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D2.1 Report on Interregional value chain analysis

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Executive summary

Value4Pack is an Interregional Innovation Investment (I3) project aiming to strengthen the capacity, competitiveness, and resilience of stakeholders in the European food packaging value chain, and their ability to address environmental, societal, and economic challenges. The main objective of Work package 2 (WP2) is to build an interregional ecosystem, to strengthen the connectivity between the penta-helix actors of the EU food packaging value chain and create a value-chain thinking approach with respect to food packaging innovation at the background of the EU Green Deal goals. Deliverable D2.1 provides a comprehensive interregional value chain analysis, evaluating the current conditions, challenges, and opportunities as well as possibilities for knowledge exchange and cross-fertilisation of competences and best practices between more and less developed regions in regional food packaging value chains across Europe.

The methodology for this analysis included regional value chain mapping to define the scope and identify penta-helix stakeholders such as academia, industry, government, society, and environmental actors. It also incorporated regional desktop analysis, workshops, in-depth interviews with key stakeholders, and an interregional comparative analysis through benchmarking groups and joint report to compare regional performances.

Key findings from the study indicate that developed regions often possess robust infrastructure and advanced waste management systems, particularly in recycling. In contrast, many of the less developed regions exhibit significant gaps in infrastructure and technology, and particularly in effective waste management practices. Interregional major challenges include the need for improved recycling systems to produce high-quality recyclates suitable for food packaging use and the variability in recycling systems and packaging labelling across the regions. There is also an emerging interest in reuse practices though economic feasibility and sustainability metrics remain major barriers. Reducing packaging waste is generally well-practiced, but there is a need for benchmarking best practices to enhance packaging efficiency across regions. Refusing needs an interregional focus to emerge and strategies and visions how to be applied to the markets.

Opportunities for the industry include the adoption of new technologies like laser scoring and QR codes for product information, which could drive sustainability. Cross-regional collaboration and knowledge exchange are essential to address disparities, particularly in waste management and recycling practices. Recommendations from the study emphasise the need for policy harmonisation to standardise packaging labelling and waste management regulations across regions, as well as the creation of business models and economic incentives to make reuse and recycling more viable and attractive for their many stakeholders.

In conclusion, the interregional value chain analysis reveals a diverse landscape of capabilities and challenges within Europe's food packaging sectors. While developed regions demonstrate advanced practices, they still face issues in achieving for example closed-loop recycling. Less developed regions require substantial support to enhance their infrastructure and practices. Collaborative efforts, driven by innovative technologies and harmonised policies, are crucial for building a resilient and sustainable food packaging value chain in Europe.

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Abbreviations

Abbreviation	Description
4R	Refuse, Reduce, Reuse, Recycle
B2B	Business to Business
B2C	Business to Consumer
BE	Belgium
CCIS-CAFE	Gospodarska Bornica Slovenije
CLIC	CLIC Innovation Oy
Clusaga	Asociacion Cluster Alimentario de Galicia
Clust-ER	Clust-ER Agroalimentare
DRS	Deposit Return Scheme
EPR	Extended Producer Responsibility
ES	Spain
FI	Finland
FR	France
HoReCa	Hotels, Restaurants, and Cafes
HU	Hungary
I3	Interregional Innovation Investments
IT	Italy
KOM	Kick Off Meeting
LCA	Life Cycle Assesment
LitMEA	Lietuvos Maisto Eksportuotoju Asociacija
LT	Lithuania
LV	Latvia
M	Month (example M7)
MS	Milestone
Natureef	Stowarzyszenie Natureef
NUTS 2	Nomenclature of Territorial Units for Statistics, level 2
Packaging cluster	Associacio Cluster del Packaging
PET	Polyethylene Terephthalate
PL	Poland
PP	Polypropylene
PPWR	Packaging and Packaging Waste Regulation
RIS	Regional innovation scoreboard
S3	Smart Specialisation Strategies
SE	Sweden
SI	Slovenia
SUP	Single-Use Plastics
T	Task (example T2.1)
UniBO	University of Bologna
Valorial	Association du Pole de Competivite Valorial
WP	Work Package

1 Interregional value chain analysis methodology

This chapter focuses on the methodology used in Value4pack Work package 2 and its interregional value chain analysis. The interregional value chain analysis will initiate the building of the interregional ecosystem helping to strengthen the connectivity between the penta-helix actors of the European food packaging value chains. The value chain analysis sets a benchmark between the regions, helping to understand regional strengths and weaknesses. It will identify challenges and opportunities of the regions and help to turn them into interregional collaboration and innovation topics to better respond to the changing environmental needs and relating regulation, such as Packaging and Packaging Waste Regulation (PPWR).

1.1 Regional value chain mapping and analysis methodology

This chapter describes the value chain mapping and analysis methodology that was used for the creation of the regional reports on the food packaging value chain performance in the context of the future green deal regulation and 4R's (Refuse, Reduce, Reuse, Recycle) deriving from it. CLIC Innovation had a work package leader role in the WP2 and the responsibility to lead T2.1, Mapping and analysing regional food packaging value chains, actions; value chain mapping, desktop study, regional workshops, and in-depth interviews. CLIC prepared the necessary guidance, SharePoint file structures and templates, and together with Natureef the reporting template for the mapping and analysis exercises. Following chapters will further define the methods and actions taken. The work divided to project months M1-M5.

1.1.1 Value chain scope and penta-helix stakeholders

Defining the specific regional food packaging value chains scope together with identifying the relevant Penta-Helix stakeholders (Business, Public, Knowledge, Capital, Community stakeholders) was the first action in the value chain analysis. The value chain scopes were initially discussed in the project Kick off meeting (KOM) and further defined into a template before moving into the stakeholder mapping. The following Table 1 and Table 2describes the region-specific scopes. These exercises took place during the months M2-M3 in the project.

Table 1 Value chain scope in developed regions

Developed regions			
Partner	**Region name**	**Region identifier (NUTS 2)**	**Final value chain scope**
Valorial	Pays de la Loire	FRG0	Food (general)
	Lower Normandy	FRD1	Food (general)
	Upper Normandy	FRD2	Food (general)
Clusaga	Galicia	ES11	Food
Packaging Cluster	Catalonia	ES51	Food packaging in general
Polymeris	Auvergne	FRK1	Packaging Plastic

	Rhône-Alpes	FRK2	Packaging Plastic
Packbridge	Region of Skåne	SE224	Food in a broad perspective with eye for circularity (to be decided)
CLIC	Helsinki-Uusimaa Etelä-Suomi	FI1B FI1C	Food packaging in general Food packaging in general
Pack4Food & Flander's Food	Antwerp Limburg East Flanders Flemish Brabant West Flanders	BE21 BE22 BE23 BE24 BE25	Food and packaging, plastic, PP Food and packaging, plastic, PP Food and packaging, plastic, PP Food and packaging, plastic, PP Food and packaging, plastic, PP
Clust-ER & UniBO	Emilia Romagna	ITH5	Food and Packaging Fruits, Dairy, Poultry & Meat

Table 2 Value chain scope in less developed regions

Less developed regions			
Partner	**Region name**	**Region identifier (NUTS 2)**	**Final value chain scope**
DBH InnoHub	Hungary	HU11	Take-away
		HU31, HU31, HU33, HU21, HU22, HU23, HU12	Multi-material films to mono-material films
Natureef	West Pomarian	PL42	Flexible plastic and paper food packaging (material approach for the value chain)
Food Products Quality Cluster	Latvia	LV00	Food packaging (Sweets and confectionary, Dairy)
LitMEA	Lithuania (Central and Western region)	LT01	Food Sweet confectionary, Dairy
	Lithuania (Central and Western region)	LT02	Food Sweet confectionary, Dairy
CCIS-CAFE	Eastern Slovenia	SL03	Dairy sector (firm yogurt) and Bakery sector (fresh and bake-off station for bread and bakery wares)
	Western Slovenia	SL04	

A template seen in Figure 1 was created jointly by CLIC and Natureef to perform the stakeholder mapping within the selected value chain scope considering different Penta-Helix stakeholder groups. The mapping was done in all the defined regions before the region-specific workshops

to map the necessary workshop participants. Mapping was completed in the workshops by filling in the missing stakeholders and the results were presented in the regional repots.

SCOPE	INPUTS	PRODUCTION	STORAGE & TRANSPORT	PROCESSING	STORAGE & TRANSPORT	WHOLESALE & RETAIL	CONSUMPTION	PACKAGING END-OF-LIFECY CLE
PUBLIC SERVICES								
COMMUNITY								
CAPITAL								
KNOWLEDGE SECTOR								
SWEET& CONFECTIONARY COMFORT FOOD BISCUITS COOKIES CANDIES CHOCOLATES BREAD	PLANTS WATER PESTICIDES FERTILISERS CHEMICALS SUGAR ADDITIVES PACKAGING RAW MATERIALS ADDITIVES PACKAGING PRODUCTION	CLEANING MILLING ROASTING GRINDING PRESSING COLLECTION CENTERS PACKING LABELING	DRY WAREHOUSES COOLED WAREHOUSES TRANSPORT	MIXING FORMING BAKING PACKING LABELING	COOLING TRANSPORT COOLED WAREHOUSES	SUPERMARKETS RESTAURANTS OTHER	DRY STORING COOLED STORING CONSUMPTION PACKAGING REUSING/REFILLING PACKAGING RETURN PACKAGING DISPOSAL	COLLECTING FIRST SORTING TREATING SECOND SORTING RECYCLING ENERGY RECOVERY
FOOD VALUE CHAIN STAKEHOLDERS IN THE REGION								
PACKAGING VALUE CHAIN STAKEHOLDERS IN THE REGION								
PACKAGING APPLIED								
PACKAGING MATERIAL								

Figure 1 Value chain Penta-Helix mapping template

1.1.2 Desktop analysis

Desktop studies were performed according to a set guidance and template created and provided by CLIC. The desktop study consisted of studying Regional Innovation Scoreboard (RIS) materials as well as regional Smart Specialisation Strategies (S3). To further understand the innovation capacity of the regions in terms of the project scope "Food packaging", an online questionnaire was created with specific questions to increase the understanding of the regional innovation and business strategies and actions.

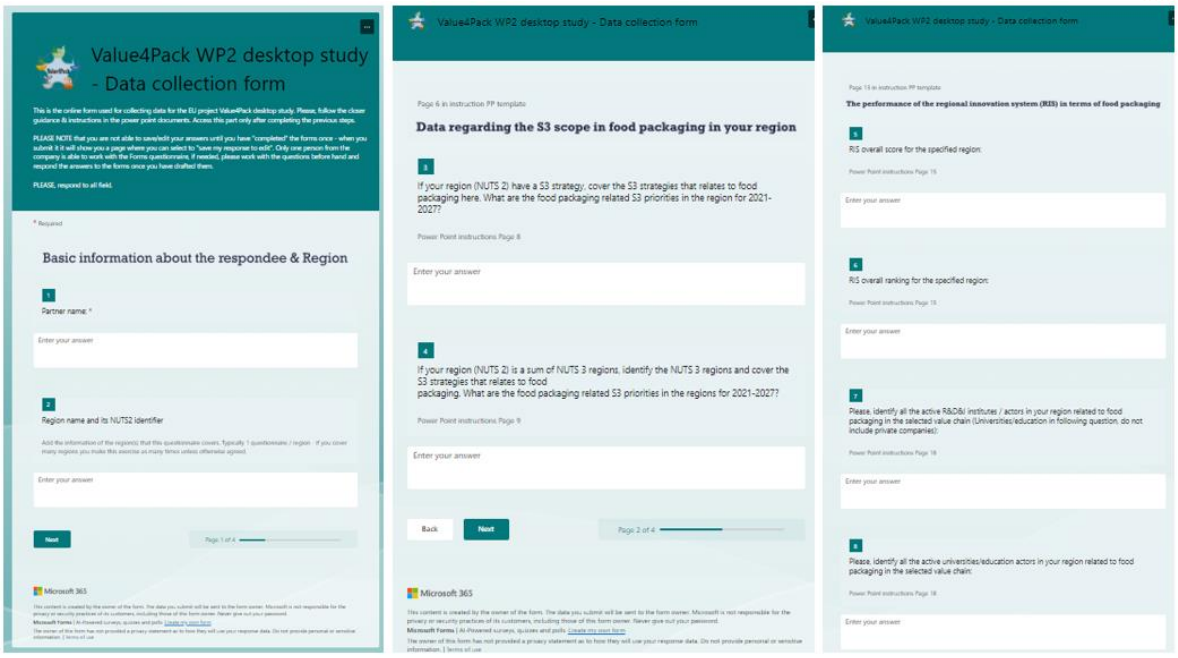


Figure 2 An online questionnaire for analysing regional food packaging innovation performance

The desktop study generated a deeper understanding of the regional strengths and challenges to build on towards the workshops.

1.1.3 Regional workshops

The regional workshops were defined to deepen the understanding of the regional Food packaging value chains competences, challenges and bottlenecks, and opportunities in innovating towards the 4R goals.

CLIC Innovation created methodology and templates for the workshop and trained all partners to facilitate their region-specific workshops. Workshop invitation letters and general Value4Pack presentation were created together with Pack4Food and handed over to the partners. The Padlet online tool was utilised in the workshops and dedicated templates were prepared for all the partners to collect the needed input for the creation of the regional reports.

1.1.4 Regional interviews

A word interview template and instructions were created for the project partners to facilitate the regional interviews which purpose was twofold: 1) Refining and validating the description of the dedicated value-chain and 2) Further identification of the strengths, weaknesses, opportunities and challenges within the value chain and its actors in reaching the Green Deal 4R targets.

1.1.5 Regional reports

The partners of the Value4Pack project prepared their regional reports on a template provided by CLIC and Natureef to collect all the information from the regional value chain analysis. The

regional reports were prepared during the M4-M5 and were uploaded to the project SharePoint at the end as project internal documents as part of Milestone 4 (MS4) at the end of the M5.

1.2 Interregional comparative food packaging value chain analysis methodology

Activities described under chapter 1.2 are activities that took place in WP2 Task 2.2 Interregional comparative food packaging value chain analysis (benchmarking) to identify the synergies and opportunities between more and less developed regions. The activities included the creation of benchmarking groups between less and more developed regions, creation of the joint report to form a basis for interregional food packaging value chain analysis and dedicated interregional workshop.

1.2.1 Benchmarking groups

The basis for creating the benchmark grouping was the value chain focus mapping that was done in the very beginning of the T2.1 work as described in chapter 1.1.1. The groups were formed so that the value chain focuses would support each other between the less and more developed regions as well as possible:

- The first group was established between West-Pomerania with a focus on flexible plastic and paper food packaging with a material perspective, and Catalonia focusing on Food packaging in general and with Auvergne-Rhône-Alpes with a focus on Plastic packaging.
- Second group was established between Hungary with a focus on Multi materials films to mono material films and matched with Flanders with a focus on Food and packaging especially in plastic and polypropylene.
- Third group was established between Lithuania with a focus on Food, sweet confectionery and dairy, and Emilia-Romagna with focus on Food and Packaging and Helsinki-Uusimaa & Etelä-Suomi with focus on Food packaging in general.
- Fourth group was established between Latvia with a focus on Food packaging (Confectionary, dairy) and Normandy & Pays de la Loire with a focus on Food, and South Sweden with a focus on Food in a broad perspective.
- Fifth group was formed between Slovenia with a focus on dairy and bakery and Galicia with a focus on food.

Table 3 Benchmarking groups

Nb.	Less-developed region	Developed region
1	West-Pomerania (PL)	Catalonia (ES) Auvergne-Rhône-Alpes (FR)

2	Hungary (HU) Developed region: HU 11 and less-developed regions: HU31, HU32, HU33, HU21, HU22, HU23, HU12	Flanders (BE)
3	Central and Western Lithuania (LT)	Emilia-Romagna (IT) Helsinki-Uusimaa (FI) Etelä-Suomi (FI)
4	Latvia (LV)	Normandy (FR) Pays de la Loire (FR) South Sweden (SE)
5	Eastern Slovenia Cohesion Region (SI) Western Slovenia Cohesion Region (SI)	Galicia (ES)

1.2.2 Joint report

The joint report was created with the lead from Natureef to highlight the identified gaps, challenges and main comparable data from the regional reports described in Chapter 1.1.5 to support and enable the benchmarking exercise in interregional workshop. The joint report represents the data from the regional reports in condensed and comparable format. The joint report combined the data from the less and more developed regions based on the benchmarking groups as presented in chapter 1.2.1.

The joint report was delivered to all project partners in M6 first for quality checking and then for learning and preparing for the upcoming interregional workshop on M7.

1.2.3 Interregional workshop

The interregional workshop was organised in M7 as a face-to-face event in Helsinki, Finland with the aim to reveal the synergies and opportunities for interregional collaboration, knowledge exchange, cross-fertilisation of competencies and best practices between more and less developed regions. During the workshop all the participants of the Value4Pack project joined together to benchmark the regions against one another to formulate innovation topics based on interregional collaboration. The event also included a study visit to a local frontrunning food packaging actor, Inex partners and their logistic centre.

The workshop approach followed the structure below:

- Roundtable sharing approach, 1 less developed region (LDR) with 2 developed regions (DR). 1 Moderator per group:
    - Group 1: West-Pomerania (LDR) with Catalonia (DR) & Auvergne-Rhône-Alpes (DR), facilitator CLIC

- Group 2: Hungary (LDR) with Flanders (DR), facilitator Natureef
- Group 3: Central and Western Lithuania (LDR) with Emilia-Romagna (DR) & Helsinki-Uusimaa (DR) & Etelä-Suomi (DR), facilitator Natureef
- Group 4: Latvia (LDR) with Normandy (DR) & Pays de la Loire (DR) & South Sweden (DR), facilitator CLIC
- Group 5: Eastern and Western Slovenia Cohesion Region (LDR) with Galicia (DR), facilitator CLIC

- Approach: less developed regions share their findings about their target value chain and its identified challenges & bottlenecks
  - Pre-work: Each region studies the joint report (chapter 1.2.2)
  - Identified challenges/bottlenecks topics to be documented to Flipboard by facilitator
  - Facilitated discussion about possible solutions to challenges from more developed regions and identification of best practices & specific competencies to tackle challenges
- Discussion flow:
  - Less developed region presents their top challenges & bottlenecks and possible competences for 4R in question
  - Roundtable discussion about possible solutions /best practices that can be benchmarked from more developed regions and vice versa
- Flipboards
  - Listing of major challenges/bottlenecks for RIS towards 4R in question
  - Listing solutions/best practices/competences against challenges/bottlenecks
  - Choosing challenges/bottlenecks for inter-regional innovation topics from those identified. Voting in the group if necessary.
- Support questions:
  - Regarding Refuse/Reduce/Reuse/Recycle, what were the top 5 challenges / bottlenecks identified in less developed regions? Share these with the group.
    - Are these challenges similar across the benchmarked regions or are there already solutions to the challenges in developed regions (knowledge sharing)?
    - If the challenges are the same, would there be an opportunity for interregional collaboration to tackle them?

- Are there topics where the regions have their own unique solutions and space for cross fertilisation of the competencies between the regions?

- In case you don't identify common challenges, check out the opportunities table to initiate discussion on common innovation needs for the 4R in question

Finally, the task was to consider the innovation topics from 4 points of view: Challenge, Solution, Solution providers and Target groups to further refine the innovation topics as illustrated in the Figure 3 **Refining innovation topics** We introduce also sharing method in the last part of the workshop by using Gallery Walk sharing method, where all the regions were able to see each group's results and vote for the best innovation topics for inter-regional development.

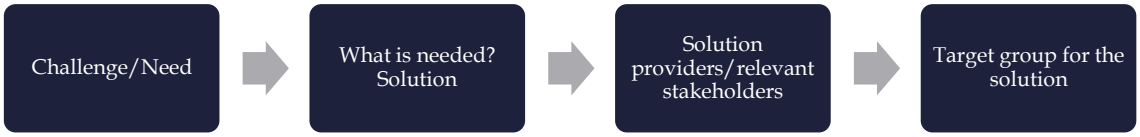


Figure 3 Refining innovation topics

The benchmarking was a full day workshop exercise and resulted in additional identified interregional collaboration and innovation topics that are presented in chapter 3.

2 Regional value chain mapping results

The regional value chain mapping reports, regional reports as explained in chapter 1.1.5, condense the findings of the desktop studies, workshops, and interviews into interregional cooperation recommendations for the food packaging value chains from all the studied regions. The main findings are presented below and separated to inputs from less developed regions and more developed regions. These topics forms an important starting point for the work package 3 and 4 activities and serve as a baseline for synergies and opportunities for interregional collaboration, knowledge exchange, cross-fertilisation of competences and best practices between more and less developed regions. The regional reports have also been merged into Joint report as discussed in chapter 1.2.2 and used as a starting point for the interregional benchmarking exercise.

2.1 Regional value chain competences

This chapter contains the competences identified in the regional value chain mapping for less developed regions and developed regions.

2.1.1 Value chain competences in less developed regions

Table 4 Competences of the less developed regions

Refuse	The debate on refusing packaging has not yet reached its momentum in the less-developed regions. Since refusing packaging, for instance secondary packaging, potentially could impact the logistic process or the handling process in wholesale or retail, companies are not eager to change current approaches. Also refusing packaging, for instance in the case of fruits and vegetables, would require changes in consumers' habits. However, the impact of the directive (EU) 2019/904 on the reduction of certain plastic products on the environment (SUP) on the amount single-use packaging in supermarkets is already noticeable in certain regions. For instance, in Central and Western Lithuania the use of plastic single-use bags at the point of sale has been reduced by 60% over a short period of time. In Hungary collaboration between academia and industry has been supported to explore new business models allowing refuse of packaging. In Latvia retail centres have been undertaking awareness raising campaigns to promote less packaging among consumers.
Reduce	In West-Pomerania (Poland) several companies (mostly branches of multinationals) have already selected mono-materials (reduction of multi-material packaging), provided investments in new production lines, and are prepared to deliver materials that meet food quality and safety requirements. Again, other food processing companies are cooperating with packaging producers in research and development initiatives to define new plastic packaging in line with European regulations. In Lithuania, one of the meat processing companies has introduced innovative packaging solutions resulting in an 80% reduction of plastics applied. Other companies have been applying eco-design to reduce the amount of PET in bottles. In Hungary packaging producers have been focussing on improving packaging production processes to diminish the amount of material waste at the production level. Also, research has been performed in the field of food product life cycles to get better insight in food quality, food safety and shelf-life issues related to packaging reduction. Food processing companies in Latvia have been applying vision control and machine learning technologies to sort products early in the process to improve packaging technologies for same-sized/same-quality products, limiting the amount of packaging. In the Eastern Slovenia Cohesion Region and the Western Slovenia Cohesion Region (Slovenia) actions taken by packaging companies and food processing companies have been focussing on packaging weight reduction, on the use of mono-materials and on decreasing the number of food-contact packaging materials.
Re-use	In West-Pomerania some companies have tried to introduce secondary packaging made from materials allowing to provide a re-use model. However, customers were not interested in these solutions and preferred single-use packaging. Packaging producers and food processing

	companies confronted with the impact of the Single-Use Packaging Directive have been investigating alternative materials that can be applied in re-use models. In Lithuania plastic containers instead of cardboard boxes and plastic pallets instead of wooden pallets have been introduced to establish re-use loops in food logistics. Lithuania boasts a successful deposit system for bottles. Hungarian companies have been analysing scenarios for establishing systems for collection, sanitation, and redistribution of re-usable packaging. In Slovenia packaging re-use systems have only been established in B2B logistics processes but not yet in B2C packaging streams.
Recycle	In West-Pomerania material producers (plastics), because of their size, are in the position of fast-followers rather than material innovators. Although they do not have the capacity for creating new material markets, they are open for increased cooperation with packaging waste sorters and recyclers to improve access to and quality of recyclates. The paper food packaging value chain in West-Pomerania is well-prepared and already delivering satisfying results in securing a circular economy approach for paper packaging. In Lithuania companies have been replacing plastic packaging by paper packaging that can be easier collected and recycled in available facilities. In Hungary the research sector and industry are considering research in the field of chemical recycling and advanced sorting and recycling technologies to enhance material recycling. A company in Latvia is developing and testing a disposable varnish for cardboard packaging improving the recyclability of packaging. Latvia is currently applying gamification techniques in awareness raising campaigns to address circular economy issues at all levels of society. In Slovenia the collection system is rather fragmented. Because of the small amounts of certain packaging materials collected, recycling within the country is not always financially feasible.

2.1.2 Value chain competences in developed regions

Table 5 Competences of the developed regions

Refuse	In Catalonia (Spain) there is a strong strategy to refuse waste. This strategy has been implemented through eco-design guides that promote designing and manufacturing packaging optimized for the needs of each product, eliminating all overpackaging. An example could be an online tool to identify alternative packaging solutions with the aim to refuse some current materials and replace them with more sustainable ones. Also, steps have been taken to avoid the use of inks in graphic design for packaging. Food processing companies in Galicia (Spain) are considering refusing certain packaging through new eco-design concepts and applying new materials, while at the same time maintaining consumers' perceived quality of the presented food product. In Auvergne-Rhône-Alpes (France) companies have taken already action to eliminate 2-pack and 3-pack packaging. Companies in Emilia-Romagna (Italy) have taken action

	to eliminate unnecessary extra-packaging. The regions of Helsinki-Uusimaa and Etelä-Suomi (Finland) are characterised by strong collaboration between Penta Helix stakeholders. Specific competencies in the field of food safety and new technologies (data management, materials) among companies could be applied in new business models to refuse certain packaging. Flanders (Belgium) has excellent knowhow in the field of food, enabling stakeholders to make scientifically grounded decisions where rejecting food packaging is a viable option while maintaining the food quality, safety, and shelf-life. In the regions of Normandy and Pays de la Loire (France), as well as in the region of South Sweden (Sweden) competencies among companies to develop solutions allowing to refuse certain kinds of secondary packaging are in place, yet concrete applications are still missing.
Reduce	Most attention goes out to weight reduction of cardboard, plastics, and glass packaging as well as to reducing the use of multilayer materials. Companies are involved in redesigning primary and secondary packaging to reduce the amount of packaging. In Galicia companies are cooperating on improving eco-design for logistics tackling all aspects of the logistics process in terms of packaging formats, space optimisation in trucks and warehouses, reduction of films in logistics. Food processing companies are also investigating into new materials for tray type packaging to ensure product quality and freshness during transportation, while at the same time reducing the number of materials applied in packaging. In Emilia-Romagna, as well as in the regions of Normandy and Pays de la Loire, discussions are taking place on increasing the volume of certain food products in one package to limit the amount of packaging (instead of buying two or three packages, the consumer buys one larger package). However, this approach is confronted with issues like for instance: ensuring food quality in larger packages, consumer habits towards single-portioned products and possible increase in food waste). In Finland food processing companies have already considerably reduced the amount of packaging. Also, eco-design has led to the reduction of plastics in packaging and to the replacement of traditional plastics by biobased and fibre materials. Flemish research and technology organisations and companies demonstrate excellent expertise in reducing the layers in flexible food packaging while ensuring continued functionality and recyclability for the food product. Furthermore, they explore how transitioning from multilayer to mono-layer food packaging impacts the implementation of packaging machines. In Sweden several organisations are working on a total approach for decreasing the amount of packaging material through optimised packaging design, materials application, and logistics.
Re-use	Companies in the HORECA sector in Catalonia have already started to apply reusable packaging. Packaging as a service, for instance during events, can be observed in Catalonia as well as in Flanders. Food processing companies in Galicia are investigating circularity scenarios for labels and containers. Specific attention goes out to re-usability through appropriate handling of labels and packaging during packaging processes (proper maintenance of equipment and machinery in packaging lines) and logistic processes. In Auvergne-Rhône-Alpes

	companies have been testing recharging solutions consisting of a re-usable base and recyclable packaging. These kind of eco-design projects were also identified in Emilia-Romagna where packaging companies have been developing packaging solutions to facilitate their re-use (among secondary and tertiary packaging in logistics). Finland has several good practices in the field of re-using packaging and on-going research projects in the field. Examples such as reusable meat and ready-made meal transportation boxes, reusable consumer take-away packaging and refillable bottles show that research and development in innovation networks combined with cooperation between stakeholders can lead to technically and financially feasible re-use systems. This kind of cooperation is also visible in Flanders, where a strong regional network related to reusable packaging (Green Deal Anders Verpakt consortium) is generating technology-related pilot projects with the aim to further develop re-use value chains. Flanders has specific know-how on design for re-use, including the Reuse Lab that supports companies in making the transition towards reusable packaging. Flanders has several washing streets and has know-how on automated quality control systems for washing streets. In the regions of Normandy and Pays de la Loire deposit systems for reusable packaging are gradually being introduced. Companies in the food packaging value chain are looking for cooperation with existing collection centres and exploring new ways to re-use certain food packaging. In Sweden steps have been taken in the HORECA sector to replace single-use plastic cutleries, plates, and cups by re-usable products (based on materials that can be washed over 1.000 times), along with the development of a circular collecting, sorting and washing system.
Recycle	In Catalonia much attention went out to raising consumers' awareness on correct sorting of packaging waste and increasing companies' awareness about the need to avoid certain materials and inks to ensure recyclability of packaging. On the other hand, companies in Galicia have already been working with recyclates in packaging. QR technologies are being considered to improve traceability and to support awareness campaigns concerning sorting and recycling, directed to consumers. Companies in Auvergne-Rhône-Alpes are cooperating with other stakeholders in the region to identify opportunities for improving the regional sorting and recycling system. There is also a strong representation of material producers. Packaging companies are providing eco-design. Investment in recycling facilities has led to increased quality of recycled materials. In Emilia-Romagna packaging companies are focussing on mono-material packaging to facilitate recycling. A discussion is going on about the use of biobased packaging and the possibility to ensure appropriate sorting and recycling processes. Recycling companies in the regions of Helsinki-Uusimaa and Etelä-Suomi have many years of experience in packaging recycling processes (for instance PALPA DRS system for bottles). There is also ongoing high quality basic and applied research on both chemical and mechanical recycling of plastics in Uusimaa region together with pilot plants and first commercial applications. Flanders has a well-developed deposit system and recycling system, including mechanical recycling plants as well as chemical recycling plants and state-of-the-art sorting facilities. There is a strong research

	and development base on various aspects of the recycling PP food packaging chain, with knowhow from previous and current running projects. Companies proficient in the manufacturing of recyclable flexible and rigid PP food packaging, offering knowhow and services in this field. Organisations in South Sweden have competencies in the field of fibre-based liquid packaging recycled to new material and new packaging (secondary food packaging, not in direct contact with food). The region has also a well-developed value chain for paper/cardboard and plastic recyclable food packaging.

2.2 Regional value chain challenges and bottlenecks

This chapter describes the challenges and bottlenecks identified in the regional value chain mapping for less developed regions and developed regions.

2.2.1 Value chain challenges and bottlenecks in less developed regions

Table 6 Challenges of the less developed regions

Refuse	• To refuse secondary packaging • To refuse paper covering of plastic packaging for marketing purposes • The SUP stipulations implemented in the national law, but interpreted in different ways by stakeholders resulting in a lack of understanding when to pay or not for applied single-use packaging • A lack of concrete business cases that prove technological and financial feasibility of applications in which food packaging was eliminated
Reduce	• The price of the new packaging (including new materials allowing to reduce the number of traditional materials) compared to the previous version • A lack of access to new materials (including mono-materials) that meet the food packaging quality and safety requirements (a lack of information and standardisation, a lack of certification and labelling procedures for materials) • Packaging producers cooperating with packaging wholesalers in Europe and globally not knowing the destination of their packaging solutions, as such not being able to provide material minimisation projects on their own (rather must be in line with requirements from the wholesalers and their clients) • A lack of knowledge about barrier properties and stiffness parameters of new packaging materials and their role in securing the functionality of packaging for specific products in terms of shelf-life and securing overall food quality (the need to define new shorter supply chains for certain food products); difficulty in balancing packaging functionality with minimal material use • Resistance to transportation: meeting logistics requirements for durability, including resistance to air transportation pressure differentials

	• Material producers providing non-verified information about new "mono-materials" for specific applications (for instance: non-plastic-coated paper for hot drink cups) • Economic and logistical challenges associated with redesigning packaging for reduced material use
Re-use	• A lack of a thought-through deposit return system; insufficient systems and logistics for the collection and redistribution of re-usable packaging • A lack of education of the society and a lack of promotion of new lifestyles concerning packaging re-use, resulting in packaging ending up in non-reusable waste streams • A lack of transparency in the packaging waste management streams, a lack of knowledge from the side of material producers and packaging producers about the packaging waste management streams • A lack of "washing streets" infrastructure in the packaging re-use system • Difficulties in engaging local shops, bars and restaurants in re-use systems because of lack of space to store returned packaging • A lack of good practices in applying re-usable hard plastic boxes as secondary packaging replacing traditional flexible plastic packaging (issues: storage space in shops, storage space at home, packaging washing infrastructure, hygiene responsibilities) • Ensuring hygiene of food packaging and food safety in situations in which consumers bring their own refillable packaging to shops. • Food product shelf-life in situations where consumers bring their own refillable packaging • Cleaning of certain packaging material (water, detergents…) can be even more energy and environmentally wasteful than the production of new packaging materials
Recycle	• A lack of a unified system for collecting and sorting packaging waste into different types • A malfunctioning recycling system, a lack of cooperation leading to higher risks concerning optimal waste input (in terms of amounts as well as quality of fractions) for recycling plants • Inadequate sorting facilities and poor sorting methodologies (technologies) leading to low-quality of sorted materials and low quality of recyclates at the recycling facilities • Each recycling company applying its own recycling standards (e.g. for quality) • The complexity of food packaging materials that hinder recyclability • Difficulties in getting the necessary permits for new recycling installations (long procedures, protests from people living in the neighbourhood) • A lack of inter-sectorial dialogue to discuss the role of packaging in specific product life cycles and to define innovative sustainable solutions for packaging that do not negatively impact specific stakeholders in the value-chain

	• A lack of education of the society and a lack of promotion of new lifestyles concerning packaging waste sorting resulting in packaging ending up in nonrecyclable waste streams • A lack of transparency in the packaging waste management streams, a lack of knowledge from the side of material producers and packaging producers about the packaging waste management streams on the level of sorters and recyclers, that leads into recyclers / sorters not knowing the material inputs • A non-competitive high price of recyclates of European origin • Limited market availability for recycled materials, particularly for those approved for food contact • The impact of recyclates on the colour of packaging vs. the expectations of the consumer to see the product • The role of the plastic window in cardboard boxes and paper bags (search for biodegradable plastics that can be included in the paper waste stream) • The role of coatings as part of marketing and product placement vs. the role of coating in ensuring proper barrier properties vs. the recyclability of the coated materials • A lack of awareness among sorters about the number of different categories of polypropylenes in the packaging waste stream, as well as the difficulties in efficiently separating kinds of polypropylene materials • A lack of information about recyclates that meet the food packaging quality and safety requirements (a lack of information and standardisation, a lack of certification and labelling procedures for recyclates and packaging containing recyclates) • A lack of knowledge about laboratories that have the capacity to analyse the content of recyclates in terms of their compliance with requirements for food quality and safety • The forest traceability directive – the use of traceable materials for packaging. There is a significant lack of understanding about the regulations and their implementation • A lack of certified organisations capable of chemical recycling • A lack of sufficient quantities of collected materials to make recycling within the region or country financially feasible

2.2.2 Value chain challenges and bottlenecks in developed regions

Table 7 Challenges of the developed regions

Refuse	• Loss of ergonomics in packaging design • Removing packaging should not compromise the shelf life and safety of the food product (food loss – must be prioritised before refusing food packaging) • Removing packaging must continue to ensure hygiene standard and logistics • Increased cost of purchasing new, eco-friendly packaging materials allowing to eliminate certain packaging (secondary, tertiary packaging)

	• Adaptation of existing or new packaging machinery and equipment • Consumer rejection due to ergonomic, sensory, and/or functional issues • To ensure food safety and hygiene, while at the same time not increasing the labour intensity of product handling on the level of retail • A lack of understanding about consumers' behaviour and a lack of consumer data regarding the impact of eliminating certain kinds of packaging on the consumers' habits • Smaller packaging required by large-scale retail • Lack of identification of food products when products are unpacked (e.g. fruit varieties)
Reduce	• Eco-design challenges in creating sustainable packaging solutions • Food waste vs. packaging waste dilemma (life cycle and risk analyses) • Reducing thickness of packaging should not lead to lowered barrier properties inducing shorter shelf-life and possibly more food losses • Reducing plastics in packaging should not lead to increased layers (to ensure food safety), which would decrease the recyclability of the final packaging • Altering the packaging composition influences the functioning of packaging machine and can influence to the seal ability of the packaging • The impact of reducing the number/volume of materials in packaging on production processes and logistics processes • Establishing structural limits for sustainable long-distance transportation • Technological challenges in substituting materials and dyes • Replacing plastics by paper which in certain packaging applications lead to heavier packaging • Flexible design rather than lids: thinner, flexible thermoforming • Ensuring food safety and shelf-life amidst material substitution and packaging changes • New solutions to diminish over-packaging of food products • The business model is moving towards more individual packaging • To include legally required information on reduced packaging (product info vs. space in the product packaging) • Bulk purchasing solutions to reduce packaging waste (changes in consumers' habits and in retail logistics)
Re-use	• Eco-design challenges in creating sustainable packaging solutions • Hygiene and food safety in re-useable packaging systems • New business models and service design to make the reuse of packaging affordable and convenient for the consumer • A lack of traceability systems for returned packaging • A user-friendly system to collect and return reusable packaging • Sterilisation challenges for reusable packaging (washing street technologies, cleaning costs, potential residue problems during cleaning operation, such as cleaners, water footprint) • Logistical constraints and space requirements for packaging return systems • Transportation costs associated with collecting and redistributing reusable packaging (returnable empty packaging, carbon footprint)

	• Challenges with placing marketing, ingredient, and usage information on re-usable packaging • Liability and responsibility questions regarding food quality and food safety • Food security and allergen cross contamination. Need for reliable microbiological and organoleptic properties • Food safety is a bottleneck. Packaging that is intensively used and washed is different than packaging used at home or single-use packaging. Migration, contamination by the consumer and hygiene are an issue. • Scaling up is important to make reuse economically viable. It is a challenge to engage SME's and not only larger companies who are able to scale up • As standardisation in packaging design might be useful for reuse. Deciding on the adoption of standardised packaging and agreeing on its characteristics will pose a significant challenge • Sealing packaging to ensure the consumers receives a closed product might be a bottleneck • It is a challenge to define for which products/situations reusable packaging is ideal and for which a single-use packaging is more sustainable • Cleaning quality control and verification of packaging to be processed in the washing street • Reusable packaging for food products which are exported is a challenge. Interregional collaboration is needed
Recycle	• Eco-design challenges in creating sustainable packaging solutions • A lack of complete and collective comparative Environmental Life Cycle Analyses of recycled solutions • Recyclable material missing to enable food contact (clean enough recyclate with acceptable price), food safety issues when recycled material is being used • Flexible plastics have not many recycling options • Strong need to food grade plastic recyclate • Few recycled plastics can be used as food contact materials, according to law • Limited availability of compatible recyclable materials, recycled materials don't have the same properties as raw materials • Setting up platforms for purifying recycled materials • Pricing (nobody is willing to pay premium for recycled material, recycled materials end up often being more expensive) • Majority of consumers not willing to pay extra for recycled materials • Recycling technology or infrastructure partly missing, technological limitations in recycling processes • Improving the sorting to purify the packaging waste streams, and reducing the loss of small sized packaging materials • More easily recyclable materials often need new packaging lines, investments are high and long-term planning necessary • Harmonisation for pictograms still missing for recyclable packaging especially on EU level, a lack of comprehensive recycling information on packaging labels

	• Use of labels can disturb the recycling. Clear design4recycling guidelines including the use of labels • Printing on food packaging reduces the yield of recycling • Critical mass of sorted packaging waste for making recycling financially feasible on the regional/country level is not achieved • Financially feasible concepts for chemical recycling • More consumer awareness and education are needed to improve the separation of the packaging waste (e.g. separation of lidding film and tray)

2.3 Regional value chain opportunities

This chapter describes opportunities identified in the regional value chain mapping for less developed regions and developed regions.

2.3.1 Value chain opportunities in less developed regions

Table 8 Opportunities identified in less developed regions

Refuse	• Replacing plastic coated paper bags and cups by paper solutions with additional protection/coatings ensuring appropriate barrier properties and mechanical properties of the packaging (for instance: liquids, temperature) • Leveraging advanced IT and startup ecosystems to develop digital solutions that minimise the need for physical packaging. • Encouraging policy-driven shifts towards packaging-less products and systems in urban retail and delivery services. • Develop a code of conduct for marketing and packaging to prevent overpackaging, aiming for a balance between brand visibility and environmental responsibility, and share this across regions for broad adoption. • Approaches for rejection of unnecessary packaging • Research and development on edible packaging
Reduce	• Mono-material categories according to their field of application (information about research provided on food quality and material recyclability) • Innovation in lightweight and minimal material use in packaging • Engaging with local environmental agencies to foster public-private partnerships aimed at reducing packaging waste • Promoting research grants and incentives for SMEs that develop packaging reduction technologies • Develop and implement guidelines for eco-design in packaging • Approaches for finding balance between product safety, resource efficiency, and cost-effectiveness • Application of new "more sustainable" materials for production using existing equipment • Technical characteristics of the new packaging to ensure product safety and maintain the shelf-life

	• Resistance to transportation: meeting logistics requirements for durability, including resistance to air transportation pressure differentials • Developing more easily recyclable and thinner coatings for cardboard/paper
Re-use	• New delivery and take-back approaches for packaging in the food-delivery segment • New delivery and take-back approaches for packaging in shops and HORECA (including storage spaces and machinery allowing to store packaging waste in a secure and hygienic way) • A joint information campaign with local governments to address packaging waste issues in HORECA entities and shops • Implementing return-and-refill systems in cooperation with logistics and retail sectors • Set up a collaborative refillable packaging program that can be piloted in multiple regions, sharing best practices and technology for refill stations and systems to encourage reuse • Cultivating a culture of reuse through educational programs and local community initiatives
Recycle	• A joint approach of stakeholders in marketing and quality to diminish "over-packaging" (refuse additional packaging for the sole purpose of marketing) and to avoid the use of certain coatings in order to ensure recyclability (recycle) of the packaging • In certain applications PE-coated insert to make the packaging look aesthetic, can be replaced by ecological material and the cardboard still can be protected against grease • Replacing plastic windows in paper and cardboard packaging by a solution that meets SUP and PPWR regulations (e.g. made of milk paper not plastic) • The future of laminated packaging (paper-plastic) – scenario's for replacing laminated packaging and for recovering/recycling laminated packaging • Cooperation in sorting and recycling specific PP categories (cooperation between a material producer and packaging waste sorting companies) • New materials ensuring appropriate barrier properties and required shelf-life that comply with the goal "all packaging shall be recyclable" • A joint information campaign with local governments to address packaging waste issues in HORECA entities and shops • Packaging labelling agreement on EU level • Advanced recycling technologies, particularly in chemical recycling • To drive the simplification of packaging designs, encouraging the standardisation of packaging sizes and formats to facilitate recycling and reduce production complexity • Developing and testing mono materials to replace difficult to recycle materials • Find the balance between cost of the food packaging production, recycling and taxation legislation and other rules

2.3.2 Value chain opportunities in developed regions

Table 9 Opportunities identified in developed regions

Refuse	• Eliminate unnecessary extra-packaging • Avoid superfluous packaging in the company's business model • Cellular agriculture (local food streams, direct contact between farmer and consumer) emerging, and this could reduce the need for packaging (new food distribution channels) • Utilise water-based dyes in packaging for environmental friendliness • Awareness raising campaigns concerning sustainability among consumers focussing on behaviour change • Exploiting competences in data management and existing customer loyalty schemes that could be utilised for incentivising new habits • Laser printing technology for labels
Reduce	• Standardise packaging formats for waste reduction, re-design of primary and secondary packaging • Improve packaging design for less material usage • Machinery eco-design (food processing and filling equipment allowing to apply thinner packaging or packaging with less materials) • Develop lightweight packaging materials • Substitution of materials in packaging for sustainability • Optimise production processes for resource efficiency • Balance tradition with environmental sustainability • Utilise bulk packaging options to minimise waste • Implement bulk selling strategies • Adopt collaborative logistics for emission reduction • Repurpose waste and optimise waste sorting • Replace labels with QR-code • Standardisation of packaging with GS1 engraving • Increasing the size of packages (increased product) to reduce plastics (however this contrasts with new consumption methods, e.g. single portions and may lead to increase in food waste) • Innovate packaging design for ergonomics and sustainability
Re-use	• Exploiting existing good practices like PALPA, EPR system that have been developed via agreements between industrial stakeholders • Exploiting existing solutions driving packaging re-using • Design of specific type of packaging to facilitate re-use • Utilisation of re-usable secondary or tertiary packaging • Use QR codes for traceability in reusing products • Creation of a universal traceability software • Employ digital technologies for efficient traceability systems • Develop micro system for infrastructure for distribution • New cleaning system for allergen contamination risk • Recycle water in cleaning processes for sustainability • Implement closed-loop systems for water cooling

	• Reduce emissions through reusable systems • Implement effective cleaning processes for reusables • Utilisation of plastic collection dispensers that provide cash reward • Shift toward collapsible-sided boxes to facilitate re-use in logistics • Innovate packaging design for ergonomics and sustainability
Recycle	• By-products utilisation for the development of packaging coatings • Mono material packaging to facilitate recycling • Research barrier layers that fit the recycling streams • Design packaging with materials easy to be separated • Mechanical and chemical recycling technology developing • Incentivise recycling for example through customer loyalty programs and its consumer data • Building on existing best practices like PALPA, DRS system for closed loop recycling • Incorporate recycled materials into packaging • Ensure material traceability through QR codes/watermarks to enable higher quality recyclates • Implement container return systems for recycling • Recover secondary materials for resource efficiency • Increase utilisation of recycled packaging materials • Evaluation of the recycling percentage of packaging materials • Implementing chemical recycling • Increasing recycling plants efficiency

2.4 Regional recommendations for interregional value chain cooperation

This chapter contains the merged list of different cooperation recommendations from the regional reports of both less developed regions and developed regions. These cooperation recommendations are an important starting point for future Value4Pack activities aiming to build the interregional ecosystem, cross fertilisation and knowledge sharing activities as well as building of the future innovation projects.

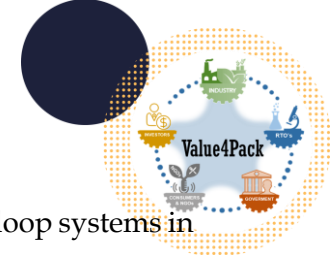
2.4.1 Less developed regions

These are the merged and categorised findings for interregional cooperation from the less developed regions.

- Stakeholder Cooperation and Legislation:
    - Foster better cooperation among stakeholders (food producers, packaging producers, recycling companies, public authorities, other Penta-Helix actors) based on a defined sustainability strategy.
    - Conduct analysis of current practices and challenges and assess the impact of specific measures with stakeholder engagement throughout the value chain.

- Organise meetings/study visits between industries to gain insights into production processes and logistics for proposing new packaging solutions.

- Digitalisation and Traceability:
  - Digitalise the whole packaging process, including material certification and packaging labelling.
  - Develop a digital platform for stakeholders to report raw material specifications, contact details, packaging materials, products placed on the market, and packaging waste generation.
  - Enhance traceability and accountability using digital tools to better manage packaging materials and their end-of-life impact helping to hold companies accountable for their packaging choices.
- Packaging Recyclability and Consumer Education:
  - Increase understanding of packaging recyclability and address issues like dirty packaging and impacts of effective consumer sorting.
  - Organise education and awareness-raising campaigns for young people and the general public on handling packaging waste and sorting.
  - Improve recycling infrastructure, especially for plastic materials, and increase recycling capacity via cross-regional approach.
- Resource Allocation and Development:
  - Allocate more resources for the development of sustainability initiatives, sharing of the resources among stakeholders.
  - Establish a joint interregional task force to simplify packaging designs, standardise packaging sizes and formats to facilitate recycling, and reduce production complexity.
  - Incentivise the development and use of monomaterials through tax subsidies.
- Shared Platforms and Collaboration:
  - Create a shared platform for developing and testing monomaterials and other sustainable packaging solutions across regions.
  - Set up collaborative refillable packaging programs piloted in multiple regions, sharing best practices and technology for refill stations and systems.
  - Foster R&D collaboration on bio-based and compostable packaging solutions.
- Regulations and Eco-Design:
  - Develop and implement guidelines for eco-design in packaging, encouraging design with end-of-life considerations for recycling and reusability.
  - Advocate for policy alignment and harmonisation at regional and national levels to support sustainable packaging initiatives.
  - Standardise packaging regulations across regions to ease the transition to sustainable packaging structures and materials.
- Public Campaigns and Awareness:
  - Fund campaigns to educate consumers about the functionality and environmental impact of packaging choices and the importance of recycling and reusing.
  - Develop a code of conduct for marketing and packaging to prevent overpackaging while balancing brand visibility and environmental responsibility.
  - Organise interregional innovation contests or hackathons focused on food packaging challenges to generate sustainable solutions.
  - Support for Circular Economy Initiatives



    - Provide funding and support for projects aimed at creating closed-loop systems in packaging use and recycling within the food industry.
    - Promote resource optimisation and circular economy principles through joint initiatives to reduce packaging material consumption and increase the use of recycled materials.
- Technology Transfer and Capacity Building:
    - Facilitate technology transfer and capacity-building programs for businesses to adopt sustainable packaging technologies.
    - Encourage collaborative R&D projects between packaging manufacturers, material suppliers, and equipment providers.
- Examples of Concrete Business Cases:
    - Document and share concrete business cases that demonstrate the technological and financial feasibility of sustainable packaging solutions.
    - Highlight successful examples of cooperation between sorters, recyclers, and material producers to secure quality and price-competitive recyclates in the production process.
    - Showcase joint stakeholder approaches to diminish overpackaging and ensure recyclability by avoiding certain coatings.
- Reducing Overpackaging:
    - Introduce regulations to discourage overpackaging, especially when it serves no functional purpose beyond marketing.
    - Advocate for eco-design solutions to decrease the use of unrecyclable materials in packaging for different food products.

2.4.2 Developed regions

These are the merged and categorised findings for interregional cooperation from the developed regions.

- Uniform European Practices and Standards:
    - Develop more uniform European practices in packaging value chains focusing on the 4Rs (Refuse, Reduce, Reuse, Recycle).
    - Create reuse standards for European food packaging value chains to allow cross-border practices.
    - Develop uniform recycling pictograms and standards and ensure reliable waste/recycling statistics between regions.
    - Address the need to reduce material diversification within companies, aiming for one material per product category.
- Knowledge Sharing and Best Practices:
    - Create a method to share best practices, knowledge, and information across the EU to avoid duplicated efforts and induce knowledge-scale up.
    - Highlight and share concrete case examples proving the technological and financial feasibility of various sustainable packaging solutions.
- Economic and Environmental Impact:
    - Demonstrate the profitability of Refuse, Reduce, Reuse, and Recycling actions

- Increase understanding of harmful incentives hindering environmentally better solutions, such as governmental company aids / tax reductions for certain industries and businesses.

- Food Waste and Safety:
  - Increase understanding of the real reasons behind food waste and potential food safety and hygiene risks by comparing practices between countries with different food distribution methods.
- Community Involvement and SME Support:
  - Enhance community stakeholder involvement for better impact, considering both community and nature.
  - Support European SMEs in adapting to changing regulations and reporting requirements and help them develop innovative solutions towards the 4Rs.
- Transportation and Logistical Eco-Design:
  - Improve efficiency in transportation and logistical eco-design, particularly for space-occupying products.
  - Conduct design sprints and Life Cycle Assessment (LCA) evaluations to explore alternative designs.
- Consumer Education and Engagement:
  - Implement QR code technology in consumer education campaigns on recycling and sustainability policies.
  - Explore the potential for QR technology to incentivise recycling habits through reward systems.
  - Assist consumers in choosing sustainable options at the point of sale by offering products with varying sustainability levels at similar costs.
- Circular Economy and Resource Optimisation:
  - Setting up closed-recycling loops to reuse/remanufacture new food packaging materials
  - Promote the circularity of products and packaging by utilising food waste to manufacture packaging materials.
  - Explore case studies on circularity, such as reusing discarded materials or adopting models like CHEP's pallet reuse.
- Regulatory Coherence and Policy Advocacy:
  - Address the limited coherence of EU regulations and often contradictory trends by collecting stakeholder opinions to better define regulatory needs.
  - Advocate for policy alignment to support sustainable packaging initiatives, including 4R's, bio-based and compostable materials, and separate packaging collection.
- Innovative Packaging Solutions:
  - Develop and offer recyclable and reusable PP (polypropylene) food packaging materials.
  - Explore new barriers for PP food packaging that do not hinder recycling.
  - Standardise packaging design for reusable PP packaging and develop innovative deposit return systems.
  - Implement digital solutions for reusable and recyclable food packaging, such as digital product passports.

- Facilitate R&D infrastructure and tools to test and validate food packaging innovations.

- Market Development and Recycling Innovations:
  - Develop new markets for PP recyclate and optimise chemical and mechanical recycling plants.
  - Innovate sorting techniques for PP plastic packaging waste and design infrastructure for reuse and recycling.
- Transparency, Traceability, and Consumer Trust:
  - Enhance transparency and traceability of packaging materials using digital watermarks.
  - Conduct investment calculations for sorting, washing, and recycling processes.
  - Communicate effectively to build consumer trust and knowledge about the recyclability and reuse of packaging materials.
- Value Chain Evolution and Cooperation:
  - Foster innovation to evolve the packaging value chain and strengthen regional economies.
  - Share good practices and experiences among European actors in the value chain to address current issues like the recyclability of food-contact materials.

3 Interregional workshop results on defining innovation topics

This chapter will focus on the results deriving from the interregional workshop that took place in Helsinki 20th-22nd May 2024 as a face-to-face event between the project consortium. Chapter **Error! Reference source not found.** dives into the results from the workshop and **Error! Reference source not found.** shows the benchmarking group starting points

3.1 Benchmark group 1: West-Pomerania (PL)

The benchmarking group consisted of less developed region West-Pomerania who was represented in the workshop by Natureef. The developed regions were Catalonia, represented by Packaging cluster, Auvergne-Rhône-Alpes, represented by Polymeris. The workshop session was facilitated by CLIC. Following are the identified innovation topics achieved by utilising the methodology described in chapter 1.2.3.

Below are identified innovation topics in relation to the 4R's:

Refuse:

1. Companies do not know how their packaging can address the refuse requirements; they don't know their environmental impact and they struggle to fulfil current and upcoming regulatory requirements.
   a. Proposed solution: Development of a tool/platform (based on existing platform & tools) to help SMEs to select the best options between replacing and refusing

(materials) to face the restrictions (PPWR, SUP others). Introduce a framework that allows to address companies' environmental, social, and governance needs and obligations and create one shared database (tools) through API integration

2. Lack of knowledge about responsibility to use 3rd party packaging
    a. Proposed solution: Identifying and implementing solutions for consumers to use their own packaging (Example from University of Amsterdam to bring your own mug or pay 1 euro extra)

Reduce:

1. Reduce the layers not affecting the quality / properties of the packaging
    a. Proposed solution: Evaluation of the necessity of the different layers and new, more easily recyclable coatings that reduce the need for the many layers.
2. Mono-material packaging for food products with no need for secondary packaging

Reuse:

1. Lack of certified solutions for washing processes that meet the hygienic requirements and lack of space for storage in HoReCa needed for reusable packaging
    a. Proposed solution: Use best practices from the developed regions / regions with more advanced solutions for packaging reuse

Recycle:

1. Waste that is a good source of PP but currently is not recycled due to technology issues or other factors – generates huge costs for sorters/collectors as sorters/collectors do not meet the recycling % and once the waste is incinerated instead of recycled, it costs a lot.
    a. Proposed solution: A new business model to better sort the waste and sell it when well collected for recyclers / parties interested in recycling
2. How to ensure / check whether materials marketed as recycled are actually of recycled content?
    a. Proposed solution: Technology (HW/SW) to check if the material content was recycled in a closed loop

3.2 Benchmark group 2: Hungary (HU)

The benchmarking group consisted of less developed region Hungary, who was represented in the workshop by DBH Innohub. The developed region was Flanders, represented by Pack4Food and Flander's Food. The workshop session was facilitated by Natureef. Following are the identified innovation topics achieved by utilising the methodology described in chapter 1.2.3.

Below are identified innovation topics in relation to the 4R's:

Refuse:

1. Refuse primary food packaging for fruit and vegetables without reducing the shelf-life
    a. Proposed solution: "No-packaging" alternatives to primary food packaging materials for fruit and vegetables that preserve the shelf-life such as coatings and active-stickers

2. Identification of different unpackaged fruits and vegetables for consumers and during wholesale/retail checkout
    a. Proposed solution: To apply AI and vision recognition to identify fruits and vegetables at the stage of wholesale and retail (shapes and boundaries of products, machine learning process in variable conditions, laser labelling)
3. Refusing secondary packaging in multi-packs food products
    a. Proposed solution: To apply adhesive dots to hold products together, and which do not hinder the recyclability of the primary food packaging
4. To reduce the use of plastics in paper food packaging
    a. New coating solutions for paper that can ensure shelf-life. Quality / sustainability check of new coating solutions (biodegradable/recyclable/PFAS free/safe by design) in terms of avoiding green washing.

Reduce:

1. Minimalisation of packaging materials while maintaining packaging functionality and processing conditions at the food processing and filling stage (minimising the need for process and system changes of equipment at the food processing company), and recyclability
    a. Proposed solution: Applying new recyclable monomaterial packaging materials with (a) similar barrier (i.e. new types of barriers) and (b) mechanical properties (e.g. Machine Direction PE or Machine Direction PP) as the multilayer solution
2. To avoid absorbent layers in packaging (e.g. in meat packaging)
    a. Proposed solution: Utilising novel technologies to increase liquid retention capacity of the primary material (capillary recesses TRL 7-9)
3. To make packaging lighter/reduce amounts of materials used without hindering the sorting process.
    a. Proposed solution: Apply foamed structures to make the packaging lighter while using less material with similar functionality. Recycling might pose problems for these materials but will need to be checked and considered.
4. Reduce the amount of paper (or other materials) wasted in the start-up stage in printing companies but also at later stages of the food packaging value chain in new product launches.
    a. Proposed solution: Applying novel printing technologies (digital)

Reuse:

1. To develop reusable packaging solutions to fulfil the needs of for example ready-made food producers
    a. Proposed solution: Easily closeable reusable modified atmosphere packaging (TRL 7-8)
2. To invent and apply new business models in the packaging re-use processes
    a. Proposed solution: Business models: packaging as a service in secondary packaging and in take-away services (for instance catering services in office buildings, catering services and home deliveries)
3. To ensure technically and financially feasible solutions for reverse logistic systems for packaging
    a. Proposed solution: To develop business models for reverse logistic systems for re-useable packaging through standardising packaging, improving traceability of

packaging (labelling, tagging), defining quality requirements from the point of view of food safety standards and from the point of view of consumer expectations, increasing quality assessment of packaging in the washing street (AI, vision techniques)

4. To ensure food quality and food safety in packaging re-use loops
    a. Proposed solution: To improve design for re-use, with special attention to avoidance of edges on the tray and the sealing cover and of folding in the bottom, as well as with attention to specific colours applied to ensure proper identification (selection and quality assessment) by vision techniques
5. To ensure appropriate means to collect re-useable packaging from consumers
    a. Proposed solution: New kinds of deposit boxes for re-usable packaging ensuring consumers can return packaging without damaging the packaging conveniently
6. To ensure re-usable packaging does not take up odours and/or colours from the food (scalping) by the means of innovating new materials and coatings
    a. Proposed solution: New materials and/or coatings not interacting with odours and colours (TRL 4-6)

Recycle:

1. To ensure quality, food safety and shelf-life
    a. Development of recyclable functional monomaterials and/or coatings with appropriate barrier properties (e.g. alternative for metallised food packaging)
2. More available food contact approved recyclates
    a. Proposed solution: Setting up closed loop recycling food packaging systems for example in B2B environments where standardised packaging solutions can be fully controlled in the specific stages of the process. For instance: air catering products and mechanical recycling; PP trays used for catering services in home deliveries to elderly people
3. Optimisation and automatization of the sorting processes in sorting facilities. Recognition of specific materials and packaging products
    a. Proposed solution: applying novel technologies such as AI and vision technologies, robotics etc.
4. To analyse potential scenarios for large scale investment projects including the need to analyse the waste streams and scalability options
    a. Proposed solution: Software tool for scenario development and assessment for the optimisation of waste streams for a technically and financially feasible recycling process.
5. Avoiding of plastic coatings in paper food packaging without hindering the recyclability
    a. Proposed solution: Dispersion barrier coating, recyclable paper coatings
6. To increase recyclability of materials and the quality of the recycled substances
    a. Proposed solution: To provide pre-process including de-lamination, de-inking, de-metallisation of packaging before mechanical recycling and upgrading the mechanical recycling process
7. To increase recyclability of diversified materials in plastic packaging
    a. Proposed solution: To invest in and implement chemical recycling

3.3 Benchmark group 3: Lithuania (LT)

The benchmarking group consisted of less developed regions Central and Western Lithuania who was represented in the workshop by LitMEA. The developed regions were Emilia-Romagna, represented by ClustER and UniBo, and Helsinki-Uusimaa & Etelä-Suomi, represented by CLIC. The workshop session was facilitated by Natureef. Following are the identified innovation topics achieved by utilising the methodology described in chapter 1.2.3.

Below are identified innovation topics in relation to the 4R's.

Refusing:

1. Overcoming the use of packaging as an information platform/marketing tool in order to refuse the packaging
    a. Proposed solution: Utilising IT solutions like QR codes needed for carrying the product and marketing information – simplify packaging, refuse label printing
2. Lack of ideas how to refuse packaging, need for finding use-cases where packaging can be avoided
    a. Proposed solution: Utilise platforms/ecosystems/networks such as S3 Food packaging platform to ideate and accelerate ideas into projects
3. Business potential of refuse is not visible for the stakeholders, or it is not there
    a. Identifying underlying business potentials for new emerging value chains within food system to refuse packaging
4. Food distribution methods have been moving to a direction of pre-packed food and ready-made food that require packaging to function
    a. Exploring "traditional" ways of food distribution via markets / meat shops / service counters and re-innovate these in order to reduce the need for packaging

Reducing:

1. Lack of visibility over packaging performance / material use / material type used per product category in order to understand state of the art in minimising packaging waste without losing the performance
    a. Proposed solution: Within different packaging categories, there is a need for benchmarking and evaluation of material efficiency between the regions to understand the status of the specified region (e.g. comparing Finland and Lithuania in specific product / packaging categories, what material used, what cage used, amount of printing, differences in packaging design etc.) and a platform or international network to exchange good practices on reducing / optimising packaging

Reusing:

1. Infrastructure for packaging reuse is missing and would require large investments from different parts of the value chain. Simultaneously, regulation is evolving and hindering investments.
    a. Proposed solution: Support for reuse related investments,
2. Many markets are not well aware of packaging reuse and its potential, only a little experience has been gathered and research in the topic is scarce.
    a. Proposed solution: Establishing networks in the EU to share the best practices in terms of reuse, pilots already been done, research etc. to avoid simultaneous / overlapping work and avoid repeating. European reuse system / sharing best

practices on reuse within the involved regions (example water refill on municipality level in Italy)

3. Lack of strategies (in less developed regions) in terms of reuse
    a. Establishing networks for reuse / sharing strategies / roadmaps between the different European regions.

Recycling:

1. Difficulties in managing quality of the materials entering recycling
    a. Proposed solution: Closed loop recycling systems are needed. In open recycling systems, better sorting rates are needed and could be achieved by educating the consumer, incentivising the recycling
2. Lack of demand for recycled materials
    a. Proposed solution: New product ideas needed or quality improvement of recyclates. New innovative ways to utilise recycled materials
3. Making quality leap in recycling
    a. Proposed solution: Sharing of the best practices between the regions to understand state of the art in recycling and quality achievable by utilising more advanced technologies.

3.4 Benchmark group 4: Latvia (LV)

The benchmarking group consisted of less developed region Latvia, who was represented in the workshop by Food Products Quality Cluster. The developed regions were Normandy& Pays de la Loire, represented by Valorial, and South Sweden, represented by Packbridge. The workshop session was facilitated by CLIC. Following are the identified innovation topics achieved by utilising the methodology described in chapter 1.2.3.

Below are identified innovation topics in relation to the 4R's.

Refusing:

1. Consumers lack understanding on how to refuse packaging and how to make an impact with consuming decisions.
    a. Consumer education /marketing of refuse topic
2. Single-use packaging waste is increasing due to the habit of take-away / food deliveries.
    a. Proposed solution: Eating out instead of take-away concepts
3. Lack of ideas on how to refuse / how to reduce the quantity of packaging waste
    a. Proposed solution: Creating understanding of the European state-of the art regarding refusing. Sharing best practices on refusing like forbidding of single-use plastics (for example in France).

Reducing:

1. Single packaging new concept using one material (for example ICA, ground beef packaging)
2. Awareness of reducing packaging materials is not widespread
    a. Education to all target groups

3. Sharing best practices / state of the art on how to minimise /optimise / standardise the size of the packaging and utilise innovative packaging designs
    a. Proposed solution: Looking into different interregional best practices on reducing e.g. Frigg's corn cakes
4. Optimising the packaging sizes for transportation to make distribution more efficient the impact
    a. Utilising AI to the optimisation process to reduce transport and logistic chain costs and emissions.
5. Exploring the potential to reduce primary packaging by novel methods
    a. Proposed solution: Exploring potential of using of edible packaging
6. From multilayer materials to monolayer materials – refusing difficult to recycle materials
    a. Proposed solution: standardisation consulting of recycling

Reuse:

1. Lack of ideas / strategies /technologies etc. for implementing reusable packaging in different regions and suitable business models / deposit return systems:
    a. Proposed solution: Taking learnings / sharing best practices from already implemented reuse models (B2B and B2C) like IDUN (Duni Sweden), Kamupak (Finland), En Boite le Plat (France), Flexikeg (France), Transbox (Finland)
2. Creating understanding of the reuse related legislation both in European and country level
    a. Proposed solution: Sharing of the country regulations and restrictions, analysis of the regulatory environment (PPWR, Digital product passport etc.). Example single use restrictions festivals (Sweden), in France restaurants over 15 tables need to use reusable cutlery and dishes.
3. Difficulties in understanding the environmental benefits of reuse of the packaging as well as the value/benefits of reuseable packaging
    a. Proposed solution: Evaluation methods for value of re-usable packages (cost vs. impact or evidence on environmental footprint), service for smaller companies and SME's. LCA life cycle assessment evaluation service of packing.

Recycling:

1. Many of the packaging solutions claimed to be recyclable are not actually recyclable in scale.
    a. Design innovations that are recyclable from the start (as much as same material as possible used overall in the package)
2. Utilising innovative methods to help recyclability of the packaging especially when packaging consists of multiple materials.
    a. Proposed solution: packaging with easily removable parts (like paper etiquettes, stickers)
3. The recycling symbols/labels recycling systems are not standardised
    a. Proposed solution: Unifying labelling for recycling (same markings used inter-regionally)
4. The recycling / sorting / collection infrastructures in the regions are at very different levels.
    a. Proposed solution: Sharing the best practices on waste collection, sorting & recycling across the regions. Example transportation solution from waste

management, in Sweden waste trucks have different containers for different waste streams

5. Challenges in finding end-use for lower quality / non-food grade recycled materials.
    a. Proposed solution: meeting places / collaboration between different value chains and networks to create common solutions (for example car industry needs good quality plastic recyclates)

3.5 Benchmark group 5: Slovenia (SI)

The benchmarking group consisted of less developed region Slovenia, who was represented in the workshop by CCIS-CAFE. The developed region was Galicia, represented by Clusaga. The workshop session was facilitated by CLIC. Following are the identified innovation topics achieved by utilising the methodology described in chapter 1.2.3.

Below are identified innovation topics in relation to the 4R's.

Refuse

1. Overcoming the challenges associated with refusing single-use packaging in the food industry, particularly for perishable goods, is critical to maintaining food quality, safety, and shelf life. Since food producers must comply with stringent food safety laws and ensure that packaging protects these standards, they often have limited power to achieve the refuse goal using traditional methods.
    a. Proposed solution: sharing best practices for bulk distribution and encouraging interregional collaboration can help address these challenges. By creating regional strategies and sharing successful case studies, food producers can adopt innovative refuse methods that align with food safety regulations while promoting sustainability. This collaborative approach can lead to the development of standardised guidelines and support systems that facilitate the transition to bulk distribution and improve overall food handling practices
2. Distribution in bulk would be appropriate for fruit, vegetables, biscuits, etc., but the culture of food handling and hygiene on the part of consumers, traders, caterers would have to be improved to avoid an increase in food waste.
    a. Proposed solution: one practical approach for food processors to refuse single-use packaging is by selling products in bulk. For instance, a beer producer can sell large quantities of beer directly to the hospitality sector (HORECA - Hotels, Restaurants, and Cafes) in barrels or kegs.
3. Good cases could be found in refuse in the value chains but due to "broken bridge" between stakeholders (food processors or food business operators, R&D institutions, government...) there are not enough solutions, or they are too slow.
    a. Proposed solution: Hosting / facilitating penta-helix stakeholder discussions to establish new refuse business cases, foster collaboration towards shared goals, create regional strategies.

Reduce:

1. Reducing unnecessary packaging is possible in many cases - confectionery (candies, biscuits specially in one size portions), reducing weight, volume – already many good practices.
    a. Proposed solution: a practical approach to reducing unnecessary packaging is for example, juice producers distribute their products as concentrates. These concentrates can then be diluted with water and served as needed. This strategy reduces reliance on small, single-use packaging, thereby minimising waste and adhering to reduce principles. By using concentrates for post-mix drinks in restaurants, public institutions, and other venues, the need for individual packaging is significantly reduced. This approach not only cuts down on packaging waste but also lowers transportation costs and storage space requirements. Furthermore, it promotes sustainability by decreasing the environmental footprint associated with packaging production and disposal.

Reuse:

1. Unclarity over reuse benefits for environment.
    a. Proposed solution: To effectively implement reuse strategies, it is essential to establish robust regional systems. Currently, reuse initiatives are primarily driven by consumers, as food producers face challenges in adopting reuse practices without a supportive infrastructure. For food producers to actively participate in reuse, a reverse logistics system must be in place, or they must work directly with consumers or distributors who have an established reuse system. Collaboration and knowledge sharing are crucial for advancing reuse practices. It is important to develop standardised methods for calculating the environmental benefits of different packaging options, such as plastic bottles versus returnable glass bottles. This includes creating standardised methods for calculating carbon footprints, water footprints, and life cycle analyses (LCA). Without standardisation, the results of these footprint analyses can be misleading, making it difficult to accurately assess the environmental impact of reuse strategies. By establishing clear and standardised metrics, stakeholders can make informed decisions about the most sustainable packaging options. This collaborative approach can help ensure that the benefits of reuse are clearly understood and effectively implemented, leading to significant environmental improvements.

Recycling:

1. PET bottle deposit return system – just about to be implemented in Slovenia
    a. Proposed solution: Comparing this system with those in other countries, such as Germany, can provide valuable insights and help optimise the implementation process. Learning from best practices and challenges faced elsewhere can enhance the efficiency and effectiveness of Slovenia's system.
2. Utilising public procurement of foodstuffs in creating better recycling loops.
    a. Proposed solution: The food catalogue application for public procurement of foodstuffs in Slovenia allows for the digital preparation of a public procurement proforma invoice for publication on the public procurement portal. It contains detailed information about each foodstuff, such as ingredients, nutritional value, allergens, and quality schemes. By upgrading the application, public institutions can also include packaging and recyclability information.

This additional information would allow public institutions to select offers that are both economically and environmentally advantageous. Furthermore, by linking the food data to their own applications for nutritional evaluation of menus, public institutions can provide food suppliers with menu data monthly, enabling better planning of production and distribution to individual sites. Including information on the type of packaging (FCM) used for food items in the application would give access to details about the packaging waste generated in each public establishment daily. This would allow packaging waste collectors to schedule more efficient and timely collections and ensure that the waste is delivered to recycling sites more effectively. This integration would create a more streamlined recycling loop, reducing waste and improve recycling rates. This digitalisation would enable recycling centres to forecast the amount and type of recycling they will need to handle and assess the quality of the materials beforehand. This predictive capability would address the problem of recyclables being in poor condition and therefore unrecyclable. By knowing in advance what packaging materials are being used, recycling centres can plan and optimise their operations, ensuring more effective recycling processes.

3. Improving paper/carton waste sorting and recycling as currently the material stream is too heterogenous and difficult to recycle.
    a. Proposed solution: Reducing the number of different grades in paper recycling streams, improving sorting both in consumer stage and recycling facility. Learning from best practices in other regions and benchmarking the existing solutions and their effectiveness.
4. Improving the recyclability of paper-based packaging.
    a. Proposed solution: For example, paper bags for fresh bread and bakery products have plastic transparent windows that challenges recycling. Creation of design principles for recyclable packaging that fits the regions recycling systems.

4 Conclusions

This report concludes the first 7-month project work of the Value4Pack initiative and briefly describes different activities that have been accomplished and related methodologies. Overall, the project regions represent wide European area with many different approaches to food packaging and its diverse value chains. Hence the results are diverse as well and shows clear differences between the areas, the maturity levels of the industries in different areas to the Green Deal 4R topics, and very different ways of cooperation between each of the regions Penta-Helix stakeholder actors.

The project has addressed and demonstrated the importance of the cooperation between the Penta-Helix stakeholders and via its various workshops, interviews, and other activities, have given the different regions new tools to tackle challenging complex topics deriving from the triple planetary crises and resulting EU Green Deal targets. Selection of the Penta-Helix approach for the work has clearly proven to be an asset and the regional workshops arranged in all the different

regions were praised for the diversity of the different stakeholder groups involved and resulting discussions and collaboration opportunities. Collaboration between the regions and sharing best practices have been identified in multiple occasions as cooperation topics as well as in the innovation topics deriving from the workshop. The collaborative efforts must hence be taken forward in the following work in Value4pack, but also feed the collaboration needs and topics towards the S3 Food packaging partnership from where the project originates.

Regarding the selected 4R focus deriving from the EU Green Deal, it can be concluded that the level of maturity between the 4R's in all the regions is clear. Recycling is the most focused topic with a wide number of different initiatives and projects focusing on the topic. The more developed regions can clearly support the less developed regions in this field with their more established extended producer responsibility schemes, sorting and collection possibilities, investments that have already been made to recycling and sorting infrastructure and general sharing of best practices and research outputs. Reducing is also seen as an ongoing practice in all the regions with a long history in optimising primarily the cost of the packaging, but simultaneously minimising the packaging weight. The latest trend in reducing has been movement from complex hard to recycle materials towards more recyclable materials, where especially companies in the developed regions might have ready solutions for the less developed regions. On maturity level, packaging reuse has clearly been focused more than refusing, where it is hard to see the business opportunities for the companies. Reuse, however, is still in its infancy and most of the regions are only starting to understand and focus on the topic. Some areas, like France, Belgium, Sweden, and Finland, are clearly more advanced in the topic, but as reuse is not yet widely practiced anywhere, especially on the B2C market, the differences seem to be small. The demand in reuse clearly would be to find synergies, cooperation opportunities and sharing of the best practices to avoid recreating overlapping solutions to the ones already established, but rather continue the development from the state-of-the-art. As stated, refuse is the most difficult topic in all the areas with quite limited amount of identified innovation topics that really drives towards the refusing of the packaging.

The number of topics in relation to identified synergies and opportunities for interregional collaboration, knowledge exchange, cross-fertilisation of competences and best practices from the regional reports was 64. The amount of innovation topics deriving from the interregional workshop was in total 55. The high number of both, the collaborative/knowledge exchange related topics and the innovation topics indicate the need to build pathways towards the tightening legislation, but also to collaboratively build more resilient and sustainable food value chains.

Based on the interregional workshop following can be summarised:

1) Regarding refusing, there seems to be a "lack of everything". Regions are facing challenges in identifying ideas, strategies, and motivators to refuse packaging and the clear reason being the lack of business potential or the difficulty in seeing the future business potential in refusing. For food packaging value chains refusing might be seen as an opponent, something that challenges the industry in a fatal manner. From obvious reasons big concerns are seen in the possible decrease in the food safety and food quality

as well as in marketing and delivering product information. Despite the challenge of this topics some possibilities were also seen in transforming of the food value chains for example to the direction of local food, but also in implementing of new technologies such as laser scoring of the actual products for the product information and widespread use of QR codes as the information carriers. Refusing as a topic seems to be similarly difficult to all the regions without a clear leader in the topic.

2) Regarding reducing, it seems to be quite standard practice already in the industries across the different regions with a long history of optimising the packaging weight, simplifying the packaging structures to gain recyclability, and removing unnecessary parts / layers of the packaging. However, there was a clear need identified to gain an understanding of the best practices and benchmark how efficient the packaging is in different regions.

3) Regarding reuse, it seems to be emerging topic that has been gaining interest and clearly certain regions such as France, Belgium, Sweden, and Finland have made more progress. Despite this, when looking at the actual practices in place there seems to be not that big a difference. Similarly, to refusing, also reusing seems to have the challenge of "lack of everything" from ideas and strategies to technologies, infrastructure, and incentives to move towards it. Great challenges are also seen in making the reusing economically feasible and business models are still widely seen as a development point. There seems to be also great confusion regarding the sustainability of the reuse systems and a clear need was indicated to come up with reliable data and methods. This is not a surprise given the attention reuse has gained during the formulation process of Packaging and Packaging Waste Regulation and the amount of both industry and academia LCA's done in the field with very diverse end-results. Reuse clearly also needs research projects in addition to those already running is some of the regions, to support its establishment and ensure the food safety and quality aspects. Reuse, unlike refusing benefits from the possible business prospects and encouraging examples from the market can already be found.

4) Out of the 4R's, recycling is clearly the one where there has been most focus and development. The biggest challenges are seen in closing of the loop in a way that would produce good quality recyclates that could be fed back to the packaging production. In this topic, based on the studies and benchmarking exercises, the biggest differences between the less developed regions and developed regions can be observed. In the developed regions the waste systems have a longer history and EPR systems have been in place for longer times. The recycling systems among the studied regions, however, seem to have very different approaches and innovation and collaboration needs were identified in harmonising the systems and particularly the packaging labelling. In addition to plastic recycling also challenges in paper recycling were mentioned.

In conclusion, the Value4Pack project has already made considerable strides in promoting sustainable food packaging practices and addressed the collaboration needs across Europe. The progress achieved thus far sets the stage for impactful developments in the coming phases, ultimately contributing to a more sustainable, cooperative, and resilient European food packaging value chains.