CIRCULAR FoodPack

D8. 5 A COMPLETE BUSINESS MODEL(S) BASED ON THE BUSINESS MODEL CANVAS METHODOLOGY

WORK PACKAGE 8

Associated Task(s): T8.2
Exploitation of Results, Innovation Management and Technology Transfer

Lead Partner: NTUA
Partners involved: ALL
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ABBREVIATIONS

Abbreviation	
B2B	Business-to-Business
B2C	Business-to-Consumer
BMC	Business Model Canvas
CEO	Chief Executive Officer
CMO	Chief Marketing Officer
COO	Chief Operating Officer
EC	European Commission
EU	European Union
EVOH	Ethylene-Vinyl Alcohol
IPR	Intellectual Property Rights
KER	Key Exploitable Results
KPI	Key Performance Indicator
PCRs	Post-Consumer Recyclates
PE	Polyethylene
PET	Polyethylene Terephthalate
QAS/DSS	Quality Assurance System/Decision Support System
SWOT	Strengths, Weaknesses, Opportunities, Threats
TBS	Tracer-Based-Sorting
WP	Work Package

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PUBLISHABLE EXECUTIVE SUMMARY

In this deliverable, the most promising technologies in terms of market penetration have been identified and grouped in three (3) Key Exploitable Results (KERs). These include the development of laminates containing recycled PE for food or non-food packaging application (KER No.1: Design 4 PCR- meaning design for and from recycling), the optimization of the whole process chain for producing high-quality recycled PE (KER No.2: Sorting and Physical recycling cascades), as well as the development of innovative and improved testing concepts for compliance / safety assessment of recycled materials (KER No.3: PCRs with certified quality). Three different business models were created based on the business model canvas methodology (BMC), describing the value proposition, customers, channels, key resources, key partners, key activities, and structure of revenue and costs. The aspect of environmental and social impact was also incorporated into the BMCs, describing the possible environmental and social benefits and costs.

The business model canvas for KER1 describes the value proposition of recyclable mono-materials for food or non-food applications containing PE recyclates. The laminates are machinable at the existing packing production lines and are in line with European regulations for reduced use of virgin PE and incorporation of recycled material into the final products. In addition, they contain functional barriers and tracers in the printing inks for sorting, tracing and waste management after use. The customer base is divided into several key interest parties, such as packaging production companies or retailers and the revenue streams include sales of food packaging containing recycled PE, as well as tax and fee reduction due to the use of recyclates.

The value proposition for KER2 includes the production of high-quality recycled PE, the development of a new whole process chain - consisting of different technical steps - for PE recycling, the enhancement of environmental performance due to the reduction of the use of virgin PE and the limitation of plastic waste. New technologies for recycling and sorting are proposed, competing with the widely used conventional ones. KER2 refers to sorting and recycling companies, packaging production companies, as well as ink and tracer producers and retailers. The main revenues come from sales of offering services to waste management companies, sales of recycled PE to plastic packaging companies, as well as tax reduction due to the use of recyclates.

KER3 proposes the production of high-quality PE recyclates, as well as the introduction of innovative and improved protocols for testing the quality, safety and shelf-life of recycled materials, and is addressed to providers of raw materials, packaging production companies and plastic industries.

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1. INTRODUCTION

Work Package (WP) 8 aims to ensure commercial integration of CIRCULAR FoodPack technologies by implementing comprehensive market analysis and developing business and organisational models. The identification of consumers demands and preferences is based on market research using qualitative and quantitative methods, engaging surveys with consumers (Business-to-Consumer; B2C) and experts (Business-to-Business; B2B). The sectors that create a value for business customers are identified and analysed. The key exploitable results of the CIRCULAR FoodPack project have also been identified, taking into account the innovations of the project, the technical partners' opinion, as well as the market and consumers demands. The potential of integration of the key exploitable results into the market is evaluated through the development of business models using the Business Model Canvas (BMC) methodology. The business models are developed based on the customers' needs and preferences and determine the most promising and sustainable technologies for sorting and recycling of food packaging films, as well as for producing packaging films for food and non-food applications. In addition, in order to enhance and boost the market acceptance of the CIRCULAR FoodPack innovations, a SWOT analysis is implemented, identifying the strengths, weaknesses, opportunities and threats of each KER that affect market integration, proposing solutions to overcome existing bottlenecks. In addition, WP8 is responsible for the dissemination and communication of the CIRCULAR FoodPack findings, developing a complete communication and dissemination package for creating brand awareness and making the project's achievements accessible to the wider scientific and industrial community, including waste, recycling, converting and packaging end-users.

The specific deliverable is linked with Task 8.2: Exploitation of Results, Innovation Management and Technology Transfer that includes the development of business plans that are developed based on the Business Model Canvas (BMC) methodology, describing the actions that have to be taken in order to reach a successful market introduction of the project innovations. The technical feasibility of the project's innovations is assessed by identifying opportunities and pitfalls, market barriers, etc. An IP assessment is also taking place focusing on the ownership, the nature of the knowledge, its potential for exploitation, and the measures that are required to ensure protection of IPRs.

In the specific deliverable, the most promising technologies in terms of market penetration have been identified and grouped in three (3) Key Exploitable Results (KERs) and a business model for each one has been developed based on the BMC methodology. The key business components, such as value proposition, customer segments and relationships, communication channels, key activities and resources, key partners, cost structure, as well as revenue streams have been identified, separately, for each KER. Furthermore, the organizational, ownership and partnership structure for the market launch of the proposed solutions is provided.

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1. METHODOLOGY

In order to develop the business model that will promote the industrial uptake of CIRCULAR FoodPack achievements, the key parameters that are important for market acceptance have been defined. In the context of Task 8.2 data were collected, organized, and analyzed for implementation of the business model of the developed CIRCULAR FoodPack technologies and products. The collection of the required data was conducted using various methodological tools. Desk research was carried out, with the aim of collecting the necessary data from previous deliverables (D8.3 Progress report on market analysis, D7.4 Defined scenarios and data inventories for final sustainability assessment), as well as literature. In addition, teleconferences, or meetings with the technical partners were held, and questionnaires were circulated to obtain the missing data and decide on the Key Results that can be exploited after the project end.

2.1. Selection of KERs

The selection of KERs was based on the list of KERs that were already identified from the proposal submission stage. Among these, three (3) KERs were sorted and selected based on the following methodology[1]:

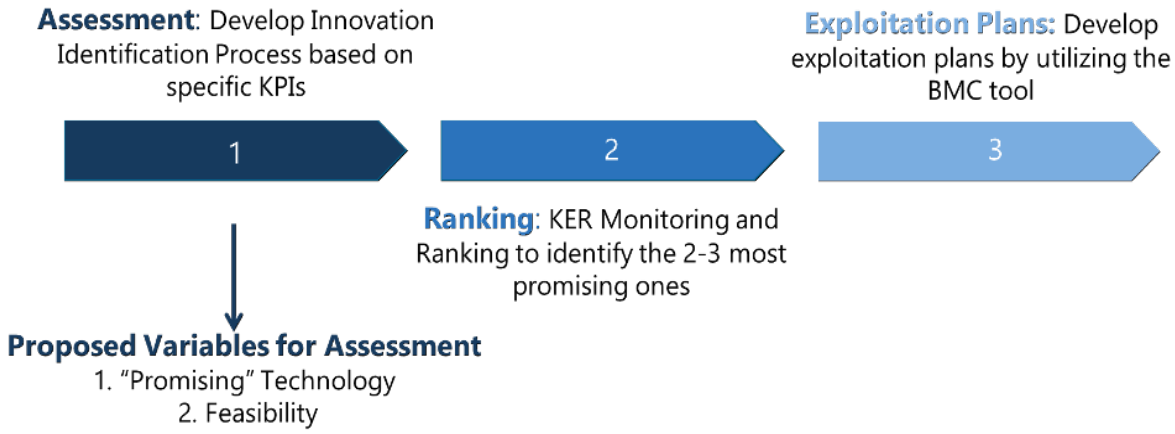

Figure 1: Methodology for KER selection (Adapted from: European Commission (2012))

For confirming the key exploitable results/technologies, a questionnaire has been circulated to the project partners containing questions on general information and details on the stakeholders' profile, innovation and maturity of the technologies, market potential and competitive advantages, required resources and economic feasibility of the proposed solutions (Figure 2). The developed questionnaire is presented in the Annex.

[1] Adapted from: *European Commission (2012), Evaluation of Innovation Activities: Guidance on methods and practices, US Government Accountability Office (2016), Technology Readiness Assessment Guide , Kavoos M., Laxman S. (2014), A Criteria-based Approach for Evaluating Innovation Commercialization*

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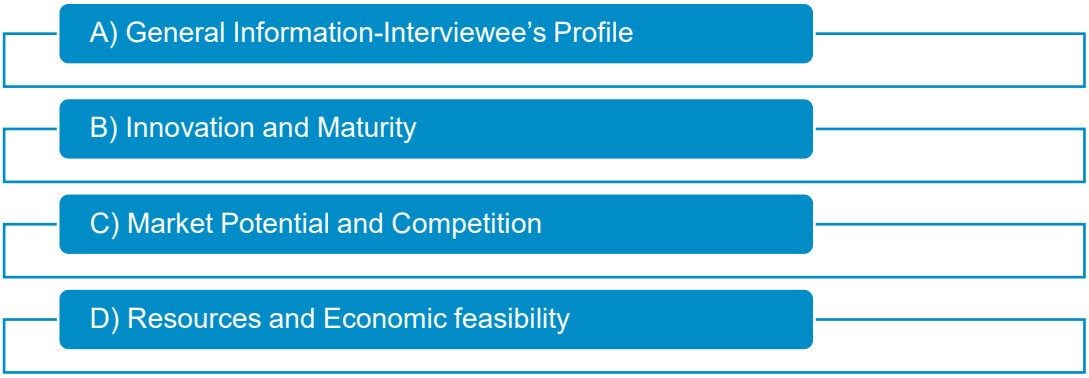

Figure 2: Questionnaire's structure

The creation of the questionnaire was based on two variables:

- Promising Technology
- Feasibility

The parameters that were taken into consideration to calculate each variable were based on the methodology shown in the next figure.

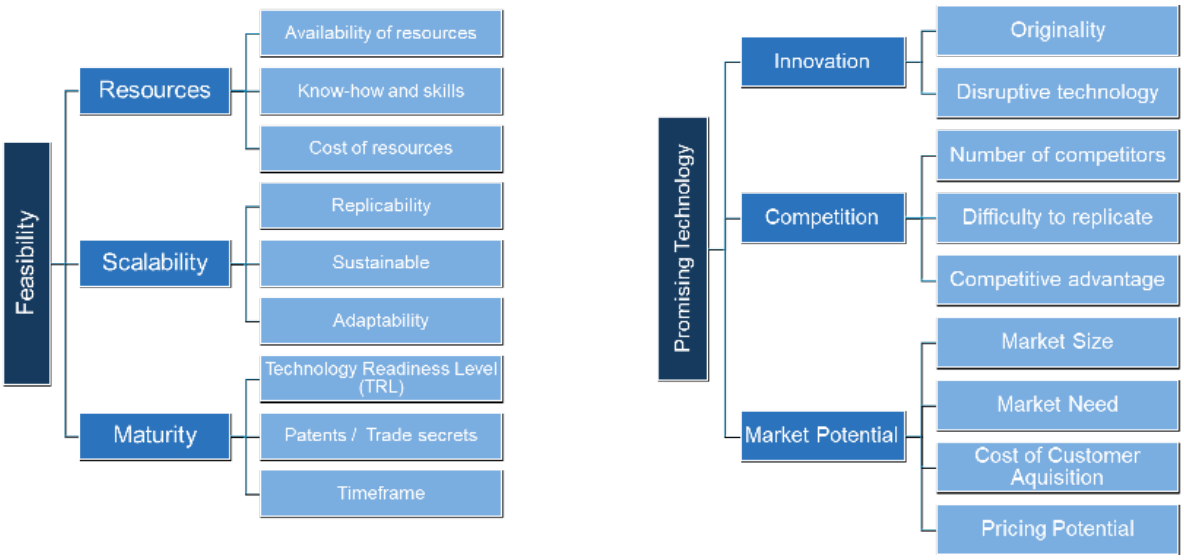

Figure 3: Parameters and sub-parameters for assessment

The classification of the KER's was among four groups, according to the ranking they receive on "Feasibility" and "Promising Technology" variables (Figure 4). The four groups of classification are:

1. Promising Exploitable Results → Identification of top three KERs that will be exploited.
2. KER with difficulty in execution
3. Non applicable KERs
4. KER with low levels of innovation

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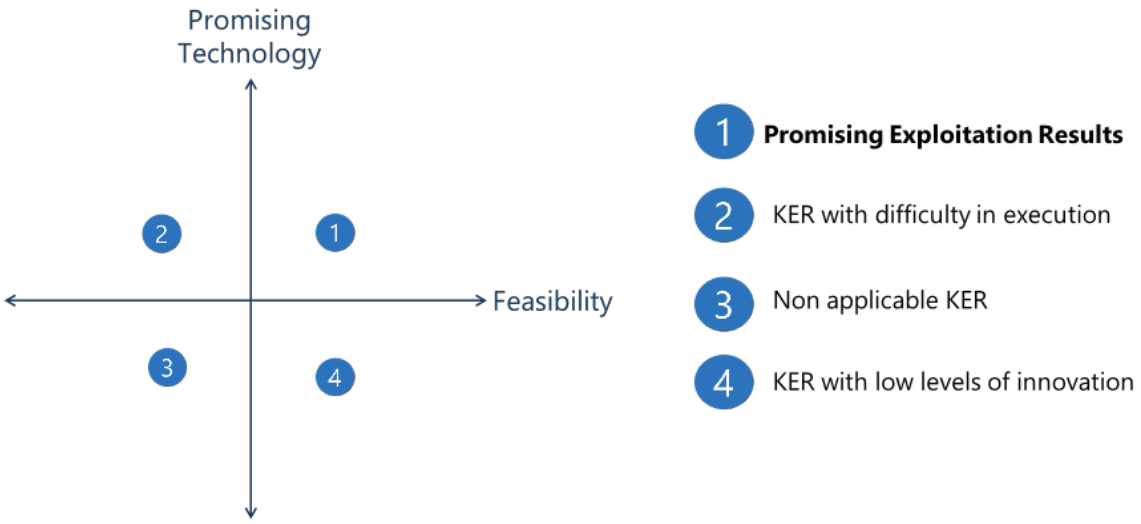

Figure 4: Innovation Identification Process: Ranking

Following the data collection through the questionnaires, a workshop was organised during the 4th GA meeting that was held in Paris (June 2022), to which all partners involved had the opportunity to discuss some of the issues raised in the questionnaires. Through this process, the 3 most promising Key exploitable results were identified, as given in Figure 5:

- Design 4 PCR (this means design for and from recycling)
- Sorting and Physical recycling cascades
- PCRs with certified quality

Provider:	KER No:	Content for Business Model	"Customer"
WP5	Design 4 PCR:	Recyclable mono-materials, Debondable primer+ink, tracers, functional barriers	Nestlé
WP3	Sorting and Physical recycling cascades	Pre-treatments, Mechanical recycling, CreaSolv®, post-treatments	SUEZ
WP4	PCRs with certified quality	Analytics and modelling	Amcor

Different Business Models

Figure 5: Key Exploitable results of the project coming out from WP5, WP3, and WP4

Three different Business Models are developed with the customers being: Nestlé, SUEZ and Amcor, respectively, representing end-users (brand owners) from top target groups, like food companies, recycling companies and packaging material producing (converters) industries. The 3 different Business Models and exploitation plans are based on the Business Model Canvas (BMC) methodology.

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2.2. Business Models

The business model concept is widely used to transform entrepreneurial opportunities into specific ideas that are feasible and can be commercialized. The development of a business model offers a sustainable advantage over the competitors and is structured by identifying:

- the value proposition, that describes the solution offered in order to solve a customer's problem or to provide value to the customer
- the market segment, that describes the market that can adopt the proposed solution
- the value chain that will lead to achieving the value proposition
- the costs and potential profits of adopting the value proposition
- the potential competitors, as well as end-users of the value proposition

Among the various methodologies that have been developed for structuring a business model, the Business Model Canvas (BMC) is an advanced way of presenting the key elements and the actions required to prepare a sustainable and successful market introduction of the project innovations. The BMC was developed for gathering all the elements that constitute a business idea. The Business Model Canvas consists of nine building blocks, namely the:

- **Value proposition**: It describes the proposed business case, the proposed processes or products, the advantages and disadvantages it offers, as well as the customer needs that the proposed business case satisfies.
- **Customer segment**: It describes the customers of the value proposition, the characteristics of the market, the locality or the wideness of the customer segments.
- **Channels**: The block of channels refers to the ways of disseminating the value proposition and of communicating with the potential customers.
- **Customer relationships**: It describes the type of relationship with the customers, the time framing, the data exchanged, etc.
- **Key activities**: The major activities that are required for the creation of the value proposition, the communication with the customers, and the creation of revenues are described in the specific block of the BMC.
- **Key Resources**: Also, the major assets that are required for the creation of the value proposition, the communication with the customers, and the creation of revenues are described in the specific block of the BMC.
- **Key partners**: The key partners, the key suppliers, as well as the activities they conduct are mentioned in this block.
- **Revenue stream**: It describes the source of revenue, the sales efficiency and the costing of the value proposition.
- **Cost structure**: The basic costs required for the realization of the value proposition as well as the most expensive processes are described.

In CIRCULAR FoodPack, the environmental and social aspect of the proposed technologies have also been considered during the construction of the BMCs.

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2. CIRCULAR FOODPACK BUSINESS MODELS

3.1. Description of KERs

The three most promising Key exploitable results that were identified in the frame of the CIRCULAR FoodPack project are:

Figure 6. Key Exploitable Results of CIRCULAR FoodPack project

KER No.1: Design 4 PCR, concerns the development of the laminates that are intended for food and non-food packaging. The business case includes the value chain of laminate production that also incorporates debondable ink and primer production, as well as tracer production and integration in the laminates. The data required for developing the value proposition and analysing the components of the BMCs are extracted from WP5 Design for Circular Food Packaging, including the selection of the functional barrier formulations, the production of recyclable PE-based mono-material multilayered films through extrusion, incorporating the produced recycled PE, and the printing of tracers and inks that enable identification and managements after use.

KER No.2: Sorting and Physical recycling cascades describes the processing chain for sorting and recycling the packaging waste in order to produce high-quality PE recyclates. The processing chain includes the pre-treatment methods, recycling technologies and post-treatment methods required:

- Collection and sorting
- Pre-treatment (oversorting, shredding, washing, grinding and float-sink separation)
- Purification and recycling (Dissolution-based purification and recycling (Creasolv®), Water-based purification (delamination, deinking) and mechanical recycling (recompounding: densification, melting, pelletizing))
- Post-treatment (deodorization)

KER No.3: PCRs with certified quality regards the provision of high-quality PE recyclates, evaluating the performance of the PCRs and the compliance with regulatory safety requirements. In addition, the business case includes the development of innovative and improved testing methods for evaluating the compatibility of recycled materials with food products, their safety when incorporated in food packaging, as well as their purity.

Three (3) different business models have been developed for the three identified KERs. The Business Model Canvases for the three KERs are described in the following sections.

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3.2. Business Model Canvas of KER No.1: Design 4 PCR

The Business Model canvas of KER No.1: Design 4 PCR is presented in the following table.

Table 1: Business Model Canvas of KER No.1: Design 4 PCR

<table>
<tr>
<td rowspan="2">Key Partners
• Film/Packaging production companies
• Packaging converters
• Plastic recycling companies having adapted the Circular FoodPack technologies
• Functional barriers manufacturers/ providers
• Tracers for identification and sorting manufacturers/ providers
• Ink producers
• Virgin polymer providers
• Quality evaluators
• Distributors
• End-users</td>
<td>Key Activities
• Development of PE-based mono-material laminates with target properties
• Performance of laminates
• Development of functional barriers with desired properties
• Development of tracers for identifying and sorting of packaging films after use
• Film/Packaging production
• Interaction with food and non-food end users
• IPR management</td>
<td rowspan="2">Value Proposition
• Final flexible recyclable mono-materials for food or non-food applications containing PE recyclates with performance similar to virgin PE
• Mono-material laminate that is machinable at the existing packing production lines
• Films containing PE PCR, functional barriers and tracers in the printing inks for sorting
• Reduced use of virgin PE
• Recyclable packaging materials in line with European Recycling Regulation No 2022/1616
• Packaging and packaging waste directive (PPWD) of EU drives the companies and RTD towards recycling, packaging design, integration of PCRs, etc.
• Competitive advantage over companies using no PCRs in packaging
• Rapid tracing and management after use</td>
<td>Customer Relationships
• Relationship between producers of packaging material with PCRs and end-users of these materials
• Relationship between PE PCR manufacturers and packaging manufacturing companies for flexible films
• Communication with retailers</td>
<td rowspan="2">Customer Segments
• Flexible packaging production companies
• Food companies
• Other companies utilizing plastic packaging
• Retailers</td>
</tr>
<tr>
<td>Key Resources
• Equipment, raw materials, energy
• Existing packaging production lines
• QAS/DSS tools to select most feasible routes for packaging with recyclates, among others
• Personnel, Patents
• Financial resources
• Know-how on packaging and recyclable packaging
• Creativity, inventorship, innovation
• Speed to delivery</td>
<td>Channels
• B2B market
• Recyclate forums
• Social media and Website
• Personal communication with representatives from the entire packaging value chain
• Existing distribution channels
• Marketplaces
• Customers' network
• Supply chain relationship</td>
</tr>
<tr>
<td colspan="3">Cost Structure
• Equipment, maintenance and depreciation costs, upgrading of existing facilities
• Raw materials and utilities
• Costs for pre-treatment
• Personnel costs
• IPR protection fees</td>
<td colspan="3">Revenue Streams
• Sales of food packaging with recycled PE to food or plastic companies
• Tax and fee reduction (eco-modulation) due to the use of recyclates</td>
</tr>
<tr>
<td colspan="3">Environmental and Social Costs
• Addition of new technologies
• Social costs for increasing consumers awareness and convincing them about the benefits of using recycled packaging materials
• Consumer sophistication regarding mainly food packaging</td>
<td colspan="3">Environmental and Social Benefits
• Reduction of environmental footprint
• Recyclable packaging materials
• Compliance with European Recycling Regulation No 2022/1616
• Less dependency on fossil-based sources
• Customers are willing to pay higher prices for the Circular packaging</td>
</tr>
</table>

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KER No.1 targets the development of recyclable laminates containing PE recyclates for food or non-food applications that can be processed in existing packaging production lines, including functional barrier, and printed layers with tracers for sorting at the end of their lifetime.

3.2.1 Value proposition

The block of the value proposition refers to the proposed products, processes, or services, which provide a solution to a problem that a customer or a sector is facing. Packaging and Packaging Waste Regulation (PPWR) of EU drives the companies, as well as research institutes and organizations towards recycling, sustainable packaging design, and substitution of virgin plastic material with recyclates.

In the framework of the project, flexible recyclable mono-materials containing PE recyclates are developed. The recycling process of PE food packaging waste, as well as food and non-food mixed waste, has been optimized, targeted to produce recycled PE with properties and characteristics similar to the virgin raw material. Depending on the origin of waste and the selected recycling and sorting processes, both food and non-food applications are realized. The developed laminates are machinable and can be incorporated in the existing packing lines of the end-users, either regarding food or non-food applications. For the flexible food packaging applications, functional barriers and/or tracers contained in the printing inks are incorporated in order to prevent migration of any residual contaminants from the PCRs, as well as to make the collection and sorting more efficient, respectively. The tracing and management of the developed laminates will result in closed-loop systems and will enhance circularity, contributing to better environmental performance and reduction of greenhouse gas emissions. In addition, the substitution of part of the PE with the PE PCRs for the production of laminates result in the conservation of the virgin raw material enhancing the viability and sustainability of the process. The PE PCR content in the final flexible packaging laminate is aligned with the latest PPWR2. The developed materials will be in alignment with the current European Recycling Regulation No 2022/1616 that aims to increase the content of recycled materials in final applications, without compromising safety. The incorporation of CIRCULAR FoodPack innovations in the production line of flexible packaging production companies, or end users of food and non-food packaging will offer a competitive advantage over companies that has not yet incorporated recycled plastic into their materials or are using recycled PE of low quality.

3.2.2 Customer segments

The business model canvas includes different dimensions of the business entity among which is the **costumer segmentation**, which allows the company to orientate its efforts more effectively. In particular, the customer groups that can be interested in the CIRCULAR FoodPack laminates are segmented as below:

- **Flexible packaging production companies**: •Flexible packaging production companies can utilize the produced laminates for developing advanced packaging solutions that can provide quality and innovation to their products.
- **Food or non-food companies using plastic packaging**: In order for food to reach consumers, packaging is needed that provides optimal food safety and shelf-life, while meeting health

[2] Proposal for a Regulation of the European Parliament and of the Council on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC

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standards. There are also various other non-food industries that utilize plastic packaging to protect and transport their products. The utilization of PE PCRs for substitution of virgin PE offers competitive advantage, makes the branding of the company stronger and opens new markets towards environmentally conscious consumers and end-users.

- **Retailers**: Retailers can use sustainable packaging as a unique selling point for increasing their reputation among competitors and positively influence consumers, that demand eco-friendly products. Retailers that use packaging that contains recycled materials can develop more integrated waste management practices, targeting the goals for circularity and sustainability. In addition, the use of recycled polymers helps retailers comply with the continuously changing regulations on plastic waste management, as well as obtain eco-label or certifications that offer a competitive business model and differentiate them from the market.

3.2.3 Customer relationship

Customer relationships are a key aspect of a business model as they involve the contacts and the interactions that are established and maintained among the customer segments. In the context of the project, these are:

- **Relationships between producers of packaging materials containing PCRs and end users.** Producers of packaging materials that contain the developed recycled PE are expected to offer high-quality products that are tailored to the needs of end users, either in the food or in the non-food industry. Cooperation between them ensures trust and mutual understanding of the requirements and specifications of both parties. Continuous communication and feedback help end-users to get the advanced and sustainable materials they need, while producers improve their products and respond to market needs.
- **Relationships between PE PCR manufacturers and flexible film packaging manufacturers.** These parties need to maintain close collaborations in order to ensure a continuous flow of materials and quality products that meet technical, safety, and environmental requirements, for the productions of sustainable packaging films. The revenues from the PCRs scheme of PCR manufacturers are reinvested into the recycling of the produced laminates. In addition, packaging manufacturers should also be continuously informed about the market trends and customer needs in order to develop innovative circular products.
- **Communication with Retailers.** The success of the supply chain and consumer satisfaction depend on effective communication with retailers, who connect producers with final consumers. Understanding the retailers' needs and ensuring the product availability and high-quality are essential elements for successful relationships. Feedback from retailers helps companies improve their strategies and the quality of their products and services.

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3.2.4 Channels

Channels are the pathways through which the value proposition of the project reach customers. More specifically, multiple channels can be used for KER1 of the CIRCULAR FoodPack project, as described below:

- Sales are focused on the B2B market which can be approached in a multidimensional way, using the capabilities of recyclate forums, social media, and the company's website. These networks attract target groups interested in recyclable and sustainable packaging. The companies can promote their products and technologies and establish partnerships with companies with similar or complementary objectives.
- Direct communication between key partners and representatives from the entire packaging value chain or use of existing distribution channels for promoting and disseminating the benefits of the project innovations is also very important. The promotion through marketplaces or through the customers' wide network along the value chain, can also contribute to the increase of awareness of the relevant stakeholders for the new developments and the economic and environmental benefits they offer. The relationship building is of high importance for creating confidence and trust between the various stakeholders.

3.2.5 Key activities

The key activities that are crucial to achieve the value proposition include the:

- **Development of PE-based mono-material laminates with target properties.** The PE pellets produced either using the CreaSolv® recycling method or the mechanical recycling combined with delamination and deinking set the basis for the development of non-food and food laminates with PE PCRs, respectively. The developed PE recyclates can replace virgin materials in a percentage greater than 50%. The developed laminates for food packaging also include functional barriers behind the PE PCRs for ensuring safety, and tracers for improving sorting, and thereby make the management after use easier and more efficient.
- **Performance of laminates.** The performance of the developed laminates should be evaluated, regarding, initially, the adaptability and compatibility of the innovative recyclates and tracers to the process line. In addition, the developed packaging films should be in line with the recycling guidelines and the requirements for the maintenance and extension of shelf-life of the packaged products. Regarding the laminates that are intended for food applications, their safety and suitability for getting in direct contact with the food product is of primary importance for developing advanced, high-value final packaging films.
- **Development of functional barriers with desired properties.** Highly effective functional migration barriers are crucial to be developed in order to be incorporated into the final packaging applications and achieve protection against migration of any residual contaminants from the recyclates to levels below any toxicological concern. The functional barriers should be validated and recyclable in order to contribute to circularity and sustainability issues.
- **Development of tracers for identifying and sorting of packaging films after use.** The effective sorting of waste is crucial for the recycling process and the development of high-quality end products. In CIRCULAR FoodPack, TBS tracers, that are easily washable and

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debondable as well as compatible with the existing sorting equipment, are produced for enhancing sortability of food and non-food packaging waste. The tracers can be incorporated into printing inks, enabling their application to the existing production lines.

- **Film/Packaging production.** PE based mono-material multilayer flexible packaging laminates containing the recycled PE, functional barriers and tracers should be produced for reaching the value proposition, and develop an easily recyclable, cost-effective and sustainable product. The developed flexible packages should have tangible environmental benefits compared to similar products on the market.
- **Interaction with food and non-food end users.** The interaction with food and non-food end users is also vital for determining the desired properties and specifications of the developed innovations, in order to design and create new flexible packaging films that cover the customers' needs. This interaction will help to end-up to a user-friendly, efficient, sustainable and marketable packaging that will be well-received by the consumers.
- **IPR management.** Patenting the developed products is important to maintain and secure the usage of the product and provide the companies a competitive advantage to the market.

3.2.6 Key resources

This Building Block refers to the Key resources that the success and viability of the business case depends on. These resources include the following categories:

- **Physical resources,** which include:
  - **i.** Equipment, the availability of which, is fundamental for the production of PE-based mono-material laminates
  - **ii.** Raw Materials (virgin and PCR PE, inks, primers, solvents, adhesives, additives, barrier layers, etc.) that are necessary for the laminate production
  - **iii.** Utilities (electricity, natural gas, water, compressed air) needed for the operation of the plant. Utilities are crucial since the production process requires a constant supply of energy to ensure the continuous operation of the production lines.
- **Existing Packaging Production Lines.** The existing production lines of a packaging manufacturing company can be used for the development of the CIRCULAR FoodPack laminates, incorporating the produced PE recyclates, as well as the inks, tracers and primers. The use of the existing production line makes the introduction of the technologies to the market easier, reducing the required cost and time of the new product development.
- **QAS/DSS tools.** The QAS/DSS tools being developed within WP7 by the partner IRIS can also support the waste-managers during the selection of the proper processes for sorting and recycling of the developed materials, answering the specification of PE-based mono-material laminates.
- **Personnel.** Experienced staff with know-how on recyclable packaging or packaging containing recycled content allows for a substantial analysis of the properties of materials and market requirements, as well as contributes to the enhancement of innovations and adaptation to changes, the production of final products with tailored properties, the assurance of products' quality. The services of the personnel are fundamental for the success and good reputation of the packaging production company.

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- **Patents.** IPR resources including patents, partnerships, copyrights, or trademarks, are also fundamental since they can affect the value proposition and offer companies a competitive advantage in the market.
- **Financial Resources** are also important for investing in equipment, research and development, the covering of the patents, the salaries of personnel etc.
- **Creativity, Inventorship, Innovation.** These elements are key for the development of unique, innovative, cost efficient, and more sustainable packaging solutions. Taking advantage of these principles, the company results in pioneering products, enhances its branding and offer significant competitive advantages compared to the products offered by other packaging companies.
- **Delivery Speed** is related to the ability of fast development and release of new products which can offer significant competitive advantages, access to new markets, and widening of its customers.

3.2.7 Key partners

This Building Block refers to the Key partners of the Business Model Canvas that are needed for the development of PE-based mono-material laminates. Key partners are the main pillar for the success of a business model, as they provide the necessary knowledge, technologies, and resources.

- **Film/Packaging production companies and packaging converters.** Film/packaging production companies are important partners, as they have the know-how and infrastructure for the production of the laminates. They have to introduce to their production lines the high-quality recyclate and the developed tracers and barriers that will enable the management and will enhance the migration properties of the flexible films. No need for changing the production line is required, making the packaging production companies more willing to incorporate CURCULAR FoodPack innovations.
- **Plastic recycling companies having adapted the Circular FoodPack technologies** are equally important. They will process food or non-food packaging waste, using CreaSolv® recycling or mechanical recycling in line with novel delamination and deinking processes, for developing the PE PCR. This secondary raw material will form the basis of the flexible laminates by substituting more than half of the virgin PE, promoting circular economy and sustainability matters.
- **Functional barriers and tracers' manufacturers/ providers.** The developers of functional barriers and tracers play an important role for the realization of the totally new value chain that is proposed by the CIRCULAR FoodPack project. Barriers with tailored properties and characteristics, as well as markers with specified concentration and particle size incorporated in ink formulations will be used for the enhancement of the packaging laminates.
- **Ink producers.** Ink producers are crucial for the provision of inks, as well as the incorporation of tracer marking into their products.
- **Virgin polymer providers.** The final polymer is a blend of virgin PE and recycled PE. As a result, virgin polymer providers are important partners in order to produce the final product.

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- **Quality evaluators:** In order to ensure that the developed materials meet the quality and safety standards and requirements for the food and non-food industry, standardized quality assessments are required, and partners with the appropriate background are essential for the implementation of the business case.
- **Distributors** are the main contributors to getting products to market.
- **End-users** and brands are the stakeholders that will use and consume the developed products and they constitute the basis for the success of the business model. The satisfaction of their requirements and needs and the adaptation to their preferences is directly linked to the success of the incorporation of the developed laminates into the market.

3.2.8 Cost structure

The cost structure block includes all the possible costs associated with the production process, from equipment and maintenance to intellectual property rights (IPR). In particular, the costs are analysed as follows:

- **Equipment and facilities.** Firstly, the costs for the purchase, installation, operation and maintenance of equipment are amongst the most important investment costs required for the production process. The depreciation of the equipment is an important element that should be taken into consideration as it directly affects the total cost of production. The upgrading of existing installations is also necessary in order to maintain competitiveness and to incorporate new technologies.
- **Raw materials and utilities.** The main inputs to carry out the production process are raw materials and utilities, such as virgin PE, PE recyclates, additives, energy, water, that need to be purchased in order to realize the specific value proposition and produce laminates either for food or non-food applications.
- **Costs for pre-treatment**. Pre-treatment can include various processes, such as cleaning and preparation of raw materials, which are necessary to ensure the quality and compliance of the finished products to the desired specifications.
- **Personnel costs** are also an essential part of the cost structure. The new technologies require qualified personnel with academic and professional backgrounds, so that they can cope with the complexity of understanding or executing specific procedures, increasing the total amount of the assumed wages.
- **IPR protection fees.** Fees for the protection of intellectual property rights (IPR) are also important, in order to maintain a competitive advantage and to avoid copying the technology by competitors.

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3.2.9 Revenue streams

The Revenue Streams block describes the way that a company can make revenues by offering the value proposition. For KER No1, the profits of the business case come from the:

- **Sales of food packaging with recycled PE to food or plastic companies.** The main source of revenue comes from sales of the developed food packaging films, that contain significant amount of recycled PE, to food or other plastic packaging companies. The increasing interest of consumers and businesses in such products that promote sustainability and circular economy can increase both demand and sales.
- **Tax and fee reduction (eco-modulation) due to the use of recyclates**. In many countries governments and regulatory bodies offer tax incentives and fee reductions for companies that use recycled materials in their production. These reductions can substantially improve the cost-effectiveness of the project, making it more competitive in the marketplace.

3.2.10 Environmental and social costs

The development of recyclable, TBS sortable mono-material laminate with PE PCRs for food and non-food packaging applications and new methods of production and recycling of PE impose certain burdens both in terms of their application and their integration into existing systems. In addition, in a social context, information and education of consumers on the benefits of recycling and of consuming goods containing recycled materials is necessary. This may be associated with significant and potentially costly and time-consuming campaigns and changes. Finally, industry must be able to offer sustainable solutions that are safe, healthy and environmentally friendly without sacrificing products' quality and safety, mainly for the food industry, overcoming the sophistication of consumers.

3.2.11 Environmental and social benefits

The use of PE-based mono-material laminates that contain recycled material has the potential to reduce the environmental footprint, the use of virgin materials, the carbon dioxide emissions and the dependence on fossil fuel sources. Mono-material laminates are more easily recyclable than multilayer materials and at the same time can be fully recycled, thus significantly reducing waste. Mono-material laminates comply with the European Recycling Regulation 2022/1616, which sets strict standards for the recyclability of packaging materials. In addition, consumers are showing a high awareness of environmental issues which has led to an increased demand for sustainable products. Today's consumers are willing to pay higher prices for environmentally friendly packaging, which gives companies a competitive advantage.

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3.3. Business Model Canvas of KER No.2: Sorting and Physical recycling cascades

The Business Model canvas of KER No.2: Sorting and Physical recycling cascades is presented in the following table.

Table 2: Business Model Canvas of KER No.2: Sorting and Physical recycling cascades

<table>
<tr>
<td rowspan="2">Key Partners
Collectors of plastic food packaging waste, as well as food and non-food mixed waste
Waste managers
Technology providers (i.e. CreaSolv® providers, tracers and ink providers, etc.)
Sorting manufacturers
Compounders for pellets
Municipalities and public bodies
Brand owners</td>
<td>Key Activities
Collection of plastic food packaging waste, as well as food and non-food mixed waste
Recycling and sorting processes: pre-treatment (washing and deodourization, delamination and deinking), CreaSolv® process, mechanical recycling and post-treatment
Sequence of technical steps to one process chain
Interaction with packaging production companies
IPR management
Legislation setting the requirements</td>
<td rowspan="2">Value Proposition
Produce high quality recycled PE
Development of a new whole process chain, consisting of different technical steps, for PE recycling
Reduce use of virgin PE
Reduce and manage plastic waste
Enhance environmental performance
Near-zero waste approach and circularity
Introduce new technologies for recycling (Creasolv®) and sorting (sensor-based specification, tracer-based sorting)
TBS couples with Sensor-Based-Specification - tracers are incorporated in packaging that is not heavily printed
Advantage over competitive technologies (chemical recycling, digital watermarking, paper-based packaging, biomaterial-based packaging, AI sorting)</td>
<td>Customer Relationships
Relationship between technology providers and sorting and recycling companies for purchasing, installing, upgrading and maintaining the equipment
Relationship between recycling companies and ink producers with packaging manufacturing companies for providing recycled raw material</td>
<td rowspan="2">Customer Segments
Sorting and recycling companies
Waste management companies
Packaging converters to recycle on-site the packaging waste
Packaging production companies
Ink producers
Brand owners</td>
</tr>
<tr>
<td>Key Resources
Equipment, raw materials, energy for sorting and recycling processes
QAS/DSS tools to select most feasible routes for packaging with recyclates, among others
Skilled personnel for CreaSolv® process
Know-how on recycling management
Patents
Facilities for installing the equipment
Financial resources</td>
<td>Channels
B2B market
Website
Social media
Personal communication
Training activities
On-line videos
Customers' network
Associations</td>
</tr>
<tr>
<td colspan="3">Cost Structure
Equipment, maintenance and depreciation costs
Raw materials and utilities
Costs for pre-treatment
Personnel costs
Licensing of equipment</td>
<td colspan="3">Revenue Streams
Sales of offering services to waste management companies
Sales of recycled PE to plastic packaging companies
Tax reduction due to the use of recyclates</td>
</tr>
<tr>
<td colspan="3">Environmental and Social Costs
Addition of new technologies
Legislation allowing for recycling content in the products
Social costs for adjusting the local/ national legislation to waste recycling</td>
<td colspan="3">Environmental and Social Benefits
Reduction of environmental footprint
Low to zero remaining waste
Utilization of less virgin materials
Employment in research development</td>
</tr>
</table>

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KER No.2 leads to the production of recycled PE of advanced quality coming from food packaging waste, as well as food and non-food mixed waste. The recycled PE production will be based on the application of new and innovative technologies for recycling and sorting, like newly developed deodorisation process, delamination and deinking procedures, as well as CreaSolv® technology. The BMC building blocks of KER2 are described below.

3.3.1 Value proposition

In the framework of KER2, CIRCULAR FoodPack project leads to the production of high-quality recycled PE coming from food packaging waste, as well as food and non-food mixed waste. The project does not only result in a single product but also proposes a new process chain, uniting all the different technical steps, for food packaging waste as well as food and non-food mixed waste, recycling and sorting, into one production line. A newly developed deodorization process, delamination and deinking procedures, CreaSolv® process for recycling, mechanical recycling, sensor-based specification, tracer-based sorting, etc. are combined in order to produce high-quality end products as well as to contribute to the management of plastic waste and the reduction of the high amounts that are produced during food consumption. For example, high-quality material recycling can be achieved by combining conventional techniques, such as mechanical recycling with delamination and deinking, and NIR separation with new methods of targeted labelling using fluorescent tracers to identify and sort complex packaging. The tracer-based-sorting (TBS) technology enables the production of advanced plastic recyclates that can be re-introduced to the material cycle for application in similar fields of use and surpasses over conventional sorting technologies that are mainly based on the properties of the materials and the final products do not meet the expected requirements, especially for applications in the food packaging industry (Kusch et al., 2021). Moreover, the tracers are incorporated into packaging that is not heavily printed, covering a minimum area.

Consequently, aligning with the EC's Circular Economy Action Plan (2020), the efficient management and reuse of plastic waste streams will contribute to achieving near-zero waste approach by 2050 and reducing the use of virgin PE, limiting the dependence on natural resources (Bartelings and Philippidis, 2024). The limitation of primary material production also leads to enhanced environmental performance and reduction of greenhouse gas emissions in comparison to incineration, energy recovery or open-loop recycling. In addition, while both chemical and biomaterial-based recycling methods are considered to be environmentally friendly, comprehensive assessment of the environmental impact of the CIRCULAR FoodPack technologies is needed to be evaluated for their sustainability (Schyns and Shaver, 2020). The new process chain seems to be competitive with other recycling and sorting methods, like chemical recycling, digital watermarking, paper-based packaging, biomaterial-based packaging, AI sorting.

3.3.2 Customer segment

Customers are crucial for the incorporation of a business case into the market. Together with the specific regulations and legislation for the reuse of recycled materials for various applications and the eco-modulation, they set the rules and the requirements of the developed products and services. The **customer segmentation** is crucial, in order to identify the specific needs of each group and adapt the value proposition to them. The customer segmentation of CIRCULAR FoodPack includes:

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- **Sorting and recycling companies**: The sorting and recycling of multilayer materials (e.g. in high-performance food packaging) that consist of various layers of different plastics is challenging, due to the difficulty in sorting these types of packaging (not recognized by sorting equipment) and in separating the multiple layers. The multilayer packaging is made mainly of PE, in combination with other layers consisting of polymers like PET, PA for toughness or ethylene-vinyl alcohol (EVOH) for blocking oxygen. The need for transition to circularity demands the reduction, reuse, and recycling of plastic waste, producing high-quality products and reducing the environmental impacts. Mechanical recycling contributes to an environmentally and economically sustainable reuse of plastic, however, current mechanical recycling processes are constrained by cost, products of lower quality and degradation of mechanical properties (Schyns and Shaver, 2020). The proposed new value chain is targeted to sorting and recycling companies that aim to transform to resource-efficient, green, and competitive low-carbon ecosystem and to produce PCRs with better qualities.
- **Waste management companies.** This project offers a value proposition to waste management companies, which need to be aligned with relevant directives (e.g. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives amended in 2024, European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste amended in 2018) that refer measures to protect the environment and human health by mitigating waste generation and its adverse impacts (Pauer et al., 2019). Waste management companies can utilize and incorporate the developed technologies, for sorting and recycling of waste, developing high-quality recycled PE for further applications in food or non-food products.
- **Packaging production companies.** Packaging is considered an important source of waste production and packaging production companies are required to minimize their waste and to make packaging more sustainable by targeting eco-design and utilizing recycled materials. Towards eco-modulation, packaging containing recycled materials must be characterized by advanced properties and must be safe for human health, contributing also to environmental sustainability. Packaging production companies can purchase the recycled PE for substituting part of the raw material used for the development of various plastic products, offering a sustainable and environmentally friendly character to their market profile. Depending on the final application, the recipes of multilayer packaging differ, increasing the need for tailored design with specific requirements. The reuse of recycled PE into the manufacturing process should be based on innovative ways of treatment and incorporation, contributing to a resource-efficient, green, and competitive low-carbon economy.
- **Packaging converters to recycle on-site the packaging waste.** Packaging converters can apply the proposed technologies to recycle on-site their produced plastic waste streams enhancing the circularity within their operations and contributing to the enhancement of the environmental performance of their products and processes. Apart from waste management, this case could contribute to the economic feasibility of the companies, since recycling takes places in the premises of the packaging converters, limiting the transportation and processing of waste to other facilities.
- **Ink producers.** Within CIRCULAR FoodPack novel inks including tracers that facilitate sorting of waste have been developed, creating a new market opportunity for the ink producers.

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The new ink designs will be easier deinked and will facilitate the de-inking process allowing for production of more purified recyclates that can be reused or recycled. The competitiveness of ink producing companies will increase resulting in an increase of direct sales and market share. One possibility for the ink producers would be the mixing of the newly developed tracers (by dispersion) into inks for printing and include this into their product portfolio for the converters, or for other possible industrial applications (such as automotive, construction, textiles, etc.) that require sorting, independent of the material chemistry.

- **Brand owners.** Brand owners can significantly benefit from the adaptation of CIRCULAR FoodPack innovations, enhancing their environmental performance, profitability, and their competitiveness on the market. Proposed technologies can reduce carbon footprint that is associated with the production of new materials, helping the brands be aligned with sustainability goals, as well as complying with the regulatory requirements and the legislation. In addition, the brand owners will differentiate themselves from their competitors, enhancing their reputation on the market and attracting environmentally conscious customers. They will also be able to increase their collaborations and partnerships with other industries, expanding their network and market appearance.

3.3.3 Customer relationship

The Customer **Relationship** block describes the kind of relationship that can be built among the specific customer segments, which have been identified above:

- A strong relationship should be established between technology providers and sorting and recycling companies for various activities in a long-term cooperation. Specifically, these activities are associated with purchasing, installing, upgrading, and maintaining the required equipment for achieving the value proposition. Hence, the mentioned collaboration ensures the optimization of the equipment used by the sorting and recycling, as well as waste management and converters companies. Also, this relationship improves the technological support and ensures the smooth and efficient operation of the innovative equipment, reducing time and maintenance costs.
- A strong relationship should also be established between recycling companies and ink producers with packaging manufacturing companies, in order to create a reliable supply chain for recycled materials and novel ink designs to the packaging producers. This way will contribute to promoting sustainability and environmentally friendly practices within the food and non-food packaging industry. The continuous and long-term cooperation between these actors creates a stable source of recycled materials and novel materials (such as inks with tracers), which helps to reduce utilization of virgin raw materials and enhances environmental performance.

3.3.4 Channels

Distribution channels can contribute to the communication of the value proposition of a company to its potential customers and include:

- Participation in training activities and projection of on-line videos, providing opportunities to interact directly with stakeholders and showcase the company's offerings.

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- Digital platforms, such as websites and social media (i.e. LinkedIn, Twitter (X)), play a crucial role in disseminating information about the value proposition to a wider audience and facilitate professional networking, enhancement of market presence, and engagement with relevant industry stakeholders.
- Direct communication of the key partners (B2B) with possible clients, through the customers' network or through associations, such as the Forum Plastics Recyclate, serves as an alternative approach to conveying the value proposition, allowing for further discussions addressing specific needs.

3.3.5 Key activities

The Key Activities are a very vital component of the BMC since they include the most important actions that are required in order to reach the value proposition and build collaborations with customers:

- **Collection of plastic food packaging waste, as well as food and non-food mixed waste.** The collection of plastic waste is crucial for the operation of the recycling plant, since it affects both the quantity and quality of the materials to be recycled. The accomplishment of the continuous supply of plastic waste will ensure adequate recyclable material and will warrant the continuous operation of the recycling plant. The collection of the appropriate waste materials will determine the economic feasibility of the recycling process, and the environmental performance of the recycling unit, minimizing, in parallel, the quantity of waste that goes to incineration or landfilling.
- **Manufacturing Process.** The manufacturing process is considered to be a key activity since it affects the quality and quantity of the final products. It includes the following processes:
    i. Pre-treatment processes (oversorting, shredding, washing, grinding and float-sink separation). Clean, separated and deinked waste enhances the recycling rate, increases the efficiency of the recycling process, and leads to final products with advanced quality and characteristics.
    ii. Recycling process, using CreaSolv® or mechanical recycling. CreaSolv® is a solvent based recycling method that can be used for numerous polymers and has been performed in technical scale, enabling to increase the overall plastic recovery rate. Mechanical recycling is amongst the most effective method to recycle plastics in terms of time, economic cost, carbon footprint and environmental impact.
    iii. Post treatment process (deodorization). This process removes the odors and volatiles, leading to high quality recyclates.
- **Sequence of technical steps to one process chain**. CIRCULAR FoodPack project does not only yield a single high-quality product, but also proposes a series of technical steps that are combined to create an overall new process chain. This is of high importance for the holistic exploitation of the waste, the increment of the recycling yield and the production of final recycled products with advanced properties similar to the virgin polymers.
- **Interaction with packaging production companies.** The interaction with packaging production companies is also considered a key activity, since it can contribute to the exchange of information, regarding the characteristics and specifications of the developed products, as well as the needs and requirements of the packaging industries.

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- **IPR Management.** The CreaSolv® process is a solvent based recycling technique improving both process yields and product qualities. It is a patented technology, and the intellectual property must be protected, in order to maintain and track the usage of the patent.
- **Legislation setting the requirements.** Legislation and eco-modulation set the rules and incentives for waste management and reuse in various applications. The legal framework is ruled by legislation that sets the recycling targets and consequently the appropriate collection, sorting and recycling efficiency of the produced waste. In addition, they determine a minimum recycle content in the plastic materials, encouraging sustainable design and environmentally friendly products. In the same way, eco-modulation adjusts fees and taxes according to the environmental impact of materials. Higher fees can be imposed for non-recyclable flexible packaging and for packaging without any PE PCRs, enforcing plastic producers to incorporate recycled material to their final products. On the other hand, packaging that includes recycled content, is accompanied with tax reduction, contributing to the increased economic viability of the packaging manufacturers.

3.3.6 Key resources

The **key resources** block explains the assets that are required, in order to reach the value proposition and produce high-quality recycled PE from plastic food packaging waste, as well as food and non-food mixed waste:

- **Physical Resources** that include:
  - **i.** the appropriate equipment (machinery, installation, maintenance, etc.)
  - **ii.** the raw materials (food packaging waste, food and non-food mixed waste, solvents, auxiliaries, etc.)
  - **iii.** utilities (water, fuel, gas, thermal energy, electricity, etc.) needed for the plant operation
- **Personnel.** Human resources are key components of a business case since they are responsible for efficient operation and provision of their know-how in the recycling process chain and the recycling management. The operation of CreaSolv® unit requires also skilled personnel with research background on solvent recycling and processing.
- **Facilities for installing the equipment.** Appropriate infrastructure, location and buildings are necessary in order to demonstrate and setup the whole process chain for sorting and recycling of food packaging waste, as well as food and non-food mixed waste.
- **Financial Resources.** Financial resources are essential for the purchase, installation, operation and maintenance of the equipment, the covering of the patents, the salaries of personnel etc. in order to provide the value proposition.
- **QAS/DSS tools.** The QAS/DSS tools being developed within WP7 can also support the waste-managers during the selection of the proper processes for sorting and recycling, as well as feasible routes for packaging with recyclates.
- **Patents.** IPR resources including patents, partnerships, copyrights, or trademarks, are also fundamental since they can affect the value proposition and offer companies a competitive advantage in the market.

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3.3.7 Key partners

The Key Partners refer to the primary partnerships that are crucial in order to reach the value proposition and end up to the production of high-quality laminates for food or non-food packaging containing the recycled PE. The key partners are divided into:

- **Collectors and sorting manufactures for plastic food packaging waste, as well as food and non-food mixed waste.** Collectors and sorters constitute crucial partners since they are responsible for effective and targeted collection of the waste, as well as the clearance of the waste in order to be further processed in the recycling unit. This process can be difficult and expensive depending on the collected waste.
- **Waste managers.** Waste managers play an important role in offering the waste management and recycling site and incorporating the developed technologies into their processing line for optimizing waste recycling and developing advanced recycled products.
- **Technology providers.** Technology for packaging recycling involves improvement of sorting processes, efficient and sustainable recycling processes, and development of new methods that reduce the environmental performance of the processes. Continuous technological improvements allow for the recycling industry to meet the demand for high-quality recycled materials. The suppliers of the technologies that are optimized within the CIRCULAR FoodPack project, such as the CreaSolv® providers or the tracers and ink providers, can offer the advantageous equipment and can contribute with their expertise and know-how. Also, they can endorse the company, through networking with food packaging producers in EU, seeking for more efficient methods for offering recycled PE and assimilating knowledge for the current legislation about recycling of food packaging waste, as well as food and non-food mixed waste in EU.
- **Compounders for pellets.** Pellets producers are crucial for developing secondary PE pelletized material, containing recycled PE coming from the CIRCULAR FoodPack process chain with properties similar to the virgin material. The pellets will then be used for development of laminates for food and non-food packaging applications.
- **Municipalities and public bodies.** Municipalities are responsible for efficiently collecting household waste. In addition, together with public bodies, they can set local and regional laws and regulations for waste management, affecting the whole treatment process of waste. They can also provide subsidies or grants to the recycling plants in order to purchase innovative viable and sustainable sorting and recycling equipment, or can offer eco-modulation designs, determining the fees according to the recyclability of materials.
- **Brand owners.** The brand owners set the rules and determine the requirements and specifications of recycled materials for the developed final products.

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3.3.8 Cost structure

The achievement of the value proposition of a business case presupposes cost expenses, for implementing all the vital procedures for the production of high-quality recycled PE. The Cost Structure Block has been condensed to five (5) primary expenses that warrant additional analysis:

- **Equipment, maintenance and depreciation costs.** The most important expenditures are those that are associated with the purchase, installation, operation and maintenance of the equipment which is required for the process implementation.
- **Raw materials and utilities.** These materials, like collected waste, additives, auxiliaries, energy, water, are essential for the operation of the various installed technologies. The price and the quantities of raw materials and the costs of the utilities needed during the whole value chain are regarded as a fundamental component of the Cost Structure Block.
- **Cost for pre-treatment.** The collection and pre-treatment of waste requires sufficient cost expenses in order to produce a uniform waste that will be treated in the recycling plant and will end-up to a high-quality final product for further applications. Sorting companies should invest on the sorting step in order to reach the desired results. The TBS technology developed in the project is compatible with the existing sorting lines. As long as the NIR sorting line is equipped with a suitable HSI detection technology, TBS can be implemented on the line with a feasible upgrade. TBS separating the food from the non-food packaging waste at 99% purity, creates a closed loop for flexible food packaging EOL, enabling the production of PE PCRs applicable for food packaging.
- **Personnel costs.** The total cost of the business case is affected by the salaries of the employees. The operation presents a new technology that involves multiple steps, factors, or consideration necessitating the commitment of employees that have a more advanced academic and professional background, demanding a substantial wage package.
- **Licensing of equipment.** Licensing of equipment or technology for the developed novel pre-/post-treatment and recycling processes is essential for a waste recycling plant to ensure compliance with regulations, efficient operation of the units, and assure quality.

3.3.9 Revenue streams

The main revenue streams are divided into three (3) groups, analyzed below:

- **Sales of offering services to waste management companies.** CIRCULAR FoodPack project provides an innovative and feasible solution for managing food packaging waste, as well as food and non-food mixed household flexible packaging waste. The provision of the new whole process chain for the treatment of waste could create a revenue source for the technology providers.
- **Sales of recycled PE to plastic packaging companies.** The sales of high-quality recycled PE to plastic packaging companies for producing laminates for food and non-food packaging containing recycled PE, could be considered as the main revenue stream. Recycled PE is a very useful material for the production of new packaging which results in the conservation of new, virgin material, the enhancement of the environmental performance and the alignment with the continuously changing regulations. According to the PPWR, by 2030, plastic contact-sensitive packaging materials, excluding PET (except single-use plastic beverage bottles), must contain a minimum of 10% recycled content derived from post-

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consumer plastic waste, specific to each packaging type and format. This requirement increases to 50% by 2040 for contact-sensitive packaging. For non-food applications, the PCR content requirement is set at 35% by 2030 and 65% by 2040. The term 'other than PET' primarily refers to polyolefin materials, including polyethylene (PE), which was the primary material in the CIRCULAR FoodPack project. These targets will drive a significant demand for PE PCR content in the market, subsequently leading to increased sales for the recyclers.

- **Tax reduction due to the use of recyclates.** The process uses, as a raw material, food packaging waste, which is sorted by TBS technology, or collected by B2B directly after use without leaving the premises, or food and non-food household flexible packaging mixed waste to produce recycled PE that could be further exploited. The utilization of virgin PE is decreased in the flexible packaging materials and substituted by the PE recyclates. The recycling and reuse of PE reduces the dependence on the purchase of virgin materials. It is also in accordance with eco-modulation that poses high fees for the use of non-recycled PE and also sets a minimum recycled content in the ne formulations.

3.3.10 Environmental and social costs

Regarding the environmental and social aspect, there is a burden from the addition of new technologies, that could refer to the costs and complexities associated with integrating these new technologies into the existing process chains. In addition, social costs for adjusting the local/ national legislation to waste recycling may be incurred, including costs related to legal revisions, enforcement measures for reaching the minimum recycled content, public awareness campaigns, or other social impacts connected with legislative changes aimed at promoting waste recycling.

3.3.11 Environmental and social benefits

The recyclable packaging materials containing recyclate content contribute to the utilization of less virgin materials, the reduction of environmental footprint and of the dependency on fossil-based sources, as well as the enhancement of circularity. It also involves designing products that can be recovered and reused, therefore reducing the need for virgin materials. The project contributes significantly to environmental improvement due to energy saving, since the production of new materials from virgin sources requires significantly more energy than the processing of recycled materials (Ross and Evans, 2003). Furthermore, it provides circularity, since it contributes to minimizing the volume of waste, limiting the amount that ends to landfilling or incineration (Volmajer et al., 2022). These results can also contribute to an increase of employment in research development due to the new technologies added in the production activity, and also an enhancement of environmental awareness and social responsibility of citizens, whether they are producers or consumers (Rutkowski, 2020).

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3.4. Business Model Canvas of KER No.3: PCRs with certified quality

The Business Model canvas of KER No.3: PCRs with certified quality is presented in the following table.

Table 3: Business Model Canvas of KER No.3: PCRs with certified quality

<table>
<tr>
<td rowspan="2">Key Partners
Material producers
Plastic recycling companies having adapted the Circular FoodPack technologies
Packaging converters</td>
<td>Key Activities
Characterization of recyclates regarding quality, safety
Characterization of migration
Development of novel migration barriers
Interaction with food or plastic companies
Interaction with packaging production companies
IPR management</td>
<td rowspan="2">Value Proposition
High quality PE recyclates, which are comparable to virgin PE used in flexible packaging.
Up to 50% reduction in the use of virgin PE for producing flexible laminates for food and non-food packaging
Introduce innovative and improved protocols for testing the quality, safety and shelf-life of recycled materials
Introduce methodologies for the challenge test protocols in order to determine the cleaning efficiency of the developed recycling technologies for Polyolefines
To develop methodologies for challenge test protocols assessing the cleaning efficiency of recycling technologies for polyolefins
Contribution to circularity and environmental sustainability</td>
<td>Customer Relationships
Cooperation between material providers/ recycling companies and packaging/plastic manufacturing companies for providing recycled raw material (PE recyclates)</td>
<td rowspan="2">Customer Segments
Providers of raw materials
Packaging production companies
Plastic industries</td>
</tr>
<tr>
<td>Key Resources
Equipment, raw materials, energy for PE-PCRs manufacturing
QAS/DSS tools to select most feasible routes for packaging with recyclates, among others
Personnel
Financial resources
Know-how on recycled packaging, analytics
Patents</td>
<td>Channels
Website
Social media
Personal communication
Training activities
Customers' network</td>
</tr>
<tr>
<td colspan="3">Cost Structure
Equipment, maintenance and depreciation costs
Raw materials and utilities
Personnel costs
Distribution costs
IPR protection fees</td>
<td colspan="3">Revenue Streams
Tax reduction due to the use of recyclates</td>
</tr>
<tr>
<td colspan="3">Environmental and Social Costs
Addition of new technologies
Social costs for adjusting the local/ national legislation to utilizing recycled packaging for food and non-food applications</td>
<td colspan="3">Environmental and Social Benefits
Reduction of environmental footprint
Low to zero remaining waste
Utilization of less virgin materials
Health enhancement</td>
</tr>
</table>

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KER No.3 leads to the production of recycled PE of advanced certified quality coming from food packaging waste, as well as food and non-food mixed waste. The recycled PE production will be based on the application of new and innovative technologies for recycling and sorting. Innovative and improved testing methodologies are developed or adopted in order to assess the compliance and safety of the produced recyclates. The process monitoring and the quality evaluation result in the improvement of the quality level of the developed products. The BMC building blocks of KER3 are described below.

3.4.1 Value proposition

CIRCULAR FoodPack focuses on the development of high-quality recycled polymers, which are comparable to virgin polyethylene, that will be used for the development of flexible packaging for food and non-food products. The proposed solution will contribute substantially to a reduction of up to 50% in the use of virgin polyethylene to produce the flexible laminates.

Achieving this reduction has important implications for both circular economy and sustainability. Reducing dependence on virgin materials reduces the need for extraction and production of new resources, which contributes to reducing carbon emissions and energy consumption. At the same time, the use of high-quality PCRs ensures that product properties remain unchanged, ensuring the same durability and functionality as products made from virgin materials. In order for the market to adopt the recycled polymers, they must have high-quality, simulate the virgin material and be characterized by compliance and safety to be used in the demanding applications. As a result, the introduction of innovative and improved protocols for testing the quality, safety and shelf-life of recycled materials is a key element of the value proposition. It ensures that recycled materials meet the highest standards of quality and safety and thus giving consumers and businesses confidence in their performance.

3.4.2 Customer segment

The project targets an audience that is interested in high quality recyclable PE as input waste, as well as in PE PCR material performance evaluation methods after its recycling. The main customers targeted by the project are:

- **Raw Materials Providers**: Raw material providers, e.g. recyclers, or plastic manufacturers, are those who ensure the continuous supply of recycled PE to be transformed into final sustainable products. By understanding their needs and requirements, the plant can ensure that it offers high-quality products that can be easily transformed into end products, like packaging films for various applications.
- **Packaging production companies**: Companies in the packaging manufacturing sector are seeking for more environmentally friendly materials to meet consumer and regulatory requirements and be in line with eco-modulation. The use of PCRs allows them to reduce their environmental impact, gain significant revenues from tax reduction, due to the substitution of virgin PE with certified recycled material, as well as enhance their brand image. Furthermore, based on the PPWR requirements, there will be a requirement for the converters and brand-owners to integrate the PE PCRs into the products.
- **Plastic industries**: The plastics industries are an important industrial key player that can use recycled materials to produce new high-quality products. The use of recycled PE instead of virgin materials reduces taxes related to their purchase and contributes to circular economy.

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3.4.3 Customer relationship

This block details the relationships the business establishes with the above customer segments. The relationship with customers is a key element of the business model. Building consistent relationships with customers allows for the feedback management and personalization of services based on the needs of each customer. Close relationships with material suppliers allow them to monitor PCR's compliance with quality standards and make necessary adjustments. In addition, the trusting relationships between packaging and plastics recycling companies help to exploit methods for the production and use of recycled materials and to jointly research and develop new methods.

3.4.4 Channels

The value proposition of the project can reach its target audience through actions such as organization of training and educational activities such as seminars and courses or cooperation with academic institutions. These are effective ways of promoting the recycled PCR evaluation technology as well as the high-quality, certified final recycled products, through which new business contacts can be established and target markets can be informed about the functions and advantages of the technology. In addition, the channels that can be used to promote this product include websites and social media. These tools include detailed information about the product and its features, and also allow the regular release of updates that keep customers engaged and interacting with them. Equally personal communication is important to develop trust and create long-term relationships with customers. Personal meetings, professional presentations and communications, webinars can provide experienced support and guidance. Existing customers can be leveraged for product distribution.

3.4.5 Key activities

The Key Activities define the most important activities that the business performs in order to deliver the value proposition to remain operational. These include:

- **Characterization of recyclates regarding quality, safety**: This process involves the analytical study of the physical, chemical, optical, migration, functional properties of recycled plastics to determine whether and to which degree they meet all health and safety standards for food packaging, as well as non-food packaging.
- **Characterization of migration**: Analytical instrumental equipment (e.g. gas chromatography coupled to flame ionization detection (GC-FID), Fourier-transform infrared (FTIR) or gas chromatography-mass spectrometry (GC-MS)) is needed for evaluating the migration analyses of any contaminant that may be contained in the recycled PE and performing compliance and safety testing for using the developed materials in high-quality applications.
- **Development of novel migration barriers**: Functional barrier combinations are crucial for effectively separating PE recyclate from the layers in direct contact with food in new packaging structures containing PE PCRs. These barriers also play a key role in preventing set-off migration. Approval from EFSA would be required for these functional barriers, along with the corresponding PE PCR, to ensure compliance for use in food packaging.
- **Implementation of challenge tests for the assessment of the cleaning efficiency of the recycling processes for polyolefins**: Challenge tests are crucial for evaluating the effectiveness of recycling processes in removing contaminants from polyolefin waste. While these tests are well-established for PET-based recyclates, further research is needed to

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develop reliable protocols for polyolefins. The CIRCULAR FoodPack project achieved a significant milestone by demonstrating challenge tests on LDPE-based flexible packaging waste, providing insights into the cleaning efficiencies of the developed recycling cascade in the project. These findings will serve as the basis for creating challenge test protocols for the industry to assess the cleaning efficiency of their recycling processes for PE PCR production, specifically for food packaging applications.

- **Interaction with food or plastic companies and packaging production companies**: Cooperation with food and plastics companies is necessary for the successful implementation of this model, also in cooperation with the relevant research institutions with competences in migration, product analytics, etc. This cooperation has a dual value as it enables the adaptation of recycled materials to the needs for quality and safe packaging and enables the technology to be focused on the market needs.
- **IPR management**: Intellectual property rights (IPR) management is important for protecting innovation and enhancing the commercial value of innovative processes and technologies. Good IPR management helps to protect patents and safeguard business interests.

3.4.6 Key resources

The development of such a technology to assess the quality of PCRs and produce certified products requires specific resources which are described below.

- **Specialised equipment** is one of the essential elements for the analysis and quality assessment of PCRs. In addition, the raw materials and energy required for the manufacture of PCRs are also important resources for the evaluation process.
- **QAS/DSS tools to select most feasible routes for packaging with recyclates, among others**. The QAS/DSS tools being developed within WP7 can support the waste-managers during the selection of the proper processes for sorting and recycling, linked with the types of packaging which is targeted to use recyclates.
- **Equally important is human resources**. Skilled professionals with knowledge and experience in the production and evaluation of recycled materials are key components. Their contribution to the operation of CIRCULAR FoodPack processes is critical to maintaining competitiveness in the market.
- **Financial resources** are required for each stage of implementation of this technology. Funding is needed for research and development, equipment purchase, and to support the company's operating costs, and for the researchers, research institutions to progress with the implementation of test protocols for high-quality recyclates.
- Expertise in recycling of packaging materials and **patents** are strategic resources that can give a company a competitive advantage. This key proposition with its patented technologies and deep understanding of recycling and manufacturing processes offers valuable solutions and maximizes the market value of the products produced.

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3.4.7 Key partners

The key partners are the external partners who will help optimize both resources and operations in order to provide PE recyclates that meet quality standards.

- Material producers are an important partner, as they produce the primary materials that enter the recycling cycles. Ensuring the quality of PCRs depends mostly on the raw materials and, by extension, on the producers of these materials.
- Plastics recycling companies and sorting companies that have adapted CIRCULAR FoodPack technologies also play an essential role. This collaboration enables recycling companies to have access to high quality flexible packaging waste as input material and to produce high quality recycled plastics that can be used in the creation of new products, while ensuring food safety and environmental sustainability.
- Finally, packaging converters are another key partner, and their role is very important for the final product that reaches consumers. They are responsible for converting recycled materials into finished packaging products. Their ability to incorporate certified PCRs into their production processes determines the quality and safety of the final packaging.

3.4.8 Cost structure

The costs incurred by a company successfully running its business model are:

- **Costs of equipment, maintenance, and depreciation**: The infrastructure for the assessment of PCR quality is highly specialised and therefore requires significant initial investment capital. In addition to the initial purchase of the equipment thereafter, ongoing and necessary maintenance is required to ensure that it works accurately.
- **Raw materials and utilities**: The cost of the materials required for the PCR process can be high, especially in the specific case where the company seeks the highest quality and certification. In addition, utilities, such as energy and water required to run the laboratories, contribute significantly to the overall costs.
- **Staff costs**: Specialized laboratories require well-trained and experienced staff. The costs of these professionals are quite high as they are directly linked to their expertise and knowledge.
- **Distribution costs**: These include advertisements, promotions and public relations activities aimed at directing the message to existing and potential customers.
- **IPR costs**: the cost of acquiring and maintaining patents, and the costs associated with defending them, are significant costs, but are necessary to protect technology and maintain the company's competitiveness.

3.4.9 Revenue streams

This block describes the sources from where the business generates revenue. The choice of recycled materials for packaging can benefit its users with tax deductions. This technology enhances the utilization of less virgin PE and recycling and reusing of PE. Those who apply this solution are exempted from the high fees for the use of non-recycled PE, being aligned with the eco-modulation, enhancing the economic viability of this activity.

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3.4.10 Environmental and social costs

Although new eco-friendly technologies help to enhance the environmental performance of the developed products, their introduction in the process line can hinder high costs. In addition, the social costs associated with adapting the local and national legislation towards utilization of recycled PE and application of recycled packaging in various food and non-food products, as well as for convincing consumers to prefer products with recycled packaging may be significant.

3.4.11 Environmental and social benefits

On the other hand, the incorporation of recycled polymers with certified quality into final business cases can pose significant environmental and social benefits. The use of recycled PE contributes to the reduction of the environmental footprint, as well as the reduction of waste that is promoted for incineration or landfilling, enhancing the well-being and protecting public health. In addition, the limitation of the use of virgin materials helps to the protection of natural resources and the maintenance of the ecosystem's balance. Overall, the use of PCRs promotes sustainable development and offers solutions for a sustainable future.

3.5. Organisational, ownership and partnership structure for the market launch of the proposed solutions

3.5.1. Organizational Structure

Plastic recycling companies, sorters, packaging production companies or material providers can utilize the novel whole value chain approach for producing high-quality post-consumer recycled PE. The organizational structure of the companies should ensure that a deep expertise and know-how is distributed among the various domains. The Chief Executive Officer (CEO) will be responsible for the overall management of the organization, the Chief Operating Officer (COO) will manage the daily operations, whereas the Chief Marketing Officer (CMO) will lead the marketing initiatives and the marketing communications. Research and Development, Marketing, and Sales departments will consist basic departments of the company, dealing with the development of high-quality products and the successful introduction of the innovative products into the market, respectively.

3.5.2. Ownership and Partnership Structure

Strategic partnerships are of significant importance for incorporating the innovative solutions into the market. Recycling companies should be partnered with waste management companies to ensure a steady supply of raw materials with high quality, as well as packaging production companies to ensure the utilization of their developed products. In addition, collaboration with environmental NGOs could be helpful for enhancing market credibility. At the same time, packaging production companies should develop partnerships with raw material providers and packaging end-users either from the food or non-food sector, in order to realize their value proposition. These collaborations bring key resources and expertise, in order to deliver innovative recycling solutions effectively to the market.

An effective ownership structure of plastic recycling companies or packaging production companies should support sustainable growth and strategic alignment. A possible ownership structure could include founders holding 50% share, early investors holding 25% share, as well as employees and advisors holding 25%.

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4. CONCLUSION

In this deliverable, the most promising technologies in terms of market penetration have been identified and grouped in three (3) Key Exploitable Results (KERs). The business models for the CIRCULAR FoodPack business cases were analysed through a business model canvas methodology (BMC), describing the value proposition, customers, channels, key resources, key partners, key activities, and structure of revenue and costs. The aspect of environmental and social impact was also incorporated into the BMCs, analyzing the possible benefits and costs to the environment and the society. Separate BMCs were performed for the three different KERs that focus on the development of laminates containing recycled PE for food or non-food application, the optimization of the whole value chain for producing high-quality recycled PE, as well as the optimization of safety and compliance protocols and methods for the quality assessment of the developed products.
CIRCULAR FoodPack project leads to the development of a sequence of technical steps constituting a whole new process chain that processes waste material and produces high-quality final products. The business cases involve the collaboration of several key stakeholders and target various markets, like packaging production companies, sorting and recycling companies, ink and tracers'producers, retailers, providers of raw materials, as well as plastic industries in general.

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ANNEX

Table 4: Questionnaire form

A.	General Information – Interviewee's Profile		
A1	Partner		
A2	Representative information		
	Full name		
	Title/Position		
	Phone number		
	Mobile number		
	E-mail		
A3	KER		
B.	**Innovation and Maturity**		
B1	How innovative is the proposed technology?	Disruptive innovation (It is a revolutionary technology)	☐
		Incremental innovation (It is a technology that improves an existing process)	☐
		Breakthrough innovation (It is a technology that addresses new markets)	☐
		No innovation detected	☐
B2	What is the Technology Readiness Level (TRL) of the proposed technology?	1 (Basic principles observed)	☐
		2 (Technology Concept Formulated)	☐
		3 (Experimental proof of concept)	☐
		4 (Technology validated in lab)	☐
		5 (Technology validated in relevant environment -industrially relevant environment in the case of key enabling technologies)	☐
		6 (Technology demonstrated in relevant environment -industrially relevant environment in the case of key enabling technologies)	☐

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		7 (System prototype demonstration in operational environment)	☐
		8 (System complete and qualified)	☐
		9 (Actual system proven in operational environment -competitive manufacturing in the case of key enabling technologies)	☐
		Not applicable	☐
B3	Are there any existing patents or pending applications for patents?	☐ Yes	☐ No
		If yes, please fill in the following:	
		Number of National patents	
		Number of European Patents	
		Number of Patents in other countries	
		Number of Pending Applications	
C.	**Market Potential and Competition**		
C1	What kind of market is the technology targeting?	New dynamic market	☐
		Emerging market with high demand	☐
		Niche Market	☐
		Mature market with steady demand	☐
		Market with decreasing demand	☐
		I do not know	☐
C2	Are there any competitive technologies available in the market?	No competition	☐
		Few competitors	☐
		High competition	☐
C3	How difficult is to replicate the current proposed technology? [Define from 1 to 5, 1: very easy, 5: very difficult]	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5
D.	**Resources and Economic feasibility**		
D1	The key resources needed for the technology are easily available	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5

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	[Define from 1 to 5, 1: not available, 5: easily available]					
D2	A properly trained staff is required for the process?	☐ Yes		☐ No		
D3	Could you describe the most cost consuming processes?					
D4	Could you estimate if the proposed technology is economically sustainable?	The initial investment cost is low and the return on revenue is particularly high				☐
		The initial investment cost is low and the return on revenue is low				☐
		The initial investment cost is high and the return on revenue is particularly high				☐
		The initial investment cost is high and the return on revenue is low				☐

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