The role of information flows in the plastic packaging value chain

(PlasticInfoFlow)

This report is the summary of the selected deliverable reports from the project PlasticInfoFlow.

DEL 01 - Regulation overview in the European Union with detailed focus on the countries Germany, Austria and the Netherlands.

DEL 02 - Comparison of plastic packaging value chain scenarios

DEL 05 - Qualitative and quantitative assessment of scenarios with industry stakeholders

DEL 06: Co-creation workshop with industry stakeholders

DEL 07 - Maturity level assessment of developed scenarios for business implementation

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DEL 01: Benchmark study on the specifications regarding what information is required to be shared due to regulation

Summary

This report describes the work and results of Work Package 1 from April 2019 to June 2019, DEL 01 – an overview of regulation concerning plastic packaging in the European Union with detailed focus on the countries Germany, Austria and the Netherlands.

The key outcome of this analysis is that the regulations at European or at several member state levels are not a barrier for the implementation of Blockchain (BC) or other Distributed Ledger Technologies (DLT) regarding plastic packaging value chains. Nevertheless, the reviewed legislation does not offer a holistic approach on plastic packaging value chains, as different stakeholder groups are covered by different specifications. Thus, there might be resistance among stakeholders to implement DLT due to the uncertainty of regulations within packaging and waste management systems. Still, legislation stays the key tool to pressure higher standards since producers (incl. distributors, retailers) are incentivized by regulation to deal with plastic packaging waste reduction.

Current regulatory norms do not offer incentives for prevention measures, as no targets are in place except recycling. Recycling is moderated by recycling rates both on the EU and national level. Extended Producer Responsibility (EPR) measures the degree of implementation on the national levels and contributes in most cases to achieve recycling targets but at the same time remains a barrier to push for further prevention measures. In the reviewed countries, deposit schemes are introduced mainly for bottles; some types of transportation packaging are the only regulation incentives currently available to promote re-use and refillables. Thus, incentives currently come from the motivation of individual stakeholders. Another crucial challenge remains the compliance to legal regulation across diverse schemes operating in each country, due to the lack of a holistic information perspective.

Next to the analysis of specific legislation, different types of data (required, not required and recommended) were identified that are currently part of the regulatory norms. For example, packaging manufacturers, distributors, and retailers are obliged to share the following (for more details see p.21):

- Type of packaging material made available or discarded;
- The weight of the packaging per material;
- The country of delivery of the packaged product and the total weight of the packaging
- Amount of packaging placed on the market subjected to either own collection or use of any national collection / compliance schemes
- In Germany: obligation to be registered in the collection / compliance scheme
- Information about transportation packaging that are mandatory to be taken back

An example for information that packaging manufacturers are recommended to share:

- Information about recycling materials and its type to enable the recycling of a certain percentage by weight of the materials used for manufacturing of marketable products
- Necessary level of safety, hygiene and acceptance for the packed product and for the consumer to limit the packaging volume
- Noxious and other hazardous substances and materials as constituents of the packaging material or of any of the packaging components with regard to their presence in emissions
- Description of manufacturing processes that enable the recycling of a certain percentage by weight of the materials used for manufacturing of marketable products

1 Regulation overview on packaging and packaging waste with the focus on plastic containing packaging

The regulations selected for this project are the following:

Tab. 1 Selection of the directive and regulations:

1.	European directives
1.1	European Directive 94/62/EC on packaging and packaging waste
1.2	Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste
1.3	Waste Framework Directive (WFD), 2008/98/EC
2.	Germany
2.1	Packaging ordinance (Verpackungsverordnung) 1991, 1998
2.2	The packaging act (Verpackungsgesetz), 2019
2.3	The Circular Economy Act ("Kreislaufwirtschaftsgesetz – KrWG") from 2012 (last amendment 2017)
3.	The Netherlands
3.1	Waste Management Contribution Agreement
3.2	National agreement
3.3	Packaging Management Decree 2014
4.	Austria
4.1	Waste Management Act of 2002 (Abfallwirtschaftgesetz)
4.2	Packaging Ordinance 2014
4.3	Packaging Differentiation Ordinance

The objective to focus on this particular legislation is to identify:

- what stakeholder groups it is targeting, and who remains less approached looking at the general plastic packaging value chain;
- what strategies for circular economy approach are incentivized mainly through the regulation;
- where the gaps for the incentives are.

1.1 The European Commission and packaging regulation

European Directive 94/62/EC

According to the European Directive 94/62/EC economic operators ' in relation to packaging shall mean: suppliers of packaging materials, packaging producers, packaging converters, fillers, users, importers, traders, distributors, authorities and statutory organizations.

This Directive covers all packaging placed on the market and all packaging waste, whether it is used or released at industrial, commercial, office, shop, service, household or any other level, regardless of the material used. It provides the definition of 'packaging' that reads *all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. 'Non-*

returnable' items used for the same purposes shall also be considered to constitute packaging. Mainly the same definition was further disseminated in the national legislations

'Packaging' consists only of:

(a) *sales packaging or primary packaging*, i. e. packaging conceived so as to constitute a sales unit to the final user or consumer at the point of purchase;

(b) *grouped packaging or secondary packaging*, i. e. packaging conceived so as to constitute at the point of purchase a grouping of a certain number of sales units whether the latter is sold as such to the final user or consumer or whether it serves only as a means to replenish the shelves at the point of sale; it can be removed from the product without affecting its characteristics;

(c) *transport packaging or tertiary packaging*, i.e. packaging conceived so as to facilitate handling and transport of a number of sales units or grouped packaging in order to prevent physical handling and transport damage. Transport packaging does not include road, rail, ship and air containers.

It provides definitions of different strategies, such as prevention, reuse, recovery, recycling, energy recovery. organic recycling, and disposal.

According to the directive, member states are obliged to have measures in place that ensure prevention, encourage reuse system of the packaging, to attain targets on recovery and recycling. The Packaging Directive does not include targets for prevention but introduces explicit prevention obligations. It also introduces diverse methods and criteria for better packaging production and choice:

- criteria and methodologies for life-cycle analysis of packaging,
- the methods for measuring and verifying the presence of heavy metals and other dangerous substances in the packaging and their release into the environment from packaging and packaging waste,
- criteria for a minimum content of recycled material in packaging for appropriate types of packaging,
- criteria for recycling methods,
- criteria for composting methods and produced compost,
- criteria for the marking of packaging.

Directive (EU) 2018/852

In 2018, the Directive (EU) 2018/852 amends Directive 94/62/EC and contains updated measures designed to prevent the production of packaging waste, and promote the reuse, recycling and other forms of recovering of packaging waste, instead of its final disposal, thus contributing to the transition towards a circular economy (as part of Circular Economy Package). According to this demand EU countries must take measures, such as national programmes, incentives through extended producer responsibility schemes and other economic instruments, to prevent the generation of packaging waste and to minimise the environmental impact of packaging.

EU countries should encourage the increase in the share of reusable packaging put on the market and of systems to reuse packaging without compromising food safety. This may include:

- deposit-return schemes
- targets
- economic incentives
- minimum percentages of reusable packaging placed on the market for each type of packaging, etc

Thus, the recycling targets for plastic packaging were set by 31 December 2025 is 50% and 2030 55%. One specific target of the European Commission (EC) in 2018 was **lightweight plastic carrier bags**.

The measures were requested to reduce their consumption. However, the measures have to be defined by the member state. The reporting mechanism has to be in place, either per Number or per weight.

Communication from the Commission — Beverage packaging, deposit systems and free movement of goods 2009/C 107/01

Specific role also considered the beverage packaging and how deposit system is organized. National reuse systems for packaging operate with regard to several types of packaging. Some of these systems work very well, particularly those for transport packaging, such as crates and pallets, but also for beverage packaging in the hotel, restaurant and catering sector. In other areas, however, public intervention may be needed to encourage reuse systems, regardless of their actual commercial viability. In this respect, most of the debate in the European Union is focused on consumer beverage packaging (which accounts for around 20 % of total packaging by weight).

In the case of beverage packaging 'reuse' means that a specific container, which has been conceived and designed to accomplish within its life cycle a minimum number of rotations, is refilled for the same purpose for which it was first put on the market. Reused beverage packaging is often named 're-fillable'.

The Directive 94/62/EC does not establish a clear hierarchy between the reuse of packaging and the recovery of packaging waste. The eighth recital in the preamble to the Directive states, however, that 'until scientific and technological progress is made with regard to recovery processes, reuse and recycling should be considered preferable in terms of environmental impact'.

To make non-refillable beverage packaging subject to a mandatory deposit and return system creates barriers to trade, given that such systems make it impossible to sell the same product in the same packaging in more than one Member State. Instead, producers or distributors may have to alter the packaging or the labelling of the imported products and have to bear additional costs connected with the organization of the take-back system, the refunding of sums paid by way of deposit and any balancing of those sums between distributors. In these cases, even if such systems do not actually prohibit imports of drinks in non-reusable packaging, they do require substantial modifications and investment and thereby hamper the access of imported beverages to the market.

Waste Framework Directive (WFD), 2008/98/EC

It defines key concepts such as waste and recycling, lays down key waste management principles and includes provisions on the setting up of so-called End of Waste criteria, which determine when waste ceases to be waste.

The WFD also sets out the Waste Hierarchy for different waste management options, which Member States shall apply. According to the hierarchy, waste prevention is the preferred option, followed by preparation for reuse, recycling, recovery and disposal.

The Directive outlines Extended Producer Responsibility (EPR) in Article 8 as a principle in EU waste legislation. It outlines that EPR can be used by Member States as a way to strengthen re-use, prevention, recycling and other recovery of waste. In order to strengthen the re-use and the prevention, recycling and other recovery of waste, Member States may take legislative or non-legislative measures to ensure that any natural or legal person who professionally develops, manufactures, processes, treats, sells or imports products (producer of the product) has extended producer responsibility.

Such measures may include an acceptance of returned products and of the waste that remains after those products have been used, as well as the subsequent management of the waste and financial responsibility for such activities. These measures may include the obligation to provide publicly available information as to the extent to which the product is re-usable and recyclable. Member States may take appropriate measures to encourage the design of products in order to reduce their environmental impacts and the generation of waste in the course of the

production and subsequent use of products, and in order to ensure that the recovery and disposal of products.

Such measures may encourage, inter alia, the development, production and marketing of products that are suitable for multiple use, that are technically durable and that are, after having become waste, suitable for proper and safe recovery and environmentally compatible disposal.

Tab. 2 Overview of the regulations and targeted stakeholders.

Stakeholder groups	Information targets (obligatory and not obligatory)
European Directive 94/62/EC, 1994, Directive (EU) 2018/852	
Packaging manufacturer	Not obligatory: -Necessary level of safety, hygiene and acceptance for the packed product and for the consumer to limit the packaging volume and to the minimum adequate amount to maintain of packaging -Noxious and other hazardous substances and materials as constituents of the packaging material or of any of the packaging components with regard to their presence in emissions, ash or leachate to minimize its presence - Description of manufacturing process that enable the recycling of a certain percentage by weight of the materials used into the manufacture of marketable products
Packaging design, production and commercialization	Not obligatory: - Process description to permit its reuse or recovery, including recycling, and to minimize its impact on the environment when packaging waste or residues from packaging waste management operations are disposed of -Physical properties and characteristics of the packaging to allow reuse -Number of trips or rotations in normally predictable conditions of use, - Possibility of processing the used packaging in order to meet health and safety requirements for the workforce -Requirements specific to recoverable packaging when the packaging is no longer reused and thus becomes waste.
Waste management	Not obligatory: -Packaging waste generated in a particular Member State from reusable packaging may be deemed to be equal to **the amount of reusable packaging placed on the market** within that Member State in the same year. -Composite packaging shall be reported under the predominant **material by weight**. Additionally, separate data on recovery and recycling of composite materials may be provided on a voluntary basis. -The weight of recovered or recycled packaging waste shall be the **input of packaging waste to an effective recovery or recycling process**. If the output of a sorting plant is sent to effective recycling or recovery processes without significant losses, it is acceptable to

	consider this output to be the weight of recovered or recycled packaging waste.

1.2 Germany

Packaging ordinance (Verpackungsverordnung) 1991, 1998

In 1991, Germany enacted the packaging ordinance (Verpackungsverordnung), and in 1994 the EU adopted the Packaging Directive. The German regulation was harmonized with the EU directive via enactment, in 1998, of a new version of the packaging ordinance. Since that, this regulation has been amended seven times to harmonize it with European law and current requirements.

The packaging ordinance is Germany's first law to assign the task of *waste management product stewardship* to *product manufacturers*, who are required to take back the packaging that they have placed on the market and either reuse or recycle it, or have this done by a third party. *Retailers* are also subject to product return obligations. The return-deposit rule for certain types of disposable beverage containers aims to support reusable packaging, strengthen recycling, and reduce uncontrolled disposal of packaging waste (via garbage or littering). For sales packaging typically arising at the private consumers, manufactures and distributors have to take part in one or several compliance schemes (Duale Systeme) to ensure the collection and recycling of the sales packaging on full-coverage basis. Later this legislation was substituted by **the new Packaging Act 2019.**

The packaging act, 2019

The packaging law determines the requirements concerning product responsibility in order to force primary avoidance, preparation for reuse or recycling of packaging waste. The main change is the introduction of the Central Authority (Zentrale Stelle). The Zentrale Stelle is empowered with sovereign rights and, as an independent authority, is intended to increase the efficiency of the enforcement and to strengthen competition. Among it's supervision role, it is responsible for the development of a minimum standard for measuring the recyclability of packaging and review of branch specific solutions.

Main objectives of the new act:

- to strengthen recycling of packaging waste, especially from private households, by significantly higher recycling quota for the „dual systems" and by creating legal certainty for the bin for reusable materials in order to obtain additional material for recycling
- to encourage producers to use ecologically advantageous and recyclable packaging, and
- to create more transparency by "highly visible" signs on the shelves for disposable or returnable bottles retailers have to affix. The share of beverages in reusable bottles shall be strengthened and a recycling quota of 70% is introduced (appellative quota to illustrate the political target).

The new Packaging Law redefines certain terms: *sales packaging* to be licensed with a packaging scheme will be defined as primary and secondary packaging used for sales, which occurs predominantly as waste with the consumer after use; these must then be 100 percent licensed with a packaging scheme. In the future, *secondary packaging* (Umverpackung) will be treated as sales packaging. *Shipping packaging* (to the consumer e.g. online-sales) is now clearly considered as sales packaging.

Packaging items that require registration and licensing under the new GPA are sales packaging ("*Verkaufsverpackungen"*) and secondary packaging or outer packaging ("*Umverpackungen"*) under two conditions:

1. They are filled with products, and
2. typically end up, after being used, as waste at (i) a private final consumer or (ii) equivalent places of waste generation ("*gleichgestellte Anfallstellen"*) – such as restaurants, hotels, canteens,

administrations, hospitals, educational , charitable or military institutions, service stations etc. – all irrespective of the quantities of waste generated there, smaller craft and agricultural businesses.

The new Packaging Act 2019 is also intended to make retailers more responsible for promoting the use of eco-friendly and recyclable packaging. The product responsibility is conducted via an extended producer responsibility scheme applied via *the Dual Systems*. The so-called Dual Systems (the new packaging law calls them „systems“) are companies which pool recycling duties for packaging waste from private end users and facilitate their joint recovery. They organise collection, sorting and recovery of used sales packaging, and task private or communal disposal companies with execution.

Dual systems are financed by license fees from participating companies. The Dual Systems have to shape their “participation payments” (“license fees” producers have to pay) in a way that they provide an incentive for producers to pay attention to the recyclability of materials they use and to use recyclates or renewable raw materials. The systems have to collect it separately from municipal waste and “primarily” supply for preparation for reuse or for recycling.

Part of Deposit systems are Standard deposit for one-way drinks packaging incl. beverage cans and PET bottles, € 0.25 (incl. VAT) as well as deposit for reusable drinks packaging: € 0.08 - 0.15 (incl. VAT)

The Circular Economy Act (“Kreislaufwirtschaftsgesetz – KrWG”), 2012 (last amendment 2017)

Each Federal State adopts its own waste management act containing supplementary regulations to the national law, e.g. concerning regional waste management concepts and rules on requirements for disposal. There is no national waste management planning in Germany. Instead, each Federal State develops a waste management plan for its area.

The Circular Economy Act determines product responsibility (polluter pays principle) for producers of waste, creates a legal basis for introduction of a bin for recyclable waste (“Wertstofftonne”), defines the relationship between public and private waste management industry, determines responsibilities of public authorities, sets targets for recycling of municipal waste (“Siedlungsabfall”): from 2020, at least 65% (percent by weight) of it shall be treated for reuse or recycled (this target includes all kinds of waste, not only plastic waste), defines that different types of waste (paper, metal, plastic, glass) have to be collected separately.

The act itself includes relatively little specifications.

Tab. 3 Overview of the requirements for the stakeholder group in Germany

Stakeholder groups	Information targets
Packaging ordinance (Verpackungsverordnung) 1991, 1998 (also on the status 2009)	
Product manufacturers (Anyone who manufactures packaging, packaging materials or products from which packaging is directly manufactured, and anyone who imports packaging into the territorial scope of this Ordinance.)	-Circulation of placed packaging on market to take back the packaging to reuse or to recycle -Amount of packaging placed on the market, if part of the dual scheme in order to pay to third party - Information about available compliance scheme to take part in one or several compliance schemes for sales packaging (Duale Systeme) to ensure the collection and recycling - obligated to accept returned transport packaging after use.
Third party	-required to take back the packaging that they have placed on the market to reuse or to recycle
Retailers	Obligation to product return
Distributors	(must)

(Anyone who puts into circulation packaging, packaging materials or products from which packaging can be directly manufactured, or goods in packaging, at whatever level of trade)	-to remove such secondary packaging upon delivery of the goods to the final consumer or to give the final consumer the opportunity to remove and return the secondary packaging free of charge at the point of sale or on the premises of the point of sale. - to provide at the point of sale or on the premises of the point of sale suitable collection containers to accommodate the secondary packaging which are clearly visible and easily accessible to the final consumer. - for Sales packaging have to take part in one or several compliance schemes (Duale Systeme) to ensure the collection and recycling - to accept returned transport packaging after use.
The Circular Economy Act ("Kreislaufwirtschaftsgesetz – KrWG") from 2012	
producers and owners	defines basic duties to avoid unnecessary waste and have to care for its recovery and recycling
developers, producers and distributers	In §23, the act determines the principle of product responsibility (polluter pays principle). Products have to be "preferably" designed and generated in a manner that waste production is minimised and recycling or environmentally safe disposal after use is ensured.
Law on the distribution, return and high-quality recycling of packaging (packaging law), 2019	
-Manufactures of the packaged goods - first distributors of sales packaging materials -retailer / online retailers (Anyone who puts packaging into circulation is responsible for its return or its recycling – based on ERP system).	-Mandatory registration with the Central Registry to provide name of the packaging scheme contacted by the manufacturer -Registration with a Dual System. Legally not permitted to organize the return and recycling of their packaging individually, but are obligated to participate in a permitted packaging scheme (Dual System). - Annual reprting regarding the amount and type of packaging materials. - provide annual so-called Declaration of Completeness - to collect the packaging back und to recycle it

1.3 The Netherlands

As part of the implementation of European Directive 94/62/EC, the Netherlands address prevention measures and packaging reduction via different Volunatary Agreements. (Worrell and A. E. van Sluisveld, 2013) In Packaging Covenant I: introduction of prevention targets on the market in 1997 and 10 per cent less packaging material in 2000, both compared with 1986. Packaging Covent II aimed to realize the targets and agreements made in the Packaging Directive. The amount of packaging newly on the market in 2001 was allowed to grow by a factor equal to 90 per cent of national income—measured in gross domestic product (GDP)—still using 1986 as the reference year. The covenant stated that producers and importers had to maximize packaging prevention. Packaging Covenant III (PC III): the third covenant was signed on 4 December 2002. In the period 2005–2010, the general effort of the industry in the Netherlands has been aimed at prevention, mainly through lightweighting (Worrell and A. E. van Sluisveld, 2013).

Food packaging and transport packaging (also referred to as industrial packaging) have been most frequently subject to packaging optimization. The explanation for food packaging is probably due to the

relatively large volumes sold and large expenditures required for these types of packaging (Worrell and A. E. van Sluisveld, 2013).

Although, the reuse of products is preferred over material recycling or recovery in the waste hierarchy, this is decreasingly stimulated by Dutch policies over time. This seems to be partly owing to the costs and efforts of companies to implement infrastructure to recycle the products.

Currently, producers and importers of packaged products are legally responsible for the prevention, collection and recycling of packaging waste. However, targets for the prevention do not remain anymore the focus of legislation. This extended producer responsibility follows from Dutch national legislation implementing the European directive on packaging and packaging waste (the Packing (Management) Decree 2014 (Besluit beheer verpakkingen 2014), which implements European Directive 94/62/EC). This extended producer responsibility applies to companies that are the first to make packed products available to another in the Netherlands and/or who remove the packaging on import.

`High quality recycling´ and `quality standards for the relevant recycling sectors´ are not literally transposed into the Dutch legislation (Article 11(1) WFD). With respect to the `by 2015 separate collection set up for paper, metal, plastic and glass´ (Article 11(1) WFD), this is not transposed in the Dutch national legislation. This has to do with the fact that national legislation is rather a framework, and more detailed subjects are laid down in provincial and municipal ordinances

Waste Management Contribution Agreement

The Waste Management Contribution Agreement (ABBO) is binding on all producers and importers of packaged products in the Netherlands. Producers and importers responsible for more than 50,000 kg of packaging in any given calendar year must register with Afvalfonds Verpakkingen, declare their packaging weight and pay the fees accordingly. By doing so, producers and importers meet the majority of obligations they have under the Packaging Decree, including the recycling targets. This also applies to foreign entrepreneurs who are the first to make packaged products available to consumers in the Netherlands.

The Packaging Waste Management Contribution (PWMC) covers the costs of implementing the Packaging Agreement, and consists of two components:

1. The main costs per material for collecting and processing, and for acquiring a guarantee from recycling companies that they will use the collected materials;
2. The system costs: the prevention of litter, monitoring and organizational costs.

The modulated fee is intended to reward companies that use well-recyclable rigid plastic packaging with a positive market value after sorting, leading to lower net costs for Afvalfonds Verpakkingen (‘Packaging Waste Fund’). For rigid plastic packaging that is sorted and recycled without impediments, and with a positive market value in 2019, a lower rate of € 0.38 per kg applies. The fees are re-established annually and the relative discount compared to the regular plastic rate will be maintained for a multiannual basis.

To determine if a plastic packaging is easily recyclable or not, Afvalfonds Verpakkingen uses the recycle check for rigid plastic packaging, which has been developed by Netherlands Institute for Sustainable Packaging (Kennisinstiuut Duurzaam Verpakken, KIDV)

No Packaging Waste Management Contribution is due on logistieke hulpmiddelen. Logistieke hulpmiddelen are exclusively:

- pallets, including pallet collars, pallet boxes and insert sheets, intended to be used in combination with a pallet and which have the same surface area as the pallet;
- glazing carriers;
- Intermediate Bulk Containers;
- roller containers;
- drums, jerrycans and gas bottles with a capacity of 20 litres or more;
- crates with a capacity of 8 litres or more;
- boxes with a capacity of 1 m3 or more;
- big bags with a capacity of 250 litres or more; and

- drums, spools and reels with a length of 50 cm or more.

Bottles in a deposit system
Producers and importers who place bottles on the Dutch market are subject to a deposit refund system and may apply the deposit refund rate. This also applies to labels, screw caps and swing-tops which, in practice, are collected with the bottle within the deposit refund system. It does not apply to crown caps and other bottle components, which, in practice, are not collected with the bottle within the deposit refund system. For these components you have to apply the fee for the specific material the component consists of. Plastic bottle > 0.75 l without deposit fee is for plastic bottles for soft drinks and waters with a capacity of > 0.75 litres that are not part of the applicable mandatory deposit refund system.

Thus, the only subject of the deposit system is beer bottles deposit system and plastic beverage bottles deposit system.

National agreement
On 27th June 2012, the Ministry of Infrastructure and Water Management (at that time the Ministry of Infrastructure and the Environment), the Association of Netherlands Municipalities (VNG) and the Packaging Industry signed the Packaging Agreement (Raamovereenkomst verpakkingen) 2013-2022 which states, that companies must recycle more packaging material and make the entire packaging chain sustainable. The collective implementation of the extended producer responsibility is guaranteed via Afvalfonds Verpakkingen.

Based on the desire of all parties, producers/importers guarantee that they will have one, robust organization that finances extended producer responsibility for packaging. Stichting Afvalfonds Verpakkingen is this organization. It has signed a contract with large producer association for fast moving consumer goods, non-food and industrial packaging, and by publication in the official Dutch state gazette (“Staatscourant”), this agreement is declared legally binding for all producers/importers.

Nedvang is a collective organization of producers and importers organizing collection and processing of packaging waste, was assigned as the executive organization to implement the Decree

Packaging Management Decree 2014

The Decree provides definition of packaging and its type, all products, produced of material whatsoever, which can be used for the enclosing, protection, transshipment, delivery and offering of other products, from raw materials to finished products, across the entire path from the manufacturer to the user or consumer, including any disposable articles used for these purposes. Packaging is deemed to be exclusively sales or primary packaging, combination or secondary packaging, and dispatch or tertiary packaging.

The components of a packaging and the associated components, incorporated into the packaging, shall be deemed to be part of the packaging into which they have been incorporated, and where the associated components suspended from or attached to a packaged product and which have a packaging function, shall be deemed to be packaging.

The Decree names manufacturer, as a producer of the packaged goods (or importer who imports packaged good), commercially instruct others to provide the packaging of substances, preparations or other products with its name, logo or brand (packaged good distributor), and the one who places a packaging on the market.

The decree also defines deposit on beverage system.

Nevertheless, the Decree leaves a lot of responsibility to manufacturer and mainly focuses on effective recycling. E.g. the municipalities decide on the collection of packaging waste, e.g. by source separation or by post-separation from residual waste. Businesses have indicated that they wish to decide for themselves whether to use deposits PET soft-drink bottles as a collection tool. In collection with deposits, the bottles are not refilled but shredded and recycled. There is a collection path for other plastic packaging waste, namely the Plastic Heroes system. It may be more efficient for the collection of PET soft-drink bottles to follow the Plastic Heroes collection route.

Re-use as the definition is not mandatory in Decree.

Tab. 4 Overview of the requirements for the stakeholder group in the Netherlands

Stakeholder groups	Information targets
Packaging Decree 2014	
Manufacturer (producer) and importers User of take-away packaging	1. Packaging volume and weight must be the minimum amount to maintain the necessary levels of safety, hygiene and acceptance for the packaged product, and for the consumer. 2. Packaging must be manufactured so as to permit reuse or recovery in accordance with specific requirements. 3. Noxious or hazardous substances in packaging must be minimised in emissions, ash or residues from incineration or landfill. To meet the limits on heavy metal concentration levels. The aggregate heavy metal limits apply to lead, cadmium, mercury and hexavalent chromium, or in packaging or packaging components subject to some exemptions (e.g. for glass and **plastic crates/pallets**). For the packaging the following should be recorded and registered: • the type of packaging material made available or discarded; • the weight of the packaging per material; • the country of delivery of the packaged product (both within or outside the Netherlands); and • the total weight of the packaging. Must also report every three years to the Ministry of the Environment on the preceding three years take back results, including measures taken to allow take back, recovery and recycling targets to be achieved, quantities of packaging placed on the market, packaging waste generated and any shortcomings in the packaging chain - responsible for eco designing their packaging and for achieving material specific recycling targets
Municipalities	-responsible to collect the waste of citizens within their borders based on the “Wet milieubeheer”, the Dutch environment act. -to collect at least paper/cardboard, glass and plastic packaging separately
Beverage point of sale (more than 200 m2)	shall charge a deposit on the beverage packaging. shall provide return point and collect beverage packaging after use (one of the exception is wine packaging)
Packaging waste management contribution	
Producers of packaged goods	If you bring more than 50,000 kilograms of packaging material onto the Dutch market for the first time, remove or transport packaging as an importer, you must pay a packaging waste management contribution (formerly packaging tax) to the Packaging Waste Fund (*Afvalfonds Verpakkingen*). To report the quantity of packaging annually. To do so, you must first register with the Packaging Waste Fund (*Afvalfonds Verpakkingen)*

1.4 Austria

The obligations companies have to fulfil when they place packaging or packaged products on the market in Austria are set out in the Austrian Waste Management Act and the Packaging Ordinance.

Austria has three sets of targets in effect: material-specific targets for businesses individually complying with the recovery objectives, expressed as percentages of packaging taken back and own packaging waste arisings; targets for reuse and recovery (material and energy) for beverage containers; and targets for economic operators (manufacturers, importers, fillers and distributors), which take part in a collection and recycling scheme. Materials that are subject of packaging regulation are all material (mainly paper, cardboard, paperboard, corrugated board, plastic packaging (incl. EPS but excl. returnable plastic), glass, metal (ferrous metals and aluminum), wood, textile, composites,…).

Waste Management Act of 2002 (Abfallwirtschaftgesetz)

The Austrian Waste Management Act adopted in 2002 is the main piece of legislation transposing the requirements of the European WFD into domestic law. In addition, various ordinances, which are based on the Austrian Waste Management Act, support the implementation of the WFD at national level. Further, the collection of non-hazardous municipal waste is regulated under the Waste Management Acts of the nine Austrian Federal Provinces.

The purpose of the Act is to hinder harmful effects on human beings, animals, plants and their natural environment through the principles of waste prevention, waste processing and waste disposal.

The legislation defines waste as a term, as well as waste hierarchy, separate collection target.

The fact that the requirements on separate collection are further regulated on regional level has to be taken to account with regard to this assessment.

In terms obligations for packaging the legislation also defines primary obligated parties of packaging, which are manufacturers and importers, packers whose registered office or place of business is within the local area, importers and distributors. Household packaging waste is deemed to a special consideration, also considering where waste is generated that are comparable in terms of packaging to households; this includes, in particular, restaurants, hotels, canteens, tobacconists' shops, administrative buildings, barracks, hospitals, doctors' practices, educational establishments, law firms, notaries, consulting firms and accountants, charitable institutions, cinemas, theatres, opera houses and museums, or holiday resorts, parks, sports facilities, open-air swimming pools, solariums, fitness centres and service areas, public squares and other micro-enterprises.

Packaging Ordinance 2014

Packaging encompasses all means of packaging made of various materials, packaging aids, pallets for loading, protecting, handling, delivery and presentation of goods. The packaging is broken down into transportation packaging, sales packaging and service packaging. Relevant is also the classification into household packaging and commercial packaging.

The present Ordinance obliges producers of packaging material to either take back and recycle/reuse packaging or deliver it to their retailers or to take part in a collection and recovery system. Special rules apply to major accumulation points and smaller deliverers. Definition of packaging is all materials/products used for the containment, protection, handling, delivery and presentation of goods from the producer to the end-user and consumer. This includes sales packaging which is used to enclose the item and transport packaging which is used to protect goods from damage during transport. Transport packaging includes grouped packaging.

Parties responsible for packaging are manufacturers, importers, packers/fillers and distributors of packaging and packaged goods. It requires the stakeholders that place packaging or packaged goods on the Austrian market to take these packaging materials back free of charge and ensure their recovery or reuse. It brings some major changes regarding overall packaging waste obligations and the collection and recovery of packaging (i.e. now several collection and recovery systems offering compliance services for household packaging, area-wide). To be emphasized are the separate collection targets

(based on total mass (defined as “Teilnahmemasse”) of all collection and recovery systems per calendar year) and recycling targets (input recycling facility) for household packaging waste for plastic is separate collection 60 %, recycling 50 %

The producer responsibility in Austria is a “Dual model” which means that there is a full responsibility for the industry for the collection, sorting and recycling of packaging waste; that there is a separate collection system besides the collection systems developed by the local authorities and that there is very small influence from the local authorities. Currently only organization ARA is licensed to use the Green Dot symbol.

The objective of new legislation in Austria relating to waste management and packaging is to enable increased competition through the approval of more waste collection and processing systems in the household sector.

Small producers, packers, importers and distributors are exempted from their packaging obligations, if they place on the market less than a specific threshold quantity/material of packaging per year, for the plastics it is 100 kg and, whose annual turnover does not exceed 726,728.00 euros.

A voluntary agreement for beverage containers (the so-called Sustainability Agenda for Beverage Containers) is supported by the beverage industry, the packaging industry and the recycling systems. The aim of this agreement is to target a 55% material recycling target for PET bottles, to recycle 9.000 tonnes of PET into new bottles by 2012 and to recycle 70% of cans by 2013. There is also a target to reduce net greenhouse gas emissions by 10% by 2017 (against a 2007 baseline).

A deposit system only exists for returnable packaging in Austria. There is no deposit system for disposable packaging.

Packaging Differentiation Ordinance

The present Ordinance implements the Waste Management Act 2002 (BGBl. II No. 102/2002) and the European Parliament and Council Directive 94/62/EC on packaging and packaging waste of 31 December 1994. The purpose is to establish a clear differentiation between household packaging and commercial packaging to avoid distortions of competition between the parties required to collect and recycle packaging.

The ordinance provides the split between packaging use types and between sales, transportation and pallets

Ordinance on Taking back and deposit payments for refillable plastic beverage containers, 2002

This ordinance establishes a compulsory deposit of € 0.29 for refillable plastic beverage containers at national level.

Tab. 5 Overview of the requirements for the stakeholder group in Austria

Stakeholder groups	Information targets
Waste Management Act, 2002	
manufacturers, importers, distributors, collection and recycling systems, waste collectors, waste handlers and final consumers	- labelling of products indicating the need for dismantling of individual parts or separation of components or return, or the nature of the product, in particular its pollutant content, and the precautions to be taken during collection or treatment, reuse or specific treatment; -information on the design or characteristics of products for recovery, on the dismantling or separation of individual components, on environmentally sound treatment, on the development and optimisation of

	possibilities for re-use and recovery, including the necessary testing of parts for re-use and recovery - the return, take-back, re-use, preparation for re-use, recycling or other recovery of products or waste or participation in a collection and recovery system compliance with waste prevention, collection, collection, recycling or recovery quotas within a specified period of time; -the collection of a deposit; - the delivery of products only in a form and condition that significantly relieves the burden on waste collection and treatment; - to refrain from placing on the market products containing certain ingredients in order to prevent their release into the environment, to facilitate preparation for re-use and recycling, not to complicate disposal or to avoid the disposal of hazardous waste; - prohibiting the use of individual types of conventional mineral oil-based lubricants, provided that technically equivalent biodegradable lubricants are available in sufficient quantities for the purpose in question; - the record-keeping, verification and reporting obligations, insofar as these are necessary for the review of the obligations - the prohibition or authorisation of additives to biodegradable lubricants, minimum and maximum levels of vegetable and mineral oils and their degradation rates; - the payment of a treatment fee; the treatment fee must be commensurate with the value of the products and the treatment costs
Packaging Ordinance 2014	
manufacturers, importers, packers/fillers and distributors Businesses that do not join a packaging compliance scheme	• Collect packaging waste through a scheme of your own • Organise the re-use or recovery of packaging waste in state-of-the-art facilities • Fulfil minimum recycling rates for each packaging material • Submit annual data reports to the Ministry of Environment, including a breakdown by packaging materials, the amount of packaging placed on the market, the amount collected, the coverage rate in percent, the amount transferred and the transferee
manufacturers, importers, packers/fillers and distributors Businesses that register with a packaging compliance scheme	• Enter into a compliance agreement • Submit data reports on the amount of packaging placed on the market • Pay the material-specific compliance fee

2 Outcomes

In this report, different legislation for packaging and waste management systems was reviewed. The objectives were to identify best available practices among the reviewed countries in the legislation and to use it as a benchmark for assessing the implementation of Distributed Ledger Technology (DLT) within plastic packaging value chains. The key results include:

- Regulation is not a barrier for DLT implementation, however there might be resistance among stakeholders to implement DLT due to the uncertainty of regulations within packaging and waste management systems. The reviewed legislation does not provide clear incentives for DLT to be introduced to the market as an obligatory tool to track material composition and other information.
  Currently, producers (incl. distributors, retailers) are mostly pressured by regulation to deal with plastic packaging waste reduction
- Most regulation focuses only on recycling, which is measured by recycling targets, but no other targets for prevention are in place
- Currently, there are no incentives for the market stakeholders to foster re-use that is driven by regulation; thus, incentives need to come from individual stakeholder's motivation.

These results lead to assumptions of enablers and barriers for the DLT implementation in plastic packaging value chains including the following:

> This analysis suggests that there are no incentives by regulation for the implementation of DLT. It could be driven by the market if financial incentives were identified. At the same time, DLT might play a role as supporting technology for the market stakeholders (primary retailers and distributors), product packaging manufacturer and mostly for recycling strategies. In terms of reuse and prevention strategies, due to the weak specification of current regulation, there is a lack of incentives for stakeholders to use DLT technology, as it is not a compulsory part of the reporting. The exception might be beverage and transport packaging. **(barrier)**

Main affected stakeholder groups by legislation

The European directive defines clearly all stakeholders involved in the plastic packaging production process, such as suppliers of packaging materials, packaging producers, packaging converters, fillers, users, importers, traders, distributors, authorities and statutory organizations.

However, national legislation of the selected countries focuses only on the specific groups that put packaging on the market. These are manufacturers, retailer, and distributors of packaged products. Currently, there is no dedicated waste management legislation only for plastic packaging treatment. It is covered under the general national legislation for waste management, where all other types as for example household and industrial waste treatment is described. The legislation gives a lot of flexibility around sorting and collection methods for local authorities. Main instruments, in this case, are established recycling quotes for plastic materials through recycling.

> There is no holistic view through legislation on the full plastic packaging value chain, starting from materials until end of life. Different stakeholder groups in the plastic packaging value chains are subjected to different legislations. It might lead to the information break between suppliers of packaging materials, packaging producers, packaging converters, fillers. **(barrier)**

> For distributors and retailers, it can be even more complex to collect information upstream on the value chain, as they do not work directly with the packaging suppliers (only if it is not a case or transportation packaging) **(barrier)**

> Due to evolving regulations, many stakeholders might still not be fully aware of the current reporting schemes and compliance approaches. Thus, in the new German Packaging Act, online-retailers are for example also obliged to reporting. **(barrier)**

Policy recommendations

For market operators engaged in activities in the several member states of the diverse systems make it difficult to take advantage of business opportunities on the internal market. Instead of selling the same product in the same packaging in different markets, they are required to adapt their packaging to the requirements of each individual member state, which usually leads to additional costs.

> The challenge remains around compliance for cross country packaging also within the EU. It means that there is no harmonization among stakeholder groups on the EU level. **(barrier)**

In Europe, waste recovery is managed by recycling rates. Among the reviewed countries, the incentives to achieve recycling rates targets are promoted via collection recycling schemes. Member states are obliged to have measures in place that ensure prevention, encourage the reuse systems of packaging to attain targets on recovery and recycling. However, it does not include targets for prevention but introduces explicit prevention obligations. All reviewed countries have the principle of Extended Producer Responsibility (EPR) in place.

Such systems might indeed contribute to achieve a more ambitious recycling rate for different materials. Current changes in the regulation, e.g. in Germany, also contribute to the promotion of recycled materials through new packaging brought to the market. However, it does not contribute to strategies on the packaging prevention and reuse measures, which still remain voluntary measures for the producers.

> Currently, regulation does not provide any incentives for prevention and reuse. Thus, the stakeholders might develop these strategies only if they identify individual financial benefits from packaging prevention and reuse. **(barrier)**

At the moment, deposit systems are stimulating reuse only within beverage packaging. Germany was a first adopter. The system changes from multiple use bottles (reuse) to one use way, where the bottles are recycled after use. Nevertheless, this approach helps producers to conduct recycling on their own, without having to purchase recycling content from the waste management companies. Such a measure helps to identify products returning from the user.

> It means that deposit schemes for bottles do not necessarily promote the reuse strategy but stimulate material recycling (recycling rate). In such schemes, the role of retailers and users increases as they need to ensure the information exchange between user and packaged product, which is reusable. (**enabler)**

> Transport packaging is also mentioned among regulations as part of the reuse / deposit scheme. There was no explicit information identified, but clearly the role of information exchange between the transportation company and producers of transportation exchange is crucial. (**enabler)**

The gap between mandatory information to be reported and voluntary/recommended information to know for stakeholders

Packaging placed on the market is automatically compliant with the essential requirements. However, in most of the regulations an extensive description is given on desirable measures to promote prevention and reuse. But there is no reporting/information collection that contributes to these suggested measures. Thus, there are particular information gaps identified that either are being managed voluntarily or that stakeholders can individually search incentives for. Currently, by legislation, only some

information is part of mandatory reporting. As a conclusion, additional information might be useful to collect that could lead to extended prevention/reuse schemes.

1. **Required information among reviewed legislation**:

Packaging manufacturer, Distributor, Retailer:

- Type of packaging material made available or discarded;
- The weight of the packaging per material;
- The country of delivery of the packaged product and the total weight of the packaging.
- Amount of packaging placed on the market subjected to either own collection or use of any national collection / compliance schemes
- In Germany: obligation to be registered in the collection / compliance scheme
- Information about transportation packaging that are mandatory to be taken back

Retailer:

- Information on how environmentally friendly the packaging in the placed-on market product is
- Information about packaging in case of product return (possible to reuse ? / possible to give back?)

2. **Not required information from legislation (but recommended) or potential information gap but mentioned in the regulation that contributes to prevention and reuse:**

Packaging manufacturer:

- Information about recycling materials and its type to enable the recycling of a certain percentage by weight of the materials used for manufacturing of marketable products
- Necessary level of safety, hygiene and acceptance for the packed product and for the consumer to limit the packaging volume
- Noxious and other hazardous substances and materials as constituents of the packaging material or of any of the packaging components with regard to their presence in emissions
- Description of manufacturing processes that enable the recycling of a certain percentage by weight of the materials used for manufacturing of marketable products

Packaging developers / Designers:

- Description of manufacturing processes that enable the recycling of a certain percentage by weight of the materials used for manufacturing of marketable products
- Process description to permit its reuse or recovery, including recycling, and to minimize its impact on the environment when packaging waste or residues from packaging waste management operations are disposed
- Physical properties and characteristics of the packaging to allow reuse
- Number of reuse/recycling loops in predictable conditions of use
- Possibility of processing the used packaging in order to meet health and safety requirements for the workforce
- Requirements specific to recoverable packaging when the packaging is no longer reused and thus becomes waste

End of life:

Amount of packaging waste generated from reusable packaging. Currently calculated as to be equal to the amount of reusable packaging placed on the market in the same year. There is currently no information available in terms of statistics on reusable packaging waste

- Information on composite packaging. Currently reported under the predominant material by weight.

- Separate data on recovery and recycling of composite materials
- Information on weight of packaging waste sent to an effective recovery or recycling process between sorting plant and recycling plant without significant loss
- Information about product is design and generated in a manner that waste production is minimised and recycling or environmentally safe disposal after use is ensured.

Conclusion

Based on the analysis, the following conclusion regarding enablers and barriers for DLT implementation in plastic packaging value chains can be derived:

Enablers:

- EPR schemes contribute to recycling targets
- National recycling targets stimulate increase of recycling
  Available deposit schemes on the national level support re-use measures

Barriers:

- EPR schemes provide less incentives for other prevention measures, such as re-use / refill, prevent producing the package in the first place
- Chemical and hygiene regulations might be a barrier for implementation of particular prevention measures
- Due to diverse country schemes, no information alignment among EU countries is required to be reported and also there is a lack of transparency for stakeholders to understand ERP schemes

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DEL 02: Comparison of plastic packaging value chain scenarios

Summary

This report describes the work and results of Work Package 1 from April 2019 to July 2019, DEL 02 - comparison of plastic packaging value chain scenarios. This comparative study selects and describes at least three plastic packaging value chains for further investigation according to different packaging types, and price segments, etc. The selection includes plastic value chains with the highest potential for waste.

The main scope of this project for future focus is packaging made from hard plastics. The prioritized are the value chains of bottles, pallets and keg's as a first choice, and barrels, crates and containers as a second choice. The focus should be on the producers with products that have a high throughput (e.g. bottles) or products with a high value, e.g. heavy-duty pallets (heavy and therefore more expensive) or high-end (price) kegs. The main stakeholders that were taken into consideration for this study are the producers, traders and users of the packaging.

Judging different packaging materials to be interesting for Blockchain technology, a set of criteria was defined (see p. 7). Important variables to make a Blockchain application in plastic packaging value chains realistic are:

- total mass of the packaging material (tons/year)
- value of the product (euro/item)
- potential application reused material (to be high) and the recycling rate (to be low)

These variables show that bottles, pallets and kegs are to be seen as a first choice for the further course of this project and barrels, crates and containers as a second choice.

1 Plastic Packaging Value Chain and main scope of this project for future focus.

The plastic packaging value chain consist basically of the following parts:

1. Production of primary and secondary plastic granulates:
    a. Primary granulates from chemical polymerization processes, making virgin plastic
    b. Secondary granulates from plastic recycling operations.
2. Compounding: in many cases done at the plastic product extrusion process
3. Extruding/molding the (half-)products
4. Assembling half-products to one product
5. Wholesale/trade, offering a variety of packaging options, also other materials than plastics
6. Use of product

In many cases, compounding and assembling is not necessary, therefore the plastic packaging value chain has 4 to 6 parts. Because the information stored in a Blockchain is mostly read from a QR-code, for now only hard plastics are part of the scope of this project for future focus, so: no foils. The value chains are defined by the product: e.g. a pallet or a bottle.

1.1 Prioritising value chains in this project

Criteria relevant for the primary focus:

- Price segments/massive amounts of units
- Highest waste potentials
- B2B products as it decreases logistics and transportation costs

Currently, regulation is not an issue as demonstrated in DEL01. Compliance to regulation can be achieved via other methods such as mass balances, invoices etc. However, to show the certified amount of recycled content in a (half-) product, Blockchain technology via a QR-code is to be used. Price segment is a focus; the higher the price, the larger the incentive to implement Blockchain to show the recycled amount of plastics. Due to the simplicity and use of low-priced plastics, the size of the product does matter and can be only compensated through the large amount of product (e.g. soda bottles). The costs of the packaging depend somewhat on transport costs but that is difficult to make an overview of. In the cost of the packaging (in the table below), material costs are included. The product with the highest waste potentials are:

- the product that could technically contain large amounts of recycled or depolymerised plastic, (potential application reused material) and
- the product that could mostly benefit from tracking, so the product with the lowest recycling rate

The following value chains of packaging made from hard plastics are presented in the table below, in which:

- Type of packaging; presented in the table are the most found types
- Price segments (euro); per single packaging
- Amounts per type of packaging; typical amounts of a single packaging for a certain purpose; equals the typical run of products through a mold.
- Typical weight of packaging; in grams per single packaging (in grams per piece)
- Total weight of packaging type; per run of packaging material (amounts per type times the typical weight); in tonnes
- Potential application reused material in packaging: the amount of plastic that could be used to make a new same type of packaging. This depends on the use, for food applications this is usually low, for non-food applications this is usually higher.
- Recycling rate: rate of currently recycled packaging
- Relevance of specific material information due to difficult additives (e.g. colour, flame retard-ant…)

Tab. 6 Type of packaging

Type of packaging	Price segments (euro)	Amounts per type of packaging	Typical weight of packaging (gram)	Total weight of packaging type (tonne)	Potential application re-used material	Recycling rate	Information necessity due to unknown additives
Blisters	0.01 to 1	100.000 – 1.000.000	1 – 100	0,1 - 100	Low	46.5%	low
Bottles	0.05 to 0.15	10^9	50	100.000	Low/high*****	50%***	low
Jerry cans	0.1 - 1	100.000 – 1.000.000**	100 – 2.000	10 – 1.000	Medium	46.5%	medium
Buckets	0.5 - 5	100.000 – 1.000.000**	50 – 5.000	50 – 5.000	Medium	Medium/high*	high
Inter Mediate Bulk containers (IBC's)	100 - 200	100.000 – 1.000.000**	10.000 – 20.000	1.000 – 20.000	Medium	Medium****	medium
Barrels	10 - 50	100.000 – 1.000.000**	1.000 – 5.000	100 – 5.000	Medium	Medium****	medium
Beer/wine containers ("kegs")	10 - 50	100.000 – 1.000.000**	1.000 – 3.000	100 – 3.000	High (framework)	Low (disposable)	high
Trays	0.05 – 0.5	100.000 – 1.000.000**	10 - 100	1 - 100	High	Low/medium****	high
Crates	1 - 5	100.000 – 1.000.000**	1.000 – 5.000	100 – 5.000	High	Medium/high*	medium
Container (small)	5 – 10	100.000 – 1.000.000**	100 – 5.000	10 – 5.000	High	Low/medium****	medium
Pallets	5 - 30	100.000 – 1.000.000**	5.000 – 15.000	500 – 15.000	High	Low/medium****	high

- *: depending on application, e.g. food application
- **: same amount as blister taken, due to the same method of production
- ***: depending on refund system, in that case usually higher.
- ****: typical reuse in closed loop
- *****: low: thermoplastic recycling of bottles; almost not possible due to hygiene. High: when material is depolymerised. PET-bottles are recycled into other materials as fleece.

The blisters, bottles, beer/wine containers ("kegs") and trays are in most cases one-way packaging. Here there is in some cases a desire to have it tracked and traced (e.g. kegs by a Dutch producer), in other examples not, such as some flower trays in the Netherlands due to financial incentives. Intermediate bulk containers (IBC's), crates, small containers and pallets are in most ways two-way products. There is not always a take back system in place. In many cases, traders take care of the reuse of these packaging materials. In other cases, there is a refund system, where the packaging is cleaned and reused (e.g. crates). Jerry cans, buckets and barrels are in some cases one-way and in some cases two-way packaging. In general, it is not of direct influence on the desire for tracing and tracking if a packaging material is one-way or two-way. Some two-way packaging materials are sold and used in a refill system, within a company (e.g. IBC's).

The strategy for recycling is in general quite simple. In B2B, the plastic packaging is directly sold to recyclers, so that they have a steady flow of material with known quality at a modest level. Because these plastic packaging are mixed with other plastics for the production of regranulate, there is in most

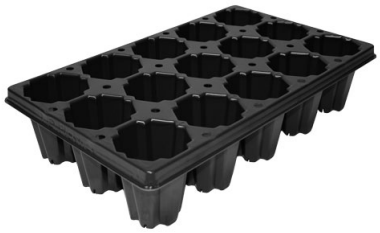
cases no desire to have more information on the quality of the plastic packaging. Lately, there is some focus on closed loop recycling, however by each turn, the quality of a plastic deteriorates, so other re-granulates also have interest. B2C plastic packaging is taken back for recycling. When a refund scheme is in place, the material is quite defined for recycling, but not used for the same application (e.g. bottles). PET of bottles could be reused when depolymerised, but those technologies are still in first plant stage. When the material ends up in a mix, the quality of the regranulate is usually low.

Blister packaging

IBC

Keg's

Jerry can



Flower tray

Pallet

From the table above, the types of packaging that are selected for this project are those packaging materials that have per type of material made at specific producer a high mass. In that case the economic impact (recycled mass represents value) and the ecological impact is larger. This would be the bottles, buckets, IBC's, barrels, keg's, crates, containers and pallets. The IBC's are difficult to recycle due to the mixture of steel (recycled) and plastic, and the value of the IBC is also based on the steel and the higher production costs. The next variable to choose is the potential application reused material (to be high) and the recycling rate (to be low), which would place the barrels on a second choice. The value of the product is a driver for tracking and recycling, because the value depends on the price of the plastic and the amount used in a product. This would eliminate trays and put containers and crates on a second choice. This elimination leaves bottles, pallets and keg's as a first choice for this project, and barrels, crates and containers as a second choice.

In searching and choosing producers and their product lines, it would be wise to choose producers with products that have a high throughput (e.g. bottles) or products with a high value, e.g. heavy-duty pallets (heavy and therefore more expensive) or high-end (price) barrels.

1.2 Main stakeholder groups at different stages in the value chain.

The main stakeholder groups in the value chain are the stakeholders that have benefit from tracing by a Blockchain technology. The stakeholder groups should have interest in:

- proving that a certain amount of recycled content is in their products. The reason for this is public pressure from consumers or pressure groups or demands at circular procurement.
- sharing of information of the material in their products (type of plastic and possible additives and fillers), to increase the chance of recycling, and therefore dampen price fluctuations of plastic (re)granulates.
- tracing, for take back and refund systems.

The stakeholders with these interests are the producers, traders and users of the packaging. Some of these stakeholders are already interested from an operational point of view; they need their products back, as for example the B2B two-way plastic pallets. Some stakeholders are interested when asked about tracking and tracing via Blockchain. Others have other priorities and are not interested.

2 Outcomes

Judging different packaging materials to be interesting for Blockchain technology, the framework of enablers and barriers is not practically suitable but instead a set of criteria was defined. Important variables – as shown in the table above – to make a Blockchain application in plastic packaging value chains realistic are:

- total mass of the packaging material (tons/year)
- value of the product (euro/item)
- potential application reused material (to be high) and the recycling rate (to be low)

These variables show that bottles, pallets and kegs are to be seen as a first choice for the further course of this project and barrels, crates and containers as a second choice.

3 List of Literature

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DEL05 Qualitative and quantitative assessment of scenarios with industry stakeholders

Executive Summary

Following the choice of plastic packaging value chains and the development of a guideline for blockchain implementation, in this work package we involve the plastic packaging industry to evaluate their actions towards plastic packaging waste prevention and prospects of blockchain implementation.

The five industry partners selected covered most of the plastic packaging value chain, from the plastic converter down to the plastic recycler. The content of both the five qualitative and the six quantitative interviews was divided into two sections covering the following topics: one section focused on strategies for prevention of plastic packaging waste and the second on the potential of implementing blockchain technology for optimising processes along the supply chain.

The key problem from different perspectives (technical, organisational, regulatory) is to achieve higher recycling rates. There is a common understanding that an increased amount of secondary raw material is the biggest economy incentive for plastic companies. Reuse is the second type of concept associated with prevention; however, the scalability of this model is questionable. Finally, using alternative materials to substitute fossil-fuel plastics (such as bio-based polymers) is considered as another strategy to reduce excessive plastic packaging waste.

There seems to be a disconnection along the supply chain in terms of information exchange although companies tend to be open to share information with other stakeholders. This accounts specifically for plastic packaging producers and recyclers.

The quality of recycled materials is one of the key barriers to achieving closed loops. The demand for recycled material is increasing but the secondary raw material offer is dragging behind. The waste is hard to collect and recover but it seems that a more granular data provision of waste or waste streams in general could be of high value.

Blockchain technology has not entered the plastic packaging market yet and is seen as a very advanced yet complicated technology. It is often not clear what tangible results can be achieved with blockchain. However, material specifications is the most important information that is currently missing from the plastic packaging waste supply chain.

From a consumer perspective, it is a challenge to buy reusable products because they are usually more expensive, it is hard to understand the entire impact of a product and there are misbehaviours in disposing plastic packaging. There is a big potential and economic incentive to measure the impacts of a supply chain in a holistic way. This can be considered as a gap since it is not controlled and, in some cases, not trustworthy.

1 Introduction

This report includes the analysis of five interviews carried out with industry partners. Five industry partners along the plastic packaging value chain were selected: a plastic packaging producer/converter (ALPLA Werke Alwin Lehner GmbH & Co KG), an online retailer of bioplastic packaging (BioFutura), a producer of refillable water bottles (BeOBottle), a recycler who produces secondary raw materials and finally a secondary raw materials converter (Extruplas) as well as a waste management company (Veolia).

The interviews were structured in two sections: one section focused on strategies for prevention of plastic packaging waste and the second on the potential of implementing Blockchain technology for an improved information flow within plastic packaging value chains.

The qualitative interviews were structured based on the following field manual:

1. Identification of enablers/barriers for plastic packaging waste prevention
    a. What is your understanding of plastic packaging waste prevention (recycled content/reuse/incineration/recycling rate, etc.)?
    b. What actions/strategy are you implementing in order to prevent plastic packaging waste/achieve environmental impact goals?
    c. What stops you from achieving your plastic packaging waste goals?
    d. To what extent are regulations part of plastic packaging waste prevention?
    e. Do you collaborate with other plastic packaging value chain stakeholders? Would you want to collaborate with other stakeholders in order to prevent plastic packaging waste?
    f. What are the main incentives to operate and shift business models towards plastic packaging prevention strategies?

2. Identification of enablers/barriers for Blockchain implementation
    a. To what extent is transparency or better information flow along the value chain a way to prevent plastic packaging waste? (not at all/to some extent/a lot)
    b. What type of information do you have to share with other plastic packaging value chain stakeholders?
    c. To what extent do you share or are you willing to share information across the value chain? (not at all/to some extent/a lot) What other barriers do you see in order to achieve more transparency along the plastic packaging value chain?
    d. What information do you miss from the other stakeholders in order to prevent plastic packaging waste?
    e. Have you heard about Blockchain technology? What interests you most in Blockchain technology? Where do you see the potential for your business? What stops you from implementing Blockchain?
    f. To what extent does Blockchain help preventing plastic packaging waste? (not at all/to some extent/a lot) How do you see Blockchain helping to prevent plastic packaging waste?

In parallel, an online questionnaire was developed, also covering the above-mentioned topics, to involve several additional organisations that were sourced from the consortium member's networks.

The online survey was structured into two main parts; one to understand enablers and barriers for plastic waste prevention and the other one to identify enablers and barriers for the introduction of Blockchain Technology. In total, the survey contained 23 questions and it was spread among a broad audience. The objective of the survey was to broaden the results of the interviews through a higher outreach.

Section 00: Introduction

1. Please indicate which industry you are from:
2. How many employees does your company consist of?
3. Which packaging stakeholder group do you belong to?

Section 01: Identification for enablers and barriers for plastic packaging waste prevention

1. Specify below what plastic packaging waste prevention means for you.
    a. Increased use of recycled content
    b. Increased transparency in the supply chain
    c. Decreased units consumed and therefore produced
    d. Better waste management
    e. Higher recycling rates
    f. Stricter policies and more regulations
    g. More education for the producer
    h. More education for the consumer
2. What strategies have you implemented in your company in order to prevent plastic packaging waste?
3. Below are some examples of barriers from achieving plastic packaging waste goals. Please select all that apply to you.
    a. I find regulations to be overly complex
    b. It's difficult to integrate a change within my large organisation
    c. The costs of new solutions are too high
    d. I am not aware of solutions for my company
    e. Other (please specify)
4. To what extent are regulations part of plastic packaging waste prevention?
5. Do you collaborate with other stakeholders of the plastic packaging value chain?
6. Which stakeholders of the plastic packaging value chain do you collaborate with?
    a. Polymer producer
    b. Plastic packaging producer
    c. Recycler
    d. Converter
    e. Retailer
    f. Other
7. Would you want to collaborate with other stakeholders in order to prevent plastic packaging waste?
8. Which other stakeholders would you want to collaborate in order to prevent plastic packaging waste?
    a. Polymer producer
    b. Plastic packaging producer
    c. Recycler
    d. Converter
    e. Retailer
    f. Other
9. What are the main incentives that would enable you to shift the business models towards plastic packaging prevention strategies?

10. Below are some examples of strategies to prevent plastic packaging waste. Rank the 3 most promising strategies to prevent plastic packaging waste? (1 being the most promising)
    a. Increasing the use of recycled content
    b. Increasing the transparency in the supply chain
    c. Improving the collection of packaging waste
    d. Using renewable resources to produce packaging
    e. Re-designing packaging products for a better end-of-life which avoids generation of waste
    f. Implementing a deposit and return system

Section 02: Identification of enablers and barriers for blockchain implementation

1. To what extent transparency - or better information flow - along the value chain is a way to prevent of plastic packaging waste?
2. Which type of information you have to provide to external stakeholders?
    a. Number of units
    b. Weight of products
    c. Quality of products
    d. Chemicals specifications
    e. Percentage of recycled content
    f. Other (please specify and separate with a comma)
3. To what extent is your company willing to share information across your value chain?
4. What stops you from sharing information with other stakeholders?
5. Below are some examples of barriers from sharing information with other stakeholders. Please select all that apply to you.
    a. The information we hold are too sensitive or confidential to be shared
    b. I am not the one making the decision
    c. I am not allowed to share information to third parties
    d. I do not see added value from sharing the information
    e. It requires costly technological solutions
    f. Regulations do not allow me to share information
    g. Other (please specify)
6. What information do you miss from the other stakeholders in order to prevent plastic packaging waste?
7. To what extent do you know about blockchain technology?
8. What interests you most in blockchain? What potential do you see for your business?
9. To what extent does blockchain help preventing plastic packaging?
10. Below are some examples of barriers to implementing new technologies such as blockchain in a company / business model. Please select all that apply to you.
    a. It's difficult to integrate such tools within my company
    b. The costs of these technologies are too high
    c. I don't find a suitable fit my needs
    d. I don't know enough about the new technologies
    e. Other (please specify)
11. What processes in your organization would you apply blockchain in order achieve your plastic packaging prevention strategies?

The goal of both qualitative and quantitative interviews was to identify whether there is a common understanding of plastic waste prevention in the plastic packaging industry, what the development tendencies are and whether future scenarios for the use of Blockchain can be identified. Further, through both the interviews and the online questionnaire, the aim was to identify barriers and enablers for the prevention of plastic packaging waste and whether Distributed Ledger Technologies (DLT) including Blockchain can bring benefits for an improved information flow between relevant stakeholders.

The report gives an overview and interpretation of the results obtained from both the interview types. The transcripts of the qualitative interviews are summarised in the Annex using Intelligent Transcription. This means that not every single word is transcribed but only those that add value to the content because the purpose is to identify further enablers and barriers for using Blockchain for plastic packaging waste prevention. The detailed analysis of both interview types can also be found in the Annex.

1.1 Evaluation and interpretation of the qualitative interviews

The analysis of the five qualitative interviews resulted in altogether 28 hints to barriers and 19 hints to enablers for plastic packaging waste prevention. The interviewed experts referred 12 times to regulation, 16 times to information flows, 16 times to business models and 21 times were potential future ideas mentioned.

The following insights could be captured regarding barriers:

TECHNICAL:

- For HDPE, you also have certain migration of product from the content to the packaging; for instance, laundry detergent migrates into the matrix of the polymer, so then you need to deal with de-contamination
- Packaging sometimes has a middle layer, for example in a bottle structure, having a multi-layered structure to hide or mask that layer
- One challenge is to obtain good quality recyclates for the manufacturing process
- Another challenge is to adapt the manufacturing sites to handle recyclates
- Certain types of plastic take on smell, so it is necessary to do process variations and make amendments in the process to be able to deal with that

ORGANISATIONAL:

- **Blockchain is still an abstract topic**
- Blockchain was tested for different applications, and came to the conclusion that for low tech plastic, it is not a relevant approach
- **The right end-of-life option needs to be considered but when a product is sold, the control over it is lost**
- **Recycling companies are not very keen to take bioplastics because the amount is still quite low, and they cannot earn money from that**
- In most cases, it is hard to find a purchasing partner for the low-tech secondary plastic
- **Another challenge is to measure the whole impact of a supply chain. And to do that for every single material because working with many suppliers makes this very complicated**
- **It is a big challenge to rely on the information provided by actors along the supply chain, there is no control of these processes**
- Many producers of the packaging just don't know how the market works and what is environmentally good. They go for appealing branding, but not the sustainability of the product

- One of the biggest challenges are critical customers. Sometimes they are very critical because an entire sustainability story cannot be presented for one product. Being transparent with supply chains and customers is important but sometimes it is very difficult for them to understand the whole impact of a supply chain

- It is a challenge to ensure that people buy reusable products. It is still a question of money (costs) to buy reusable products. Only consumers who already have a sustainable mindset take this option.

REGULATIONAL:

- Not sure about the effects on plastic waste prevention because according to EU legislation, there are currently only ten products in place for plastic waste, but the plastic waste topic is of course much broader

- A regulation challenge is the cross-border waste transportation

- It seems that for the market it is not a big issue that the plastic is made of oil. E.g. for the car industry it is a big issue already using gas, and petrol because of environmental perspective. As for the plastic, people are still not aware what it is made from

- Regulation with regards to plastic packaging is not an issue. In Germany, it is actually very well organised, and we see it more as an advantage for our work. Regulation around deposits and take back systems is also helpful. However, it is mainly part of extended producer responsibility, where waste management companies are not part of.

The following insights could be captured regarding enablers:

TECHNICAL:

- The key would be to be able to reclaim our bottles back. Probably with blockchain we would reach higher number of bottles back

- Being more transparent throughout the supply chain, being able to carry more efficiently information through. I guess that's for sure potential for the future. I think in our industry, the end of life has more potential because we have huge interest in getting our products back from the waste collectors and if there is an attributed information existing in the empty bottles in the trash cans, I think that can be helpful

- At the recycling point, we could get a better-quality product back, meaning if we would be able to find a smart system the very specific L'Oreal shampoo bottle for instance of a very specific colour and sort it out in a smart way, that could be a big enabler

- We don't really miss information. If in the future we get more information, for instance on specifications. Let's say there is a railcar with PET resin coming with X tons of material, first of all it represents a big monetary value, but it also comes with a certain specification, for instance viscosity or colour. Right now, this info is on a sheet of paper. If we get more granular, if we were able to track this in a better way, there could be some value. If you could attribute some characteristics to the granulates, there could be some value, too

- When you have manufacturing you have process variations. Typically, the material supplier has to send certain specifications, such as viscosity range. If the manufacturer manages to get the viscosity reading more accurately rather than one global measurement for X tonnes of material, then there's value to it as it could enable us to have better manufacturing. Maybe it could be the DNA of a granulate, maybe there is a value in generating this DNA

ORGANISATIONAL:

- We are in discussion with brand owners, everyone wants recyclates within their products

- If a client comes to us and want to use polystyrene or polyamide for certain applications, we put the red flag up and tell them to do it differently as we want to keep recyclability in focus

- Data from the collected waste. If we were able to collect data from the bottles themselves, such as where does it come from, what material is it, what was the content. This is definitively an enabler, which would also enable to close the loop

- Biofutura does that without compromising: so we only sell compostable tableware and packaging made from 100% renewable resources

- Prevention starts from choosing the selection of materials and we believe in renewable materials. To have end of life option ready is also the way of prevention

- Sooner or later, we realised, we need to think more systemically and believe in the circular economy approach – from the source to the end of life options. So, this is now really embedded in our business model. But of course, this is very challenging to work from that point of view and make money at the same time

- As for waste management company's cooperation is not necessary for these materials, because we work with PE (2). It is a standard material, which is comparable with every recycling facility dealing with oil based PE. It is well recycled material. Thus, there is no need to sort it out. Currently we see it is as the best way to do it for the end of life strategy

REGULATIONAL:

- We signed the commitment with the EllenMcArthur Foundation to show our engagement

- The biggest advantage is the EU single use regulation brings awareness to customers, but the focus should also go together with the recycling / composting options

- According to regulation, we are obliged to buy the plastic via auction, which is good. Because everyone has to be registered who supplies it, and it brings clarity. This process established by regulation works well for us. And there is no issues with the price volatility

1.2 Evaluation and interpretation of the quantitative interviews

From the online questionnaire, we obtained the following insights:

- Achieving higher recycling rates is the main common concept associated with plastic packaging waste prevention.
- Right after it comes an increase of recycled content and a better waste management system, including a better collection system for packaging waste.
- The substitution of polymer material with other sustainable material options is also a strategy company use.
- Among barriers are the cost of new solutions which could be too high to implement and the capacity of the supply chain to implement changes.
- The confusion from the consumer side regarding how to dispose of the plastic packaging is also considered as a cause for the excessive waste generated
- The majority thinks that regulations play a role in preventing plastic packaging waste.
- All companies interviewed collaborate with other stakeholders in the value chain. And most of them would like to collaborate with additional stakeholders, including the end-user and retailers.
- Business profits and incentivised collaborations are the main incentives to implement new business models based on plastic packaging prevention and a measurable footprint of current activities, a way of better mapping the impact from activities is also an incentive to act
- There is an understanding that more transparency in the value chain could help prevention of packaging waste, however not real/tangible measures can be thought of.
- Data related to the weight of the products, units number, material source and percentage of recycled contents are examples of data shared across the value chain.
- Companies are open to share information with other stakeholders.
- Material specifications is the most important information that is currently missing from the plastic packaging value chain.
- Companies representatives seem to have a superficial understanding of what blockchain does.
- The technology is still not directly associated to prevention measure.
- Not enough knowledge is shared about the technology and what it can do.
- One of the barriers to innovation implementation is the difficulty to find a suitable fit to the companies' needs.

2 Outcomes

In the last section of the report, both qualitative and quantitative results are being compared and the main conclusions are summarised.

Barriers

- The key problem (from all perspectives: technical, organisational, regulation) is to achieve higher recycling rates; or in other words, to get products back from the customer
    - Achieving higher recycling rates is the main common concept associated with plastic packaging waste prevention.
    - Right after it comes an increase of recycled content and a better waste management system, including a better collection system for packaging waste.
    - The right end-of-life option needs to be considered but when a product is sold, the control over it is lost
    - Recycling companies are not very keen to take bioplastics because the amount is still quite low, and they cannot earn money from that
    - The key would be to be able to reclaim our bottles back. Probably with blockchain we would reach higher number of bottles back
    - Being more transparent throughout the supply chain, being able to carry more efficiently information through. I guess that's for sure potential for the future. I think in our industry, the end of life has more potential because we have huge interest in getting our products back from the waste collectors and if there is an attributed information existing in the empty bottles in the trash cans, I think that can be helpful
    - At the recycling point, we could get a better-quality product back, meaning if we would be able to find a smart system the very specific L'Oreal shampoo bottle for instance of a very specific colour and sort it out in a smart way, that could be a big enabler
- There seems to be a disconnection along the supply chain, specifically with producers and recyclers; there is no holistic thinking regarding plastic packaging
    - Many producers of the packaging just don't know how the market works and what is environmentally good. They go for appealing branding, but not the sustainability of the product
    - All companies interviewed collaborate with other stakeholders in the value chain. And most of them would like to collaborate with additional stakeholders, including the end-user and retailers
    - Interestingly, companies are open to share information with other stakeholders
- Blockchain is an abstract topic for companies within the plastic packaging supply chain and there is only a superficial understanding of what Blockchain can really do
    - It is not directly related to plastic packaging waste prevention measures
    - Not enough knowledge is shared about it
    - Not applicable to low-value plastics due to economic considerations
- Material specifications is the most important information that is currently missing from the plastic packaging waste supply chain; more granularity for materials could be of high value
    - Data related to the weight of the products, units number, material source and percentage of recycled contents are examples of data shared across the value chain.

- We don't really miss information. If in the future we get more information, for instance on specifications. Let's say there is a railcar with PET resin coming with X tons of material, first of all it represents a big monetary value, but it also comes with a certain specification, for instance viscosity or colour. Right now, this info is on a sheet of paper. If we get more granular, if we were able to track this in a better way, there could be some value. If you could attribute some characteristics to the granulates, there could be some value, too
- When you have manufacturing you have process variations. Typically, the material supplier has to send certain specifications, such as viscosity range. If the manufacturer manages to get the viscosity reading more accurately rather than one global measurement for X tonnes of material, then there's value to it as it could enable us to have better manufacturing. Maybe it could be the DNA of a granulate, maybe there is a value in generating this DNA
- Data from the collected waste. If we were able to collect data from the bottles themselves, such as where does it come from, what material is it, what was the content. This is definitively an enabler, which would also enable to close the loop

- There are some specific technical problems with plastics when it comes to recycling or waste prevention, as for example different layering, the packaging taking up parts of the content or smells
  - For HDPE, you also have certain migration of product from the content to the packaging; for instance, laundry detergent migrates into the matrix of the polymer, so then you need to deal with de-contamination
  - Packaging sometimes has a middle layer, for example in a bottle structure, having a multi-layered structure to hide or mask that layer
  - Certain types of plastic take on smell, so it is necessary to do process variations and make amendments in the process to be able to deal with that

- From a consumer perspective, it is a challenge to buy reusable products because they are usually more expensive, it is hard to understand the entire impact of a product and there are misbehaviours in disposing plastic packaging
  - The confusion from the consumer side regarding how to dispose of the plastic packaging is also considered as a cause for the excessive waste generated
  - One of the biggest challenges are critical customers. Sometimes they are very critical because an entire sustainability story cannot be presented for one product. Being transparent with supply chains and customers is important but sometimes it is very difficult for them to understand the whole impact of a supply chain
  - It is a challenge to ensure that people buy reusable products. It is still a question of money (costs) to buy reusable products. Only consumers who already have a sustainable mindset take this option

- A regulatory challenge is the cross-border waste transportation since there are many different legislations in place across the EU

Enablers

- There is an understanding that more transparency across the value chain could help the prevention of packaging waste, however not tangible measures can be thought of

- There is big potential and economic incentives to measure the impacts of a supply chain in a holistic way; yet information management is not controlled and is in some cases not trustworthy
  - Another challenge is to measure the whole impact of a supply chain. And to do that for every single material because working with many suppliers makes this very complicated

- It is a big challenge to rely on the information provided by actors along the supply chain, there is no control of these processes

- There is a consciousness about waste prevention and recycling both at client and producer side
  - We are in discussion with brand owners, everyone wants recyclates within their products
  - If a client comes to us and want to use polystyrene or polyamide for certain applications, we put the red flag up and tell them to do it differently as we want to keep recyclability in focus
  - Biofutura does that without compromising: so we only sell compostable tableware and packaging made from 100% renewable resources

- Regulation on plastic packaging waste is seen as positive and the majority thinks that regulations plays a key role in preventing plastic packaging waste
  - Voluntary agreements are signed with NGOs
  - The biggest advantage is the EU single use regulation brings awareness to customers, but the focus should also go together with the recycling / composting options

- There is not enough consciousness about plastic being made from a non-renewable resource as opposed to the car industry for example
  - It seems that for the market it is not a big issue that the plastic is made of oil. E.g. for the car industry it is a big issue already using gas, and petrol because of environmental perspective. As for the plastic, people are still not aware what it is made from

DEL 06: Co-creation workshop with industry stakeholders

Executive Summary

Following the choice of plastic packaging value chains and the development of a guideline for blockchain implementation, in this work package we validated the results of the previous deliverables with the plastic subject matter experts (SMEs) from packaging industry.

In order to accomplish the validation process with SMEs, the project team took part in the world biggest plastic fair, K-Messe, with the objective to discuss current barriers and opportunities for the topic of information flow in the value chain and to what extend the blockchain can support this process. The results collection was in the form of individual discussion with the SMEs that covered different stages of plastic (packaging) value chain: raw materials and additives, producers of finished products (primary packaging, actors involved into high performance (high tech) polymer production, distribution, machinery, transportation and recycling.

The objective was to evaluate the entire plastic packaging value chains - to understand where improved information flows and blockchain technology can lead to the prevention of plastic waste. The main focus is on the lack of transparency and trust between stakeholders along the plastic packaging value chains. The interview was structured into 3 main parts:

1. Plastic Packaging waste prevention strategies
2. Validation of enablers, barriers and policy recommendation
3. Understanding of the role of digital technology, such as blockchain for the prevention strategies

Overall around 35 SMEs took part in the current validation process, which brought us to the following results we obtained:

Plastic waste and its treatment in overall evaluation was recognized as a problem, however there was not clear link that it is necessarily the problem of packaging, rather than specific polymers and industry focus. Biopolymers were often seen as a solution for the plastic packaging waste prevention the same as high value recycle (improving machinery recycling and developing chemical recycling), appropriated design, like use of mono-material and deposit system.

Blockchain technology has not entered the plastic packaging market yet and is seen as a very advanced technology. Currently the stakeholders do not see the lack of information in the value chain as a challenge, while they refer mostly to the current regulation. In case of high-performance plastic, they are subject to REACH, which already requires high transparency and content verification for producers. In terms of packaging that gets in contact with food, there is already high controlling mechanism in place. The highest interest was from the perspective of product verification. In case if the producer is interested to take it back from the waste management company or even the user then there was more interest in the product verification process.

1 Validation approach through the K-Messe visit

K 2019, known as “The World's No. 1 Trade Fair for Plastics and Rubber” and scheduled to take place in Düsseldorf from 16 to 23 October 2019. K is the performance barometer for the entire plastic industry and its global marketplace for innovations.

The decision to take part in K-Messe was taken in order to enlarge the feedbacks with Plastic Industry SMEs and validate current assumption and results from the previous deliverables.

The objective was to evaluate entire plastic packaging value chains - to understand where improved information flows and blockchain technology can lead to the prevention of plastic waste. The main focus is on the lack of transparency and trust between stakeholders along the plastic packaging value chains. The validation process was structured in the form of interviews.

3. Preselection of the partners

The preselection of the partners was made according to the following criteria:

- Geography: key focus on the European companies.
- Business area: polymers raw materials (biopolymers and fossil fuel polymers) for packaging market, diverse packaging producers primary operating with rigid packaging, packaging distributors and plastic recyclers. Also, companies that operate with bottles, buckets, IBC’s, barrels, keg’s, crates, containers and pallets.
- Other focus areas: companies operating in the field of high-performance plastics (mainly the plastic types for the construction, automobiles or agriculture markers), as well as additives for these industries. Even though these plastics do not address the packaging market, it was already identified in the previous work, this is the plastic type with the highest potential for traceability and verification, because of the high material value.

4. Areas for validation

The key objective was to conduct the validation of the previously developed assumptions.

The first area for validation was Plastic Packaging waste prevention strategies. Based on the previous deliverables, the identified strategies could be summaries as following:

Tab. 7 Strategies and their realisation

Prevention	No production: • Less production of the items to reduce overpackaging • Less production of the items because of less consumption (e.g. due to refill) Material: • Material substitution with no plastic solutions • Develop packaging with ready end of life option
Reuse	Design / Product development • Redesign packaging, where the refill packages are resupplied by minimalized packaging format • Develop packaging with ready for reuse Business model diversification: • Into service or refill Collection: • Deposit system • Take back systems for reuse
Recycling	Design / Product development • Develop packaging with ready for recycling Collection and recycling: • Take back systems for recycling • Higher Recycling rate Material • Introduce recycled plastic content into the packaging

In the previous work the current list of barriers and enablers were already identified, which aimed to be verified with SMEs:

Tab. 8 List of barriers

		Material producer	Packaging / packaged product producer	Distributor and retailer	User	Municipality and regulator	Waste collector and recycler
Regulatory challenges	No holistic legislation for closed loop starting from materials until end of life					😐	☹
	Challenge to collect information upstream due to multiple suppliers or no direct access to material producers			☹			
	Due to evolving regulations, stakeholders are not fully aware of the current reporting schemes and compliance approaches		☹	☹		😐	
	Cross-EU waste transportation legislation administratively and for content verification		☹	☹		😐	☹
Recycling content	It is a challenge to obtain good quality recyclates for manufacturing process and to enable future streams	😐	☹				😐
	To process recyclates to produce diverse product range is a challenge, e.g. due to decontamination		☹				
Supply chain	Challenge to measure the impact of supply chain and understand environmental impact of materials		☹	☹			
	Lack of transparency and verification from the recycling systems about their solutions		☹	☹			😐
Monetisation	Low price of low-tech plastics does not incentivize producers to take it back		☹				

Tab. 9 List of enablers

		Material producer	Packaging / packaged product producer	Distributor and retailer	User	Municipality and regulator	Waste collector and recycler
The role of incentives	Individual financial incentives among actors can enable product return for further strategies	☺					
	Deposit schemes stimulates reuse & close loop material recycling. The role of retailers and users increases to ensure the infrastructure availability & information exchange		☺	☺	☺		☺
	Plastic price segment is important: the higher the price, the larger the incentive to implement blockchain to show the recycled amount of plastics		☺				☺
Sustainability	Higher sustainability pressure pushes brands to search for sustainable solutions with producers		☺				
	Customers demand transparent supply chain, evaluation of its impact on the environment				☺		
	Fossil fuel polymers (resin suppliers) understand the danger for their business, as petrol based material will not grow, thus business diversification tends to recycling	☺		☺			
Product specifics	Transportation packaging subjected to be returned and partly part of deposit schemes		☺	☺			
	Currently beverage bottles are mostly integrated into infrastructural deposit schemes		☺	☺			
	For the producers it is important to claim product back and specific high quality product (e.g. with specific color)		☺				
	Waste management sector determines recycling content depending on the high demand for materials						☺
	Product that possible to gain back that technically contain large amounts of recycled or depolymerized plastic		☺				
	Product that could mostly benefit from tracking, so the product with the lowest recycling rate		☺				

Tab. 10 Topics to envision Blockchain implementation for Plastic packaging waste prevention.

Materials and products fitting for blockchain:

- Price segment is a focus; the higher the price, the larger the incentive to implement blockchain to show the recycled amount of plastics. Due to the simplicity and use of low-priced plastics
- Product that could technically contain large amounts of recycled or depolymerised plastic (potential application reused material)
- Product that could mostly benefit from tracking, so the product with the lowest recycling rate.
- High-tech plastic relevant for re-used schemes

Content / Information verification:

- Secure material origin for instance for plastic bottles' lifecycle. If the plastic bottles contain a certain percentage of bio-content, you can get visibility into that.
- Get a better-quality product back, meaning if we would be able to find with a smart system the very specific L'Oreal shampoo bottle of a very specific colour and sort it out in a smart way, that could be a big enabler.
- Transparency from waste companies would be great and verification of this information is important
- If we get more granular, we are able to track this in a better way, there could be some value. If you could attribute some characteristics to the granulates, there could be some value. To get DNA for granular. The manufacturer manages to get the viscosity reading more accurately rather than one global measurement for X tons of material, then there's value to it as it could enable us to have better manufacturing
- Show the certified amount of recycled content
- Gain more information on material specification
- Information from recyclers

Enable reclaim systems:

- Producers with recycled content would like to reclaim their product back, as they also need to source recycled content globally

- The end of life has more potential because we have huge interest in getting our products back from the waste collectors and if there is an attributed information existing in the empty bottles in the trash cans

Tracking

- Supportive for transborder regulation
- Possibility of tracking such products as flower crates
- In terms of B2B market and tracking potentially it can be relevant for transportation packaging, like pallets (also wooden pallets). For us what is important is the volume of Received materials, then it is relevant to think of the tracking systems.

Security

- Secured information sharing.

The interview for the validation was divided into three blocks.

I. Plastic Packaging waste prevention strategies

- Specify what Plastic Packaging waste prevention means for you?
- Please name 3 top relevant plastic packaging waste prevention strategies that your company contributes or willing to contribute to?

II. Validation of enablers, barriers and policy recommendation

- What kind of barriers you face to close the loop for plastic packaging waste prevention in your business?
- What incentives can help to close the loop in the plastic packaging value chain to prevent plastic packaging waste?
- What kind of **political support** would you suggest improving information transparency and information exchange along plastic value chains? * What type of political instruments (legislation, regulation, planning, information, incentives/financing...) could support it?
- Who do you think are the **key stakeholders** that need to be addressed by political instruments/support?

III. Understanding of the role of digital technology, such as blockchain for the prevention strategies

- Would your work change if it was possible to identify the exact material composition and additives of any piece of material at hand?
- How would your business strategy change if you could turn the use of sustainable material or processes into a business model?

2 Results overview

The results of the 38 interviews are summarized based on the stakeholder category, as well as the three interview's topics (Plastic waste prevention / Barriers, enablers and policy / understanding of the role of digital technology).

2.1 Raw materials suppliers

Plastic waste prevention

- Replacement of current virgin plastics with alternative sources, bio-based plastics or recycled material.
- Recycling is a major point when it comes to reduction of waste.
- Producing more durable products is also linked to waste prevention.

Strategy:

- The replacement of current materials with alternative more sustainable (often bio-based) materials.
- Investing in recycling and adding recycled content in products.
- Creation of partnerships and the participation to foundations initiatives, such as collection of plastic waste in developing countries.

Barriers:

- Having a sizable and reliable feedstock of secondary raw materials.
- Contamination of post-consumer waste.
- Not enough financial incentives for raw materials suppliers as the most important factor is the profitability of the company.
- Lack of responsible sorting from the consumers side is also considered as a barrier.
- Low quality of the secondary raw material, the high costs of new technologies and in some cases regulations.

Enablers:

- Government support, including new legislations and financial incentives.
- Demand from the customers side as enabler for new business models around plastic prevention.
- Marketing and communication enabling change in their business as usual.

Political support:

- Initiatives / Foundations on plastic prevention
- More transparency is not currently the focus of regulations, Transparency is not the issue
- More knowledge/education on plastic material/industry and closed loop potentials
- More and better separation
- Moves to push market demand
- More deposit scheme for PS
- Better sorting
- New legislations regarding recycled material
- Political support for the company / good communication
- More education for the policy makers

Stakeholders to be involved:

- OEMs
- Consumers
- Product designers
- Take back systems
- Recyclers
- Sorting facilities
- Government

Understanding of the role of digital technology

- There are enough solutions to identify material composition.

- Not relevant for chemical recycling, we have certifications for that.
- Certifications do not give exact results, only general.

Business model:

- Categories of recycled material with different quality standards.
- Issue certifications.
- Apply in addition a calculation for the environmental impact (CO2 emissions) from the materials production.

2.2 Finished products

Plastic waste prevention

- Increased recycling.
- Durability of products.

Strategy:

- Increased recycled content.
- Develop durable products.
- Recycling of industrial production scrap the most relevant recycling.
- Production of mono-material packaging.

Barriers:

- Contaminated waste post consumer.
- Demand for high quality material.
- Not enough info on the waste content.
- Quality driven demand.
- Cost.
- Bad quality of secondary raw materials

Enablers:

- Higher quality levels of recycled material.
- Better perception of recycled material.
- Better separation at collection.

Political support:

- Transparency is not the issue.
- More regulations forcing the consumers to send products back to the producers.
- More regulations for the consumers.

Stakeholders to be involved:

- Customers
- OEMs
- Brand owners
- Waste managers

Understanding of the role of digital technology

- Not interested

- Identify the various layers in a composite material.
- In order to take it back for reuse.

Business model:

- Not interested.
- Relevant for reverse logistics.

2.3 Machinery

Plastic waste prevention

- Lost information therefore lost material.

Strategy:

- Investing in recycling plants.
- Increased recycled content.
- Adding info on the product which stays along the value chain.

Barriers:

- Lost information along of the value chain.
- With more info, the recycling would result in better quality recycled material.

Enablers:

- Higher quality levels of recycled material.
- Better perception of recycled material.
- Better separation at collection.

Political support:

- Higher waste fees.
- Standardized independent coding system.

Business model:

- No direct business advantages.

2.4 Recycling

Plastic waste prevention

- More recycling.
- Increased recyclability of products, maintaining purity of materials.
- Increased recycling content in final products.
- Preventing is not an option.
- More education for the consumer.

Strategy:

- Investing in new machines for recycling.
- More support from the government.
- Increasing the purity of the secondary raw material.

- Market-driven demand.
- Increased recycling.
- Educate the consumer for right disposal.
- Decrease the packaging amount in products.
- Design for recycling.
- Work together with manufacturers.
- Prices competition.

Barriers:

- Needed quality of the end product.
- Higher cost of recycled material.
- No standardization for plastic.
- Contamination.
- Different colors.
- Consumers don't put efforts to sort waste.
- Product design is not recycling friendly.
- Mixed waste hard to recycle (sorting costs are high).

Enablers:

- No more marketing spreading a bad image of plastics.
- New regulations.
- Customers demand increase.
- Government subsidies.
- Designing reusable packaging.
- Designing recyclable packaging.
- Policy enforcement.
- Financial incentives for higher quality recycled material.

Political support:

- More education for politicians on technical advance.

Stakeholders:

- Market driven
- Price driven
- OEMs
- Certification institutions
- Producers (design for recycling/reusing)
- Designers
- Recyclers

Understanding of the role of digital technology

- Not interested.
- Very relevant for recycling.
- High costs.
- Very interested in checking if material can be recycled or not.
- To enable selective recovery

Business model:

- Business model would not change

3 Outcomes

Most of the players in the plastic packaging sectors are aware of plastic waste and are reacting. However, the main focus is finding new business opportunities, which are easy to implement and scale.

The biggest plastic waste prevention area associated with business opportunity where companies actively invest is recycling. The market demand for secondary raw material is validated and the supply does not meet the demand. Therefore, companies are developing new recycling technologies, such a chemical recycling. Not only recyclers are investing in new recycling technologies, but also virgin plastic material suppliers. They clearly recognise they need to diversify their portfolio by offering alternatives materials to virgin plastics.

The risk of bringing new products with new materials or with higher recycled content in the market is shared by forming collaborations between raw materials suppliers and product developers.

Plastic packaging stakeholder are also joining sustainability initiatives for good communication and to show they are actively trying to reduce their impact. The use of bioplastics keeps an important role in tackling plastic waste. Bioplastics are considered as having the other biggest potential to reduce waste. Generally, bio-based polymers have a good reputation in the market. Therefore, many companies are developing their own proprietary recipes to produce bioplastics.

However, the more bioplastics types are being developed, the more confusing is the understanding from the end-user' perspective. The need for educational information and standardisation for bioplastics is therefore increasing.

Product design is also an acknowledged strategy for preventing plastic waste. Creating durable products as well as designing products which take into consideration the end-of-life is a strategy that companies understand. The main designs considerations mentioned are high durability (longer lifespan) as well as design for recycling. An example is the design of mono-materials packaging, which do not need complex separation processes to be recovered during the recycling process.

The biggest barrier identified lies at the post-use phase of the value chain. Contamination in post-consumer waste, directly impacts the quality of the secondary raw material, while the market demands high quality materials. Contamination also makes the recycling process very expensive, therefore creates a barrier for the delivery a new resource from waste.

In response to the above, recovering methods (such as chemical recycling) which keep the quality of the material as prioritised. In addition, education for consumers is considered as an enabler for decreasing the levels of contamination in post-consumer waste. Easy access to information on how to responsibly dispose of waste would enable a more efficient waste recovery process. Better product design should also be incentivised to improve the consumers perspective on plastic waste, which should be accompanied with easily understandable information about the end-of-life.

Surprisingly, collection/deposit schemes are not considered as solutions for contamination, as their costs and complex logistics implications are outside of the stakeholders' focus.

Responding to the growing demand for secondary raw materials is becoming a challenge. Demand is exceeding the supply, implying an increasing market price for recycled content. The increased demand for recycled plastics needs new legislations specifically targeted on the quality requirements for recycled plastics.

More information access on post-consumer waste content is a widely recognised opportunity by the stakeholders. This stars with easily accessible information of the packaging material. At the same time, transparency is not always recognised as being the issue, as there is a lack of understanding of

what transparency means across the stakeholders. Education on how digital technology would enable easier access to information within the plastic sector is needed. There is not enough awareness in the plastic sector of digital advancement, as they are considered expensive and hard to implement.

The first step would be educating the plastic packaging value chain stakeholders, as well as consumers and finally policy makers.

DEL 07 - Maturity level assessment of developed scenarios for business implementation

Executive Summary

In this work package, we focus on the assessment of business scenarios to achieve most possible prevention strategies, following the choice of plastic packaging value chains (1) Beer Kegs, (2) Bottles and (3) Heavy-duty pallets, understanding diverse enablers and barriers for the plastic packaging waste prevention and the development of a guideline for blockchain implementation.

As it was identified that the key stakeholders who are mostly in charge to act upon prevention strategies are packaging producers. Nevertheless, brand owners have a significant role in decision making as the one who can demand change in the production process. In order to correspond to the demand, the producers need more specifics about materials ("DNA" of granular) to improve the manufacturing process, including waste content, as well as information about secondary products sourced from external suppliers. As it was identified in deliverables 5 and 6, one of the approaches is to go into close cooperation with waste management organizations or become an organization sourcing and producing secondary materials. Thus, the role of Blockchain-based Communication Technology (BbCT) is mainly in the need for the proof of the material's certification and the need for full transparency.

Despite the fact that the selected PPVCs have a complex supply chain, the results of deliverables 5 and 6 showed that stakeholders do not have any specific demands in the supply chain transparency, as analyzed plastic packaging types do not have any high reporting pressure for transparency and materials mainly have low value.

Considering these factors, we mapped the plastic packaging waste prevention strategies with the circular business models and conducted their maturity assessment. For the assessment the CE Strategist tool was used, which is based on the Value Hill methodology.

For the beer kegs, three most promising business models are maximization of production efficiency, provision of use-oriented services and material recapture. The first strategy reflects the value creation and accordingly increases the value of a keg. It focuses on the efficient use of resources (energy, water and polymers) to reduce material loss in the kegs production process. It leads to an increase in price per unit upfront and stimulates reuse strategy to recapture the full product value. It is closely connected with the second strategy that focuses on the uphill use. The shift can be done from kegs' sales to the improvement of use-oriented services. The role of takeback system as a service is important. This method will impact kegs design (design for reuse). The use of tracking technologies needed to avoid kegs stocking on the customer side. BbCT for tracking and product verifications play a crucial role. With this model kegs' producers can profit through new service revenue stream, while customers can reduce storage and waste from one-way kegs. It can increase transportation costs as a new return channel has to be in place.

The pooling potential of the kegs is still not explored, as these products are less standardized among the producers and more individualised for the customer. The third strategy operates on the value retention and it can work together with the use-oriented services through the take-back system. The key focus here is to increase the use of secondary material in kegs' production. The direct source of secondary material is possible via sourcing it back from the customers or cooperating with waste management companies. Material waste becomes a value, but extra investments for the deposit system has to be planned. If it is not possible to use real lifetime tracking and increase product value, then product design for recycling is more relevant, where customer can just compress the product to reduce the space before it is collected. The producer is interested to take back his / her specific keg (not a competitor product), as even though most one-way kegs using similar materials, the design is different. The importance of the product material specifics is essential, as it is usually patent technology suiting for beer preservation. The role of BbCT is to verify material, as it is important information to improve the manufacturing process for the kegs' producers. This strategy is costly as it requires investments into material recovery assets, in case it is not outsourced.

Bottles remain a challenging PPVC due it is diverse segmentation in raw materials and vertical customers. In this report we took a look at the PET beverage bottles, however, even in this case, big water cooler bottles used for specific customer segments have higher potential for reuse rather than average drinking bottle. 20 Litres bottles promote sharing business model. The customer pays for the amount of water consumed, which leads to use of more robust material.

Bottles used in the pharmaceutical industry have a higher potential to be integrated with BbCT, due to specifics requirements for reporting of the content and information verification. Nevertheless, the common strategies for this value chain are maximization of production efficiency to increase the value of the initial packaging item, material recapture and, in some cases, reuse.

As for the third selected PPVC, heavy-duty plastic pallets, the markets are already advanced in terms of circular business models, mainly focusing on product-oriented services, reuse, and the use-oriented services provided by pallets pooling systems. It is possible to realise due to more standardized solutions among pallets. To manage pallets as an asset, help smart solutions via RFID and IoT systems through track and trace. The key stakeholders interested in the process are pallets' producers who cover logistic services, logistic companies and retails. The penetration of BbCT is at the beginning that can lead to transparency in the pallets' user communication through the elimination of the middleman, as well as lead to identifying the more standardized solution for pallets. Pallets producing company can be incentivized through the costs reduction associated with unused, lost, or stolen pallets, as well as the technology should improve business models and processes such as vendor-managed inventory, automatic customs clearance, and pay peruse.

1 Introduction

This report includes an assessment of the identified business models for the selected plastic packaging value chains. The project “the role of information flows in the plastic packaging value chain (PlasticInfoFlow)” focuses to identify the enablers and barriers for stakeholder groups involved in the plastic packaging industry to use prevention strategies. The assumption was made that the use of distributed ledger technology (DLT) or blockchain can bring transparency in the communication among stakeholders. It can lead to improved information flows and contribute to efficient and sufficient use of resources and reduce the use of virgin petrol-based plastic.

In order to identify specific focuses among diverse plastic packaging, in the deliverable report 2, five the most promising PPVCs were named, where the use of Blockchain-based-Communication-Technology (BbCT) could be most relevant. These were bottles, heavy-duty pallets, barrels, kegs, crates and containers. In this report, we will focus on the assessment of beer kegs, bottles and heavy-duty pallets. The incentives for BbCT use were summarised in the deliverable report 3. As it was mentioned, the first important precondition for the stakeholders to use BbCT is the ability of stakeholders to create a business model based on the tool. Other relevant considerations for the use of BbCT were the need for the proof of certification, e.g. for material's certification, the need for full transparency, or the need for easing sustainability reporting. Further, we will look at the circular economy business models, using the methodology of Value Hill, developed by Achterberg, Hinfelaar and Bocken [2]. This approach helps better understand business models for selected PPVCs, as well as where BbCT is most relevant.

After detailed development of the business models for each PPVCs we will use the tool CE Strategies [4]. With its help, circular packaging business models will be assessed.

As the conclusion, the main outcomes will be derived and the most relevant business models for Kegs, bottles and pallets will be specified.

2 Understanding of circular economy business strategies for plastic packaging waste prevention.

2.1 Strategies for the plastic packaging waste prevention

Based on the analysis of Deliverables 5 and 6, the following prevention strategies in the plastic packaging industries were named by the stakeholders:

I. Decrease the packaging amount in the product

The approach with packaging reduction could be achieved through (a) less production of the packaging parts to reduce the unnecessary amount of packaging (*overpackaging*) and the use of fewer different materials. It will lead to less material use itself. Another approach is (b) less production of the items that require packaging, targeting the problem of *overconsumption*. Decreasing consumption demand for unnecessary productions will lead to less packaging production. Currently, this strategy is mainly popular only among consumers and very conscious packaging producers, mainly coming from multi-use functioning products.

II. Material substitution

For the diverse packaging types, material substitution was often named as prevention strategy, which is currently getting more importance among plastic packaging producers. One approach that was mentioned is the (c) material substitution through non-plastic or non-petrol-based plastic. The interest in bioplastic use was always mentioned as a prevention method. On the other hand, the increased (d) use of the recycled content in the packaging production was listed as a high priority for some producers. Nevertheless, the interest and demand for this approach are also coming from the product brand owners who raise pressure on the producers to innovative with the selection of the materials. Increasing use of recycled content in the packaging links material producers with the recycling sector.

III. Redesign of the packaging

The most prominent and acceptable approach is the redesign of the packaging. Two design strategies for the circular economy were named: (e) Design for reuse and (f) design for recycling. In the case of design for reuse, the objective is to bring a multi-usable product on the market, which preferably has to be made of durable materials. In combination with the design for recycling, it has to fulfil the possibility of the current end of life stage of the area the product is disposed. This approach requires the involvement of the user to make sure that the right disposal of packaging is known.

Across the stakeholder involvement, such prevention strategies will impact different business models differently.

a) *Reduction of overpacking* seems like a very straightforward approach for users, as they are mostly the ones who experience an unnecessary amount of waste. Brand owners might increase savings as the less amount of materials and packaging is bought. Packaging producers, however, have to reconsider the production process and less packaging on the market might negatively impact the packaging distributors business model.

b) *Reduction of overproduction* is considered as the most radical approach and mainly only demanded by the packaging users. However, in order to transform the industry towards less production, both regulatory and monetary incentives must be in place for the industry.

c) *Substitution with non-plastic material* is seen by brand owners as part of a sustainability agenda, which brings more incentives for material development to innovate with alternative options. Nevertheless, the sorting and recycling sectors might react negatively to this approach as it leads to an increased variety of new materials to be processed. It requires extra investment into the technological recycling solutions. As for the packaging producers, it is mainly the question of material accuracy for the function of the packaging.

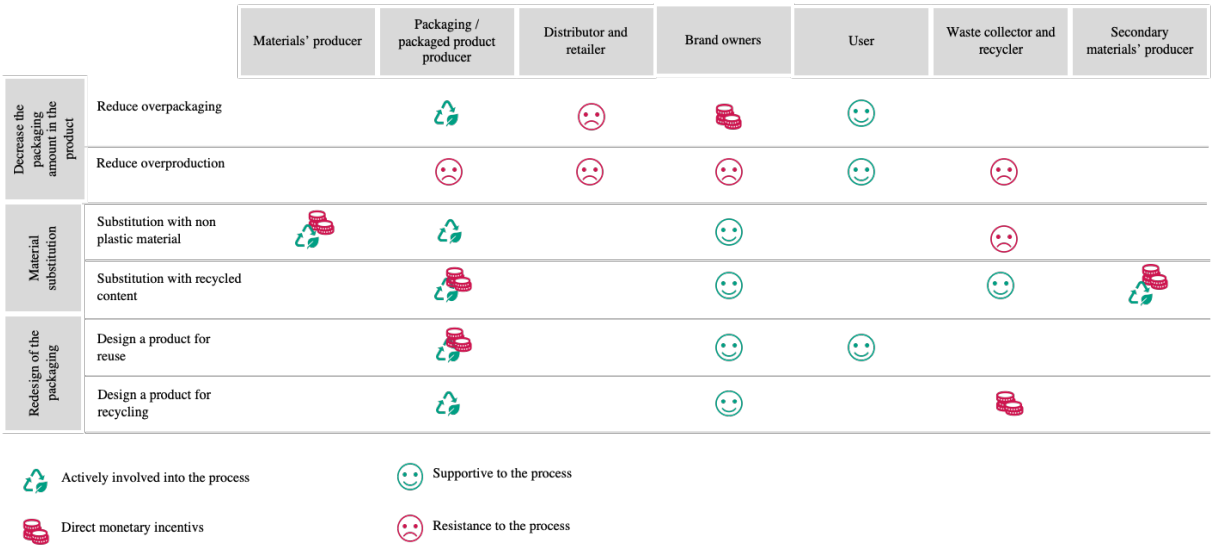
d) *Substitution with recycling content* is seen as a part of a sustainability agenda by brand owners. Secondary material's producers are directly incentivized and might work closely with waste collectors and recycling companies. This demand will accelerate the demand for better waste sorting. As for the packaging producers, it is mainly the question of material accuracy and its property for the function of the packaging. The packaging producers step into this market to take back their product to close the loop with fewer costs for material search.

e) *Design a product for reuse* is considered as a positive approach for packaging producers, potentially acting through the business model diversification. The strategy focuses on product as a service and development of product loyalty. Among sustainably conscious consumers, as stated in Deliverable 5 and 6 this approach is also considered to be good. For some packaging items, however, it requires extra infrastructure development focusing on reverse logistics through leasing, take-back systems or deposit system.

f) *Design a product for recycling* was one of the most discussed mentions, which addresses the need for a higher recycling rate. Based on the talks with the stakeholders conducted during deliverable 6 the key stakeholders have interest in this process. For some packaging items, however, additional infrastructure development is required focusing on reverse logistics through leasing, take-back systems, deposit system in order to make sure that specific products with specific content comes back.

See the figure 1 for the overview.

Fig. 1 Impact of the strategies of the plastic packaging waste prevention



Based on the information collected in the Deliverables 5 and 6, we can also summarize the key incentives or needs for the stakeholders to optimize their processes.

Tab. 11 Stakeholders' incentives and needs to improve prevention strategy

	Materials' producer	Packaging / packaged product producer	Distributor and retailer	Brand owners	User	Waste collector and recycler	Secondary materials' producer
Secondary materials	Need to be able to provide DNA of granular (technological connection)	-Want to know what materials are used in the secondary products sourced not from external suppliers - Want to know more concrete	Want to know the supply chain specifics in order to track back the product origins	Increase amount of recycling content as it contributes to the positive image		Need to improve technologies for separation	Want to improve the quality of their secondary material relevant for the manufacturing process

		and specifics about materials ("DNA" of granular) to improve manufacturing process, including waste content					
Primary materials	Need to be able to provide DNA of granular (technological connection)	- Want to know more concrete and specifics about materials ("DNA" of granular) to improve manufacturing process, including waste content	Want to know the supply chain specifics in order to track back the product origins			Want product producers use material that they can technically recycle, without increasing new content of some material Want to work only starting with	NA

						specific volume of the waste	
Product level		Want to reclaim very specific products back from sorting/ recycling	Want to know the supply chain specifics in order to track back the product origins	Want to know what is sustainable and what is not	Want to know what is sustainable and what is not	Need to be able to give information to producers via sorting to producers to give specific products back Want to work with less multi-layer packaging	

2.2 The impact of Blockchain-based Communication Technology on the business model development

In Deliverable 3, the success factors for replication of Blockchain-based communication technology (BbCT) were named. This is done based on a selection of characteristics, which contain

common models of market analysis. The analysis seeks to determine the status of each market criteria that is most likely to lead to a successful application of BbCT for circular practises.

Success was defined as increasing the likelihood to be replicated, which depends on:

- The ability of stakeholders to create a business model based on the tool (monetary value)
- The scarcity of the material and the market need and supply risks
- The difficulty of its practical implementation, e.g. due to a long value chain involving many stakeholders (technical difficulties)
- Societal and consumer expectations (value for society)
- Openness of companies to innovative data privacy solutions (innovation-readiness)

For the need of current analysis, we will focus on the business development where the BbCT will have a significant role. BbCT is more likely to be implemented if it fulfils a market need for the sector or type of supplier or producer. BbCT for supply chain communication fulfils the market need for proof of material claims. Based on the identified stakeholders needs in the part 2.1 we can narrow down relevant for us market needs to:

- the need for the proof of certification,
- the need of full transparency,
- the need for easing sustainability reporting,

Despite the fact that BbCT can cover further needs, described in the Deliverable 3, 3 above were mentioned by the stakeholders as the most relevant.

In terms of supply chains, the market needs are more likely to adopt BbCT, should have following characteristics:

- Supply chains with high regulatory or reporting pressure for transparency
- Supply chains with products relevant for health (e.g. food packaging of baby products)
- Supply chain stakeholders that expect competitive advantages from being innovative or transparent
- Supply chain stakeholders with an interest in new technologies

For our assessment however it was not mentioned that stakeholders experience any pressure in the reporting and selected PPVCs are not subjected to the strict regulatory frameworks. Thus, these incentives will be not be most decisive for the business models. The most important enabler for BbCT use in supply chains is clearly the existence of circular economy business models for the stakeholder in question and thereby monetary value that exceeds the costs for the technology and the costs of the circular practises itself [1]. The most important enablers are therefore:

- Higher willingness of customers to pay for circular products
- Regulatory incentives or subsidies that decrease the costs
- Circular loops with lower costs than the deployment of virgin material
- The acquisition of new customers due to a sustainable image

- Customers specifically requesting circular products or takeback/buyback options

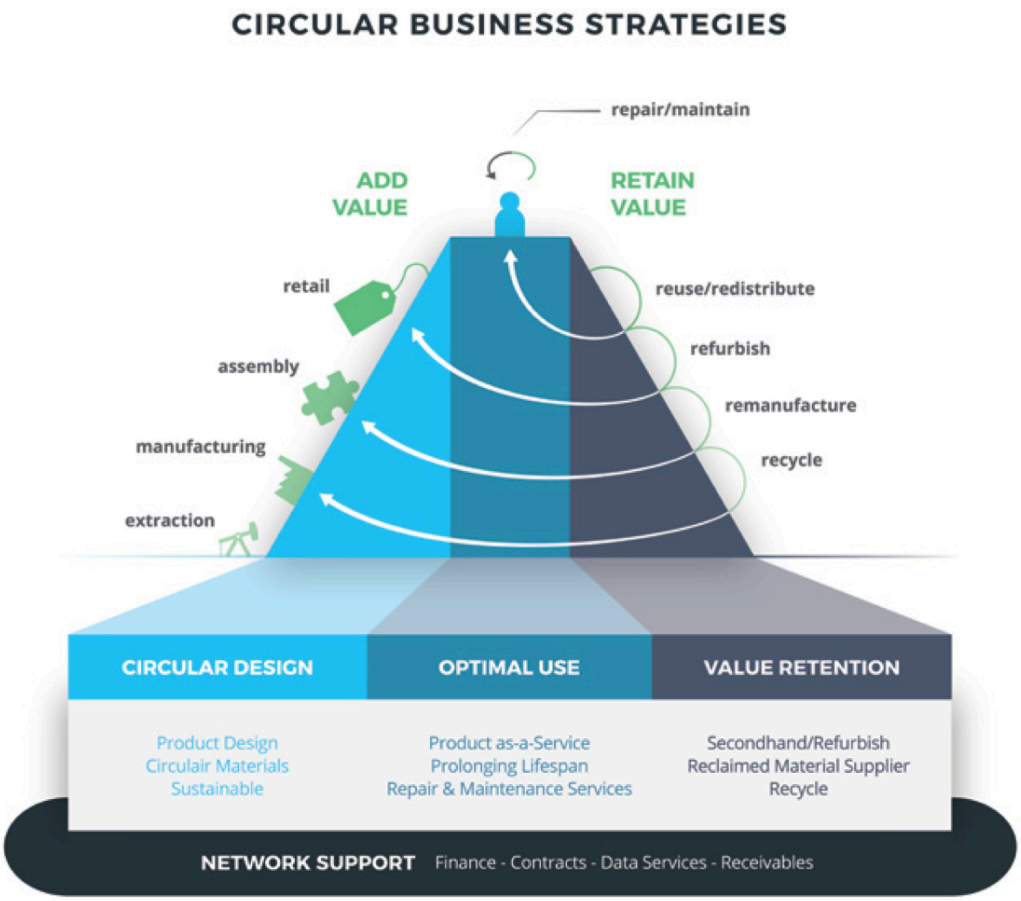
For the selected PPVCs there is no currently regulatory pressing points, neither willingness to pay more for the circular products. However, there is incentives to create circular loops reducing virgin materials and introduction of takeback systems.

3 Identification of the business models and its maturity assessment

3.1 Circular economy business strategies in terms of plastic packaging waste prevention

In a circular economy, business activities are organized in such a way that products are kept as high and as long as possible on the Value Hill. Four categories of circular business activities have been identified: Circular Design, Optimal Use, Value Recovery and Network Organization [2,3]. In the Figure 2 Value Hill approach is presented, which focuses on the value creation, use, and value retention stage.

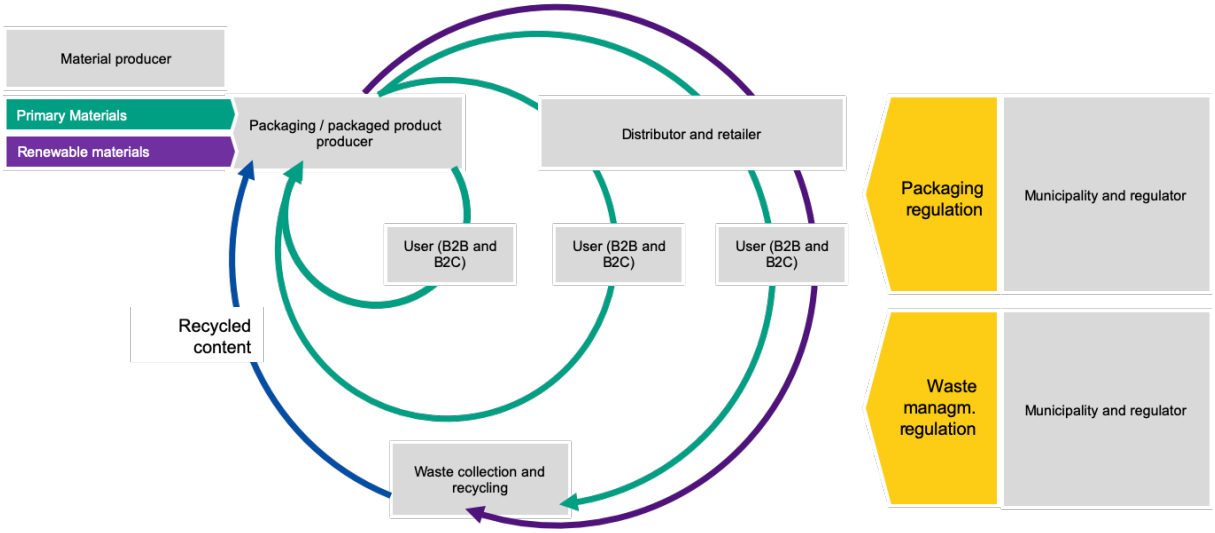
Fig. 2 Circular business activities on the Value Hill (Achterberg, Hinfelaar and Bocken, 2016).



The pool of the business strategies mapped here mainly mentioned on the use stage. As for the value creation and value retention stage, this are the approaches that make add circular characteristics to the product.

Figure 3 demonstrates two key scenarios suitable for the plastic packaging and circular approaches.

Fig. 3 Circular economy strategies in the for the plastic packaging industry



According to Deliverable 2, the current project focuses on the following value chains: bottles, pallets and keg's as a first choice for this project, and barrels, crates and containers as a second choice.

Scenario 1. Packaging producers source back their own product after the usage phase.

a) In the case of the B2B market, this approach is more realistic because it can be coordinated via contracts. In terms of selected plastic packaging value chains, it could be valid for all selected types except bottles (only if it is not 20-liter bottles delivered to the corporate clients). In the case of B2C (final consumer), the realization of such a model is only possible through tracking approaches in combination with take back systems. Current deposit schemes support the approach for B2C packaging types.

b) If the packaging distributor and retailer are involved in the process, it becomes very complex as distributors and retailers act as supplier's aggregates. It breaks the link between packaging producers and the customer. Hardly any selected value chain will be applicable in this case. The way it is currently enabled is through deposit schemes (relevant only for PET bottles).

In both cases, the source of the product can contribute to the reuse of primary producer packaging and serve as a cleaner source for secondary materials.

Scenario 2. Packaging producers source back the recycling content from the waste collection systems.

In this scenario, the relevance whether it is B2B or B2C market is not important, as waste collection and sorting entities become aggregated sources or waste streams. In this regard, they become the sourcing entity for the secondary material provision, which either will be obtained or bought by the original packaging producing company, or by specialized organizations preparing recycled materials for secondary use. With the help of value hill approach, we can state see current business strategies in place for each of the plastic packaging value chains.

Tab. 12 Detailed strategies description for Value Hill (Achterberg, Hinfelaar and Bocken, 2016)

Value Hill	*Business model*	*Description*
Circular Design (Uphill)	Circular product design	Designing products with their end of life in mind by making them easy to maintain, repair, upgrade, refurbish and remanufacture.
	Circular Sourcing	Utilise input materials such as renewable energy, bio-based-, less resource intensive- or fully recyclable materials. 1- Material used applicable for the current recycling system 2 - Products designed with mono material principles, or the one that easy disassemble
	Classic long-life	Delivering longevity with a high level of guarantees and services for a high price up front. Selling **consumables**, add-ons, spare parts or even upgrades which support the longevity of products and/or providing repair & maintenance services
	Encourage sufficiency / Long life design	A high price per product can justify lower volumes. Focusing on delivering long-lasting and energy-efficient products the customers are attached to. Products are often comparatively expensive when acquired. Durability and Sustainability is a major part of the company's communication.
	Maximising Production Efficiency	Describes a number of manufacturing principles that focus both on maximising the material and energy efficiency in the production process, such as **Industrial Symbiosis**, Low Carbon Manufacturing, **Additive Manufacturing**, On Demand Production, Dematerialisation, renewable energy, etc.

Optimal use (Top hill)	Product-as-a-service	Product leasing - Delivers access to a product rather than the product itself so that the service provider retains ownership of the product. The primary revenue stream comes from payments for the use of the product and a single user uses the product at any given time. Product renting - Delivers access to a product rather than the product itself so that the service provider retains ownership of the product. The primary revenue stream comes from payments for the use of the product and different users use the product sequentially. Performance provider - Delivers product performance rather than the product itself through a combination of product and services, where no predetermined product is involved and the service provider retains ownership of the product. The primary revenue stream is payments for performance of the product, i.e. pay-per-service unit or another functional result.
	Life Extension	Sells consumables, spare parts and add-ons to support the longevity of products
	Repair & Maintenance Service	Repairs, maintains and possibly upgrades products that are still in use
	Sell and buy-back	Provides a product and agrees on repurchasing after some time
	Sharing platforms / use oriented services	Enables and increase utilization rate of products by enabling or offering shared use/ access or ownership through which, different users use the product sequentially. The ownership of the product remains with the service provider. It is made available in a different form and is sometimes shared by a number of users. Examples include: leasing and renting (single user), sharing (sequential use by different users) and pooling (simultaneous use by various users).

Value recovery (Downhill)	Recaptured material supplier / recycling facilities	Supplies recaptured materials and components to substitute the use of virgin or recycled material. Transforms waste into raw materials. Additional revenue can be created through pioneering work in recycling technology
	Refurbisher / Remanufacturer	Restoration of a used product to a condition as good as new either, possibly also providing upgrades.
	Reuse	Provides used products
Network organization (cross hill)	Recovery provider	Provides take back systems and collection services to recover useful resources out of disposed products or by-products
	Process design	Provides services around processes that increase the re-use potential and recyclability of industrial and other products, by-products and waste streams
	Value management	Provides services around managing information, materials, transparency, payments and governance in a circular value network. For example, ICT solutions for smart contracts and payment systems, or consultancy on circular management systems.
	Tracing facility	Services to facilitate the trading and the marketing of secondary raw materials

3.2 Maturity assessment to evaluate opportunities of the Circular Economy

In order to identify the opportunities of the circular economy for the selected value chains we will use CE Strategist tool developed by Knowledge Alliance on Product-Service Development towards Circular Economy and Sustainability in Higher Education, which was designed by Rainer Pamminger, Stephan Schmidt in collaboration with Cristina Rocha, David Camocho, Jorge Alexandre [4].

The tool is designed to help the user identify Business Opportunities of the Circular Economy and provide ideas and inspiration along the process of defining a new Business Model. The tool consists of the 5 key steps:

Step 1 - Describe the current business model

Start by describing the current Business Model within a template of the Business Model Canvas, which can be used to compare the current model with the result of the tool. This step is optional. You can also start with Step 2.

Step 2 - Evaluate opportunities of the Circular Economy

In Step 2 you are asked to evaluate different value capture opportunities for your product system. The opportunities relate to the whole product life cycle, from the choice of materials until the end of life phase.

Step 3 - Choose fitting circular economy strategies

Dependent on your evaluation, the tool will propose the best fitting circular business strategies to your product system and provide examples. It also shows which design strategies are important to maximise the value of the business strategy. Use the CE Designer Tool to evaluate your product design.

Step 4 - Defining your Circular Business Model

After you choose fitting circular business strategies (you are encouraged to follow up more than one opportunity!) you are redirected to the Business Model Canvas template. This new template will highlight typical influences related to the chosen strategies, which need to be considered in the design of the new business model.

If you have filled out the original template, these fields will be imported. You are now invited to further define the (re)design of your business model by adding new fields and descriptions.

Step 5 - Compare and Export the results.

In terms of evaluation question-based methodology is used to identify the best fitting Circular Economy Business Strategies by evaluating opportunities to capture value throughout the life cycle of a product. The questions cover the whole product life cycle, from the Uphill, Tophill- and Downhill-phase of product systems.

In the table 7, the questionnaire for circular business model is presented. The business model assessment tool provides a general evaluation of the strategies. The tool does not consider specifics of the packaging market, such as short use time, and the key specifics of the packaging to fulfil specific function such as transportation, protection etc. Nevertheless, the tool offers a good methodology to assess circular business models from the perspective of material use, value creation and usage.

Tab. 13 Business models maturity assessment approach (CE Strategist tool)

Can you capture value...

	False	Mostly False	Mostly True	True	Not Applicable
... choosing sustainable and recoverable materials for your product?					
Materials are mostly renewable and non-hazardous.	o	o	o	o	o
Materials come from local sources, resulting in low transportation emissions.	o	o	o	o	o
Materials are sourced under fair working conditions.	o	o	o	o	o
A high rate of recyclates is used and the product itself is recyclable.	o	o	o	o	o
The materials are highly eco-efficient, having few environmental impacts.	o	o	o	o	o
The materials are easily separable. Composites and coatings are avoided wherever possible.	o	o	o	o	o
Value Hill Category: Uphill					
... maximising the resource efficiency in the production process?					
The manufacturing stage is highly energy and resource intensive.	o	o	o	o	o
The production requires significant warehouse capacities.	o	o	o	o	o
The energy needed - power and heat - in the production process stems mostly from non-renewable sources.	o	o	o	o	o
The production process results in a number of unused waste streams (heat, waste materials, water, etc.).	o	o	o	o	o
Value Hill Category: Uphill					
... anticipating after use scenarios in the design?					
Product parts with a short life time are easily accessible and separable.	o	o	o	o	o
Products are easy to disassemble (with standard tools, in a short time, supported by a modularised design).	o	o	o	o	o
Product failures are easy to identify and its design anticipates the most likely failures.	o	o	o	o	o
Technical Obsolescence (e.g. due to short innovation cycles), if relevant at all, only relates to parts of the product.	o	o	o	o	o
Value Hill Category: Uphill					
... providing long-life, high-quality products?					
Technical product innovation cycles are relatively long.	o	o	o	o	o
The product is timeless and/or customizable in its design.	o	o	o	o	o
Users are attached to the product (due to its performance, aesthetics, experience, etc.).	o	o	o	o	o
The use phase of the product is relevant in terms of its power consumption or use of consumables.	o	o	o	o	o
Customers are willing to pay more for a eco-efficient, long-lifetime product.	o	o	o	o	o
Value Hill Category: Uphill					
... offering services that prolong the product life during the use phase?					
The product is characterised by parts with different lifetimes and/or requires consumables.	o	o	o	o	o
The usetime of the product is shorter than its potential lifetime.	o	o	o	o	o
Reasons for product failures are similar.	o	o	o	o	o
Value Hill Category: Tophill					
... adding services on top of sold products that prolongs their lifetime?					
Customers often hesitate to purchase the product due to uncertainties in the product performance.	o	o	o	o	o
Value Hill Category: Tophill					

... retaining ownership of the products and renting them out?					
Customers don't need to own the product, but are interested in the functionality it provides.	o	o	o	o	o
Products have a high residual value at the end of the use time.	o	o	o	o	o
High purchase prices act as barrier for more customers.	o	o	o	o	o
The average product use time is shorter than its lifetime.	o	o	o	o	o
There is an incentive to take the products back after the use phase.	o	o	o	o	o
Value Hill Category: Tophill					
... offering only the functionality that users seek as a service?					
Customers mainly seek the functionality not the ownership of the product (e.g. mobility instead of car ownership)	o	o	o	o	o
Products often underperform in their use phase in relation to their potential (e.g. due to limited user expertise)	o	o	o	o	o
Products are characterised by high investment (purchase prices) and/or operational costs.	o	o	o	o	o
Customer requirements are highly individual.	o	o	o	o	o
Value Hill Category: Tophill					
... remarketing used products?					
Products are often still functional at the end of their use time.	o	o	o	o	o
There is a high customer demand for used products (e.g. due to lower prices).	o	o	o	o	o
Value Hill Category: Downhill					
... remarketing upgraded / remanufactured / refurbished products?					
Products are discarded because parts of it are faulty / technologically obsolete / look worn / are out of fashion.	o	o	o	o	o
Professional product-specific expertise (such as knowledge, skills, equipment) is needed to reintroduce products into the market.	o	o	o	o	o
Value Hill Category: Downhill					
... recapturing materials from discarded products?					
High material costs are associated with the production of the product.	o	o	o	o	o
Large amounts of discarded material are available as potential a secondary source.	o	o	o	o	o
Value Hill Category: Downhill					

3.3 Beer Keg's plastic packaging value chain

Beer kegs PPVC was selected among others with the highest potential to create economic and environmental impact.

The market for using beer kegs is driven by the rise of alcohol beverages. Kegs help in maintaining the quality and flavour of alcoholic beverages over long durations. Draught beer is mostly served through kegs in order to maintain its pressure, and therefore, the product witnesses greater demand from on-trade sales. Sustainability is a crucial factor that companies have been focusing on in the overall packaging industry, resulting in growing usage of recyclable and environment-friendly materials. As a result, steel kegs are preferred over other product variants, as it is the preferred recycling approach [5].

Plastic kegs are expected to have the highest CAGR of 4.6% from 2019 to 2025 [5]. High costs associated with manufacturing and recycling metal kegs has compelled manufacturers to invest in PET plastic kegs. These are supplied as ready-to-fill or preforms that can be blown into a PET container whenever required at the site. They are made available in different sizes of 15,

20, 30, and 40 litres, depending on the requirement. The global production and consumption volume are increasing at a steady pace. Europe dominated the global market, accounting for a 29.9% share in 2018. Increasing consumption of beer and cider is the main driving factor in this region [5].

Based on this global trend, we can claim that beer producers started switching from steel kegs for one-way plastic kegs. In 2018, Carlsberg, for example, named plastic kegs as the most significant innovation in packaging of the draft beer in 50 years [6].

The value proposition for a business model for one-way plastic kegs is to deliver fresh and good quality beer from the beer producer to the customer. The current approach is taken through the sale of a one-way beer keg. In such business model producers focus on the cost reduction through elimination of reverse transportation and as soon as the PET kegs are lighter, also saving on the transportation per item. It helps decrease logistical and maintenance costs, as well as minimizing capital investments for brewery start-ups. It is particularly effective if your beer is shipped long distances like out-of-state or to other countries After one-time use, a keg is meant to be recycled as well as their uses minimize the transportation costs due to lower weight compared to metal kegs.

In further analysis, we will take a look at the most relevant business models for this PPVC.

For this project we take a look at the following brands for comparison: Dolium 20L PET Keg, type S , ZEG, developed by Cyprus' CYPET Technologies, KeyKeg, 20 L , SmartKeg™ Rentals system, and Ecodraft.

All products from left to right: Dollium, ZEG, KeyKeg, Ecodraft, SmartKeg rentals, Ecodraft

According to the maturity assessment for evaluation the opportunities conducted through business models the following circular business strategies were suggested (see Appendix 5.1)

Circular Design (Uphill)	Optimal use (Top hill)	Value recovery (Downhill)
Circular product design	Product-as-a-service	Reuse
Circular sourcing	Sell and buy-back	Refurbisher / remanufacturer
Classic long-life	Use oriented services	Recaptured material supplier
Encourage sufficiency	Lifetime extension	
Maximise production efficiency	Repair & Maintenance Service	
Network organization (cross hill)		

Value management
Process design
Tracing facility
Recovery provider

Very high potential
High potential
Medium potential
Low potential

The top 3 business strategies that will cover each step in the value hill are maximisation of production efficiency, provision of use-oriented services and recaptured material supplier. Below described the combined business model:

Value Propositions

Transportation of the fresh and good quality beer from the beer producer to the customer is a key priority for the kegs' producer. Use of secondary materials supports the sustainable image and may contribute to the lower operational costs. Shift towards user-oriented services on the product availability, flexibility and range of choices, as well as support with empty kegs disposal.

Key partners:

- Material sourcing. Currently mostly usable material for one-way keg is PET, PP, PE and PA without any addition of contaminants. Companies focus on this material with the objective to loop is the with materials end of life recycling in order to break the downward spiral of low-value applications for recycled plastics. The basecup and grip are made from recycled Polypropylene. Ecodraft, as it is offering reusable technology, made of HDPE.
- Further development partnerships with circular material suppliers, such as recycling facilities, Waste Management, Collection systems, Reprocessing Facilities. Currently KeyKeg launched this strategy through the partnership with waste management company. On this stage BbCT can support with the material certification and verification.
- Manufactures: To produce a PET container, manufacturers use a two-stage blow molding machine, a high-pressure air compressor, and a chiller which is a unit that circulates cold water to cool down the mold. The two-stage blow molding (or a reheat stretch blow molding – RSBM) processing cycle takes the mold through six key points:
- Producer of dispensing equipment and filling machines to provide extra services for the customers.

- Customer becomes a partner by initiating new valuable company processes such as take-back system.
- To realise extra circular strategies tracking technologies is needed. SmartKegs rentals currently provides the solution to track beer's kegs and to get access to customized and comprehensive reports to help proactively manage distribution. This partner pushes the concept of pay only for the kegs needed, when you need them (just in time delivery).

Key activities:

Keg's design. Most of the kegs' producers already focus on design for recycling, using mono materials which possible to disassemble, and also standard materials suitable for recycling. KeyKeg started its circular business model through taking back its PET kegs as they use a strategy design for recycling, using Bag-in-Ball principle. It uses an extra bag inside of keg, which makes it possible to separate external service from the internal one. In terms of circularity, producers prefer the product for recycling, nevertheless. Ecodraft also uses different design suitable for kegs reuse. Due to the easily exchangeable inner spears, each keg can be deployed again without expensive rinsing operations.

In terms of circularity also design for use-oriented service, design for material sustainability and design for energy sustainability could be extended.

Service around the product can be added on top such taking care for the keg collection in time, without extra storage on the customer side.

Further services such as sales, marketing, ensure storage, safety for the beer transportation, and further support with filling equipment (mainly already in place).

Key resources:

Storage facilities for the current kegs

Beers and another beverage expertise

Use-phase asset management focusing on the tracking and service provision, e.g. through the online platform, here is where support of BbCT can take place.

Material recovery such as equipment, plants and staff for the material recovery processes, may be outsourced to a Key Partner. This is the key element for the material recapture model.

Customer relationships:

Long-term relationship is already a key strategy for the keg's producers through contracts, subscriptions and recurring relationship in terms of updates

Channels:

Direct sales channel

Return channel started being offering by KeyKeg return channel for Kegs material recycling

Customers:

The main customers are breweries, wineries, cider, gastronomy and distributors.

In case if material recapture takes place, it is possible to include new customer segments outside the current value chain (like recipients of waste material streams)

Cost structure:

Transportation, logistics and storage, it will be increased for the use-oriented services.

Manufacturing and production costs, it will be increased for the maximisation of production efficiency.

The return incentives should be in place, such as mechanisms for deposits or credits are enforced to incentivise takeback schemes, it will be increased for the use-oriented services and material recapture.

Operational costs, including labour electricity etc, it will be increased for the use-oriented services (BbCT)

Revenue structure:

Kegs sale

Product-service revenue

Material waste as a value

The current business model mainly incentivizes kegs' producer to shift towards just in time kegs delivery where the key aspect is to track its own product. Firstly, it helps to understand the customer needs better, to make sure that the stock on his / her side is managed properly, but secondly this opportunity enables the return of used kegs back either for reuse or for recycling. In case of reuse strategy more use of tracking technologies needed, in order to avoid kegs stocking on the customer side. The realization of this business model could be enabled if the producer also focuses on the maximization of the production efficiency which increase the value of the produced keg as a product (not only material used), it increases the incentives to reuse. The potential of pooling system is not yet fully explored on the market.

If it is not possible to use real lifetime tracking and increase product value, then product design for recycling is more relevant, where customer can just compress the product to decrease use of space.

It is important to consider, that for this value chain producer is interested to take back his / her specific product (not a competitor product), as despite the fact that most one-way kegs using similar materials, the design is different. The importance of the product material specifics is crucial, as it is usually patent technology suiting for beer preservation. The use of BbCT could be significant for the product and material verification. It also important to consider, that kegs are usually sent abroad out of the country of production, thus in case of the cross-border transportation BbCT will help to identify its own kegs if it is imported as a waste stream.

3.4 Bottles plastic packaging value chain

This plastic packaging value chain is most complex as it mostly diverse in material segmentation and end-user verticals. By raw material types bottles are segmented in Polyethylene Terephthalate (PET) mostly used for water, Poly Propylene (PP), Low-density Polyethylene (LDPE), High-density Polyethylene (HDPE). By end-user verticals it operates in the Beverage, Food, Pharmaceutical, Beauty and Personal Care, Household Care markets [14].

PET remains mostly usable material for bottles. It is manufactured locally, while a minority share of 2% is imported from other nations. Other packaging materials, such as PP and HDPE, are also finding growing adoption, with companies looking to attract consumers by offering different types of products. Interesting observation that recent discussion around environment pollution of the bottles impacts brand owners to search for better alternatives in this segment. For the beverage products, where PET remains the dominating materials, several companies launched recycled PET bottle production. Thus, one of the brands of Nestlé Waters, Belgian brand Valvert launched new bottle made entirely from recycled plastic (rPET). This innovation is one of the tangible proofs of Nestlé's worldwide commitment to make its packaging 100% reusable or recyclable by 2025 [17]. Another example of the business strategy demonstrated by Lidl that is profiting from deposit return schemes in their retail shops. If someone throws a PET bottle of water or lemonade in a deposit machine, they support the group's unique recycling loop, as they own recycling facilities. These bottles will be used to produce new ones. Lidl brand mineral water and soft drink bottles are already manufactured from an average of 50% recycled PET material. Some products are made from 100% recycled plastic [18]. It is incentivized through established infrastructure for deposit schemes. As it is stated the key stakeholder who initiated the projects were brand owners, the most innovative packaging producer who can ensure 100% PET sorting from post-consumer waste and production of rPET bottle will be to correspond its needs. Existence of deposit infrastructure for the separate PET collection is significant enabler.

In this case it is interesting to assess recyclable, reusable water cooler bottles, also produced from PET, with the volume up to 20 L.

Circular Design (Uphill)	Optimal use (Top hill)	Value recovery (Downhill)
Circular product design	Product-as-a-service	Reuse
Circular sourcing	Sell and buy-back	Refurbisher / remanufacturer
Classic long-life Encourage sufficiency	Use oriented services Lifetime extension	Recaptured material supplier
Maximise production efficiency	Repair & Maintenance Service	
Network organization (cross hill)		

Value management
Process design
Tracing facility
Recovery provider

Very high potential
High potential
Medium potential
Low potential

As for pharmaceutical packaging it mainly uses HDPE, LDPE and PP materials. The market is very specific, due to the content of the packaging. Starting from February 2019 the serialization scheme was enforced under the EU's Falsified Medicines Directive (FMD) to combat counterfeiting of drugs [19]. The main requirement of the regulation is that the packaging should carry a unique identifier comprising a product code, a serial number based on a randomized algorithm, a reimbursement number required by countries in which the medicine is marketed, a batch number, and expiry date. It means that each plastic bottle contained the drugs already has embedded track and trace system. Apart from data management, connectivity with various supply chain entities and, where required, authorities, is one of the toughest challenges when implementing a serialization and track & trace system. Nevertheless, the packaging information is not in the focus of this regulation, only the content.

According to the assessment tool the relevant strategies for this type of packaging would be:

Circular Design (Uphill)	Optimal use (Top hill)	Value recovery (Downhill)
Circular product design	Product-as-a-service	Reuse
Circular sourcing	Sell and buy-back	Refurbisher / remanufacturer
Classic long-life	Use oriented services	Recaptured material supplier
Encourage sufficiency	Lifetime extension	
Maximise production efficiency	Repair & Maintenance Service	
Network organization (cross hill)		

Value management
Process design
Tracing facility Recovery provider

Very high potential
High potential
Medium potential
Low potential

Increasing packaging value upfront through maximization production efficiency and recapture materials after use phase seems like the common approach for both products.

The penetration of tracking technologies for production identification and material specification still did not reach the demand. Thus for BbCT it is not yet fully feasible, only if packaging producer want to test technology. But it can be more relevant to integrate BbCT with serialization scheme for pharmaceuticals, for the packaging content, where also packaging specifics could be considered.

Other strategies vary from the vertical segmentations, packaging volume, and filled content.

3.5 Heavy-duty pallets plastic packaging value chain

According to the Global Plastic Pallets Market 2018-2022 analysis conducted by technavia the market will witness a demand of 237 million units by 2022. Even though the wooden pallets are still dominating the market, experts evaluate that they reach its pick [15].

The report highlighted the benefits of the plastic pallets leading that the end-users are increasing the preference for plastic pallets over wooden or metal pallets. This is because plastic pallets offer lower shipping costs as they are lighter and easy to transport. Plastic pallets do not break or develop cracks, thereby resulting in higher durability. They are safer to handle as they do not have sharp edges and can accommodate various types of goods. Moreover, plastic pallets offer better space efficiency when they are stacked. Other benefits identified as easy cleaning, insect resistance, lack of splinters and limited import restrictions as advantages of plastic pallets over wooden models.

Increasing deployment of smart pallets is also expected to increase the demand for pallets in the coming years. Smart pallets are comprising of an RFID microchip placed inside the central plank of the pallet to collect information in real time. This approach offers a solution for product tracking, asset tracking and inventory management.

The main material used for the plastic pallets' production is HDPE and PP. Use of this material is also positioned as sustainable due to its recyclability properties. Also, there is high potential to use already recycled material in the plastic pallet production.

The European leaders of the plastic pallets production are Groupe PGS (France), Craemer Holding GmbH (Germany), Cabka Group GmbH (Germany), Schoeller Allibert Group (Netherlands) and many others. Europe however provides one of the most successful examples for wooden pallets circulation system though EPAL (European pallet association e.V.) The organization strived for the standardization of pallets which originated open exchange pool. The association however focuses exclusively on wood material.

Along with wooden pallets many companies provide plastic pallets pooling system such as CHEP, which focus on the reuse and share of the pallets. The key benefit is simplification of the logistic on the company side. The pooling system allows you to outsource the total pallet management to us: from administration and maintenance, to transport. More pallets producing companies became companies focusing on the service provision through the pooling mechanisms. One of the key characteristics in design is the standardized solutions and selection of durable materials.

According to the maturity assessment for evaluation the opportunities conducted through business models the following circular business strategies were suggested:

Circular Design (Uphill)	**Optimal use (Top hill)**	**Value recovery (Downhill)**
Circular product design	Product-as-a-service	Reuse
Circular sourcing	Sell and buy-back	Refurbisher / remanufacturer
Classic long-life	Use oriented services	Recaptured material supplier
Encourage sufficiency	Lifetime extension	
Maximise production efficiency	Repair & Maintenance Service	
Network organization (cross hill)		
Value management		
Process design		
Tracing facility		
Recovery provider		

Very high potential
High potential

Medium potential
Low potential

The available pallets' pooling solutions already cover most of the circular economy business models. Thus, selected pallets plastic packaging value chain has already advanced business model in terms of the circular economy. With the rise of pooling systems and improvement of IoT and RFID technologies, the potential for BbCT technology is also increasing. In 2018 GS1 Germany [16] ran the application test where BbCT could support with the challenges, such as the provision of transparency among the communication of pallet users, as they rarely know each, support with the plastic pallets standardization in the pallet exchange system. The kea stakeholders interested in this solution are retailers, logistic companies and pallets providers. Many supply chain partnerships improved and became stronger as a result of close collaboration–blockchain catalyzed cooperation. In this use case, BbCT enables open pooling system, eliminating intermediate company where users could communicate directly with each other. From the perspective of the pallets owned company, the expectation for the blockchain is to reduce the costs associated with unused, lost, or stolen pallets, as well as the technology should improve business models and processes such as vendor-managed inventory, automatic customs clearance, and pay per use.

Moreover, the advantage for BbCT is that logistic companies already have higher digitalization adaptation, thus they are more interested to test new solutions.

4 Outcomes

The current report provides business models assessment of the 3 selected plastic packaging value chains: (1) kegs, (2) bottles, and (3) heavy-duty pallets. For the assessments, the CE Strategist tool was used. The business model assessment tool provides a general evaluation of the strategies. The tool does not consider specifics of the packaging market, such as short use time, and the key specifics of the packaging to fulfil specific function such as transportation, protection etc. Nevertheless, the tool offers a good methodology to assess circular business models from the perspective of material use, value creation and usage.

Three packaging types are different as the first one operates with the highest value on the packaging's design and product's preservation and transportation. The second one fulfils transportation's function and significantly depends on the customer segmentation, as it operates on the B2C market. The third one has the logistics' functionality. These variations impact strategies and incentives. As soon as the packaging serves for product preservation such as beer's kegs or bottles, it is more complicated to apply circular business models and accordingly BbCT. The main value is kept not in the packaging but in the product, it is made for. This is not the case for pallets, where pooling system becomes already a standard business approach for every pallet producer moving from product sale to use oriented services. These packaging types have the highest potential for BbCT application. The key stakeholders such as logistic companies, pallet producers and retail firstly already open to new digital solutions, and secondly, they have common incentives in the detailed tracking system, pay per services function and bunding cooperation among the partners. BbCT helps to improve the standardization process for plastic pallets and simplify further reporting. In case the pooling system will be based on peer-to-peer communication.

Despite the different functionalities, the primary strategy relevant for all 3 packaging types is the maximization of resource efficiency. This strategy pushes better use of primary resources, which also increase the value of the packaging as a product. As soon as the shift will take place in the packaging market from the cheap solutions towards value-oriented production, producers will have higher incentives to get them back. Right now, brand owners might have the highest power to impact packaging selection towards more sustainable. Finally, the focus on material value recapture started playing an important role. Thus, in the examples of kegs, this strategy is testing on the market. For this case, BbCT will play a significant role in the material's verification and certification. The producers of the packaging, which key-value captured in its design and preserved via patent, will be more incentivized to get back only this specific packaging, not from the competitor. In terms of bottles, in the areas where the deposit system is already in places, tracking and material's verification will be easy to introduce. Also, an interesting case could be tested for the pharmaceutical plastic packaging (bottles), due to very specific requirements to track the packaged product.