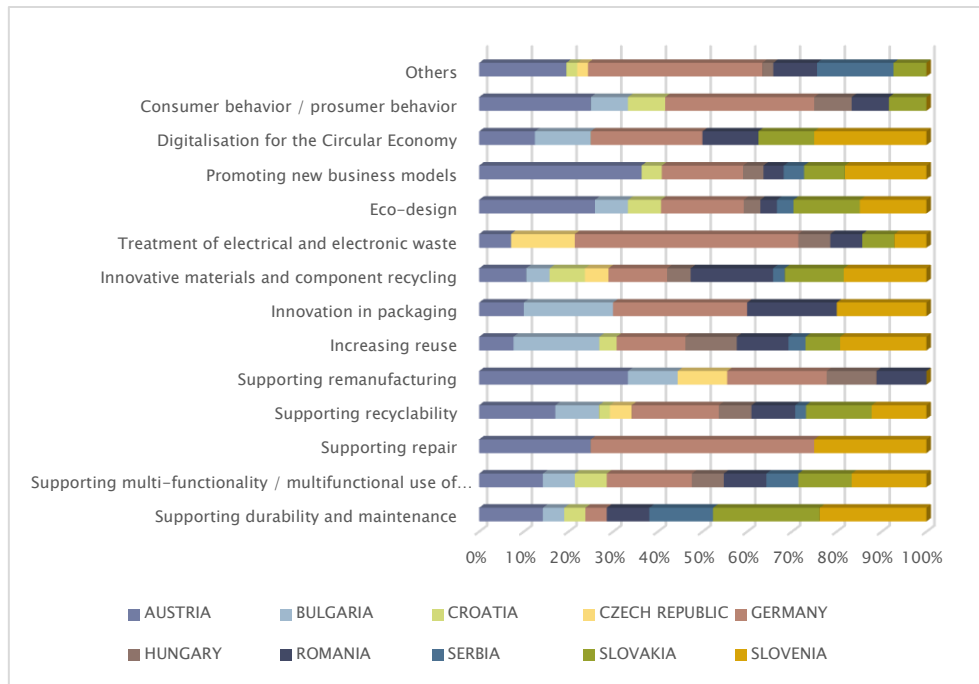
R&D in MOVECO countries is dominated by the public universities as is presented at Graf 7.



Graf 7: Type of organizations

Except Germany, Austria and Slovenia – countries that belong to the group of innovation leaders in the field of CE - all other MOVECO's countries environmental and socio-economic issues prove that they are only at the beginning of its transition from a linear to a circular economy. The policy framework in the field of general R&D and innovations is perceived as fragmented and discontinuous with other problems in practice caused thereby. There are a lot of strategies that are implemented either provisionally or to a specific extent only or that are not implemented at all. Co-ordination between the national and regional level innovation strategies has been weak.

The Graf 8 and Graf 9 present organisation's main areas of R&D expertises and innovation.

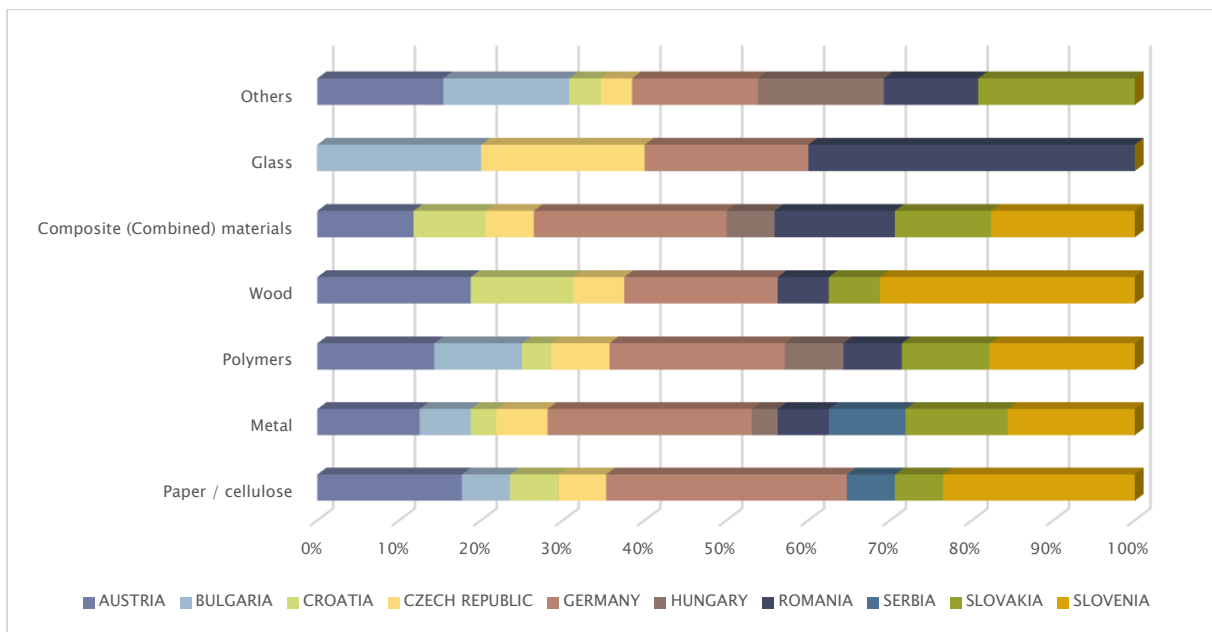


Graf 8: Organisation's main areas of R&D expertises

Except presented areas of R7D expertises, we can mention some others:

- Austria:
 - o resource recovery;
 - o supporting the innovation process for circularity;
 - o drinking water and wastewater;
 - o composting of biogenous wastes;
 - o waste minimization;
 - o sustainable buildings;
 - o economic evaluation.
- Germany:
 - o knowledge transfer;
 - o environmental awareness;
 - o thermal waste processing with energy recovery;
 - o resource policy and implementation and enforcement of EU and national waste law;
 - o waste management and policy instruments, management of specific waste streams (e.g. hazardous waste); waste prevention;
 - o Life cycle assessment studies and efficiency analysis;

- sustainable entrepreneurship.
- Hungary:
 - industrial symbiosis.
- Romania:
 - developing niche products in the field of renewable energy systems.
- Serbia:
 - energy efficiency and renewable energy systems;
 - mineral exploitation and mining.
- Slovakia:
 - battery life prolongation;
 - material recycling of wastes;
 - biotechnology.



Graf 9: Innovative materials and component recycling

Other innovative materials and component recycling:

- Austria:
 - o heat;
 - o nanomaterials and nanocomposites;
 - o nutrients;
 - o water.
- Bulgaria:
 - o Composting plant waste;
 - o eco and energy saving technologies;
 - o energy efficiency optimization and energy efficiency;
 - o biomass.
- Croatia:
 - o digestate.
- Czech Republic:
 - o bio-polymers.
- Germany:
 - o critical raw materials;
 - o waste;
 - o organic substrate;
 - o food.
- Hungary:
 - o sewage sludge;
 - o RDF;
 - o organic contented wastes.
- Romania:
 - o valuable substances recovery from waste streams;
 - o nanometrics.
- Slovakia:
 - o bio-polymers;
 - o agricultural products;
 - o electronics and batteries;
 - o recombinant enzymes and protein therapeutics;
 - o industrial textile.

In general and except countries belongs to the group of innovation leaders, R&D mapping has shown that organizations that have a tangent to the circular

economy have been more involved in waste reduction, recycling and environmental protection projects. Only a few organizations are involved in product and service innovation providing environmental benefits in eco-design and eco-friendly systems innovation.

As a major problem appeared the fact that business sector, especially SMEs, does not promote collaborative ties with R&D organizations. There is some improvement in public and private sector cooperation due to the development of consortiums for common projects and clusters. However, this type of cooperation cannot be considered as sustainable, because of terminated funding resources.

4.7 SWOT Analysis on R&D situation

Strengths	Weaknesses
<ul style="list-style-type: none"> - The support of research and innovations is included in strategic documents in the field of environmentalistics also with the adaptation to climatic changes. - Start-up/SpinOff entrepreneurship is growing and significant part of new investments are focused on energy efficiency and cost reduced using EU funding programs - Experience and knowledge of research and development staff with background in R%D activities. 	<ul style="list-style-type: none"> - Private sector is not involved within R&D activities as there is significant little motivation of SMEs to invest in R&I. They prefer rather to import technology problems or this is caused by high financial costs and bureaucratic hurdles that connecting MSP's to research/innovative activities. - The financial incentives are very limited, venture capital market is underdeveloped. - Participation in the R&D funding schemes under EC is problematic, previous experiences are missing. Moreover, there are limited number of working partnerships (especially H2020). - Slow international patent granting process in terms of national/European legislative and authorities. - Problematic enforce of the environmental criterions in the

	<p>process of public procurement.</p> <ul style="list-style-type: none"> - A large fragmentation in R&D and frequent legislative changes.
Opportunities	Threats
<ul style="list-style-type: none"> - Increased demands for quality bio polymers in the world. - The application of circular approaches shows the way how to reduce financial costs of the companies via development of new, innovative materials, which are serving a replacement for the primary non-renewable energy resources. 	<ul style="list-style-type: none"> - Legal environment face to many changes. - Limited resources within SME sector (financial, infrastructure). - Missing certification of new products does not allow to compete against quality foreign products. - Strict hygienic and safety legislations and standards prevents to propagate the usage of recycled materials while producing new products.

5. Discussion/conclusion

In the political debate, the issue of circular economy has gained significantly in recent years. The new EU commission revised the "Circular Economy Package" set up on the "Roadmap for a Resource-Efficient Europe", and almost in all EU countries there are already framework conditions and transformations on which the conversion to a circular economy can be built up.

In all MOVECO counties we recognized that spending on research and development has risen in recent decades. However, the focus of circular economy should go far beyond providing financial resources to support research and development in the field of environmental technologies. On the contrary, there is a need for a holistic, systematic approach by the public authorities to create good conditions for circular economy. The development of recent years shows that most eco-innovations are to be understood as gradual improvements to existing technologies and radical base innovations are rather the exception. This fact must be taken into account when aligning the conveyor rails.

As one of the biggest problems was identified cooperation between SME and R&D institutes. The ratio of these common projects was in the examined sample in the field of R&D too low and almost covered common activities under some of the funding scheme. The insufficient commercialisation of the university R&D activities was also a problem where the insufficient activities of the transfer centres were referred. The lengthy process of patent acceptance or utility models is also connected with this point.

Following recommendations between commercial and academic sphere were arose:

- It is necessary to create a communication platform between companies and academic sphere, where the small and medium sized companies can apply for solutions connected with innovation problems.
- To raise the engagement of the companies in research project of national and European agencies e.g. European fond for strategic investments or program Horizont 2020. It is necessary have information about current

challenges and about the way of finding partners. The circular economy is presented as one of the priorities for the period of 2018-19.

- The results of R&D activities are mostly not accessible, e.g. projects supported from national resources or the receiver does not have the obligation to have a web site about the project itself, so the information about the projects are not accessible to the public.

6. Annexes

6.1 List of R&D projects identified in MOVECO countries