HORIZON-CL6-2021-CIRCBIO-01
Innovative solutions to over-packaging and single-use plastics, and related microplastic pollution (IA)

BUDDIE-PACK

Business-driven systemic solutions for sustainable plastic packaging reuse schemes in mass market applications

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= Deliverable: D1.3 =

Technical and economic specifications of reusable plastic packaging

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Responsible WP: Anna Sutherland and Andrew Capper, WP1, ECHO
Responsible TL: Amaia Agirre Inza, AUSOLAN
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AUTHORS

Author	Institution	Contact (e-mail, phone)
Elisabet Narbaiza	AUSOLAN	enarbaiza@ausolan.com
Julie Savonitto	IPC	Julie.SAVONITTO@ct-ipc.com
Remi Lorthioir	IPC	Remi.LORTHIOIR@ct-ipc.com
Nicolas Belaubre	CTCPA	nbelaubre@ctcpa.org
Catherine Stride	CTCPA	cstride@ctcpa.org
Coline Aucoulon	Eternity Systems	caucoulon@etermity-systems.com
Sophie L. Pott	University of Sheffield	s.l.pott@sheffield.ac.uk
Thomas Webb	University of Sheffield	t.webb@sheffield.ac.uk
Ole Sharpen	VYTAL	ole@vytal.org
Francois Satin	UZAJE	francois@uzaje.com
Peter Mooney	Dawn Meats	Peter.Mooney@dawnmeats.com
Romina Pezzoli	TUS	Romina.Pezzoli@tus.ie
Lorena Rodriguez	AIMPLAS	lrodeiguez@aimplas.es
Stéphanie San Juan	AIMPLAS	ssanjuan@aimplas.es
Adeline Marchal	KNAUF	adeline.marchal@knauf.com
Diego David Martinez	Smurfit Kappa	DiegoDavid.Martinez@smurfitkappa.es
Jaume Montiel	ASEVI	jmontiel@ponsquimicas.com

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Point of Contact	Name: Elisabet Narbaiza Iriondo Partner: AUSOLAN Address: Uribarri Etorbidea 35-37, 20500 Arrasate (Gipuzkoa), Spain Phone: +34 943 79 46 11 Ext. 70189 E-mail: enarbaiza@ausolan.com
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Acronym description

APET	Amorphous polyethylene terephtalate
BiB	Bag in Box
CPET	Crystalline polyethylene terephtalate
EPDM	Ethylene Propylene Diene Rubber
FFKM	Perfluoroelastomer
GA	Grant Agreement
HDPE	High Density Polyethylene
HNBR	Hydrogenated Nitrile-Butadiene rubber
LDPE	Low Density Polyethylene
NBR	Nitrile-Butadiene rubber
PA6	Polyamide
PP	Polypropylene
PS	Polystyrene
Ra	Average roughness or arithmetic viscosity
RPP	Reusable Plastic Packaging
SUP	Single Use Plastic
UC	Use Case
WP	Work Package

Executive Summary

Single-use plastic packaging (SUP) has been around for just few decades and the impacts of this plastic waste on the environment and our health are global and can be drastic. European Union rules on single-use plastic products aim to prevent and reduce the impact of certain plastic products on the environment, in particular the marine environment, and on human health. They also aim to promote the transition to a circular economy with innovative and sustainable business models, products, and materials, therefore also contributing to the efficient functioning of the market.

BUDDIE-PACK is a circular economy project aiming at implementing a systemic approach for the large-scale deployment of reusable plastic packaging (RPP) based on multidisciplinary approach combining social, technological, and economic innovations. This project's first work package (WP1) goal is to deliver guidance on the design of sustainable reusable packaging and thus some technical and socio-economic specifications have been defined. RPP's design impacts every stage of its life cycle and therefore all stages' barriers and opportunities must be considered. The functional properties, technical and economical requirements in each of the use-cases have been identified in task 1.3 and have been translated into different types of specifications (drawing below). Deliverable 1.3 has collected all these specifications and distributed them into the steps of the value chain.

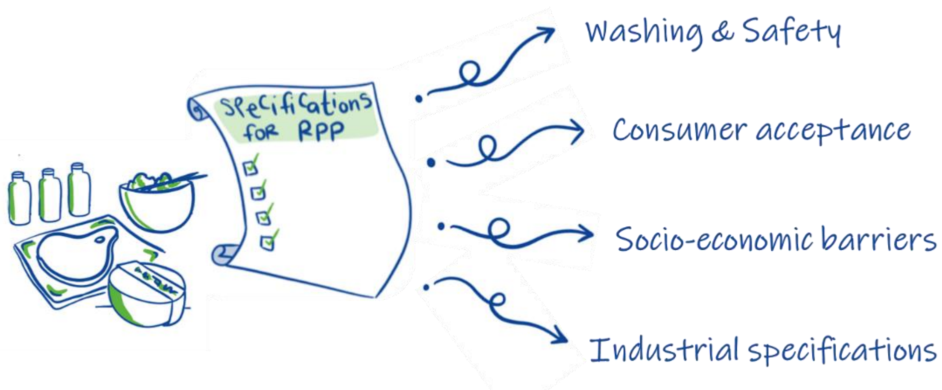

Figure 1: Graphical summary of T1.3 specifications' types (adapted from a drawing from Manuka[1])

This Deliverable will provide the packaging designers with data to devise guidelines for each of the use-case's RPP's design. Having the best design is essential to obtain a more sustainable, efficient and cost-effective reuse system. One of the main BUDDIE-PACK's objectives is to demonstrate sustainable strategies for RPP and the packaging 's design is key to a profitable result. Proving reuse-systems can be a valid replacement for SUP could encourage businesses to consider joining the reuse initiative.

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1. Introduction

In 2017, when China decided to ban the import of waste that Western countries shipped, it became clear that it was essential to manage waste with a global vision and that improving recycling performance would not be enough to deal with various problems:

- Difficulties in improving collection of waste
- Time required to set up efficient recycling facilities in emerging countries
- Time required to develop new recycling technologies in western countries (chemical recycling, etc)
- Difficulties in supplying recycled plastic materials
- Volatility of oil and energy costs
- Need to explore other methods of waste management to reduce pollutions and greenhouse gas emissions…

For these reasons, the Single-Use-Plastic directive (SUP directive) was introduced in 2019: by banning the marketing of several common single-use plastic items, it leads to a drastic reduction of this waste, which are often small, likely to fly away in nature and difficult to recycle (cotton bud sticks, cutlery, sticks for balloons, plastic bags...).

Considering this context and a population increasingly aware of the problem of waste, reusable packaging, which existed for several decades but was abandoned from the 80's and 90's in Europe in favor of single-use packaging, has been gradually brought back to the fore by commercial initiatives.
To face these upcoming challenges and develop reuse, packaging manufacturers will have to rethink their production and turn to new business models.

One of the many goals of the Buddie pack project is to give a complete guide for the implementation of RPP. The goal of this deliverable is to go through the technical and economic specifications for the production of RPP. Deliverable 1.3 compiles all the specifications that could affect the packaging's design. This deliverable has been divided into four types of specifications as it is mentioned in the project's Grant Agreement:

- **Industrial specifications for the manufacturing of the RPP:** It reviews the economic and technical impacts for the manufacturing of reusable packaging.
- **Technical recommendations from washing, safety and quality:** The aim of these specifications is to ensure optimal cleaning of reusable packaging, to guarantee the safety and quality of reusable packaging and its content, in order to avoid contamination, damages...
- **Drivers fostering consumers' acceptance:** By using these drivers we will be able to identify the needs and constraints from the consumers perspective and prioritize criteria accordingly.
- **Socio-economic specifications:** It gathers the social-economical barriers end-users will face when implementing the project's systems and RPPs in order to optimize the reuse system's profitability

Each type of the specifications has been handled separately with different participants of the consortium depending on their expertise. Every group of experts has used a specific methodology to collect information from the end-users of the project and write the respective specifications. The information provided in the deliverable will deliver guidance on the design of sustainable reusable packaging and establish relevant sustainable strategies.

2. Reusable plastic packaging

From the end of the first use (or a time which is relatively short), the single-use packaging is directly considered as a waste and can be managed in three ways: recycled, buried or recovered for energy (Figure 1). Whereas a reusable packaging must support several rotations and, between these rotations, be washed in order to be reused, until it is no longer effective to guarantee its functions. This process implies new steps and a loop structure (Figure 2).

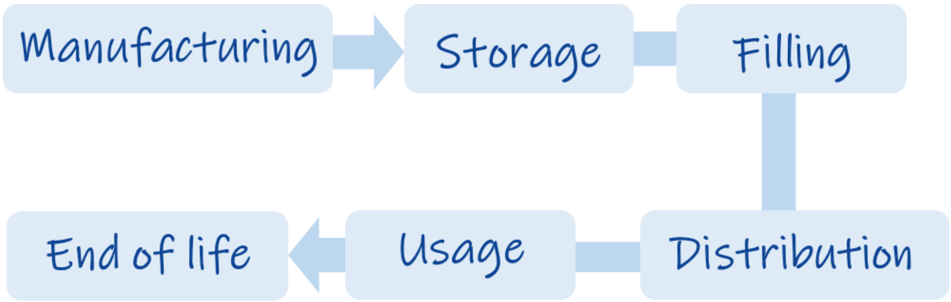

Figure 2: Single-Use plastic packaging life cycle

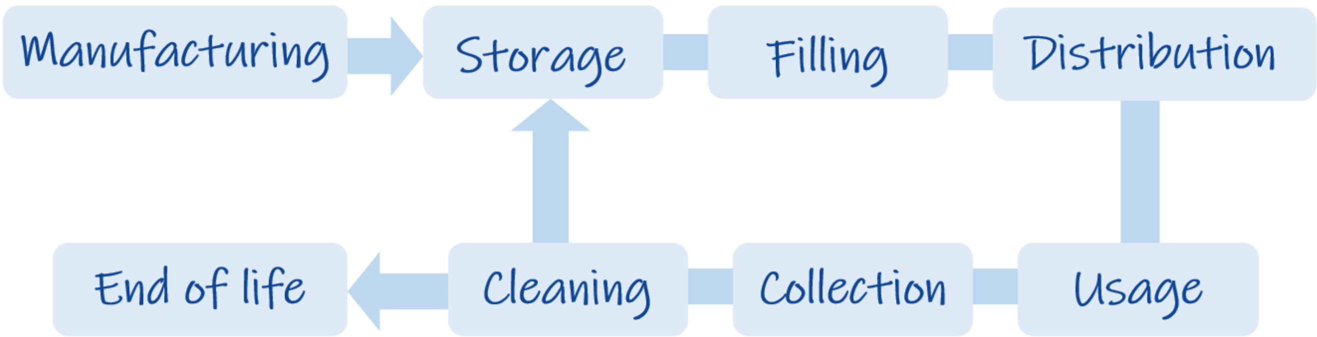

Figure 3: Reusable plastic packaging life cycle

Considering the Directive 94/62/EC and precisions which are brought in regulations of several European countries, “reusable packaging” shall mean packaging which has been conceived, designed and placed on the market to accomplish within its lifecycle a minimum number of rotations, to be refilled or reused in the same conditions that it was conceived to accept, with or without the support of auxiliary products present on the market, and to be recyclable. This work of definition “reusable packaging” will be detailed in the deliverable 1.1, from the current regulations in Europe and different countries (France, Germany, etc). In addition, the draft Packaging & Packaging Waste regulation published in November 2022 shows (revision of Directive 94/62/EC) will introduce packaging reuse goals, so it is essential to anticipate them before designing reusable packaging.

RPP life cycle's steps are very different from the most common practices in the food industry, thus organizing these steps is complicated. The business model’s steps may vary too, therefore different technical specifications must be taken into account in the packaging conception.

3. Technical Recommendations of RPP

The Deliverable 1.2, *"Business-driven systemic solutions for sustainable plastic packaging reuse schemes in mass market application*" gave first recommendation for RPP by looking into the needs and constraints in the industrial value chain. These recommendations are further explored in this deliverable and translated into technical specifications.

Table 1: First design criteria from D1.2

Manufacturing	Storage	Filling
Durable material selection Resistant to mechanical solicitations Aesthetic appearance	Stackability (when full) Nestability (when empty)	Compatible size with current filling systems Sealing adapted to shelf life See through lid (quality control) Migration free material

Usage	Transport	Cleaning
Minimize effort to operate (easy opening/closing) Easy to refill (for refill systems only) Re-seal ability	Light weighted Stackable (standardised shape) Compatible with crates and pallets (secondary and tertiary packaging)	Avoid hard to reach areas Easy to disassemble Shape that prevents residual humidity after washing

3.1. Industrial specifications

Switching from single use to reusable packaging will affect the manufacturing on a technical and economic point of view: material selection, adjustment of the production lines, production cost…
This section will review the economic and technical impacts for the manufacturing of reusable packaging. First of all, the technical specifications are listed for each step of the value chain. Then an economic overview is given for the manufacturing of RPP.

3.1.1. Technical specifications

The technical specifications are listed according to the different steps of the value chain, like mentioned in the deliverable D1.2. For each step, special requests are identified and translated into technical data. Although most of the technical specifications listed in these tables are essential in order the reuse cycle to be feasible and profitable, other interesting technical specification have been included that have been taken into consideration by the end-users of the project. This work will be very important for the upcoming work: design of RPP (WP1, task 1.4), material choice and first prototypes (WP3). During the prototype phase technical specifications will be divided into "must haves" and "nice to have" prioritizing those that are essential for the optimization of the process. Specific technical specifications might also evolve during the project, as results will be obtained from the prototyping (WP3), characterisation (WP5) and demonstration (WP6) steps. Therefore, this deliverable can also be considered a living document, to be updated depending on the lessons learned from the project Use Cases.

Manufacturing/ end of life of RPP

Topic	General request	Technical specification
Material choice	Material compatible with the current equipment of manufacturers	Select material with same properties and treatment needs, such as viscosity, drying conditions etc.
	Compliant with current regulations	Food contact compliant
	Pack dimensional stability	Maintenance of the polymers' dimensions even under varying environmental conditions. Testing the materials in WP3 will be useful to precise dimension variation accepted such as humidity (e.g., less that x%).
	Easy to recycle	Material and design compatible with the European sorting and recycling guidelines (e.g.: RECYCLASS): PP, PE, PET… Avoid non-compatible additives: carbon black. (CITEO list for compatible additives for sorting machine. (Without Carbon black)
		For close loop recycling: mono material suited for mechanical recycling: TRITAN, CPET…
	Maximum recycled content	Only rPET is commercially available for food application. It's possible to integrate recycled plastic if the recyclate is compliant with the new regulation 2022/1616. rPE is commercially available for non-food applications. rPP is available only from chemical recycling or mass balance approach. If the recycling is in closed loop, it might be possible to insert recycled material after food contact testing, with a previous EFSA closed loop approval.
Packaging functionality	Compatible with recycling processes	Design the packaging according eco-design strategies based on European recycling guidelines (e.g., RECYCLASS): Easy disassembly..., Easy to empty, Easy to read traceability systems
	Aesthetic appearance	Consumer acceptance of the packaging appearance will be studied in the WP2. Customer's preferences will be taken into account such as colour, texture and shape. Different colour for specific meals (for example, without salt: colour green, for diabetic person: blue colour…) No colour degradation after contact with different substances (Tomato, Curry, Blueberry, Dye E133, Saffron, Carrot…) and cleaning products to ensure durability appearance.
	Communication	Conceive the packaging with the option to add communication elements such as labels or QR codes.
Economic	Price neutrality	Define the target price for each use case. Can be fixed by packaging owners and validated by packaging producers. See section "economic overview of reusable packaging" for examples.
Process	Process compatible	Need to clarify process constraints of each packaging owner and end user

Storage & transport

Topic	General request	Technical specification
Material choice	Load resistance	To define: how many packaging can we stack one above each other? (Define weight and shape)
	Light weighted	Need to take into account the density of the material during the material selection. Optimize the proportion of material during design of packaging (Ecodesign).
Packaging functionality	Foldability / Nestability (empty and dirty, and empty and clean)	The shape of each container needs to be designed in a specific way to allow nestability. To be defined in the design guidelines (D1.4)
	Stackability (filled)	The shapes of the container and lid need to be designed in a specific way to allow stackability. To be defined in the design guidelines (D1.4)
Economic	Minimize costs for extra handling	Define the extra cost of reusable packaging and set a limit price that end users are willing to pay. (WP4)
Logistic	Ensure packaging availability (safety stock)	Define minimum quantity requested at each step. Especially for home care product with long shelf life.
	Avoid contamination before filling	Level of contamination will be evaluated in WP5.
	Distribution and collect service proximity	Optimize distance and transport type - local logistic supplier - take into account PR3 Guidelines[2] - low-emission transport
	Compatibility with secondary and tertiary packaging	The box format might vary depending on the use cases. Further information needs to be provided during the project: Box internal dimensions to optimize individual packaging size.

Filling

Topic	General request	Technical specification
Material choice	Insulating efficiency	Take into account the thermal conductivity of the materials during the material selection. Optimize the thickness of the packaging walls and the sealing for a better insulation. To be defined in the design guidelines (D1.4).
	Thermal sealability	Select a material that is compatible with thermal sealing, in case sealed lid is required. *(Skin Pack Meat)*
	Shelf-life duration	Good material permeability: need to define targeted oxygen transmission rate (OTR) and water vapor transmission rate (WVTR) for each use case and type of content.

		Material compatibility: identify materials compatible with product to keep product shelf-life. Barrier coating and/or surface treatment may be necessary to increase the barrier performances.
	Transparency (see-through lid) or opacity	An acceptance level of transparency needs to be defined (define limit values for Haze testing), or level of opacity. The acceptable level will be defined by the feedbacks from the consumer acceptance studies (WP2).
	No migration content/product and product/content	Clarify regulations associated to reusable packaging and safety standards (report D 1.1 and WP5)
	Thermal cycling during shelf life and filling	Choose material according to the temperatures ranges of content by use-cases: – Home care products: 15-25°C *(Refill Personal Care Bottles)* – Cold food: 1- 10°C, refrigerator *(Skin Pack Meat)* – Hot food: 50-100°C *(Take-away Food Trays, Catering Food Trays & On-the-spot Food Trays)* – Refrigerator (1-6°C) during shelf life
Packaging functionality	Durable leak proof lid	Define target and testing method before and after reuses cycles, to evaluate the durability of the lid sealing (during WP3 & WP5).
	Tamper proof (avoid contamination between filling and customer opening)	For rigid lids: paper label (suitable with washing guidelines). *(Take-away Food Trays, Catering Food Trays & On-the-spot Food Trays)* For Flexible film: Recyclable thermo-sealed film *(Skin Pack Meat)*
	Ensure shelf-life for each product	– 1 day shelf life: *(Take-away Food Trays)* – 1-3 days shelf life: *(Catering Food Trays & On-the-spot Food Trays)* – +3 days shelf life: *(On-the-spot Food Trays)* – 21 days shelf life *(Skin Pack Meat)* – 5 years *(Refill Personal Care Bottles)* The shelf-life duration will influence the level of permeability and sealing needed for the packaging to develop.
Economic	Cost impact if specific control to implement compared to single use	Identify additional control requested. This topic will be studied in WP5.
Logistic	No logistic modification	Identify major logistic challenges of current single use systems.
Process	Compatible with current process	Design opening and define packaging volume according to the needs of the filling facilities. Obtain feedbacks from packaging owners (WP3 and WP6)
	Hygiene testing before filling	Identify quality control requested. This topic will be studied in WP5.

Usage

Topic	General request	Technical specification
Material choice	Simple to wash	Non-porous material. See section 3.2. for more details.
	Cold resistance (Freezing -18 °C and deep freezing (-45°C))	During the project, we will define how to evaluate the capacity of the materials to be compliant with freezing test.
	Heat resistance (oven, microwave)	During the project, we will define how to evaluate the capacity of the materials to be compliant with microwave *(Take-away Food Trays, Catering Food Trays & On-the-spot Food Trays)* Oven resistance: 160°C *(Catering Food Trays)*
	Not damage of surface during packaging manufacturing	Non-abrasive materials, without impurities (*Refill Personal Care Bottles)*
	Durability (shape and aspect)	Clarify the consumer acceptance of the aspect degradation (WP2): stains, shape deformation, decolouration of the material...
	Scratch resistance	Clarify level of acceptance with scratch testing. (WP3 and WP5) Select material with high scratch resistance level. Evaluate impact of scratches on migration and safety (WP5). Define which kind of cutlery we can use to eat into the packaging and ensure resistance to it.
Packaging functionality	Communication	Identify clearly all information requested to inform the consumer: – Pre-cleaning method and level requested – Food/product composition – Proper usage of the packaging – Return procedure – Handling recommendations (to optimize packaging life time) – Ecological impact benefit QR code and/or washable label on packaging.
	High convenience level	– Wide opening to eat inside *(Take-away Food Trays, Catering Food Trays & On-the-spot Food Trays)* – Wide opening to refill or empty easily *(Take-away Food Trays, Refill Personal Care Bottles & Catering Food Trays)* – Wide opening to wash efficiently (pre-wash by consumer) *(Take-away Food Trays, Refill Personal Care Bottles & On-the-spot Food Trays)* – Easy peel lidding film *(Skin Pack Meat)* The design guidelines (D1.4) will evaluate more precisely this request.

	Environmental efficiency	Minimize consumer pre-cleaning to minimize water consumption impact, without neglecting public health's standards.
	Ergonomics behaviour	Facility to hold and handle. *(Refill Personal Care Bottles)* Size compatible with the different fridges. No sharp angles to avoid injuries.
Economic	No additional costs for the end user	Define the cost limit for consumers to choose reusable packaging. This request is studied in the WP2. Favor low prices to encourage consumers to pick RPP.
Logistic	Easy collect of empty RPP	Wide choice of collect areas for consumer.
Process	Design adapted to end user facilities	Design suitable with display shelves, storage shelves, transport carts… The feedbacks from the WP6 will help define this request.

Cleaning *(more detailed in section 3.2)*

Topic	**General request**	**Technical specification**
Material choice	Hygiene warranty	Respect HACCP (Hazard analysis critical control points). The deliverable D5.3 will give more details on the subject. (WP5)
Packaging functionality	Appearance	Define design guidelines to minimize stains, food residue, easy disassembly… Avoid light colour, sharp angles and hard to reach areas during washing.
	Communication	The customer or the operator must be informed of the actions to be taken after the packaging has been used and is to be cleaned and disinfected by the industrial cleaner or the restaurants to avoid any microbiological hazard. (e.g., Empty the container, rinse it, soak it in water...)
Economic	Cost evaluation to assume all requests	Fix target price to obtain customer acceptance (B2B / B2C). Price will be defined in WP2, WP4 and WP6.
Logistic	Traceability	Save packaging history: - Previous food contained - Cycle number
Process	Minimize environmental impact	TACT principle to evaluate different scenario (Time/Action/Chemistry/Temperature) - Close loop system water - Renewable energy - Industrial dishwasher - Chemical products - Cleaning location (on-site or outsourced) - ...
	Avoid micro-organism development	Define drying efficiency. Easy clean and dry design to prevent microbial colonisation and biofilm formation etc.
	Safety	Sanitizing (allergen contamination, pathogenic bacteria…) step after cleaning and before filling.

	Quality	Define acceptance checklist for appearance (scratches, odour, colour change, deformation…) Define monitoring plan (means, frequency…)

3.1.2. Economic overview of reusable packaging

Switching the manufacture of SUP to RPP not only changes the technical aspects of it, but also affects the cost of it. The packages' features such as raw material, additives, shape, or weight can impact in the cost of the package and so can the type of manufacturing process.

This section gives an overview of the economic changes for three examples of RPP of the project. All the characteristics impacting the manufacturing cost of Refill home care product bottles, Ready-meals trays and Skin pack for meat have been collected in the tables below. Being in early stages of the project there are still unanswered questions (CAPEX, RoI…) that will be answered as we gain knowledge and can take informed decisions.

The uniqueness of each of the use-cases translates in the RPPs' manufacturing cost in a different manner. Data from Refill home care product bottles' table implies that once invested in the new mould RPP price will be in SUP's price range. In the case of Ready-melas trays table shows a sharp cost rise, due to the raw material price, as well as the increase of cycle time. Finally, the table overviewing economic aspects of Skin pack for meat indicates that the cost of manufacturing RPPs would be more expensive due to the material selection, increase in material usage per unit and consequently the potential increment of manufacturing and moulding cycles time in order to allow recyclability.

Refill home care product Bottle 	**Technical information**	**Average costs**	**Difference with single-use packaging (SUP)**
Raw material	Material grades : PE (1400€/T) rPE 50% (2000€/T) PET (1200€/T) rPET (2000€/T)	PE: 0,1505€/bottle rPE: 0,172€/bottle PET: 0,129€/bottle rPET: 0,215€/bottle	0.1-0.2€/SUP bottle
Additives	Not required	-	Same as SUP - not required
Process	Blow extrusion		Blow extrusion, injection is not considered
			New mould investment
Shape: thickness	0.44-0.77 mm		SUP: 0.5 mm
Weight	40-50 gsm		SUP: 43 gsm
Production cost	For 1 PE bottle = 0,1505€/bottle	0,0903€/bottle	Same production cost as SUP

Ready-meal trays

	Technical information	Average Costs	Difference with single-use packaging (SUP)
Raw material	Material with low-medium MFI PP: 1600€/T PBT: 9200 €/T TRITAN: 2700 €/T	PP: 0.088€/RPP pack PBT: 0.50€/RPP pack TRITAN: 0.15€/RPP pack	SUP: High MFI (PP, PET, PS) PP: 0.008 to 0.032 €/ SUP pack
Additives	Black masterbatch without carbon black	-	Same as SUP
Process	Injection moulding Cycle time: 28s	-	Injection moulding Cycle time: 2.5-5s New mould
Traceability	Laser marking system	65 k€ (investment for year 2024)	
Shape	2-3mm wall thickness	-	SUP: 0.5-1mm wall thickness
Weight	55g to 60g	-	SUP: 5-20g

Skin pack for meat

	Technical information	Average cost	Difference with single-use packaging (SUP)
Raw material	Material grades: CPET PP	CPET: 0.4 €/tray PP: 0.1 €/tray	SUP made of PET
Additives	NIR Detectable Black masterbatch	8.20€/kg (cost of masterbatch) 164€/ton of Final product at 2% dosing.	Same as SUP
Process modification	Sheet extrusion/ Thermoforming and Injection Moulding		Injection Moulded trays not common in meat industry
Shape: thickness	Standard size tray, optimised thickness/shape for resealing and reuse		For dimension stability, thicker trays are necessary.
Weight	60g		30 - 40g
Estimated tray cost	-	0.10 €/tray	Same as SUP

3.2. Specifications for washing, safety and quality

There are different kinds of washing. We speak here about the level of washing required before the filling of the RPP with the food. At this step, the container must be free of soiling and bacteria coming from the precedent reuse cycle. To achieve this, the washing must integrate 2 main steps: the cleaning and the disinfection. A good washing protocol will ensure the safety and the quality of the product. These criteria will be further explored in WP5.

The washing efficiency and quality will depend on multiple factors. One of them is the packaging design. It is crucial to consider these following specifications to prevent any quality non-compliances.

The main design criteria to be met by the packaging for a proper washing are listed below:

3.2.1. Material selection

The material used for the RPP must resist to the washing cycle of an industrial washing machine for as many cycles as possible. The minimal number of cycles that RPP should resist to will be assessed within the project through Life Cycle Assessment. The washing criteria are the time, the temperature, the mechanical action of the cleaning, the kind and the concentration of cleaning chemicals. The Sinner Circle is used to determinate a cleaning or a disinfection protocol. Therefore, the RPP must be chosen to support these criteria.

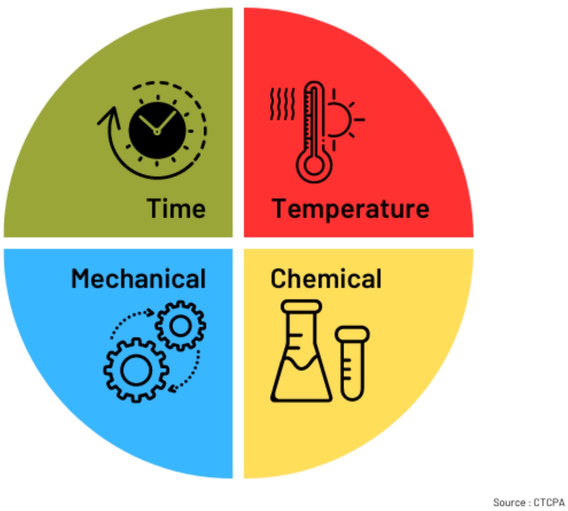

Figure 4: Sinner circle

These washing criteria must be adapted to the nature of the soils: if there are sweet, fatty, colored, dry, cooked, burned…
In general, alkalis are used when the stains are organic and, acids when they are of mineral origin or when soils are burned. So, the RPP must be able to withstand different pH levels ranging from 3 to 12.
The temperature of the water has a great impact on the kinetic of the removal. It depends on the soiling and the chemicals and maybe on the nature of the RPP.

In order to have the optimal efficiency of cleaning and disinfection, it is necessary that the packaging tolerates different types of protocols. The thermal resistance of the RPP is a key parameter during the different steps of its reuse. The structure needs to remain the same when the RPP undergoes high washing temperatures, filling with hot food, heating up using microwave oven, storage in the fridge or a freezer.

Figure 4 show thermal resistance of some widely used plastic materials. Some of them cannot resist boiling water temperatures (LDPE, PS, APET), or freezing temperatures (PP).

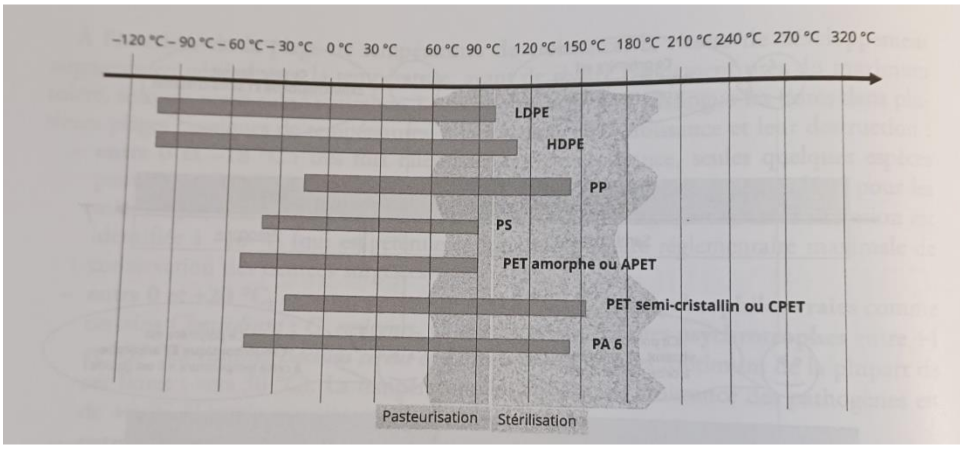

Figure 5: Thermal resistance of some plastic materials widely used[3]

3.2.2. Surface Roughness

The surface roughness is a main point for the RPP design because it drives the ease for the soils and the bacteria to remain on the surface. The surface roughness is evaluated with different parameters. One parameter, called Ra (average roughness or arithmetic viscosity) is widely used as a key parameter to describe the level of rugosity of a surface. The Ra is the average height between the roughness profile and its mean line (Figure 6)

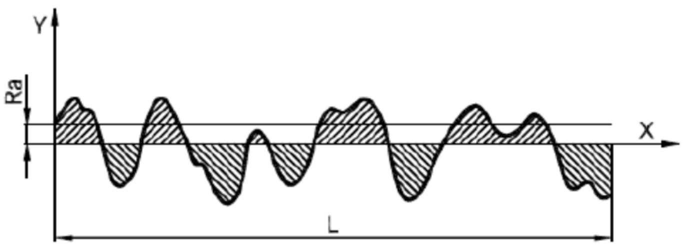

Figure 1. Determination of average roughness (Ra).

$$Ra = \frac{1}{L}\int_0^L y(x)\,dx$$

Figure 6: View of a surface profile and its Ra value.[4]

The EHEDG (European hygienic engineering and design group) made some fouling and cleaning experiments for different Ra values on stainless steel. The results showed a Ra<0,8µm was required to get an easy cleaning. There are no specific recommendations for plastic roughness, but most of the time plastic roughness is less than 0,8µm because plastic is moulded in very smooth moulds with low Ra values. Therefore, we recommend a Ra value less than 0,8µm for the surfaces of the RPP.

This Ra value must remain during the whole shelf-life of the RPP. This is important because the surface roughness can change because of multifactorial aggressions possible like scratches inflicted by knives, chemical products used in cleaning and ageing of the material due to light…

3.2.3. Angles

The RPP contain some surface transitions, for instance between the bottom and the sides of the container. For an easy cleaning sharp angles must be avoided. The presence of sharp angles helps the attachment of the soiling. The radius angle must be more than 6mm, and equal to 3mm in the worst case to ease the cleaning.

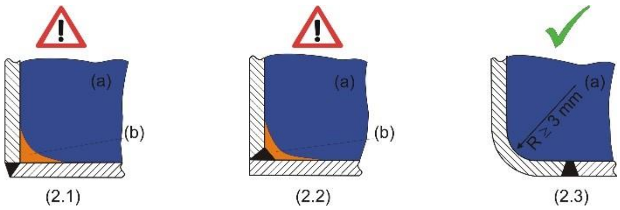

Figure 7: Example of minimal radius corner (this example is done for stainless steel surface but can also be used for plastic surface)[5]

a) product area, (b) sharp internal angle
Welded joints in corners. (2.1), (2.2) Welded seams in corners create uncleanable areas;
(2.3) radiused corners and correctly welded seams in the plain area avoid any hygiene risk.

Where a corner cannot have a radius of greater than 3 mm, its cleanability should be demonstrated by testing.

3.2.4. Draining Ability

It is important to get, at the end of the cleaning process, a totally drainable RPP. The removal of the water on the surface of the RPP allows, of course, a quick drying, and overall avoid the bacteria growth if some bacteria are still attached on the surface.

To get this drain ability two parameters must be carried out:

- Design of the RPP: The RPP must be designed in a way avoiding the water retention. More precisely, one position of the RPP must be free of water retention parts.
- During the cleaning, the RPP must be placed in this position in the cleaning machine.

3.2.5. The Interaction with the Cleaning Machine Position

The RPP must be designed to be set up:

- intuitively in the right position in the cleaning machine,
- in the most efficient way in the cleaning machine in order to clean a maximum RPP in a row.

The efficiency of bowls in a dishwasher has a critical impact on the LCA and the break-even point of the packaging over single use. If the bowls must lie flat to be washed, the number you can load into a dishwasher is limited. If the packaging has more than one compartment it is important to ensure that all compartments can be cleaned and fully drained. The design of the bowls needs to be easy to load into the dishwasher in the correct orientation; design features such as a tapered shape, flat edge, easy grip edges etc. can help indicate to the user how best to load them. Designs need to be considered for suitability in commercial dishwashers and washing lines.

3.2.5.1. Weight

RPP are lightweight dishes. Nevertheless, RPP needs to be heavy enough to keep in place in the cleaning machine during the cleaning process to resist to the pressure of the water spraying system without being flipped. In case the container is not heavy enough not to move during the process, it is possible to use supports such as racks or grids, to keep in place during the washing.

3.2.6. Sealing system

The closure of some RPP can be made using a sealed plastic film. When the RPP is closed some food can get in contact with the internal part of the sealing.

- When the plastic film is removed no residue of the seal must remain. This could affect the efficiency of the cleaning and allow bacteria (or food) to remain due to do the increase of the surface roughness. Residual film may also affect the resealability of the bottom tray/container.

- The plastic film must be easy to be totally remove by the user, in order, for the washing company, not to have to clean some RPP with a patch of plastic film remaining in place. In this case, it will be not possible to really clean the RPP.

3.2.7. Mechanical resistance

The structure and material, of the RPP must be resistant to any constrains caused by heat and/or bad storage. Material deformations and cracks can be caused, for instance, by the temperature during the cleaning process. These degradations of the packaging or lid could lead to a bad closure and compromise the shelf life of food afterwards. Therefore, a proper material with a good heat resistance needs to be chosen.

3.2.8. Gasket

To make a good closure, it may be interesting to add a gasket to the lid of the RPP. This gasket can be glued to the lid or maintained to the lid in a groove.

The interface between the lid and the gasket must be easily cleanable. It could be interesting to remove the gasket before the cleaning process, but it needs operating time.

If the gasket is tacked to the lid, some cracks can appear at the interface, and becoming a good location for bacteria growth.

The material used for the elastomer must be resistant to detergent, temperatures and food contact.
The following tables show elastomers resistance to various processes fluids and products.:

Table 2: Widely used food contact elastomers and their resistance to various process fluids[6]
(Where: Legend:1=Excellent 2=Good 3=poor 4=do not use

Type of elastomer	Operating range °C	Process fluid			
		Hot water	Steam (150°C)	ozone	UV
NBR	-40 to +120	1	4	2/3	2
HNBR	-30 to +180	1	1	2	2
EPDM	-50 to +150	1	1	1	1
Silicon (VQM)	-60 to +200	1	3	1	1
Fluorocarbon	-20 to +200	1/2	2	1	1
FFKM	-15 to +260	1	1	1	1
Butyle Cl or Br	-40 to + 150	1	1	1	1

Type of elastomer	Processed product			
	Vegetable fats	Animal fat	acid	base
NBR	1	1	2/3	1
HNBR	1	1	2	1
EPDM	3	3	2	1
Silicone	2	2	2	2
Fluorocarbon	1	1	2	3
Perfluroelastomer	1	1	1	1
Butyle Cl or Br	2	2	1	1

3.2.9. Labels

The use of label on the RPP should be avoided. The labels usually resist badly to the cleaning process and can cause problem for the re-use.

There are labels with water-soluble glue: in contact with water, the label comes off and is removed very easily, it is then necessary to have a soaking step before washing in the dishwasher. Also, there are labels that degrade when in contact with water.
If the labels glue is not water-soluble although the labels will stay on the packaging or adhesives residues will remain on. In this case, an extra step must be implemented with specific chemicals adapted to remove the specific glue.
Another point is to recover the removed labels before they stick again on the packaging or inside the dishwasher.

So, if the labels and the glue are not easy to remove, the cost of the cleaning will increase because of:

- Time into the bath of hot water.
- Extra water and energy to the bath.
- Specific chemicals to remove the glue.
- Employees to remove the labels from the bath and to check the efficiency of these steps.

3.2.10. Ageing

A lot of different parameters can affect the RPP surface roughness during its whole life. We can mention the scratches or punctures made by the users, the washing protocol with the high temperature and the detergents used (Figure 9), or the storage conditions with, for instance, the display at U.V. rays (Figure 8).

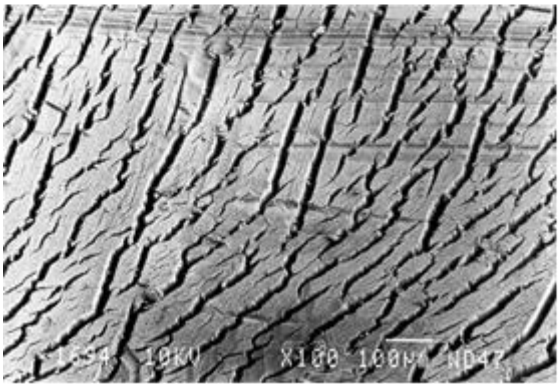

Figure 8: Ageing of polyacetal under ultraviolet rays[7]

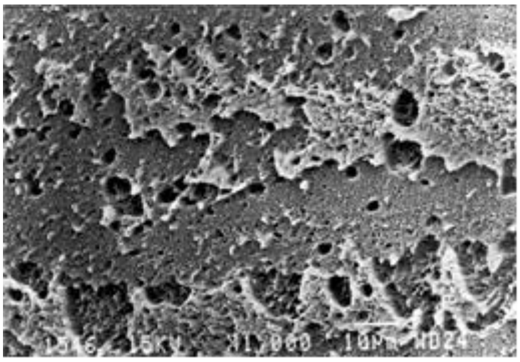

Figure 9: Ageing of polycarbonate under cleaning products effect[7]

These modifications in the surface roughness can create favorable conditions (cracks, holes...) for fouling and/or bacteria protection, adhesion and development. It can also reduce the “rinse-ability” and increase the remaining of chemical produces.

To prevent this food safety risk, a risk analysis must be done, including microbiological and chemical analysis, and also some roughness measurement to evaluate if a deviation occurs from the original roughness.

3.2.11. Storage Conditions, stackability and nestability

The storage must be done by separating the clean stock from the dirty one, to avoid cross-contamination. The clean stock must be positioned by following a forward march in space: nothing dirty must be able to contaminate the containers (other dirty containers, people with dirty equipment...). Clean stock must be protected: washed containers must not be able to be recontaminated. The area must then be maintained.

Also, it is necessary to practice the FIFO: First In First Out, thus arranging the storage so that the containers washed first can leave first.

Limit as much as possible the storage of dirty RPP, in the case where storage must be done on a longer term, do it in conditions allowing to limit the bacterial growth: storage at 4°C.

3.3. Drivers Fostering Customer's Acceptance

Customer acceptance is paramount to the success of RPP and associated systems. However, various factors may affect customer acceptance and these need to be identified in order to predict and understand how people will respond to RPP and the systems within which RPP is used. The COM-B model[8] is a behaviour change framework that can be used to understand of the types of factors that might influence consumers' behaviour with respect to RPP. According to the COM-B framework, behaviour results from the interaction between three key components: Capability, Opportunity and Motivation. Capability refers to an individual's physical and psychological ability; for example, consumers must have access to the necessary infrastructure (e.g., refill stations) and possess the knowledge and skills required to engage with the RPP system. Opportunity refers to the external factors that influence behaviour, such as social norms and characteristics of the environment. For example, if RPP is socially acceptable and easy to use, then customers are more likely to adopt it. Motivation refers to underlying attitudes, beliefs and emotions that drive behaviour. For example, consumers may be more motivated to use RPP if it looks clean and aesthetically appealing.

The table below summarises the key drivers of customer acceptance that might be relevant to the design specifications of the packaging for each of the use cases. Drivers of customer acceptance have been categorised according to COM-B domains and supported with relevant evidence indicating their importance in an RPP context.

Table 3: Key drivers of customer acceptance per use case

	Catering Food Trays	Take-away Food Trays	Ready-meals Trays	Skin Pack Meat	Refill Personal Care Bottles	Evidence
Opportunity						
Packaging is – and is perceived to be - hygienic	✓	✓	✓	✓	✓	Having a hygiene guarantee was rated as an extremely important design consideration by 71% of respondents[9] Packaging not looking/being hygienic identified as a key factor that might

						deter consumers from using a reusable packaging system[10]
Packaging is Microwaveable	✓	✓	✓			Stakeholders identified that it was important for ready meals to be microwaveable[11] Resistance to warping from heat exposure identified as key durability design requirement[12]
Packaging is suitable for oven heating	✓					Resistance to warping from heat exposure identified as key durability design requirement[9]
Packaging is Resistant to breaks/ shocks/ drops/ deformation	✓		✓	✓		Resistance to shocks, drops and deformations identified by stakeholders as important for packaged fresh food products and ready meals[11] Being durable when dropped or mishandled identified as key durability design requirement[9]
Packaging is Stackable	✓	✓	✓	✓	✓	Stakeholders identified that food packaging needs to be stackable[11] Consumers identified that packaging needs to be easy to store (Project TRACE)[9]
Packaging is pressure resistant			✓	✓		Stakeholders identified that food packaging needs to be pressure resistant[11]
Packaging is vertically stable			✓	✓	✓	Stakeholders identified that vertical stability of fresh food and ready meal packaging is important for transport and storage[11]

Packaging is labelable	✓		✓	✓	✓	Brand information visibility was rated as a key design requirement[9]
Packaging is tamper proof	✓		✓			Consumers willing to pay more for grocery and ready-to-eat deli items that have tamper evident characteristics[12]
Packaging is lightweight	✓		✓		✓	Suitable product sizes identified as a customer motivation for buying reusable products[13] Consumers identified that packaging needs to be lightweight for easy transportation (Project TRACE)[9]
Packaging is washable	✓	✓	✓	✓	✓	Ensuring that packaging is durable enough to withstand cleaning processes rated as an important design consideration[9,11]
Packaging and the system within which that packaging is employed is easy to use	✓	✓	✓	✓	✓	Ease of use identified by consumers as one of the top motivators to encourage use of reusable packaging[14]
RPP has a different design to single use packaging			✓			Consumers identified that packaging needs to be easy to differentiate from single-use packaging (Project TRACE)[9]
Packaging is transparent	✓		✓			Visibility of the packaged product identified as a key design priority for reusable packaging, particularly for fresh food products[9]
Packaging can fit in microwave/ refrigerator	✓		✓	✓		Stakeholders identified that it was important for packaged food

						products to fit in a fridge[11] Suitable product sizes identified as a customer motivation for buying reusable products[13]
Motivation						
Packaging is resistant to marks and discolouration	✓	✓	✓	✓	✓	People are generally unwilling to reuse containers that show signs of previous use[15] Resistance to scratching/wear identified as a key design consideration related to material choice[9]
Packaging has aesthetic appeal	✓	✓	✓	✓	✓	Packaging appearance was identified as an important design consideration[9]
Packaging is recyclable at end of life	✓	✓	✓	✓	✓	Recyclability at end of life was rated as extremely important by 88% of respondents[9] 56% of UK consumers said more packaging should be recyclable[16]

3.4. Socio-Economic barriers & specifications

In this section we have identified the socio-economic barriers that the project's end-users foresee when implementing the demonstration in WP6. As explained above in the document, switching from SUPs to RPP not only affects the packaging itself but every stage in the package's life cycle. While there may be overlap between the socio-economic issues with respect to each use case, each of the use-cases also represents a different scenario where RPP might be introduced and consequently it may be important to consider specific issues with respect to each of the demonstrations:

3.4.1. Catering Food Trays

Despite Ausolan already having a reuse system with stainless-steel containers, the inability to use it in a microwave forces some of their customers to use single-use plastic packaging. During the BUDDIE-PACK project this Spanish catering company will have an opportunity to replace SUP packagings with a more sustainable option. During the demonstration, Ausolan will be provided with two different designs, one for single-portion and another for multi-portions. The single-portion tray will be microwavable and will be passed down to the diner, unlike the multi-portion tray that will be handled by the kitchen staff and heated in the oven. In addition, the washing of RPP will be externalized to an industrial washing centre, contrary to the stainless-steel containers which are cleaned in the central kitchen they originated from.

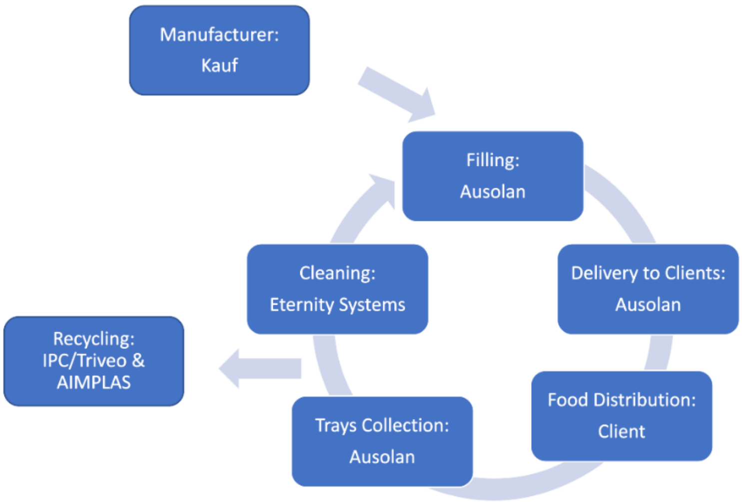

Figure 10: Value chain Ausolan's demonstration

3.4.2. Take-away Food Trays

Vytal offers tech solution to operate a digital and deposit-free reusable container system to restaurants, caterers, and canteens. This German company's portfolio includes different types of reusable bowls and cups for every type of food and drink. In their current system containers will be sent from manufacturer to Vytal's warehouse, then will be distributed to their partners where the end-user will it pick up and return once used; the restaurants will clean the RPP and redistribute it again. During BUDDIE-PACK's demonstration Vytal's current system won't vary, however a new container will be designed. This container will have three different shaped compartments that will challenge the company's logistics. The aim of the project will be identifying the weaknesses of the actual reusable system and to improve it.

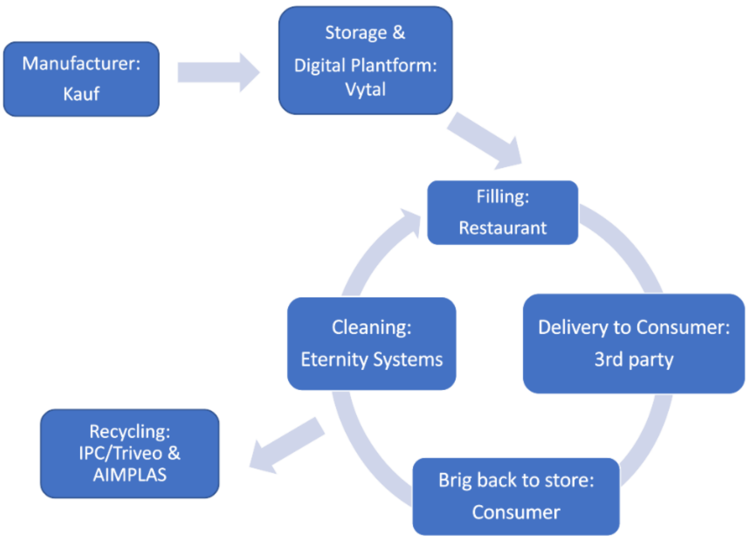

Figure 11: Value chain Vytal's demonstration

3.4.3. Ready-meals Trays

Uzaje is a French-based company offers packaging solutions, deposit management, transport and high-efficiency cleaning, providing solutions in each of the reuse value chain's stages. They provide catering and food manufacturers with solutions that enable them to eliminate packaging and consumption waste by washing containers and managing change.

Uzaje's use-case will offer on-shelf ready meals from external companies, for example in supermarkets, and will be consumed either on-the-spot or off-site. The goal is to identify suitable packaging applications in terms of material choice, convenient and safe design, as well as appropriate packaging systems and business models.

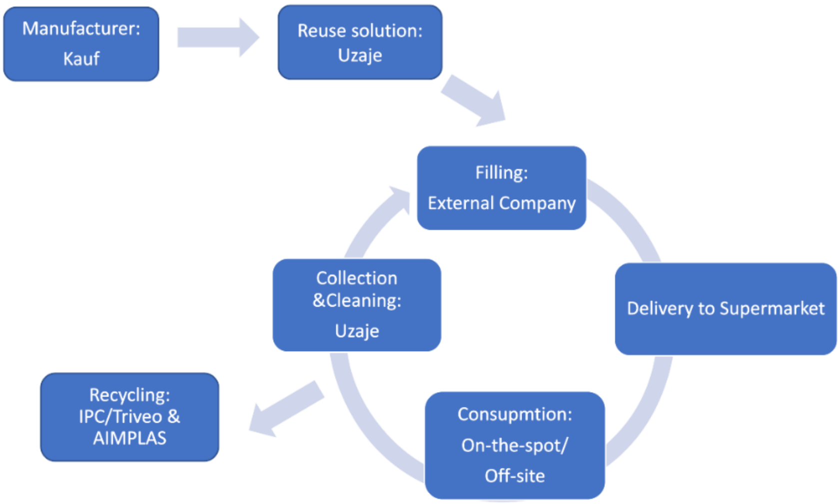

Figure 12: Value chain Uzaje's demonstration

3.4.4. Skin Pack for Meat

Dawn Meats Group is one of Europe's largest food processing companies, providing added-value meat products to important retailers all over the continent. Skin packaging is used for 100 % of retail steak packaging in the UK currently, however the current absence of data and insight on re-usable packaging would not allow a feasible retail demonstration. This company's goal for this project is to trial re-usable skin packaged steak with a suitable partner in its food service business, to gather data and answer many questions to build up a possible use-case for retail.

During the demonstration, Dawn Meats' will have the opportunity to test a reusable tray with a single-use recyclable film. This tray will be filled on its packaging line and transported to a food service client who will handle it in the kitchen; the diner will not be aware of the packaging (B2B). Unlike their current single-use skin packs, these trays when emptied will be pre-cleaned and stored to avoid any contamination, as guaranteeing food safety is a major challenge in this use-case. The used trays will then be shipped to an industrial washing center, cleaned and sanitized, and reintroduced to the system for re-packing.

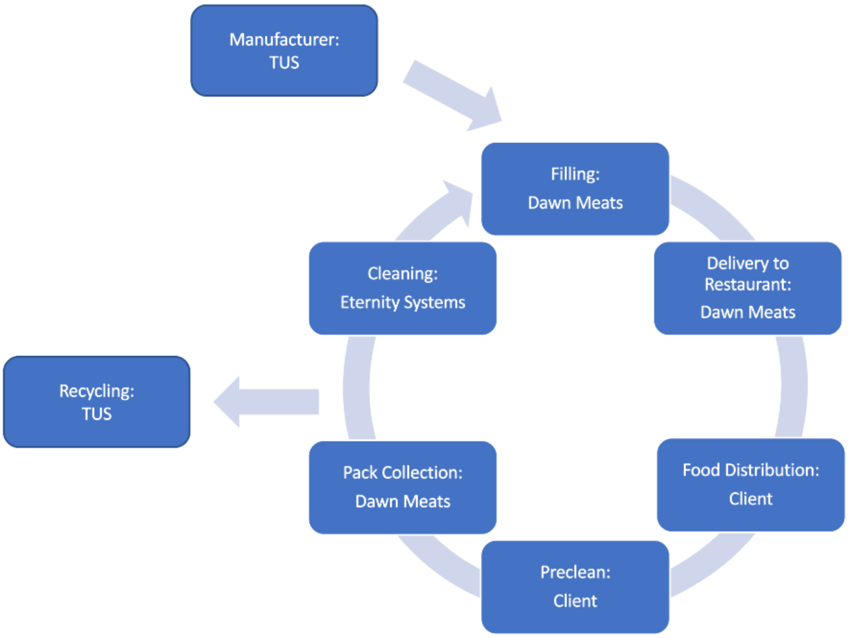

Figure 13: Value chain Dawn Meats' demonstration

3.4.5. Refill Personal Care Bottles

Asevi is a leading manufacturer of cleaning, hygiene, and home care products in Spain. The current material used for the bottle PE with a 50% of rPE incorporated in the single use version. The cap is made of PP. Both materials are already recyclable in current waste streams.

In the demonstration Asevi will manufacture reusable bottles that will be refillable in the retailer's facility. The reusable bottle will offer the customer the opportunity to refill several times (the number of times will be determined during the project) before it is recycled. The main issue of the use-case is the designing of the refillable station, to ensure proper handling of the bottle by the user, bottle tracking and the product traceability.

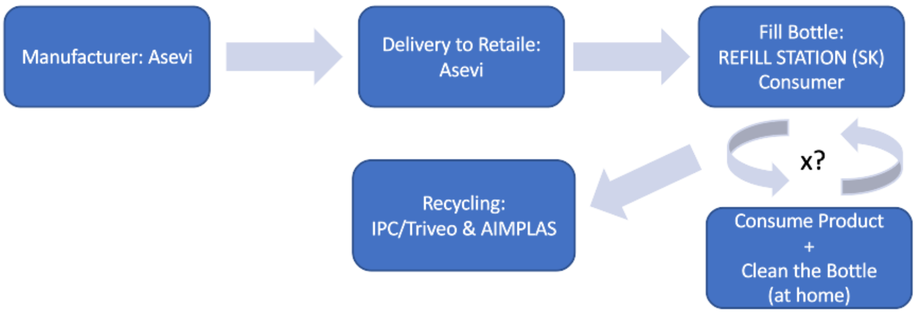

Figure 14: Value chain Asevi's demonstration

Asevi will also provide the filling product for the Bag-in-Box (BiB) manufactured by Smurfit Kappa. This use case is different from the rest as the packaging won't be reusable and therefore will not be portrayed in the present RPP specifications. The BiB is a bulk solution that will enable the user to reuse refillable containers and thus reduce the use of packaging.

The data that has translated into socio-economic issues was provided by the end-users of the project. A template was developed and uploaded to the project's SharePoint in order to collect all this data. Each of the end-users have fill in an individual table that has been merged, creating a single table. Finally, each of the factors has been assigned to each of the steps in the value chain.

- **Manufacturing**

The main socio-economic factor linked to manufacturing is the material's expenses and the cost increase that the container's characteristics imply, which is at risk of significantly increase for catering food trays, ready-meals trays, and skin packs for meat. In the refill home care bottles use case the impact of the number of possible refills per BiB has been highlighted as it will impact the number of refill bottles they need to produce.

- **Storage**

Depending on the stock needed for each of the demonstrations the storage space will vary and thus it could potentially economically impact catering food trays, take-away food trays and skin packs for meat. The RPPs from catering food trays, skin-pack and refill home care bottles could also need special conditions for storing which might also require some investment.

- **Filling**

During the filling process use cases such as Ready-meals trays, Skin pack for meat and Refill home care bottles could be in need of adapting the packaging line where investments may be required. Moreover, partners from catering food trays and refill home care bottles identified the need of training staff when introducing the new packaging and its filling system. Finally, to ensure a safe filling, most of the use cases foresee contracting some testing.

- **Distribution**

Transports mutualization is the main socio-economic factor concerning most of the project's end-users as it would be key to optimize the distribution. Packaging designers from the project have adapted the RPPs designs to the existing logistical packages, but for the refill home care bottles new logistical packaging might be needed.

- **Usage**

Teaching staff safety rules and proper use of the RPP is one of the main socio-economic factors linked to this stage in the package's life cycle. Except for take-away food trays that already have an existing traceability system that counts the reuse cycles and so on, the rest of the use case will need to design and implement a new traceability system.

- **Collection**

Aspects like return rate have concerned partners from use cases such as catering food trays, take-away food trays and ready-meals trays as could lead to losses, therefore incentives or on the contrary penalties should be considered in order to increase the return rate. When replacing SUPs for RPPs promoting inverse logistic loops for collecting RPPs would optimize the transportation and thus more profitable.

- **Cleaning**

When introducing RPPs to the current system some cases will need additional cleaning. With ready-meals trays and refill home care bottles existing cleaning process will be adapted could be by investing in new equipment, changing chemical products etc. However catering food trays, take-away trays and Skin pack for meat are going to externalize the cleaning during the demonstration which could potentially affect the cost. Moreover, companies that will be initiating their RPPs journey in this project may not be reaching the large volumes of packaging that the industrial washing companies need to reach financial breakeven point.

- **End of life**

The rate of lost RPPs and breakages will determine the amount and the frequency that the project's end-users will need to buy new packaging. The cost will increase when bigger the amount and higher the frequency.

The table below summarizes the exercise that the project's end-users have done during task 1.3 by identifying socio-economic factors that affect the use cases. These factors will need to be taken into consideration to optimize the cost of the RPP system as obtaining a cost-effective system will push other businesses to bet on reusable packaging.

Table 4: Key socio-economic factors per use-case

	Catering Food Trays	Take-away Food Trays	Ready-meals Trays	Skin Pack Meat	Refill Home Care Bottles
Manufacturing					
More expensive material/container	X		X	X	
Quantity of containers needed (depends on the number of possible refills per BiB)					X
Storage					
Physical Space (depends on the stock needed)	X	X		X	
Special conditions (adaptation of the space)	X			X	X
Stock (depending on the cycles to avoid contamination)	X	X			
Filling					
Packing line adaptation (equipment, training, tools...)			X	X	X
Training staff (transitioning from SUP to RPP)	X				X
Safety and quality tests	X		X	X	X
Less efficient process					X
Distribution					
Transport mutualization	X	X	X	X	
New logistical packaging					X
Usage					
Training of staff (safety rules, good use...)	X	X		X	
Traceability (designing and implementing a new system, individual labelling...)	X		X	X	X
Collection					
Return rate (incentives and penalties)	X	X	X		
Inverse logistic loops	X		X	X	X
Cleaning					
Additional cleaning (restaurants)		X		X	
Adaptation of current system (equipment, chemical products…)			X		X
Externalization of the washing (shipping, services…)	X		X	X	
Industrial washing centres need large volumes to reach breakeven point	X		X	X	
Short distance from massification centres	X		X	X	

End of life					
Lost/Breakage of containers during transition	X	X			

4. Use cases overview

Each of the slides in this section represents each of the use cases' RPPs portraying an overview of every reuse demonstration in the project providing all relevant specifications for RPPs' designing.

Take-away food tray
- *restaurants*

Material choice

Thermal cycles
- Heated food : 50-100°C
- Microwave compatible
- Preservation in refrigerator (0-4°C)

Barrier properties
- Shelf life: 1 day
- Barrier properties need : low
- Oil and acidity resistance
- Thermal insulation

Mechanical properties:
- Resistant to scratches (eat inside)
- Resistant to load and pressure (stacking)
- Resistant to thermal cycles

Aesthetic:
- Tray: Dark color
- See-thought lid
- Durable aspect
- No food stains

Washing :
- Resistant to washing chemicals
- Resistant to washing temperatures

End of life:
- Recyclable material

Packaging functionalities

Shape:
- Standard volume for 1 portion meal
- 3 compartments
- Easy to open
- Wide opening to eat inside

Sealing:
- No leaks during transport

Washing:
- Shape compatible with industrial dishwashers
- Round angles

Transport:
- Nest-ability
- Stack-ability
- Light weight
- Resistant to transport solicitations

Communication:
- QR code (towards the customer-User's information)

End of life:
- Easy to Disassemble

Other

Economic:
- Minimize costs for restaurant
- New potential markets for restaurant & more visibility

Logistic & Process:
- Manufacturing by injection molding
- Proximity of washing facility and restaurants
- Proximity and choice of collect bins for consumers
- Traceability: QR code

Refill home care products bottles

Material choice

Raw material spec.:

- Recycled material
- non -abrasive materials
- material stable quality

Final bottles spec.:

Thermal cycles
- Room temperature

Barrier properties
- Shelf life: 5 years
- Barrier properties need: low
- chemical resistance needed

Mechanical properties final packaging:
- Resistant to scratches
- Resistant to load and pressure (stacking)

Aesthetic:
- Durable aspect
- Atractive features

Others:
- Resistant to odour & colour

Washing :
- Resistant to washing chemicals

End of life:
- Recyclable material

Packaging functionalities

Shape:
- Standard volume for 720ml
- Easy to refill

Sealing:
- No leaks during transport
- Same material cap and bottle

Washing:
- Shape compatible with industrial dishwashers

Transport:
- Light weight
- Resistant to transport solicitations

Communication:
- Removable label (content's information)
- QR code (towards the customer-User's information)

End of life:
- Easy to disassemble

Other

Economic:
- Minimize costs for consumers.
- Final bottle grammage 40-50 gsm
- Final bottle cost (material + production): 0,1-0,2€/bottle

Logistic & Process:
- Manufacturing by ASEVI
- Traceability: QR code

Catering food tray

Material choice

Thermal cycles
- Heated food in oven: 160°C (multi-portion trays)
- Microwave compatible (single-portion trays)
- Preservation in refrigerator (0-4°C)

Barrier properties
- Shelf life: 5 days
- Barrier properties need : medium
- Oil and acidity resistance

Mechanical properties:
- Resistant to scratches (eat inside)
- Resistant to load and pressure (stacking)
- Resistant to thermal cycles

Aesthetic:
- Tray: Dark color
- See-thought lid
- Durable aspect
- No food stains

Washing :
- Resistant to washing chemicals
- Resistant to washing temperatures

End of life:
- Recyclable material

Packaging functionalities

Shape:
- Volume for 1 or 6 portion meals
- Easy to open
- Wide opening to eat inside (single portion trays)

Sealing:
- No leaks during transport
- Tamper proof

Washing:
- Shape compatible with industrial dishwashers
- Round angles

Transport:
- Nest-ability
- Stack-ability
- Light weight
- Resistant to transport solicitations

Communication:
- Removable label (content's information)
- QR code (towards the customer-User's information)

End of life:
- Easy to disassemble

Other

Economic:
- Minimize costs for consumers
- Cost-effective to the company

Logistic & Process:
- Manufacturing by injection molding
- Trays compatible with catering equipment
- Proximity of washing facility and customer's facilities
- Traceability: QR code

Skin pack for Meat

Material choice

Thermal cycles
- Preservation in refrigerator (0-4°C)

Barrier properties
- Shelf life: as per regular packaging
- Barrier properties need : High
- Sealing ability (multiple times)

Mechanical properties:
- Resistant to scratches
- Resistant to load and pressure (stacking)
- Resistant to deformation
- Resistant to thermal cycles
- Resistant to thermal sealing

Aesthetic:
- Tray: preferably dark colour; could be clear.
- See-thought lid
- Durable aspect
- No food stains

Washing :
- Resistant to washing chemicals
- Resistant to washing temperatures

End of life:
- Recyclable flexible film
- Recyclable tray at end of re-use life

Packaging functionalities

Shape:
- Standard volume
- Easy to open
- Wide opening

Sealing:
- Possible to re-seal for multiple trips with no old seal remaining on surface
- Tamper proof

Washing:
- Shape compatible with industrial dishwashers
- Round angles

Transport:
- Nest-ability
- Stack-ability
- Light weight
- Resistant to transport solicitations

Communication:
- Removable label (content's information)
- QR code

End of life:
- Easy to disassemble

Other

Economic:
- Minimize costs for manufacturer & consumers
- Maximise re-use

Logistic & Process:
- Manufacturing by thermoforming and extrusion
- Skin pack compatible with industrial process
- Proximity of washing & filling facility
- Traceability: QR code

Ready-meals tray

- *Supermarket*

Material choice

Thermal cycles
- Heated food : 50-100°C
- Microwave compatible
- Preservation in refrigerator (0-4°C)

Barrier properties
- Shelf life: 1-5 days
- Barrier properties need : High
- Oil and acidity resistance

Mechanical properties:
- Resistant to scratches (eat inside)
- Resistant to load and pressure (stacking)
- Resistant to thermal cycles

Aesthetic:
- Tray: Dark color
- See-thought lid
- Durable aspect
- No food stains

Washing :
- Resistant to washing chemicals
- Resistant to washing temperatures

End of life:
- Recyclable material

Packaging functionalities

Shape:
- Standard volume for 1 portion meal
- Easy to open
- Wide opening to eat inside

Sealing:
- No leaks during transport
- Re-sealable
- Tamper proof

Washing:
- Shape compatible with industrial dishwashers
- Round angles

Transport:
- Nest-ability
- Stack-ability
- Light weight
- Resistant to transport solicitations

End of life:
- Easy to disassemble

Other

Economic:
- Minimize costs for supermarkets & consumers

Logistic & Process:
- Manufacturing by injection molding
- Proximity of washing & filling facilities
- Proximity and choice of collect bins for consumers
- Traceability: QR code

5. Conclusions/Results

The objective of WP1 is to Identify barriers and opportunities for reusable packaging from the stakeholders, then develop and define a set of specifications to guide the design of sustainable reusable packaging.

Task 1.3 is one of the four tasks that make up WP1 and is responsible for identifying the specific critical control points in the re-use process of the packages for each business case involved in the project.

These specifications will ensure optimal washing, safety, and quality of the packaging. Added value points have been identified to encourage the acceptance of packaging by the consumers. The socio-economic determinants have been identified affecting each of the business cases. The technical and economic impacts for the manufacturing of reusable packaging have been reviewed and will help inform the next stages of the design process.

Partners involved in task 1.3 have gathered data from the end-users of the project using different methodologies and translated them into technical specifications that have been collected in this document.

The design of the packaging has an impact in every stage of the RPP life cycle and therefore all life stages barriers and opportunities must be considered. In the deliverable the technical specifications have been assembled in each of the RPP life stages, some only affect in a single stage, but specifications can also impact in a transversal manner. This document has not only gathered technical specifications for the projects use cases like the industrial specifications but also some general technical specifications that could apply to any reuse schemes in the food industry as in the case of washing, safety, and quality.

Writing Deliverable 1.3 has been challenging for various reasons but having many unanswered questions has been the main one. The BUDDIE-PACK project has a duration of 42 months and task 1.3 only covers the first 9 months, thus it is no surprise that there are still unanswered questions. This deliverable has given us the opportunity to have an overview of the work that has already been done and identify specifications that need to be clarified.

The resulting analysis report from task 1.2 fed task 1.3 and provided a baseline picture of reuse. Task 1.3 on the other hand will provide guidance to define designing rules for demonstration packaging in task 1.4. This last task in WP1 will set up the design rules for the packaging in each of the use cases. The knowledge gathered and shared across WP1 will result in an innovative and optimal packaging re-use system across the business cases in the project.

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