polynSPIRE

Innovative technologies for plastic recycling

Final Market Analysis

Deliverable 9.9

WP9 Market Analysis, Exploitation and Business Plan

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APPROVALS

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EXECUTIVE SUMMARY

One of the key objectives of polynSPIRE is to ensure the exploitation and commercialization of the knowledge and technical results obtained from the execution of the technical work packages in order to pave the way for the implementation and adoption of technologies that will favor the circular economy through the recycling and reuse of plastic waste.

This document provides the final release of the market analysis including the solutions of the project and how can these solutions benefit several sectors that will later be the potential customers of the technologies, how these can fulfil the current needs of some sectors and/or make easier and cost friendly. This is a main activity to ensure the commercialization and exploitation of all the knowledge and technical results obtained from the execution of the innovations and take them to the market.

The concept of polynSPIRE is to create a cost-effective transformation of plastic waste into raw materials through its recycling and valorization by comparing the different approaches and reveal the best technical, environmental and economic fit for the different materials depending on waste source (post-industrial or post-consumer), composition, contaminants or other relevant parameters, targeting 100% waste streams containing at least 80% of plastic materials.

To achieve this objective polynSpire is based on three innovative pillars:

- Chemical recycling via MW depolymerisation and Magnetic Smart materials system and technology, to achieve a more efficient and environmentally friendly technology to carry out depolymerisation processes of PA and PU residues to obtain monomers to be re-introduced at the beginning of the value chain.
- Mechanical recycling via Efficient process and additives for upgrading plastic residues, two technologies will be developed to improve the mechanical properties of PA and PU recycled materials will be tested, namely vitrimers and high energy radiation.
- Valorization to develop an injection system for the utilisation of recycled heterogonous plastic materials into Electric Arc Furnace (EAF), in order to reduce the consumption of coal (as carbon supply and foaming agent) by the use of a significant quantity of plastic waste. The injection of plastics in this specific case would enhance the generation of the foaming gas, increase in this way the efficiency of the process both in terms of energy and resource savings, favour the disposal of plastics otherwise often still landfilled in many countries, reducing at the same time the carbon footprint because of the high content of hydrogen in the plastic.

The following sectors have been identified, categorized by the project solutions that apply directly to them according to their business activities:
For the Chemical recycling innovation: Chemical Industry, Waste management companies and Plastic manufacturers; For the Mechanical recycling innovation: Compounders, Automotive and Plastic converters and for the Revalorisation innovation: End user industries (automotive, construction, steel industry, etc.) and Plastic manufacturers.

The market potential of these identifies sectors are the following:

- Plastic manufacturers: this is a large target segment that can benefit from practically all of the results of the project. PU and PA have a lot of applications in the market and its producers can utilize the innovations to make new quality product from recycled materials. There are more than 60.000 companies of this industry in the EU that can be potentials clients.
- Waste managers: this is an industry that works with all kind of materials and one of their main activities is to give this waste a second life. In 2020 the amount of waste recycled in the EU (recycling and composting) was 107 million tons (241 kg per capita). Of this amount, 61 million represented the incinerated waste.
  This is a market that functions both in the private and public sectors and the possibility of making business relations is infinite. It's a key industry for the project because they will have the role of suppliers of the raw material necessary to use in the recycling technologies developed.
- End users (automotive, steel, construction): this target segment includes the large size industrial companies from the automotive, construction, steel sectors, among others, that operate with plastics components made from PA and PU. These materials are widely use in the industrial sector because of their properties and big companies who have massive needs for these materials need an option that allows them to obtain them in a more effective way: this makes them potential customers.
- Furniture/mattresses manufacturers: this target segment includes middle- and large-sized companies, which design, develop and manufacture furnaces, including mattresses, from scratch making their foams from the very polyols and from previous used products that can go through a recycle processes.
- Environmental management companies: industry dedicated to the treatment of waste and improving the environment through different processes enters the potential market circle.

With regard to market barriers, several were detailed in this document. The one that stands out the most is the regulatory barrier often related to lacking legislation that would allow the collection and pre-treatment of homogenous waste streams. In addition, the legislation is neither strict nor clear for key sectors such as the automotive industry or the electronics industry.
On the social side, the plastics industry used to be resilient to change and the implementation of new solutions. However, in recent years there has been a stronger commitment to recycling and reuse of waste.

For the competitor's analysis, no similar integral solution has been identified. However, as explained in deliverable 9.1, the new ways in which plastic is manufactured and the existence of bioplastic or products marketed as recycled must be considered.

Finally, it has been concluded that when it's time to bring these results to the market, it is recommended to seize opportunities with business associations within Europe in target sectors, accentuate the positive impact for the market and for society within the available platforms, internal contacts, and the press and to record and disseminate large-scale demonstrations carried out.

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OVERVIEW OF THE DELIVERABLE

WP: 9 Market Analysis, Exploitation and Business Plan

Task : 9.9

Title : Final Market Analysis

Main Objective: To ensure the exploitation and commercialization of all the knowledge and technical results obtained from the execution of the previous WPs to pave the way for market uptake of polynSPIRE solutions for the targeted polymers along the value chain stakeholders and around Europe.

Specific Objectives:

- To analyse market potentials, applications perspectives, risk and opportunities for the implementation of polynSPIRE solutions.
- To generate a business plan to commercialize the project results and to penetrate polynSPIRE in Europe's industries.
- To assess all the issues related to the creation of the necessary infrastructure for the promotion of a mass market, with focus on regulatory barriers.
- To define the most appropriate strategy for the exploitation of the results and exploitation plan, with special focus on the IPR management among partners.
- To develop a holistic assessment on the replicability and upscaling of the developed solutions, as well as a roadmap for their large-scale implementation.

LIST OF ABBREVIATIONS AND ACRONYMS

CA – Consortium Agreement
CASE – Coatings, adhesives, sealants and elastomers
D – Deliverable
DoA – Description of Action
EC – European Commission
EU – Europe
EUPC – European Plastics Converters
FP – Framework Programme
GA – General Assembly
H2020 – Horizon 2020 The EU Framework Programme for Research and Innovation
IPR – Intellectual Property Right
M - Month
PA – Polyamide
PC – Project Coordinator
PU – Polyurethane
PolynSPIRE - Demonstration of Innovative Technologies towards a more Efficient and Sustainable Plastic Recycling
SC – Steering Committee
SME – Small and Medium Enterprise
SWOT - Compilation Strengths, Weaknesses, Opportunities and Threats
TRL – Technological Research Level
WP – Work package

1 INTRODUCTION

D9.9 Final Market Analysis (M42) is part of the WP9 Market analysis, Exploitation and Business Plan (M01-M48). The market report presented in this document results from data collected through desktop research as well as key findings identified from the Grant Agreement (GA) number 820665 for the POLYNSPIRE project thanks to the already delivered D9.2 Map of Availability of Plastic Wastes Across Europe, this report will have more accurate data of the EU plastics market and it consume.

The objective of Deliverable 9.9 Final Market Analysis is to provide a final and detailed market analysis in order to ensure the exploitation and commercialization of all the knowledge and market intelligence results obtained since the submission of the previous deliverable. In addition, to provide greater knowledge of the context in which the project is developed, a radar technology will be presented to recognize patents, inventions, or technological developments related to the results of polynSPIRE.

Moreover, when market barriers are mentioned, a summary of the European regulation trends will be made to understand the possible normative barriers or facilitators so that the technologies can be used and exploited in the market.

In this final deliverable, information on the level of development of individual solutions within the project will be updated and more detailed data on the potential market described in the previous deliverable will be added.

This report is aiming to understand the market dynamics in order to identify customers' needs divided into the targeted business sectors and how polynSPIRE solutions could cover them, following these objectives:

- Study the market dynamics of plastic: production, income, growth rate of PA and PU waste.
- Identify the sectors who would be most interested in exploiting polynSPIRE solutions and knowledge.
- Analyze the different end-of-life scenarios of plastic, such as landfill, recycling and incineration.
- Analyze the competing market and possible substitute products.
- Identify relevant market barriers which can influence on the results and the further exploitation.
- Identify patents or similar technological registrations existing on the market.

The way in which this report will be worked will be to carry out the market analysis as a perspective of the market in which the project solutions will compete, which does not depend on the consortium, but rather on what the market is like, how is it currently and what will its evolution be.

2 METHODOLOGY

According to the Amendment established by the Consortium, from this report is expected a comprehensive market analysis for the target plastic wastes, the derived fibres and upgraded plastics, and the polynSPIRE technologies (recycling technologies and technologies aimed to improve the quality of plastic wastes and facilitate their reuse).

Including the market dynamics of the plastic productions; Market segments, considering different end-of-life scenarios such as landfill, recycling and incineration (energy recovery); SWOT analysis to position the polynSPIRE innovations on the target markets; Background analysis of plastic waste management industry; Market shares, identification and approaches of potential key industrial players that would be benefited with the project's results.

The EU market will be continuously monitored in order to detect new trends and possibilities, which will allow the consortium to react to market changes and adapt the results of the project accordingly.

This market analysis is the result of a dynamic and continuous activity based on the first and the Mid-term Market Analysis. Updates are necessary because throughout the project new patents or R&D lines may appear affecting the IPR, the development of the project or the commercialization of its results.

Description of polynSPIRE solution:

The technical description of the main description and expected solution of the project aim to understand the general concept of the project, its general objective and its specific objectives and to describe its components so we can obtain a clear idea of the expected impact of where and with whom its results should be exploited.

Description of the individual innovations scopes of the system and its results:

The technical description of the separate solutions aims to describe the individual components, help understand in which TRL they are currently in and what exploitation possibilities are expected for each innovation. From each exploitable innovation several results can be obtained, which will be detailed, and it will be described what solutions they provide to the industrial sectors to which they are intended.
Additionally, it is desired to detail how the technologies have been or are being tested and thus it will be easier to show potential customers the true impact of the results.

Customer Analysis: Segments, needs and expectations:

Identifying customer segments makes it easier to visualize how the results will be exploited, which sectors to conduct business relationships with and how all can get the most out of the technologies and knowledge obtained. This selection of sector has been based on the results of the Business Canvas Model that was conducted in the Grant Agreement and in the ones identified in the EU plastics Market section on the D9.2 Map of Availability of Plastic Wastes Across Europe.

For a good exploitation strategy is necessary that the needs of the clients and consumers are aligned with polynSPIRE solutions, that's why it is necessary the study of the needs and expectations of the sectors or

industries that were identified. The needs identified of each sector will be given an importance rate that would go from “Low importance” to “Very important”, this rate information will be useful to shape the solutions according to the most important needs.

Market: Target market, competitors, substitutes products, drivers and barriers

As stated in the introduction, the plastic dynamic market will be analyzed to obtained information about the production, growth, prices and waste of the PA and PU plastics, that are those that polynSPIRE will obtain innovative process for recycling.

This section will also function to add and explore new ways of selling the results taking into account how similar or substitute products are being handled in the market. By exploring where the companies and manufacturing sectors that use PU and PA the most in their products obtain these plastics, it is possible to get an idea of the market of competitors, ally or customers.

The information developed in the DP9.2 about quantity and geographic location of the plastic consumption and information about the polymers market will be use.

This report will also include a PESTLE analysis to delimit market barriers, a list of possible competitors and a Porter Five Forces analysis to portray products, technologies and procedures that can be potential substitutes of the solutions polynSPIRE is developing considering the actual waste treatments for PU and PA plastics that were mentioned in the D9.2 report.

Recommendations: SWOT Analysis:

To summarize the recommendations that should be followed to capture exploitation and market introduction opportunities, a SWOT analysis will be carried out.

3 POLYNSPIRE SOLUTION

The concept of polynSPIRE is to create a cost-effective transformation of plastic waste into raw materials through its recycling and valorization by comparing the different approaches and reveal the best technical, environmental and economic fit for the different materials depending on waste source (post-industrial or post-consumer), composition, contaminants or other relevant parameters, targeting 100% waste streams containing at least 80% of plastic materials.

polynSPIRE proposes a circular value chain for the plastic sector. PA and PU represent two of the less recycled plastics and yet they are widely used, and it is expected that their usage will continue increasing. The project will address 100% waste containing streams ensuring the recycling of at least a 50% of total plastics containing PA and PU leading to a reduction of CO2 equivalent emissions between 30% and 40%.

To this end, three innovation pillars are addressed at TRL7:

Innovation A - Chemical Recycling

The process leading in total depolymerisation of the plastic material to obtain their monomers (raw materials for polymer production) as a path to recover plastic monomers and valuable fillers (carbon or glass fibres).

Two approaches were analyzed: recycling assisted by microwaves-assisted organic chemistry (implying an energy consumption reduction up to 68%) and by smart magnetic catalysts (which can increase efficiency around 60%).

Innovation B - Mechanical Recycling

Additivation of recycled material with specific additives that can be used to improve mechanical properties (e.g. interaction between components). The following technologies were used to improve recycling efficiency: Vitrimers, Compatibilising additives and High energy radiation.

Innovation C - Valorisation of plastic residues

Enhance valorisation of low-grade plastic wastes by using them as carbon source in steel industry and reduce mineral ore. These wastes promote foaming of the slag, thus improving the energetic and environmental performance of the furnace.

Innovations A and B can lead up to **34% of fossil fuel direct reduction for PA and 32% for PU.** Approach C can lead to **reductions of around 80% of fossil carbon sources in electric arc furnaces.**

At least these six market sectors will benefit:

- Automotive
- Appliance
- Electronics
- Constructions
- Packaging

Current technologies consume large amounts of energy and chemical products representing both high OPEX and health issues. In addition, new strategies were studied during polynSPIRE, giving second life to plastic products by means of advanced additives and the use of plastic packaging streams, which entails almost 40% of the plastics demand in Europe, as carbon source in the steel sector.

With this perspective, the following elements support the value proposition of the solution:

- Reduction of environmental impacts to comply with the current environmental legislation and even with future regulations (which are expected to be much more restrictive in a near future) along with the European Strategy for Plastics in a Circular Economy.
- Enhancing circular economy in Europe. Capability to provide recycled plastic adapted to different sectors and needs.
- Reducing energy dependence on fossil fuels and non-dependence of its variability costs.
- Technical, economic and environmental feasibility in the application (in individual or integrated way) of the solutions and possible modifications in the process.
- Risk reduction in the investment accomplishments and in their decision-making related activities. 6. Improving competitiveness due to the better performance of their equipment and industrial processes.

The demonstration is completed by the performance of a rigorous holistic environmental and economic analysis (LCA and LCC) to ensure the industrial feasibility and the accomplishment of environmental restrictions.

Furthermore, non-technological barriers such as legislative or standardization ones are also addressed at EU level and business models to integrate the aforementioned solutions in the overall plastic waste management system will be set up.

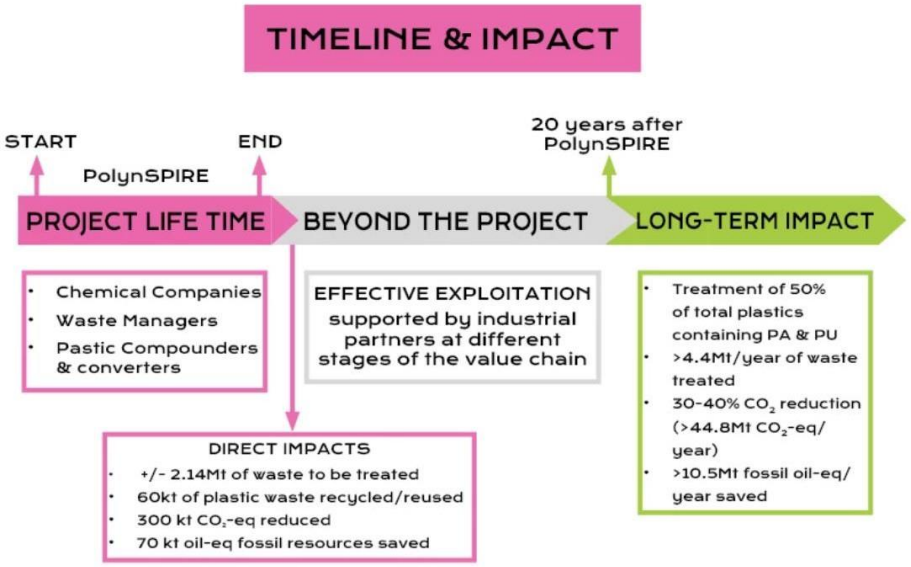

Figure 1- Diagram with text. Timeline and impact of PolynSpire

3.1 INDIVIDUALS SOLUTIONS OF THE PROJECT

The expected results from the polynSPIRE technologies implementation are achieved through the collective executions of the initiatives that are going to be described in the segment below. These initiatives lead to certain solutions that were identified as Results in the CA report and will be listed according to that document.

3.1.1 Innovation 1: Chemical recycling via MW depolymerisation and Magnetic Smart materials system and technology

This scope aims to achieve a more productive, more efficient and environmentally friendly technology to carry out depolymerization processes of PA and PU residues to recover the monomers to be re-introduced at the beginning of the value chain. This innovation currently stands at TRL 6, but it is expected to get to a TRL7 by the end of the project. The anticipated route to exploitation of this innovation is within the consortium and a full commercial offering. The Results that outcomes from this initiative are:

Result No. 1: MW depolymerization system and technology

The partners that participate in the exploitation strategies of this result are: CIRCE / FM / NIC.

Route for exploitation: **CIRCE:** offering advanced and high-quality consultancy on microwave technologies applied to various sectors (plastic, glass, ceramics, etc.) regarding design, Multiphysics simulation and basic engineering of MW innovative solutions and their material dependance. **FM:** integration of the system into their portfolio of solutions and future commercialization of it. **NIC:** offering advanced and high-quality consultancy on MW chemical depolymerisation for short chain PA and PU, and future replication of solutions to long chain PA.

Target market: **CIRCE:** engineering companies and industries willing to apply the technology. **FM:** industries and end users willing to install and manufacture reactors and industrial units within their facilities, mainly chemical companies and plastic or waste management companies. **NIC:** chemical companies focused on innovation in their chemical processes.

Competitors: Engineering companies, research institutions and consultant services companies.

IRP Strategy: New developments and systems might be protectable by patent.

Time to market: 2 years after the project completion.

Result No. 2: Chemical recycling assisted by Smart Magnetic Materials

The partners that participate in the exploitation strategies of this result are: ION / CPPE / TUe.

Route for exploitation: **IONIQA:** integration of the system into their portfolio of solutions and exclusivity in exploiting the developed system after the project. **CPPE:** providing engineering services to chemical companies and manufacturers (ION as example). **TUe:** consultancy services to chemical companies and manufacturers.

Target market: IONIQA: industries and end users willing to install and manufacture reactors and industrial units within their facilities, mainly chemical companies and plastic or waste management companies. CPPE: engineering companies, manufacturers and industries. TUe: chemical companies.

Competitors: Engineering companies, research institutions and consultant services companies.

IRP Strategy: New developments and systems might be protectable by patent.

Time to market: 2 years after the project completion.

3.1.2 Innovation 2: Mechanical recycling via Efficient process and additives for upgrading plastic residues

On the one hand, fibers coming from Innovation 1 are used to create novel additives formulations to improve both mechanical and visual properties. On the other hand, two technologies to improve the mechanical properties of PA and PU recycled materials are tested, namely vitrimers and high energy radiation. This innovation currently stands at TRL 5 but it´s expected to get to a TRL 7 by the end of the project. The anticipated route to exploitation of this innovation is within the consortium and a full commercial offering. The result that outcomes from this initiative is:

Result No. 3 Efficient process and additives for upgrading plastic residues

The partners that participate in the exploitation strategies of this result are: TUe / CIRCE / AITIIP / MAIER.

Route for exploitation: All the main actors in the value chain are included. TUe: high consultancy and service to industries related to vitrimers formulations. CIRCE: high consultancy services related to high energy radiation treatments. AITIIP: high level consultancy in compatibilizing additives and recycled additives. MAIER: as final converter, can give feedback to improve these upgrading features formulations.

Target market: TUe: PA and PU with vitrimer properties to be utilized by high requirement users. CIRCE: plastic manufactures and RTD centres related to the plastic sector. AITIIP: plastic compounders plastic parts decorators and manufacturers with specific requirements. MAIER: automotive sector.

Competitors: RTD centres. ARKEMA has 8 out of 9 last vitrimers patents. A low competitor number is expected.

IRP Strategy: New developments and systems might be protectable by patent.

Time to market: 1,5 years after the project ends. 3-4 in the case of vitrimers.

3.1.3 Innovation 3: Revalorisation via High quality steel coming from recycled plastic, high quality blends and plastic pieces coming from plastic residues, plastic injection system for EAF and new polymers coming from recycled monomers

This innovation consists in the following exploitable outcomes:

Develop steelmaking processes integrating plastic waste as a substitute source of fossil materials, reducing plastic waste mistreatment.

Create new plastic blends used as carbon supply and foaming agent, ensuring the specification and quality of obtained steel.

A new type of injector has been specifically designed for the injection of plastic residues into EAF. This plastic source is mainly polyolefins (packaging waste streams) but industrial trials with PA, PU and other carbonaceous residues are being also performed, validating the flexibility of the systems for a wide range of plastic waste streams. The Results that outcomes from this initiative are:

Result No. 4 New polymers coming from recycled monomers.

The partners that participate in the exploitation strategies of this result are: NOVAMONT / REPSOL QUÍMICA / ARKEMA / NUREL / KORDSA.

Route for exploitation: All: Sell the new recycled based polymers to final applicators, compounders or end users, to continue with the plastic manufacturing value chain.

Target market: NOVAMONT: developing bio-based polyester substituting the remaining fossil fraction by recycled material. REPSOL QUÍMICA: developing new PU material for foams, insulation, etc. ARKEMA: developing long chain PA polymers for high added value applications NUREL: developing short chain PA6 polymers for high added value applications. KORDSA: developing short chain PA6.6 polymers for high added value applications.

Competitors: Other chemical companies working in the same sector.

IRP Strategy: commercialization for industrial application.

Time to market: NOVAMONT, NUREL, KORDSA, REPSOL QUÍMICA – 3 years after the project; ARKEMA – 4-5 years after the project.

Result No. 5: High quality blends and plastic pieces coming from plastic residues

The partners that participate in the exploitation strategies of this result are: BADA / MAIER / AITIIP.

Route for exploitation: BADA: producing blends coming from this new plastic formulation. MAIER and AITIIP: manufacturing final recycled plastic products and components to be used in end user sectors like the automotive one.

Target market: BADA: automotive, electronic, electric, engineering, advanced medicine construction, house interiors and sport sector. AITIIP: plastic compounders plastic parts decorators and manufacturers with specific requirements. MAIER: automotive sector.

Competitors: Plastic compounders and converter companies.

IRP Strategy: commercialisation for industrial application.

Time to market: 1.5 years after the project ends.

Result No. 6: Plastic injection system for EAF

The partners that participate in the exploitation strategies of this result are: HTT / CSM / FENO.

Route for exploitation: **HTT:** integration of the system into their portfolio of solutions and future commercialisation of it. **CSM:** offering advanced and high-quality consultancy on plastic utilisation as carbon source in steel industry. **FENO:** low OPEX in steel manufacturing and sustainable steel production.

Target market: **HTT:** industries and end users willing to install and manufacture injectors and industrial units within their facilities, mainly steel companies and plastic or waste management companies. **CSM:** steel companies focused on innovation in their manufacturing processes. **FENO:** end users of steel products like construction sector.

Competitors: Steel sector industries and engineering companies.

IRP Strategy: new developments might be protectable by patent and commercialisation for industrial application.

Time to market: 1.5 years after the project ends

Result No. 7: High quality steel coming from recycled plastic

The partners that participate in the exploitation strategies of this result are: IDS /IBLU/ FENO.

Route for exploitation: **IDS/IBLU:** specific contracts with the steel sector to provide plastic waste streams to steel manufacturers. This is win-win situation for both waste manager and steel industry. IDS/IBLU can assure a steady sales number during the following decades and the steel industry has a constant raw material supply. FENO:production of sustainable steel that meets the High-Quality Standards certified in-house laboratory by major certification ISO 9001, ISO 14001, OHSAS 18001 and ISO 50001 to be used in the construction sector.

Target market: **IDS/IBLU:** steel industry. **FENO:** construction sector.

Competitors: coke providers, and other sector with carbonaceous residues that need treatment.

IRP Strategy: commercialisation for industrial application.

Time to market: 3 years after the project ends.

3.2 DESCRIPTION OF SECTOR SPECIFIC BUNDLE CONFIGURATIONS

The different solutions of polynSPIRE are tested in TRL 7, each one in a specific way and in a different sector depending on its application on the market.

As stated in the GA section 1.3.5 (TRL analysis), the developments are demonstrated in these ways:

- For the depolymerisation assisted by MW (Result 1), a chemical reactor was designed and will be manufactured for the recycling process of PA and PU plastics, and the final results will be validated in industries, mainly chemical companies. This reactor along with component separation processes, that is able to recover usable and high-quality monomers to be re-introduce at the beginning of the value chain of plastics creation, can be exploited as an innovative solution, that currently has been only tested at lab scale by other projects (e.g. DEMETO), making an advance from TRL5 to TRL7.

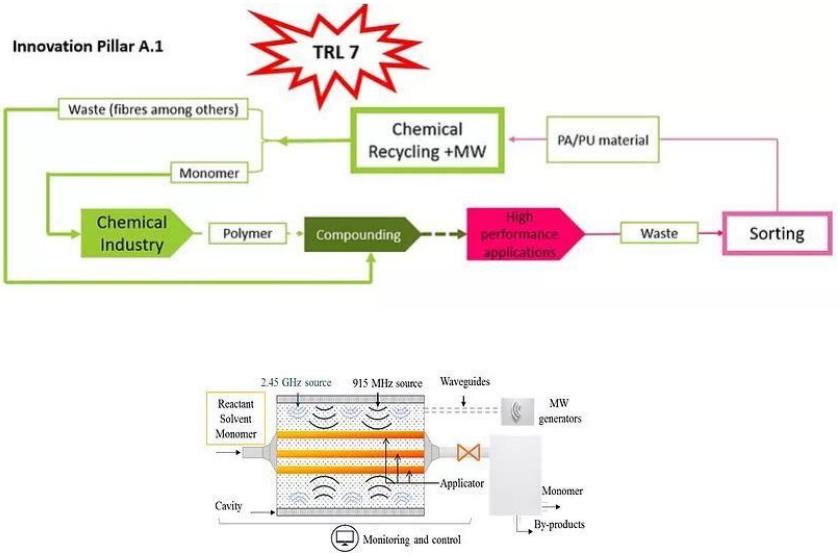

Figure 2 – Diagram. Innovation 1.1

- For the depolymerisation assisted by SMM (Result 2), a pilot that includes a reactor and separation unit will be built, and its performance will be demonstrated by processing PA and PU residues and will also be validated in chemical companies. The exploitable result will be a novel depolymerisation process and a unit within the next 4 years after the end of the project, making an advance from TRL5 to TRL7.

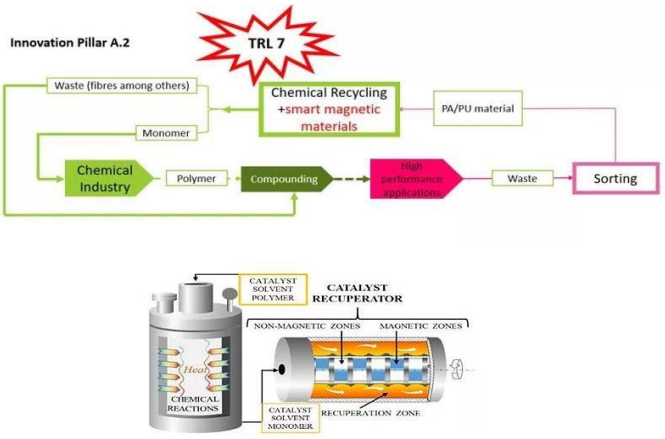

Figure 3- Diagram. Innovation 1.2

- Vitrimer formulations will be applied to plastics residues, tested and validated at industrial level with PA and PU to enhance the quality of the residues and give them a second life, which translates in exploitable knowledge and an improvement from TRL4 to TRL6.

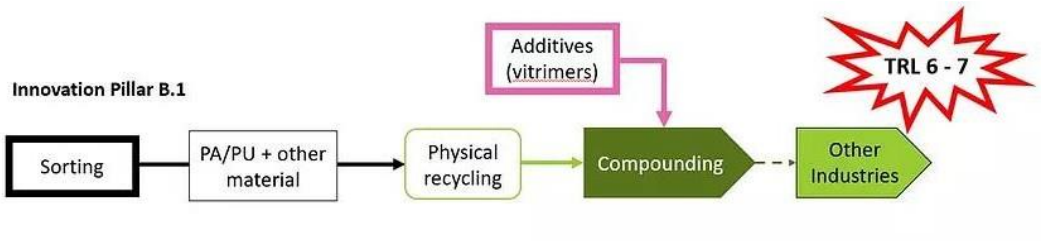

Figure 4 – Diagram. Innovation 2.1

- A study of different and innovative additives, including the ones coming from chemical recycling process, is being carried out to see their usability in masterbatches and final plastic pieces and demonstrated and validated at industrial level. This knowledge could be exploitable for the automotive sector, among others. These functional masterbatches will be able to be produced on industrial processes withing the following 5 years after the project, going from a TRL5 to a TRL7.

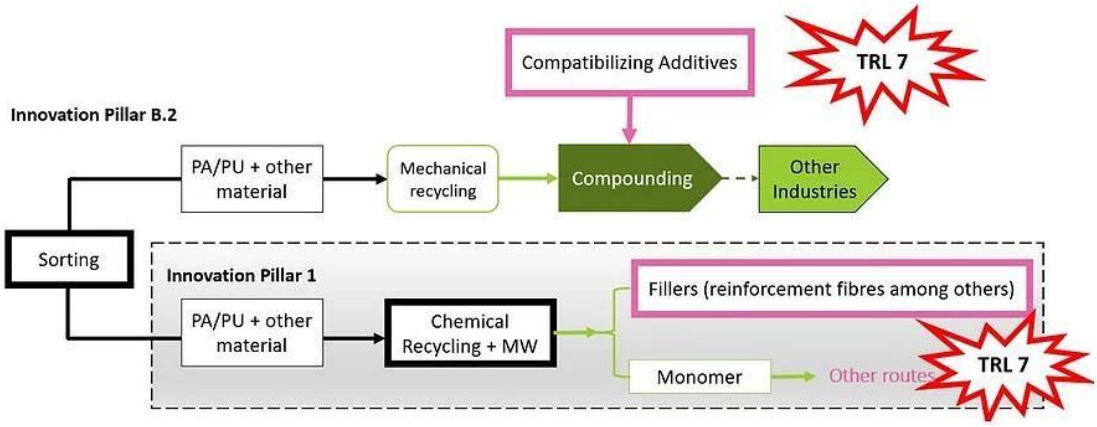

Figure 5 – Diagram. Innovation 3.1

- An application of high energy radiation processes to PA and PU waste, upgrading their properties to manufacture high-quality products able of satisfying market requirements have been developed and tested. The exploitable result will be able to process systems based on high energy radiation treatments integrated in standard manufacturing processes of plastic components coming from waste materials. The aim is to obtain recycled plastic materials improving their mechanical and thermal properties. This result will go from TRL4 to TRL6.

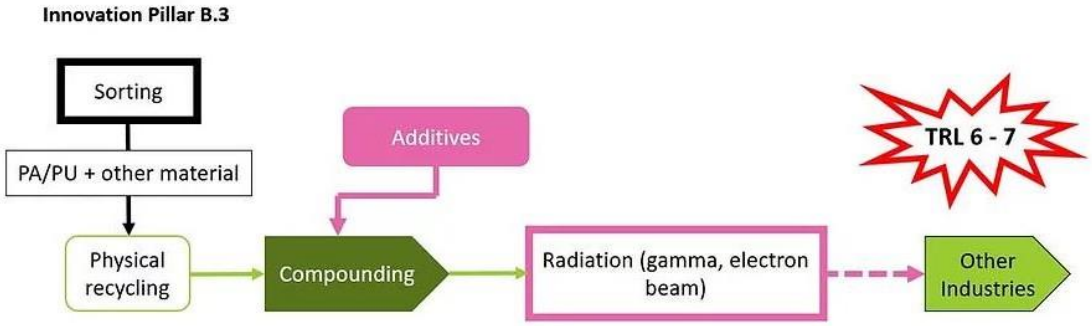

Figure 6 – Diagram. Innovation 3.2

- A fully operative injection system of plastic was designed, manufactured and installed in a real EAF at industrial scale, demonstrating that polyolefin and non-recyclable fractions of PA and PU can be used as raw material (as carbon supply and foaming agent) for the steel industry, reducing the use of fossil fuels such as coal, for steelmaking processes. This result will be possible almost at the end of the project, possibly with a TRL 7-8 paving new ways to do business.

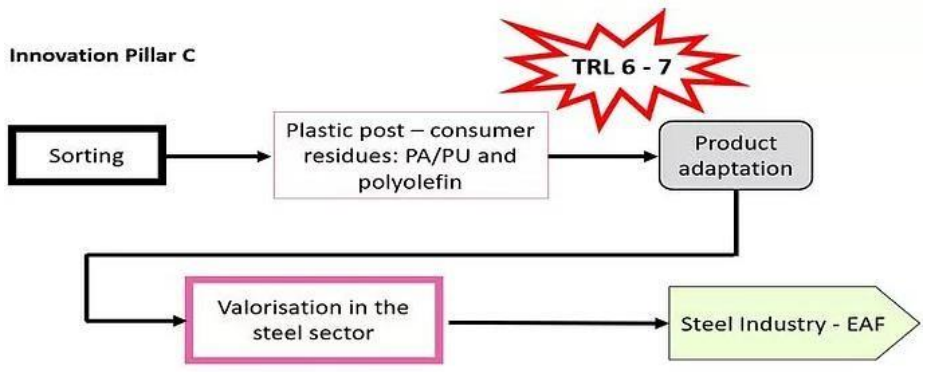

Figure 7 – Diagram. Innovation 3.3

4 CUSTOMER ANALYSIS

To identify customer segments and analyze their specific needs and expectations that the polynSPIRE results can address, this report uses the information that was collected for the Grant Agreement and described in the ANNEX 1 (part B). According to the Canvas Business Model of this document the main beneficiaries will be plastic waste managers, manufacturers of plastic products, technology providers and both chemical and steel industry for the exploitation.

4.1 TARGET CUSTOMER SEGMENTS: NEEDS AND POLYNSPIRE SOLUTIONS

The customer segments will be analysed and categorized according the three main innovations of the solution: Chemical Recycling, Mechanical Recycling and Valorisation.

Innovation 1: Chemical Recycling

Table 1 -Customers segments for Innovation 1

Key Result	Target Audience	Needs and Polynspire Solution	Type of Result
MW depolymerisation system and technology.	Chemical Industry, Waste management companies and Plastic manufacturers.	In the usual chemical recycling process, half of the properties of plastic are lost and to recover them they must be mixed with virgin material, which is a costly process. This result avoids these extra costs, making recycling more appealing and desirable, using the least amount of energy possible.	**Knowledge:** safety regulations, knowledge of the combinations of raw materials within microwaves to obtain the expected result. **Chemical reactions processes.**
Chemical recycling assisted by Magnetic Smart materials system and technology.	Chemical Industry, Waste management companies and Plastic manufacturers.	The process of separating materials within recycling is a tedious and complicated process that can require a lot of time and skills. This result allows the use of magnetic substances to obtain a better separation of plastic materials.	**Knowledge:** Magnetic Smart materials system knowledge to separate monomers.

Innovation 2: Mechanical Recycling

Table 2 - Customers segments for Innovation 2

Key Result	Target Audience	Needs and Polynspire Solution	Type of Result
Efficient systems for upgrading plastic residues.	Compounders, Automotive and Plastic converters.	During the most common process for recycling, mechanically, plastics and weaker products are usually obtained, with poor quality and highly mixed materials. With this result it can be irradiated with rays to modify the atoms and improve their properties and thus obtain better quality in recycled plastics and its residues.	**Know-how:** knowledge about how to use the systems of high energy radiation to improve plastics residues.

Innovation 3: Revalorisation via High quality steel

Table 3 - Customer segments for Innovation 3

Key Result	Target Audience	Needs and Polynspire Solution	Type of Result
New polymers coming from recycled monomers.	End user industries (automotive, construction, etc.), Plastic manufacturers and Steel Industry.	Companies that manufacture plastics whether, it is their main product or have the need for specific parts, need a large amount of carbon and all the tedious and long process of extraction of it. These solutions seek to replace carbon with plastic itself, avoid or reduce carbon extraction, and give new value to plastic waste.	**Industrial system:** innovative system that will be demonstrated in large/industrial scale.
High quality blends and plastic pieces coming from plastic resides.			
Plastic injection system for EAF.			
High quality steel coming from recycled plastic.			

All these sectors identified are attractive to the polynSpire project since they can be provided with effective solutions to real necessities. In relation to the market, it is estimated that there will be easy access to it since despite the market size is big, plastics production in the EU is increasing day by day. In addition, it is interesting to mention the effort that countries y companies are making to promote the separation of waste and the replacement of non-recyclable plastics.

Other aspect to take into considerations are the transversal activities that are being made by some of the partners of the consortium such as the thermo-economic analysis of recycling that adds to the constant fight to improve the environment and to make the impact of industries lesser every year.

4.2 POTENTIAL MARKET

The market that has to be covered are the industries that have processes with polyurethane and/or polyamide and want to improve it, reduce costs and obtain better results overall. According to the D9.2 report, packaging, automotive and building & construction are the main end-use markets for PA and PU resins, and the biggest consumers of plastic within the EU are Germany, Italy, France and Spain.

- **Plastic manufacturers:** This is a large target segment that can benefit from practically all of the results of the project. PU have a lot of different applications and use like in shoe soles, insulation for refrigerators and freezers, sports clothes and many more; PA also have a variety of applications mostly as an industrial plastic being a thermoplastic with extraordinary resistance, used in making gears, packaging, bearings and mechanical components that will operate at high temperature.
  According to PlasticsEurope, an organization that represents polymer manufacturers active in the plastics sector in Europe, this is an industry in which about 60,000 companies operate, most of them SMEs. The plastics industry in Europe ranks 7th in the contribution to industrial value added: at the same level as the pharmaceutical industry and very close to the chemical industry.
  Only in Spain there are more the 7.000 plastic companies, including manufactures plastic products from recycled materials, companies that all fit the market potential when exploiting the results.

- **Waste managers:** In 2020, more than 29 million tonnes of plastic post-consumer waste were collected in the EU27+3. More than one third was sent to recycling facilities inside and outside Europe but over 23% was still sent to landfill and more than 40% was sent to energy recovery operations.
  Currently the EU is betting on waste management, which is why different associations and government entities dedicated to the process have been created that can be interested in the results, in addition to private companies in this sector.
  One of the biggest companies dedicated to waste management are Sita, the main brand represented by Suez Environment´s waste subsidiaries in Europe, a company that operates in more than 15 countries in the EU and generates about 5.500M€ in sales. Onyx, property of Veolia Environment, also operates in more than 15 countries in the EU generating about

6.200M€ in sales. Veolia develops innovative solutions to increase the rate of waste recycling and conversion into matter or energy.
This is a key industry for the project because they will have the role of suppliers and collectors of the raw material necessary to use in the recycling technologies developed.

- **End users (automotive, steel, construction):** This target segment includes the large size industrial companies from the automotive, construction, steel sectors, among others, that operate with plastics components made from PA and PU. Packaging and Building & Construction by far represent the largest end-use markets. The third biggest end-use market is the Automotive Industry.
  As it is known, Polyurethanes are a solution to the need of special materials in construction since they allow an economic manufacture, and the Polyamides are used as parts of electrical components that will withstand high temperatures and high impact component parts (taking advantage of its strength and stiffness). Also, these plastics are widely used in the automotive sector, specifically in automobile manufacturing for the comfort, protection and energy savings it provides.
  Within the EU there are associations and sectoral platforms, both at national and European level, for example in the automotive sector in Spain a regional association for Aragón is CAAR (Cluster de Automoción de Aragón) and SERNAUTO (Asociación Española de Proveedores de Automoción) as a national one. At European Level there are CLEPA (European Association of Automotive Suppliers) and ACEA (The European Automobile Manufacturers' Association), which represent an important market when exploiting the results.
  In the construction sector, the AEEBC (Association d'experts Européens du bâtiment et de la construction) represents Building and Construction Experts who are professionally qualified in the technological and management processes and FIEC (European Construction Industry Federation) are some of the European associations within this sector.

- **Furniture/mattresses manufacturers:** This target segment includes middle- and large-sized companies, which design, develop and manufacture furnaces, including mattresses, from scratch making their foams from the very polyols and from previous used products that can go through a recycle process, in the manufacturing process of this product there are important quantities of polyurethane embedded in the wood, furniture padding and is also used as packaging for delicate equipment.
  Some of the largest furniture manufacturers in Europe are: Vitra from Switzerland, Kinnarps from Sweden, Poltrona Frau from Italy, Nowy Styl Group from Poland, Pikolin from Spain and Royal Ahrend from Netherlands, to mention a few.

- **Environmental management companies:** In all Europe there are more than 10.000 environmental management companies that specialize in different areas of the environment, going from water treatment, land management, for the plastic waste and recycling industry we can identify more than 20 companies like Erdwich in Germany, Geolinks in Bulgaria and Waste and Chemicals in Italy that can later be potential customers of the knowledge and solutions generated by the project.

- **New potential market: Chemicals and tires sector.** During the development of the project, international and European companies from the chemical and from the tire sector have reach out to the project coordinators to express interest on the recycling technologies that are being developed in the project for PA an PU.
  According to the European Commission, **chemicals industry** is one of Europe's largest manufacturing sectors. As an 'enabling industry', it plays a pivotal role in providing innovative materials and technological solutions to support Europe's industrial competitiveness. The chemicals industry produces petrochemicals, polymers, basic inorganics, specialties, and consumer chemicals. It represents around 7,5% of EU manufacturing by turnover and has sales amounting to €565 billion (2018), which is about 17% of global chemicals sales.
  The **Europe tire market** exhibited stable growth during 2015-2020. Rising demand for electric vehicles coupled with strong domestic production represents some of the key factors supporting the market for tires in Europe. The region, however, witnessed a sharp decline across both the OEM and the replacement sector as a result of the COVID-19 outbreak. As a result, the market is expected to witness a considerable decline in 2020. IMARC Group expects the Europe tire market to grow at a CAGR of 2.8% during 2021-2026.

4.3 MARKET DRIVERS AND BARRIERS

An assessment of different general framework factors that can affect positively or negatively to the deployment of the results in the market has been carried out using the PESTLE approach:

POLITICAL AND LEGAL FACTORS (P/L)

Any plastics waste management and plastics recycling activity that takes place in EU Member States occurs under the European legal framework because the EU sets the rules, criteria of action, and main objectives.

The EC has drafted several legislations to be applied to plastics and post-consume plastics. Analysing the regulatory barriers that impede the economic opportunities in a European circular economy is a polynSPIRE goal analysed in detail in the D9.3.

The Directive 2008/98/EC on waste framework defines the permits and registrations of waste treatment, and it is coupled with the Regulation (EC) No 1013/2006 which determine the procedures for transboundary waste transport. In addition, Directive (EU) 2019/904 of 5 June 2019 is the newest and most relevant as far as polluting plastics are concerned; it lists exhaustively the contaminant elements and explain the treatment that must be done with each one. It intends to reduce the consumption of this type of plastics and calls the Member States to ensure separate collection.

Several case studies identified regulatory barriers often related to lacking legislation that would allow the collection and pre-treatment of homogenous waste streams. Without specific legislation, many waste streams end up as mixed waste where high-quality recycling costs are higher than the income from its recycled materials (e.g. in the field of plastic packaging). Other type of barrier referred to legislation that

hinders the use of recycled materials in production processes is the rationale behind such legislation is frequently motivated by aspects of health and consumer protection and often undermines opportunities and benefits of circular approaches. In addition, in many cases, a lack of harmonized EU legislation mandating specific quality requirements has been identified as a major obstacle to high-quality recycling.

ECONOMIC FACTORS (E)

Energy markets and its prices influence economic decisions. Traditional plastics are made from oil and carbon. During the last years, the oil price has decreased therefore the plastic production costs. And depending on this price fluctuations, can be more expensive to recycle a plastic piece than producing a new one. Nevertheless, oil reserves are finite, and the global oil production is expected to become costlier in the coming decades. However, economic barriers are mainly related to profitability or financial feasibility of the solutions to be implemented. Payback periods are crucial in decision making process in industries. Although it is true that slightly higher payback values are being accepted by companies when talking about sustainability and better energy performance, the sector has strict requirements on this. Other obstacles, such as availability of investment funds, priorities in core business and uncertainty in economic future could hamper the implementation of polynSPIRE at industrial level. As economic feasibility is cornerstone for market uptake, special care on business models will be taken during the whole project to overcome these barriers. Also, polynSPIRE will have the support of a bank entity which will support the project in order to have a higher implementation.

SOCIAL FACTORS (S)

Plastic industry is in general characterized by being conservative to the changes and implementation of new solutions. However, it should be noted as well that, at the end, people are the ones taking decisions in companies, so their awareness on sustainability affects directly. Economic feasibility is usually the main influencing factor at decision making. Nevertheless, it should be noticed that civil society plays and important role in resolving the climate change challenge. Individual behaviour is what shapes the economy, and it seems that it will become greener throughout time. polynSPIRE will make relevant effort in disseminating its results and benefits for a better society and a positive impact on day-to-day life.

TECHNOLOGICAL FACTORS (T)

The main technical barrier is the existence of competitive technologies that could improve performance or, at least, even high poorer technical characteristics, a technology that can provide better profitability or payback ratios. The consortium has made a strong effort in analysing the current trends and market, based on commercial but also scientific review. This analysis has concluded that polynSPIRE has huge potential and will be at the technological forefront if succeeds. The chemical recycling techniques and plastic injection system that were carried out in the polynSPIRE project have been tested at lab scale showing improvements in energy consumption and time savings. This fact, supported by relevant stakeholders from the business perspective, will provide the required capabilities to get into the market appropriately.

ENVIRONMENTAL FACTORS (E)

This project and its results will generate sustainable economic activity with resources savings or resource use, which works towards circular economy. Therefore, there are not barriers from the environmental perspective. Moreover, to ensure this, LCA, LCC and TE studies and perspective were pursued during the whole project in combination to the business model definition, to ensure sustainability.

4.4 COMPETITORS

For PA and PU recycling process, no alternative integrated solution was identified on the market, however, the market doesn´t stand still and it should be considered as competition the following categories:

- The current ways in which plastic is being produce: polymerization and polycondensation (using coal, natural gas, salt and the main component, oil).
- The different recycling processes: mechanical and chemical process.
- The products that are being marketed as more eco-friendly that can be a substitute for plastic packaging, pieces, etc. such as bioplastic: made with organic raw materials that come from renewable sources, such as banana, cassava, cellulose, legumes that contain large amounts of lactic acid, polysaccharides, polylactones, polylactides, soybean oil and potato starch.
- Reused products that in some industries can be re-marketed.

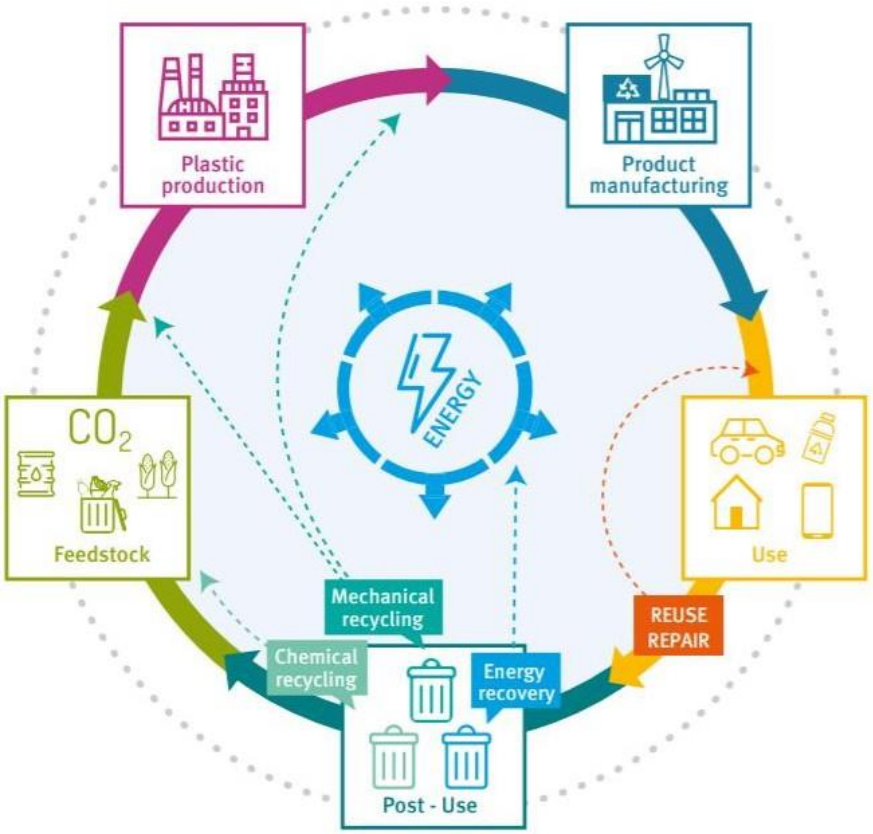

Figure 8 - Recycling circle image

4.4.1 Potential substitutes products

For the **PU** case, the demand for its products its increasing day by day, this is also generating more awareness to find a solution for the waste generated from these products. According to the D9.2 report **EUROPUR, energy recovery today (or waste-to-energy)** is the preferred technology for the treatment of EoL polyurethane flexible foam and is the one that is immediately able to divert great volumes of organic waste from landfills.

This recovery techniques based on incineration in order to regain energy, have environmental disadvantages due to the emission of atmospheric contaminants such as HCB dioxins and the emission of fine particles, which can be an advantage for polynSPIRE once its result become available in the market.

Recycling of sandwich panels process where is possible to extract in addition to the insulating material, the material of the outer layers. Polyurethane is recycled in fridge recycling plants, while steel is recovered in a shredder.

PA is currently being mainly recycled by the **melt extrusion technique** mechanically and its considered appropriate from the economic and environmental point of view. The chemical recycling process is another possibility to reduce the amount of PA waste. The purpose of **chemical recycling** is to recover and reuse monomers from PA plastic materials, obtaining the raw material to produce new PA polymers with identical properties than a new one. This method is used for polyamides as well as for polyurethanes and polyesters. The textile market has been recycling and using PA waste to manufacture their products.

A Porter Five Forces analysis was made to analyse the level of competition within an industry and business strategy development and therefore, a good approach to examine the barriers that are expected to be found during "market competition", in order to determine if the technological solution proposed is attractive or not.

The analysis has been done for the 3 project's approaches: **the depolymerisation of PA/PU using Microwave assisted reactions and classical depolymerisation assisted by SMM; upgrading of plastic waste materials features by means of advanced additives, high energy radiation and techniques and post-consumer plastic waste for its valorisation as carbon source in the steel sector.** The main conclusions are summarized next:

COMPETITIVE RIVALRY: plastic recycling is one of the main world challenges. Whereas most of the recycling processes consist in a physical recycling where the properties of the material suffer degradation, in chemical recycling processes, the monomer can be extracted from the polymer to be synthesized in new polymers which maintain the original conditions. Chemical industries can use this monomer which will have the same properties as virgin monomers do, reducing petrol-derived products and manufacturing energy consumptions. These techniques have been proved for PET and nylon from carpets at industrial scale and polynSPIRE will demonstrate them for PA and PU, which have already shown promising results at lab scale and currently Aquafil is carrying out at industrial scale for short chain PA. polynSPIRE will improve the current recycling technologies efficiency reducing 32% of oil consumption. Composites wastes can be complicated to separate into plastic and the rest of materials which conform the piece. Nevertheless, they can be directly recycled (by mechanical recycling) improving their technical features by means of vitrimers, advances additives or high energy radiation. Since vitrimers were recently discovered, their potential use

has not been totally studied and TUe who has experience on the subject will apply them to improve plastic features. Along with the new advanced additives that will be design by AITIIP, improvements with commercial additives will be brought into the market for specific applications. Packaging represents the 59% of the EU plastic waste generation. Packaging post-consumer are low quality plastics and most of them are designing for single uses. These characteristics make them hardly recyclable because recycling expenditures can be higher than manufacturing new plastics. Nevertheless, polyolefins can be used as carbon source for steel production. HTT will design a new injector able to treat plastics provided by IDS/IBLU in EAF which will be tested in FENO in continuous operation. New type of carbonaceous residues will be alsotested, provided by REPSOL QUÍMICA in order to reduce landfill and incineration, widening the plastic wastescope.

THREAT OF NEW ENTRANTS: in December 2015 the Commission adopted an EU Action Plan for circular economy in which new recycling strategies where studied. Avoiding plastic landfill and incineration is a key challenge for the EU commission as have been explained in the European plastic strategy. Considering these new strategies, it is expected that new competitors will enter into the recycling plastic market. However, new technologies and knowhow will be developed during polynSPIRE integrating the relevant actors of the plastic value chain in Europe. IPR issues will be considered before and after the project to ensure an effective protection and further exploitation of results. Three differentiated areas are being developed in the project with diverse partners that can exploit their own results and create synergies with the rest of the consortium due to the cross-links between them. Creating a plastic recycling network which will address all plastic waste types: high value and low value plastics, included in post-industrial and post-consumer plastics.

THREAT OF SUBSTITUTIVE PRODUCTS: the main advantage of polynSPIRE developments is to obtain virgin monomers that can be used to synthetize new polymers. To synthetize these monomers is the only way to obtain polymers that will be later converted into plastic pellets. Furthermore, NOVAMONT is testing these technologies for the production of Bioplastic, assuring its replicability in new markets. Therefore, the final products validated in the first pillar cannot be substitute by new ones. Plastic production has highly increased during the last decades and it is expected to grow a 250% by 2050. Moreover, Assisted MW reactions and chemical recycling with SMM will reduce energy and chemical products consumptions, reducing the OPEX. In addition to that, 1630 MT of steel where total global produced during 201679. And it is expected that in 2050 steel production will need 50% of virgin materials80. Steel has between 0.03% and 2.14% of carbon in its composition. Therefore, a total substitution of carbon in the steel manufacturing by carbonaceous plastic sources will help to reduce both, the use of virgin materials for carbon manufacturing and plastic waste.

BARGAINING POWER OF SUPPLIERS: raw materials for the project are assure due to the positive plastic production trend abovementioned. The main innovation actions carried out during the project is the know-how to be able to carry out the recycling and reutilization of plastics. Although specific technology will be implemented during polynSPIRE, components, materials, and equipment are already widely used, counting with large number or suppliers identified for this purpose all across Europe, strengthening the distribution channel. polynSPIRE will increase the demand of chemical reactor manufacturers, dropping suppliers' prices due to the scale-economy.

BARGAINING POWER OF BUYERS: chemical companies have shown interest in proving that their products can be easily recycled plus they are the only industries able to use monomers to produce new polymers. The greatest polynSPIRE advantage is that polymer´s manufactures who will produce the polymer which will be later converted into plastic waste will be the main buyer of the final product. Therefore, the usage of the resulted products is assured. Due to the awareness campaigns that have been made during the last period, both private and public sector are committed to reduce plastic waste and to utilize green materials made from recycled products. MAIER is using recycled PA to be used in the automotive sector, giving added value to automobiles brands suiting with social green requirements. Steel sector is one of the main worldwide economies and its processes are not optimized to fit with the latest European roadmaps for the following decades. Including waste materials as substitutes for virgin ones without any detrimental effect on the steel quality will attract the steel sector and will stablish links between the chemical and steel industries, waste managers, and final users.

The conclusion of this analysis is that all three pillars, if developed successfully, **group a wide number of residues and industries that solve the European´s necessities regarding plastic waste treatments.**

4.5 RADAR TECHNOLOGY

According to the report entitled "*Patents for tomorrow's plastics: global innovation trends in recycling, circular design and alternative sources",* between 2010 and 2019, Germany and France assumed 56% of the patents in the bioplastic's technology family. On the other hand, the United Kingdom, Italy, Holland and Belgium also stand out for their specialization in both plastic recycling and bioplastics technologies.

When mentioning Spain, it is indicated that between 2010 and 2019 it had the third highest degree of specialization within Europe in recycling and bioplastics. Thanks to that it has contributed within the EU with 5% of international patents on bioplastics and 4% of all patents on plastic recycling.

Overall, European countries present a positive outlook for technologies that address the recycling and reuse of plastic waste. Many companies invest in innovative solutions and R&D projects in the search for more efficient technologies.

Looking for developments for the recycling of PA and PU, no patents have been found in force today. However, it can be mentioned the dissolution recycling: a purification process through which the polymer present in a mixed plastics waste is selectively dissolved in a solvent, allowing it to be separated from the waste and recovered in a pure form without changing its chemical nature. This can be applied to different polymers including PA.

As for trends for the future, it is shown that the area of alternative plastics has grown exponentially in recent years, with an average annual growth rate of 10% since 2010. A EU Horizon 2020 collaboration showed that fungi can be incorporated into smart, sustainable textiles. The building industry has also shown interest in mycelium, exploring its use as a thermal and acoustic insulation product. While new technologies are developing, reducing plastic packaging waste by using a cost-effective, biodegradable, and sustainable alternative is within reach.

5 RECOMMENDATIONS

A SWOT analysis was made to summarize the recommendations according to the characteristics and opportunities of the solutions of the project:

5.1 SWOT ANALYSIS

A SWOT analysis of the solutions of polynSpire was made to compile its strengths, weaknesses, opportunities and threats in the market, getting input from what was stablished in the agreement and seeking information of how the plastic market is currently behaving, with the objective to help the consortium develop a full awareness of the many factors involve once the project ends and it´s time to exploit the results.

Table 4 – Text of SWOT analysis

Based on the SWOT analysis, the following strategic recommendations can be proposed:

-Seize opportunities with business associations within Europe in target sectors.

-Accentuate the positive impact for the market and for society within the available platforms, internal contacts and the press.

-Record and disseminate large-scale demonstrations carried out.

6 CONCLUSIONS / CONTRIBUTION TO THE SPIRE ROADMAP

As stated in the GA, the three innovation pillars contribute to the key components of the SPIRE Roadmap6, in particular to the following **key actions (KA):**

- **Optimal valorisation of waste, residues streams and recycled end-of-life material as feedstock (KA 1.2).** A cascade approach enables the optimal valorisation for each stage, maximizing the global valorisation rate. This is achieved due to efficient plastic waste chemical recycling (Innovation A), the quality enhancement of recycled plastic materials (Innovation B) and the valorisation of lower grade plastic waste as a carbon source for the steel industry (Innovation C).
- **Development of more efficient systems and equipment (KA 2.4).** Innovation A involves two alternatives for chemical recycling: (i) use of microwaves, completing reactions in minutes instead of hours, and at least a 68% of energy saving; and (ii) use of smart magnetic catalysts to increase efficiency by 60%, even using milder conditions.
- **Process monitoring, control and optimisation (KA 2.3).** polynSPIRE considers an "Industry 4.0" approach, therefore, all processes and technologies will be carefully analysed and optimised under a wide range of industrial conditions to reach smart productions able to adapt processes needs, while achieving a resource efficient consumption.
- **The holistic approach of polynSPIRE provides a deeper knowledge of the processes at system level (KA 4.1)** and a **better integration of the three innovation pillars under a life cycle and costs perspective methodology (KA 5.2).** This will be achieved by developing a comprehensive analysis to describe the entire plastic sector recycling scheme and its expected evolution, taking into account both, industrial perspectives and EC roadmaps.

The solutions covered in this report comprise a set of technologies that aim to improve the energy and resource efficiency of plastics recycling processes containing materials through different methods. One of the most important objectives of polynSPIRE is to deliver these solutions to the market for its exploitation and that is why this analysis of potential market, competitors and barriers to its implementation has been carried out.

That said, it is concluded that the main customer segments that can benefit the most from these solutions are:

a) End user: industries that have in their manufacturing processes materials made of PA and/or PU and can benefit recycling said plastics for its reutilization;

b) Plastic material manufacturers, waste management and environmental companies that can use these technologies in their processes;

c) Chemical industries that will be able to obtain better quality from the materials.

In this final deliverable, the executive summary and the introduction have been updated, briefly mentioning the adjustments that have been made in the document. In addition, the developments of polynSPIRE

solutions as well as the individual solutions of the Project have been updated to determine at what level each of the technologies is located. On the other hand, valuable information has been incorporated into the Potential Market to delve into the target industries and the possibilities of exploitation.

As for the barriers, it has been identified that the most important would be the legal or regulatory ones and that is why a summary of the main rules that relate to the exploitation of the results of the project has been made (the information is complete and detailed in the deliverable 9.3).

Finally, a radar technology has been incorporated and the main recommendations related to the exploitation of the results of polynSPIRE have been concluded.

LIST OF FIGURES

LIST OF TABLES