



# Self-Adhesive Labels as Circular Economy -Based Product

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## **ABSTRACT**

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Circular economy has become important topic in manufacturing industry. Self-adhesive labels are multilayer product which become waste once it has been stucked into product. The purpose of this thesis is to find out if self-adhesive labels are circular economy -based product and how the life cycle of labels can be extended after production phase.

This thesis has been done by using qualitative research methods as well as partly narrative literature research. Data collection has been done with narrative literature research. The collected data has been tried to be explained in deeper level, which is used in qualitative research. The research questions have also been tried to answer by using numeric information and LCA studies.

As a result, was discovered that labels can be circular economy -based product, when using correct raw materials. LCA studies supported this. As a conclusion, extending the life cycle of labels can be reach with various methods example burning waste to energy. For further studies the recyclability of labels should be concerned by testing it in pilot laboratory.

Keywords: self-adhesive, sensitive pressure labels, label technology, packaging, circular economy, sustainability

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**ABBREVIATIONS**

EU	European Union
LCA	Life Cycle Assessment
UV	Ultraviolet
PP	Polypropylene
PE	Polyethylene
PET	Polyethylene Terephthalate
g/m <sup>2</sup>	Grams per square meter
FSC	Forest Stewardship Council
PE-LD	Polyethylene Low Density
PE-MD	Polyethylene Medium Density
PE-HD	Polyethylene High Density
PP-H	Polypropylene Homogeneous
PP-C	Polypropylene Copolymer
Kg	Kilogram
MIT	Massachusetts Institute of Technology
MDF	Medium Density Fiberboard
LISP	Lignin-isolate soy protein
CO <sub>2</sub> -e	Carbon Dioxide Equivalent
ml	Millilitre
IBC	Intermediate Bulk Container
SCK	Super Calendered Kraft
UN	United Nations
US	United States

## 1. INTRODUCTION

In this chapter the subject is presented as well as told the aim of the study and structure of the report is presented.

### 1.1 Introduction of the subject

For years world has run with certain way. The consumption and production have been linear: consumers' needs the product; we shall produce it without thinking what happens to that product when it's not needed anymore. The linear consumption idea has worked before as there has been less humans on the planet and natural resources has seemed to be endless. The situation nowadays is quite different. With constant increase of population and over consumption of natural resources has driven companies as well as consumers to think circularity. In 2024 world overconsumption day was August the 2nd. Despite the fairly good waste collect -and recycle system in Finland, the Finnish overconsumption date was already in April (Geneva Environment network).

Consumers are choosing more and more environmentally friendly options and before new product launch, brand owners must think what happen to product once it's not needed anymore: circular economy steps in, and when think about labels; the life cycle is quite short.

We see self-adhesive labels everywhere we look; whether it's on shampoo bottle, on wine bottle or in bags of oranges, the purpose of labels is the same: to inform and show the brand. In 2021 European label consumption was 8,5 billion square meters, which is 10 billion labels per week. This means that average consumption per capita was 20 labels each week. This is huge amount, even when after Covid-19 there were lack of raw materials, energy, and transport equipment (Final, European label indst. Repots).

Depending on the end use; the raw material of label varies quite a lot. For product which needs to stand moisture like shampoo bottles, label is made from plastic.

For expensive high-quality products like wine and cosmetics, labels can be made from exotics raw materials like wood laminate, fabric, or hologram films. For most bulk product like fruit tags or the address tags in corrugated boxes the labels are made from cheapest raw materials, which most often is plain white paper.

The problem with labels is that whether it's on expensive wine bottle or in banana peel at the end, label is waste. Raw materials can be made from recycled materials but still after labels is produced and sticked into product it become one time product and will end up either to landfill or in better option energy production. European parliament says that only in EU level, over 2,2 billion tons of waste is produced annually. They have been woken up and started to update legislations and regulations concerning waste management (European Parliament, CE). This is huge amount of waste, and companies all over the world needs to find new sustainable solutions for their product, especially for disposable products.

## **1.2 The aim of the thesis and scope of the topic**

In this thesis will be present the function of labels and solutions which has already done in self-adhesive label industry concerning circularity and investigate what could be new innovations in circular economy point on view; can we expand the life cycle of self-adhesive labels after it has been sticked to product?

This thesis has two research questions which are: *Can we expand the life cycle of self-adhesive labels, after it has been sticked to product?* and *Are self-adhesive labels circular economy -based product?*

The research questions were selected because self-adhesive labels are disposal product and in circular economy mindset disposal products are bad thing which should be replaced with more sustainable and long-lasting options. The main issue in self-adhesive labels is the recyclability of labels.

To the scope of the topic was selected to be consumer labels. In this thesis the consumer labels are reference to be self-adhesive labels in its final form so once labels have been sticked into product, without the release liner or matrix waste.

The production of labels is presented, because label production is a complicated process, and it needs to be explained open due the reader to understand the circular economy challenges for further handling the label waste, example recyclability of labels. Also, due the understanding of innovation presented in this thesis, the recycle of release liner and matrix waste are presented. Self-adhesive labels are part of packaging materials so development in packaging industry is presented. The production and any life cycle analyse of packaging are excluded from the thesis as that information does not affect to self-adhesive labels. For the circular economy business models was selected to be one presented by Ellen MacArthur foundation.

### 1.3 The structure of the thesis

The thesis contains eighth chapters. The chapters can be seen on figure1.

Figure1. Structure of thesis

Introduction		
Self-Adhesive labels	Packaging	Circular Economy Business models
Methodology		
Results		
Discussion		
Conclusion		

In the first chapter is introduced the topic of thesis as well as told the research questions. Chapters two, three and four are theory chapters, and they are all equally important chapters. These three chapters gives theoretical foundation for this thesis. Chapter three and four are presented in self-adhesive labels on mind.

In chapter two the self-adhesive labels are presented. There are presented different raw materials which can be used in label face and in release liner, the chemicals which are included into label process, as well as environmentally friendly and circular economy-based options. The production of self-adhesive

labels is presented briefly, but the circular economy of production process is not handled.

On chapter three the focus is on packaging and circular economy solutions around packaging technology. In chapter three will be concentrate only ready-made packages and production of packages are not presented. Packages and circular economy solutions are presented the self-adhesive labels on mind. On chapter four the circular economy business models are presented. Circular economy business models are taken from Ellen MacArthur foundation and self-adhesive labels are linked into text by comparing the business models to self-adhesive labels. On chapter four is included the empirical portion of this thesis. The survey was used to understand the recyclability of label waste.

On chapter five the research methodology is presented, and discussion of the ethics is made. Chapter six is results chapter where the research questions are answered and in discussion chapter, number seven, all information is brought from theory chapters. Results are explained and innovations for self-adhesive labels are presented. Further studies are presented with discussion and in final chapter number eight the conclusions are presented.

## 2. SELF-ADHESIVE LABELS

There has been labels in the world in some forms since 1700`s, but self-adhesive labels were invented in 1930. Since that day's labels has evolved to be high-end product with special face materials and smart technology like temperature monitoring, food freshness indicators, security tags etc. (Kirwan M, Handbook of paperboard pack. Technology). Back in the days labels were mainly made from paper, but due innovation and research, labels can be made from plastics, bioplastics, aluminium foils, metallized paper, fabric and almost any material which can be rolled into reels.

Together with self-adhesive labels there are other labelling applications as well like shrink sleeves and in-mould labels. In-mould labels are used for example in food products, ice cream packages or plastic cookie jars. In in-mould labelling the label is attached to product during moulding process. The film label is placed into casting mould and then plastic is moulded. The label is melted to the surface of the container (The Cary Company).

Shrink films are placed without any adhesive, by shrinking the label with heat. Shrink sleeves are made from plastic film material. Shrink sleeves labels are used in beverage industry and where shape of the container is cylinder or unusual shape (Huhtamäki).

### 2.1 Face and release

Like mentioned there are multiple raw material options for labels. For release material, are usually used either film or paper. Plastic films can be either polypropene, polyethene or made from recycled plastic.

With face material there are multiple options. For bulk labels: address labels for boxes, fruit tags, price tags the face is usually made from paper/board. For labels which needs to stand water and moisture; shampoo bottles or beverages the raw material is usually plastic film.

There has been written couple of academic articles which compare the fibre-based labels with polymer-based labels. The article made by students from University of Zagreb, Croatia were compared pressure sensitive label faces material when using recycled fibre material and plant-based plastics. The raw materials which were used for fibre face was mixed from 15% from agriculture industry, for ex. grapes and citrus, 40% from recycled paper and 45% of virgin paper. The plastic face was made mainly from sugar cane ethanol. Labels were tested with different kind of tests which mimic the real-life situation which might happen for labels, like UV exposure and humidity changes. The result was that plastic labels endure better in the test than fibre -based labels, but as plant plastic was not bio gradable the recycle of film labels was more challenging that for fibre ones. (Vukoje, 2021)

In the other article, made by Brazilian students was investigated the environmental impact of two different label by LCA tool. LCA comes from words life cycle assessment, and LCA tool is used to calculate the environmental impact of certain product from raw material purchase to end-of-life. The label face on both options were PP (polypropene) and permanent adhesive, but release liner varied, other one had glassine paper liner and other one had PET (Polyethylene terephthalate) liner. The study was made for printing houses on mind, but labels were investigated from cradle to grave principle. With the LCA was discovered that the best way to affect the environmental impact of self-adhesive labels was in production phase. Even when on study the label waste was considered to end up landfilled. The best result was reached with combination of recycled raw materials in label production as well as recycling the labels in end-of-life phase. The LCA gave little bit higher environmental impact for glassine paper label than PET labels, but this was caused for higher grammage of paper label, which was 128 g/m<sup>2</sup> when PET label was only 95 g/m<sup>2</sup>. (Mederois, 2019)

Both studies show that in label making at the moment the best way to make labels circular economy based is to consider the raw materials and especially choosing the right raw materials for correct end uses. There is no point to use recycled paper face materials for labels which needs to stand humidity.

### **2.1.1. Paper materials**

For the release, its important to have smooth surface and good tensile strength, the raw material is usually kraft paper, also known as glassine paper. Paper is super-calendered which means that paper web has been processed by pressing with multiple calenders which smooths and dense the paper. For release paper its important to have dense and smooth surface so that silicone layer is even, and adhesive cannot penetrate to paper. (Karkuketo, Seppälä, Törn, Viluksela,57)

For sustainable point of view the paper is sustainable product as its own. It can be recycling multiple times before fibres are so worn out that they cannot be utilize in paper making anymore. Paper usually is certified with FSC (Forest Stewardship council) certification, which means that material comes from well and sustainable managed forests.

### **2.1.2. Film materials**

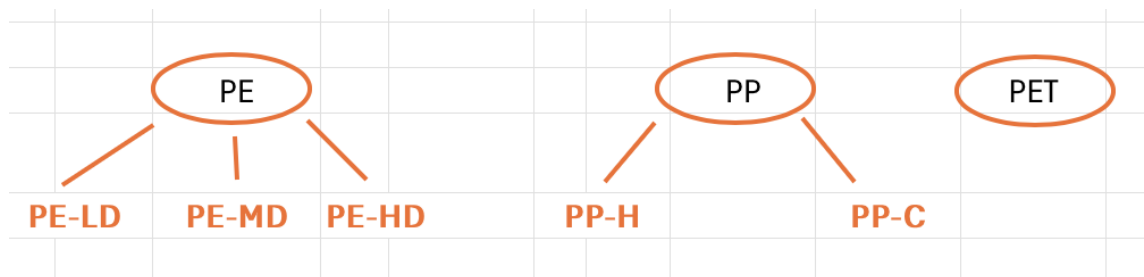
For film material, the most used plastic grades are PE and PP. PE (polyethene) is softer, and PP (Polypropene) is stiffer. PE and PP are used mainly as face material and PET (Polyethylene terephthalate) is used more as release material than as face. (Karkuketo, Seppälä, Törn, Viluksela,195)

Polyethene is most used plastic. PE is divided into different main types depending on its density. PE-LD (low density Polyethene) is used in clear plastic bags and filmic material, and it's the most used PE-plastic in paper and board technology. PE-MD (Medium Density Polyethene) is used on stronger films and in blow moulding technologies. PE-HD (High density Polyethene) is used for example in juice canisters and cloudy plastic bags. Plastic toys are made from PE-HD plastic.

As Polypropene is stiffer plastic it can be used in various end uses like ropes, wowed fabrics and films. PP has better heat resistance and impact strength than PE-HD plastics. PP is used for example in plastic hinges which can be seen in food packaging. PP-H (homopolymer polypropylene) is used for example in one-

time plastic products, fabrics and buckets. PP-C is mixed of PP and PE polymers. It's used in clear packaging's, multilayer films and plastic furniture's. (Järvinen P, Muovin suomalainen käsikirja, 20-28)

PET (Polyethylene terephthalate) is used in beverage industry and in textile industry. The products made from PET are clear and has good impact strength. (Järvinen P, Muovin suomalainen käsikirja,42) These different variations are presented in picture 1.



Picture 1: different plastic grades. Data source Järvinen P, Muovin suomalainen käsikirja

### 2.1.3. Sustainable film

When thinking sustainable in plastic labels, there are options like recycled plastic and bioplastic. Bioplastics can be either bio gradable and made from fossil-based raw materials or from natural polymers like cellulose, lignin or starch. Plastic can be made from natural polymers but cannot be sort to biowaste and bio gradable plastic can be made from synthetic polymers. (European bioplastics) On picture 2. is shown what kind of plastic can be define as bioplastics.

		<b>Biobased raw materials</b>		
<b>Not Biogradable</b>	Bioplastics Made from biobased raw material, but are not biogradable. eg. Biobased PET	Bioplastics Made from biobased raw materials and are biogradable. e.g. Starch		
	Conventional plastics Made from synthetic raw materials and are not biogradable e.g. PP, PE and PET	Bioplastics Made from fossil-based raw materials, but fibers are biogradable. e.g. Polycaprolactone (PCL)	<b>Biogradable</b>	
		<b>Fossil-based raw materials</b>		

Picture 2. made by author, data source European bioplastics.

From the picture 2. can be seen that plastics has been divided based on biogradability and biobased raw material. When thinking label material which can be sort as biowaste and it's made from natural polymers like cellulose, the right upper corner is the answer. Whether bioplastic is made from synthetic polymers or natural polymers it has it benefits. Biobased polymers do not use fossil raw materials but are made from renew material. And fossil-based material is still biogradable, so it doesn't fill the landfills. Most often the bioplastics are still made from natural renewable raw materials such like cellulose or starch (European bioplastics). In paper technology the bioplastics are made the side stream of pulp production. Tall oil is collected during pulp production and further processed into plastic granulates which can be mould to filmic material.

## 2.2 Adhesive and other chemicals

In self-adhesive labels the adhesive is one of the key components. There are several different adhesive types, but they all have same basic idea; they are in liquid form when applied into label face. The application is either roll application or curtain application. Good and even adhesive layer plays key role in self-adhesive labels. In label production process there are different chemicals mixes involved like adhesives, silicones, coaters and primers. Silicone is added on top of the release material. Due silicone, the adhesive or any other sticky material does not stick to the surface of the release liner. In label production silicone is added

either in-line at the laminating process or off-line in release film or –paper production. Coating or priming are added on top layer due good printability and to gives adhesive better anchorage (Karkuketo, Seppälä, Törn, Viluksela,62-64).

Chemicals are storage in different containers from big tanks to small 20kg jerry cans. It's crucial that in adhesive has no air bubbles or other impurities. Especially in clear film labels, air and cloudiness can be seen through face film. Another crucial step in self-adhesive labels is that adhesive anchors well, which means that it stays attached on face when liner is released off at label converting.

There are few different adhesive types what are used in self-adhesive labels depending on the end use. Wash-off adhesive is used for example in beverage industry, the label washes off completely from the bottle, and it makes bottle recycling easier.

Finat (the European self-adhesive labelling industry association) released on June 2024 document about self -adhesive labels in Pet-recycling. On that document Finat was discussing about using wash-off adhesive in PET-products. Still, most of the labels has either permanent or semipermanent adhesive, these labels are not designed to PET-recycling process. Adhesive either stick onto PET-flakes or attached itself with other material and make recycling process hard. Finat says that when implementing the wash-off adhesive to markets, the key is education. The basic idea in wash-off adhesive is that during washing, the label material is separated from the PET-material, and it floats to the surface of floating tank. The aim is to increase the amount of primary packaging flakes, which can be recycle to new PET-bottles (Final, the role of self-adhesive labels).

Permanent adhesives key task is to create high bonds between label and the product. They are chosen when label is needed to stick either long period of time or work in difficult environment like high or extremely low temperatures. These kinds of adhesive are example hotmelt and UV cured adhesive, used for example in automotive-, food- or medical-industry (UPM Raflatac).

Permanent adhesives cannot be removed from container only by washing, they usually need mechanical work like scrapping, scratching to be removed.

The difference between permanent label and removable label is that permanent label leaves adhesive residues behind, and removable label does not. The amount of time the label has been stuck into product affects how good it can be peeled off. Over time the adhesive, whether it is permanent or removable, creates a better bond between container and label. So, the removability of the label depends on the surface of the container and the time it has been stuck (Neff, M, Avery).

When discussing circular economy of labels we must discuss the possibility of bio-adhesive. Bio-based adhesives are made from natural polymers like proteins and cellulose. In label business bio-adhesives are not yet widely used but label professional company called Herma is advertising on their website that they have two adhesives with home composting certification (Herma). This news means that there would be possibilities to use bio-adhesives in label production for future. MIT (Massachusetts Institute of Technology) published on 2022 article about Surgical tape which could be alternative for stitches. The article says that "the adhesive is targeted to seal defects in the gastrointestinal tract". The tape has been developed so that it holds in place about month and then dissolves. (Chu J, MIT News). Even when this study was not self-adhesive label related, using a dissolving tape in medical industry is interesting news when discussing bio-and dissolving adhesive applications.

Bio adhesive can be made all the way from soy protein to castor-oil and lignin. As paper professional background, in this thesis was looked closely to lignin as raw material. Lignin is natural polymer which has natural adhesion and strength properties. It can be found on plants and its purpose is to hold plant cells in place by combining cellulose and hemicellulose together and protect the plant from decomposing. Lignin has water resistant and flame retard properties, and it can be used as raw material for adhesives and plastics. As lignin is side stream the use does not harm nature as raw material is anyway harvest for forest industry purposes. (Testova-Färlin L, Sweco) & (Stora Enso) Whether the raw material for bio-adhesive is lignin or soy the goal is still same. To create renewable alternatives which does not harm nature or create more waste to earth.

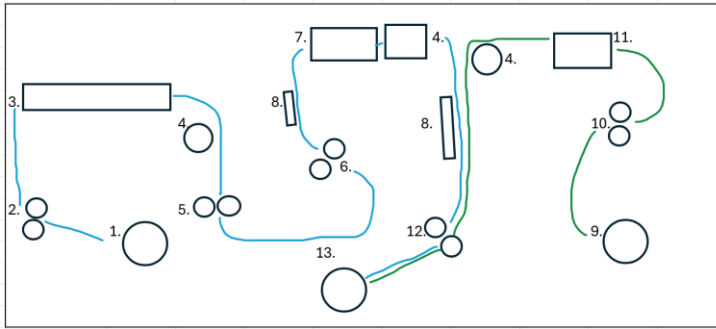
Lignin based bio adhesives has been studied a lot with other application, even when case studies with label making cannot be found. There are couple articles which both studies lignin-based bio adhesive with LCA tool.

McDevitt and Grigsby were using LCA tool to compare the bio adhesive and petrochemical adhesive in MDF wood applications. The raw material which was used in bio adhesive was lignin-based protein. The other adhesive was urea-formaldehyde-based. To have comparable result the production of both adhesives was modelled to be at the same location, in New Zealand. The result was that Petrochemical adhesive had 22% higher environmental impact than bio adhesive (McDevitt, 2014).

The other LCA study was focused only on soy & lignin based bio adhesive called LISP (lignin-isolate soy protein bio adhesive) The study showed that the global warming impact of LISP adhesive was 2,2 kg CO<sub>2</sub>-e per kg when Fossil based chemical the global warming impact was 2,82 kg CO<sub>2</sub>-e per kg (Ahire, 2024). Both LCA studies showed that using bio adhesives has lower environmental impact than petrochemical adhesives have.

### **2.3 Production**

The production of labels starts with choosing the correct face and liner materials depending on the end use of the label. In laminator machine there are own unwinding stations for face and release and one rewinding station for laminate. Silicone, adhesive and possible primer are added into release material and into face material, is only added top coating if needed Layers are combined right before rewinding at lamination nip. the layout of label machine is presented in picture 3.

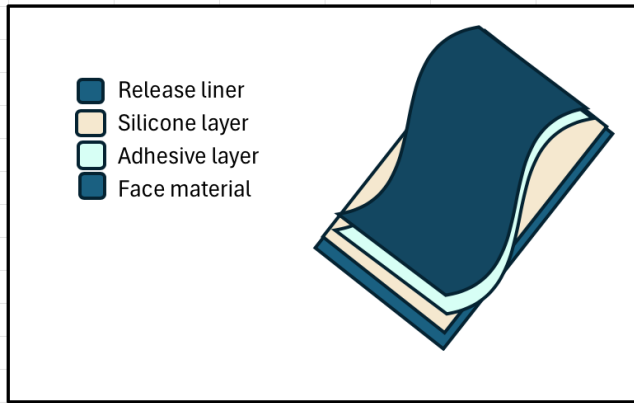


Picture3. Label production, Data source from Karkuketo, Seppälä, Törn, Viluksela, Paperin ja kartongin jalostus, page 196

Release material is unwinded (1) and from there web goes to silicone station (2). If material is pre-siliconized this phase is not needed. Silicone layer is very thin, usually under 1g/m<sup>2</sup>. After silicone application web is go through tunnel where silicone is cured with heat. After that web needs to be cooled down (4) before possible back printing (5). The adhesive is applied to siliconized web and after that adhesive is dried and cooled off before lamination nip (12). Face roll is unwinded (9) and possible top coating is added on face (10). Coating is dried (11) and cooled of and right before rewinding the layers are pressed together in lamination nip (12) (Karkuketo, Seppälä, Törn, Viluksela,78)

Sometimes the face material needs coronation for coating to stick. In coronation the surface energy of web is risen so that chemical wets the web surface and stick to it. Coronation is especially needed when film material is used. Coronation can be made either on electricity or with flame. The results of both of these methods are quite same. (Karkuketo, Seppälä, Törn, Viluksela,36-37)

The structure of label is presented in picture 4. Release liner is on the bottom and silicone layer is on top of it. Face and adhesive are sticked together and they are detached on top of the silicone.



Picture 4. Label structure. Raw structure of layers in adhesive laminate.

After lamination process the laminate reels are sent to finishing where they are slitted into smaller customer reels. Reels are then packed and sent to printing houses, where labels are printed and cut into correct forms, leaving the matrix and release waste behind.

### 3. PACKAGING

When discussing about the sustainability and development of labels we must discuss the changes what has happen generally in packaging technology. Without packaging there are no need for labels. We can almost think labels to be part of packaging itself, the changes and innovations in packaging technology affect also in label business.

The main purpose of packaging is to ensure the product during transport for example from moisture, odours and from breached. Like in labels the main function for packaging is to inform and advertise the product together with securing the product.

The materials which are used in packaging varies from carboard or paper, to plastic or glass. Depend on the material in use, the need of label is different. When using cardboard box, the label is not so necessary, brand owners could print all information needed into cardboard but still address label might needed. With plastic and glass packaging the labels might be almost only way to advertise the product.

When thinking transportation and product safety, consumer must understand that there isn't just the one small packaging what they purchase from the store. Let's take baby food for example. We have this baby food packed in small glass jars. There is label which tells what food this is and gives all needed information. The glass jars are not the only packaging involved to this baby food. These glass jars are most probably packed together in cardboard trays called store packaging with 12-24 glass jars. Then multiple store packages are packed to cardboard box also known as group packaging. On top of both packaging there is most likely label which again shows the content of packaging. Then these boxes or group packages are packed together as transport packaging and maybe even further to be as parcel, which is wrapped tightly in plastic wrap, again this packaging needs label to show the address and content of this product. So, there are quite many packaging materials and steps before consumer picks the baby food jar from store shelves.

With discussion of the environmental impact for packaging and labels we need to remember the main purpose of them, to protect the product. In food industry the environmental impact of packaging is only few percentages of the whole environmental impact which evolve in the lifecycle of food product (Suomen Pakkausyhdistys ry)

## **2. 1 History of packaging**

There has been packaging in some forms at the beginning of times. Clay pots and vases has been used to store liquids like oils and water and food has been wrapped in cloths or animal skins. Back then packaging was not onetime product, and same pot was used multiple times. After industrial revolution around 18<sup>th</sup>-19<sup>th</sup> century the packaging industry took leaps, and the use of own containers was displaced with disposal one-time packaging solutions. This continued for a while and 21<sup>st</sup> century developments were drive by light and more tailormade packaging products. Now when circular economy has become hot topic consumers has start to think and require more durable and sustainable options. Karkuketo says that packaging industry has received environment critics since early 21<sup>st</sup> century, so this is not new topic in packaging field. (Karkuketo, Seppälä, Törn, Viluksela,11)

Covid-19 epidemic increased the packaging consumption when peoples were isolated into their homes. Online shopping and food delivery services which has already increased packaging needs raised the consumption of packages to even higher. Ellen MacArthur foundation is mentioning in their website (Biopic, Ellen MacArthur Foundation) that “takeaway food is one of the fastest growing sector of the global food industry” This of course require lot of packaging which most of the time is plastic packaging, due its grease and liquid resistance. Once plastic packaging has contaminated with grease the recycle and washing takes energy and water resources, and most of the time take away container end up landfill.

## 2.2 Future and upcoming trends for packaging

The future and innovations around packaging is tightly close into circularity. When years ago, the almost only innovation was how to make packaging extra light with excellent strength properties, nowadays brand owners and packaging producers should think environment as their first driver in product development. Ellen MacArthur Foundation has listed some packaging innovations which could replace plastic packaging. Company called Ecovative has created 100% bio gradable product where the main raw material is mycelium which is mushroom roots. This product has same properties than polystyrene packaging without the plastic. (Ellen MacArthur foundation)

Wood based packaging ideas are also better options for virgin plastics due its recyclability and bio gradability. A good packaging give minimum burden to environment and environment has been taken consideration in product design all the way from raw materials to production and logistics (Karkuketo, Seppälä, Törn, Viluksela,24)

Ellen MacArthur foundations explain four different business models for reusable packaging solutions, which could be the key drivers for sustainable consumption in packaging area.

Figure 2: data source (Ellen MacArtur Foundation.d)

	Refil	Return	
	Package is refilled by consumer at home	Package is returned to business by picking it up from consumers home by business owner or other thrid party	<b>at home</b>
	Package is refill away from home by consumer	Package is returned to business on the go by consumer	<b>on the go</b>

These four business models shown on figure 2 are focused to be consumer solution. Solutions has been divided so that used package can either be refill or

return and actions would be either on the go or at home. The example of refill at home would be for example liquids which is pressed into solid form, such as cleaning products. Finnish company called Sini is selling cleaning tablets which consumer can buy. At home they combine cleaning tablet and tap water and get 500 ml of cleaning liquid.

Consumers doesn't have to purchase new liquid bottle every single time.

Example for refill on the go solutions would be buying food items in bulk or using reusable fruit bags. Consumer would take their own containers to store and fill that with bulk products. In both of these solutions' consumer wash the container by themselves.

In other two business models' package is returned to the business, and they wash the container. Business owners pick up the dirty package from consumers home and switch to new products. They wash and refill the container and then ship again the refilled container to some other customer when picking up the used one. This kind of business model is used in business-to-business retail for example in wood pallets or empty IBC-containers.

Return on the go models varies so that here consumers return the container to sorting stations. Ellen MacArthur mentioned that Coca Cola has innovation in Latin America where Coca cola collect the used plastic bottles and wash them and then refill and ship to stores again. This method is not the same as bottle recycling systems in Europe as there the bottles are melted and pressed into granulates and further processed into new bottles.

The main idea in all of these solutions is that reusable packaging solutions would replace disposal one-time options. How does this trend effects on labels. When consumers use their own container or packaging the label is not needed, but when packaging is returned to seller to be washed the product labels are again stucked into packaging. In label production point of view the packaging return business models are better. (Ellen MacArthur Foundation, d)

On social media has spread for years this fridge restocking & pretty packaging trend where social media influencers are buying clear plastic containers from Amazon and then uses these as pretty storage solutions in fridge or in pantry for storage food products. This is bad packing trend as the purpose of this packing is only decorative or to give more polish look. In these videos influencers are showing how they pour juices and milks from cardboard and plastic packages into pretty glass jars and move cheese slices and ham from their own plastic package to clear plastic containers. This increases the packaging waste as on top of the original food packaging waste there is also Amazon delivery boxes and clear storage boxes. There is also hazard that food waste will increase as there might be no expiration dates written to the clear boxes. This kind of organization would be circular economy based if consumers would buy food products as bulk but in most of the time this is not the case.

#### 4. CIRCULAR ECONOMY BUSINESS MODELS

Circular economy and recyclability of labels has become hot topic in Europe label business. FINAT together with European label producers founded on 2020 CELAB (Toward a Circular Economy for Labels). There are about 35 label industry leading companies including to CELAB and their aim is to provide solutions and education for label matrix and liner recycling. (Celab Europe) Their target is that by 2025 over 75% of release liner and matrix material would follow the circular business.

CELAB has created two reports together with label professionals about recycling of siliconized paper liner and siliconized film liner. For paper release liner the report is telling that there are two paths for paper to be recycled, either combining with other paper grades as normal paper recycling process. In this case the siliconized paper might need extra re-pulping as it might be hard to break down the liner due silicone, but not impossible. Other way is to recycle liner as its own stream to maintain better recovery of high-quality fibres. Due this kind of process the recycled fibres can be utilize in the production of same quality base paper like graphics or glassine grades. (Celab Europe, paper release liner)

The report is telling that the use of liner material is different in Europe and United States. In Europe most used paper grade for liner is Super-calendered Kraft (SCK), also known as Glassine paper. It can be in any colours from white all the way to brown. In the United States the most used paper is white based liner. Due this, in the United States the recycled liner can be utilize for example in tissue, writing and printing grades. (Celab Europe, paper release liner)

For plastic film release liner the report is telling that the raw material of film liner is either PET, PE or PP. Even when paper is still most used raw material there is some functions which requires film liner. The recycling path depends on what methods has been used to add silicone to the film. off-line application the silicone is added during film manufacture and in-line the silicone is added after film production on lamination machine. The difference between these two applications is that in off-line the amount of silicone coat is lighter. The main idea in recycling

film liner is the same, film is chipped into small pallets and then mixed with virgin film, the difference between silicone application is that in-line applied film has more silicone on it and that's why it needs more virgin material at the end product than off-line application. The amount of silicone is still under 1g/m<sup>2</sup> in both cases. The most common end use for recycled release film is to produce new film liner due it is high level raw material, but using recycled film liner in other film products is better option than dump the liner in landfill. (Celab Europe, filmic release liner)

The end use of matrix waste does not have one solution like for release liner and Celab did not gave any solutions for Matrix waste on their website, but different label professionals have their own systems to handle matrix waste. Matrix waste is the excess label material after cutting the labels to its final form.

Film manufacturer Polifilm and self-adhesive label specialist Herma had discovered solution to use PE-film matrix waste as raw material in construction films (Polifilm) Label manufacturer Avery Dennis has launch on 2020 matrix recycling program with RoadRunners recycling, where are searched other alternatives to matrix waste than energy production. They say that most of the matrix waste in America ends up to landfill (Goldsberry C, Avery Dennison). Finnish label producer UPM Raflatac uses matrix waste as raw material for bio composite deck material (UPM Formi).

The main idea in circular economy thinking is that products and services circulate either back to production or back to nature (Ellen MacArthur foundation). Most commonly labels end up to mixed waste. In some EU countries the 60% of households waste ends up to landfills (European Commission). Ellen MacArthur foundations has been listed three principals behind the circular economy idea.

#### **4.1 Eliminate waste and pollution**

This principal says that when shifting idea from linear consumption to circular consumption it all starts with product design, if there are multiples different materials stick into product it cannot be disassemble back and circulate, the products

end up landfilled, so it is design to be disposal product. (Ellen MacArthur foundation,a) When thinking about self-adhesive labels, unfortunately they are just this. We have adhesive, which is sticked on label face. When thinking about eliminating the waste in label business there comes mind the question; do we need labels at all?

For any packaging which can be printed on flat, like boxes the labels could be replaced, but when packaging is shaped as cylinder the label is needed.

For example, in medical industry the blood sample bottles are so narrow that they need label, not only for the shape but also for security, the risk of mixing patients' samples without any label tag can cause mistakes.

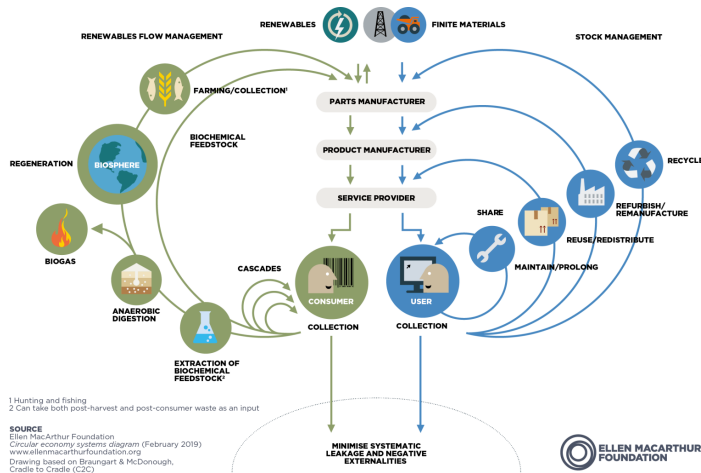
In beverage industry we could use liquid packaging made from board, but does carboard holds all the pressure of soda? Of course, we can use different kind of labels like shrinking films or sleeves in beverage industry to minimise the adhesive, which could help label recyclability little bit.

What about price tags, or fruit tags. Back in the days fruits were purchased per pieces, but nowadays when consumption has been increased, and hypermarkets are open 24 hours this kind of calculation at cash counter is not possible anymore. There are some solutions what could be utilize instead of printing the information on labels. But there are so many end-uses where we still need labels due security and informativity. So, the answer is, we do need labels.

## **4.2 Circulate products and service to maintain its highest value**

Based on this principle the idea is that product or service is kept in the loop as long as possible and once it no longer cannot be used it should recycle either as particles to make product again or to utilize as raw material for another product. There are two cycles how this principal can be looked at: Technical cycle and biological, this is shown in cycle Figure 3.

Figure 3. the butterfly diagram of biological and technical cycle (Ellen MacArthur foundation, b)



In Technical cycle the product is being reuse, repair, remanufactured and recycled. In biological cycle the material is given back to nature by composting or anaerobic digestion. (Ellen MacArthur foundation, b)

Figure 3 can be found also as appendix 1. where it is presented in bigger scale.

How will labels fit into this principal? When comparing for example computers and labels, the computer has way more value as full product than dissembled into atoms, therefore the lifecycle of computer should try to extend with repair and reuse. Labels has more value as raw material. Therefore, labels should be teared apart and recycle or remanufacture into new products.

Paper fibres can be re-use seven times before fibres are so worn out that they cannot be utilize in paper making. If we have 100% paper/wood-based label, in theory we could utilize it in paper production process. Same goes with plastic labels. Label waste could be washed and melt together with recycled plastics and further process to new granulates and new products. Unfortunately, self-adhesive labels are produced so that adhesive cannot be removed from label, but if we think that adhesive could be removed from label could it be possible to recycle?

In Mechanical recycling method of plastic, the film is grinded into small flakes, flakes are then washed and pressed to denser form. After this, flakes are melted

and formed into new plastic granulates which can be used to produce new plastic products. (Muovien kierrätys)

Recycled paper is transported to recycling plants where paper is disintegrated with water, this releases the fibres. In deinking process all inks and other toners are removed from fibres. All adhesive residues must be removed otherwise adhesive might form tacky particles which cause problems in paper making process. These adhesive residues may come from products like labels, books, envelopes, catalogues and magazines (Forest BioFacts)

At the moment labels as itself cannot be fully recycled. The issue is not only the adhesive but also the wet strength of labels. As labels are packaging materials and usually used under different weather conditions, they are needed to have good wet strength. This will be achieved by applying either wet-strength agent or coating onto the surface of the labels. It requires more energy at the recycle process to pulp the wet-strength papers. (Ulrich H, Schnabel S, 90, 116). When talking about biological circulation in label business it means that we need to use 100 percent bio gradable materials, such as paper or bioplastic as face and bio adhesive.

#### **4.2.1 Survey to discover the willingness for label recycle**

To analyse the consumers' willingness to recycle label waste a survey was made. The survey was made in social media platform, and four questions were asked. The survey did not answer to research questions, nor it was not used to answer to them. In quantitative research using surveys as part of data collection is common tool to answer the research question.

Data was collected from social media platform, by using authors own Instagram feed. The questions were launched in `Insta story` section where posts are staying for 24 hours and then disappear. The questions which were asked can be found in appendix 2. but they are presented in figure 4. Due clarity the answers were yes/no, and question one had three different options and all of those was able to answer.

The survey was presented in Finnish due the author contact persons were all Finns. This language decision was made so that survey could get maximum amounts of answers. Pictures of original survey is shown in appendix, for this report the survey was translated to English.

Figure 4. the question which was asked in survey

1. How do you sort label waste	I sort label waste together with container in plastic/glass/paper or mixed waste	Yes / No
1. How do you sort label waste	I peel off the label and sort it in mixed waste/energy waste	Yes / No
1. How do you sort label waste	I peel off the label and sort it in plastic/paper recycling bins.	Yes / No
2. If label waste could be sorted like plastic/paper/ser waste, would you sort it in sorting station?		Yes / No

As in question one had three options. The question needed to chop into smaller pieces to fit the Instagram question form. The purpose of the first question was to get understanding of how consumers handle label waste today. Recycling guides and regulations aren't saying anything concerning disposal of label waste (kierrätys.info), so therefore they belong into municipal waste.

The purpose of question two was to map out the consumers eager to recycle label waste. In this question the idea is that label waste collection bins would be in recycling station. Survey was launched on Friday 29.11 afternoon around 14:00. After 23 hours the survey had already good number of answers. The target group was 97 participant which are authors Instagram followers. The group of people comes in different socioeconomic backgrounds.

There has been several case studies and publications about using network and social media as platform for studies and research. Using social media platform in

surveys are easy and quick way to get maximum amount of answer in fairly quick and easy way. Almost everyone has smartphone on their pocket and social media is on their hand all day around. For example, in this survey only after one hour there were 12 answers. Getting 12 answers in one hour with any other methods would have been hard task to handle, but in social media platform 12 answer in 60 minute is not so good answer. A more important question is what ethical pondering must be taken in this kind of survey.

Media & Viestintä -magazine has article about researcher ethics in social media platform. The main challenge which researcher must think is related to privacy protection of participants (Kosonen,2). For surveys which are held in `Insta story` like platforms the benefit is that data is destroyed in 24 hours and not even the creator cannot see the answers or the questions after that time period.

Other issue which can cause ethical pondering when browsing participants from social media is that users does not often think twice before enrolling to surveys (Kosonen, 3). In this survey the attention was catches with two slides where first was presented the aim and the need and then explained more deeply what is actually asked. After then the questions were presented. Viewers had possibility to skip the survey completely and that was also done in this survey by some viewers. On first slide was informed that answers are handled anonymously and only percentages are used. Ethically thinking this survey was completed well and in good practise. Participants were informed where the data they give are going to be used and the methods of data analyses. Personal information's was not collected, and answers was destroyed after 24 hours.

During 23-hour time period this survey reached 71 viewers from 97, which of 67 was answered to question 1. and 63 to question 2. The answering percent on question one was 69,7% and on question two 64,95%. The answers are presented in Figure 5.

Figure 5. the answers of the survey

Main question	Sub question if needed	Yes %	No %
<b>1. How do you sort label waste</b>	I sort label waste together with container in plastic/glass/paper or mixed waste	95	5
<b>1. How do you sort label waste</b>	I peel off the label and sort it in mixed waste/energy waste	5	95
<b>1. How do you sort label waste</b>	I peel off the label and sort it in plastic/paper recycling bins.	8	92
<b>2. If label waste could be sorted like plastic/paper/ser waste, would you sort it in sorting station?</b>		51	49

From the figure 5 can be seen that almost all of the consumers do not think about the label waste when disposing the container. The container might be sorted correctly, and label is then handled on that recycle process as reject. When giving more deeper question if consumers would peel off the label and then recycle it or handle it as energy waste the answers were mainly same, most of the consumers do not peel the label off from container before sorting the container into waste. In question two the variance was amazingly equal. When asking if consumers would be willing to recycle label waste if there would be option to it, 51 % of the answers was willing to peel off the label and recycle it as own. This is interesting find and can show that consumers would be open to recycle the label waste if there would be channel for that.

#### 4.3 Nature renegeation

In third and final principal the basic idea is that we do not waste the nature but return the biological material to nature like planting new threes and letting go of fossil fuels. Ellen MacArtur foundation mention that "By keeping products and

materials in use, less land is required for sourcing virgin raw materials, e.g. from mines.” (Ellen MacArthur foundation, c)

When thinking label business this principal is more concentrated to production and procurement of label productions. Choosing the recycled materials over the virgin materials and choosing environmentally friendly energy options.

Burning fossil fuels as energy and electricity creates over 75 % worlds greenhouse gas emission, even when using renewable energy source is cheaper than using of fossil sources. United Nation is advising that use of fossil fuels should cut down to half by end of year 2030 and end completely by 2050. When labelling the sources of renewable energy UN is listing waste to be one of the sources together with sun, wind and water (United Nation).

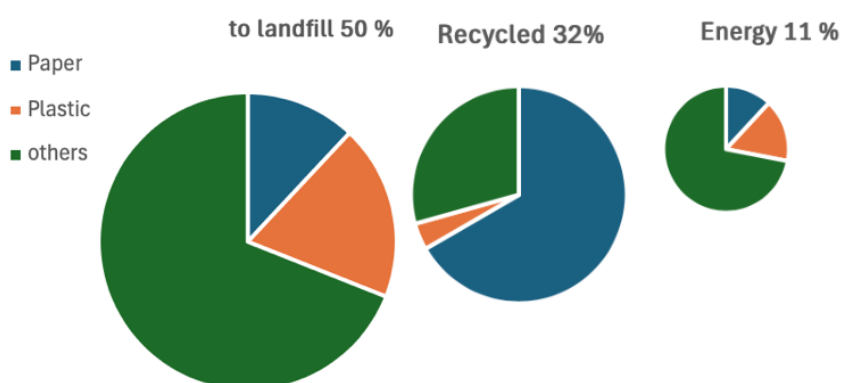
Global waste index 2022 report is telling the waste handling rate of 38 different countries all over the world. The report is mentioning that after Covid-19 the use of waste was increased due the rapid use of disposal product like face masks and other medical equipment's like covid tests. The report is showing that only 17 countries from all 38 countries were reported to burn more waste than they dumped to landfill. From these 17 countries only Japan and South Korea are outside of Europe. The report is showing that in 2022 United States generated 811 kg of waste per capita of which only the 88 kg were burned and 400kg were dumped into landfill. Never less the United States were not the biggest landfill dumper per capita, as New Zealand was reported to dump 727 kg of waste per capita into landfill from total of 781kg of waste. Now must keep in mind that in 2022 population in United States was 338 million (tilastokeskus) and in New Zeland the population was only 5,1 million (world bank group), so in reality United States was the biggest landfill dumper.

When comparing the countries who are burning most of the generated waste number ones are Finland with 354kg burn amount out of total 596 kg, Japan with 268kg burn amount of total 336kg and Sweden with 259kg burn amount of total 431kg. Five countries were reported to not burn any waste: Turkey, Mexico, New Zealand, Costa Rica and Colombia. These countries are dumping most of the waste to landfills. (Global waste index, 2022)

In the EU, an average packaging waste per person in 2021 was 189 kg, which of paper and board share was about 40 % and plastic 19%. About 65 % of waste was recycled (European Parliament, Pakkaus). In Europe the most used plastic waste handling is energy recovery. Half of the total plastic waste was sent to outside of EU for further handling due the lack of handling capacity in EU area (European Parliament, muovijäte).

In the United States the rate of recycling in 2018 for municipal waste: which includes households waste and other municipal waste was 32 %, which of paper and board covered 66,5 % and plastic 4,47%. Around 11 % was handled as energy waste, which of paper and board amount were 12 % and plastics 16%. The rate of landfills waste from total municipal waste was 50% of waste. This is 149 million short tons, which equals 135 million metric tons. The amount of paper and board which end up to landfills are almost 12 % and amount of plastic was almost 19 % (United states Environmental protection agency). So, in 2018 16 million tons of paper was dumped to landfill. This is presented in figure 6. The blue colour is for paper waste and orange is for plastic. Green is for other municipal waste like wood, metal, glass, textiles. The rest 7% of hole municipal waste was compostable waste and was handles by composting.

Figure 6. Data source (United states Environmental protection agency).



In the EU the share of all landfill waste in 2018 was 19,7% which was about 170 million tons, of which households waste 35 million tons and other municipal waste 30 million tons. the recycling rate for paper in EU was about 70% (European environmental Agency).

## 5. METODOLOGY

The purpose of this thesis is to have deeper understanding of sustainability of self-adhesive labels and understand the standard and challenges of how one-time product can be and become circular economy –based product. This is verified by LCA studies and analysing the literature with the knowledge of label production which author has.

Thesis follows qualitative research methods approach, and more specific case study methods. The circularity of labels has been measured by using LCA –based literature and other numeric information, but the basic idea of circularity around labels are tried to understand in deeper level which is familiar with qualitative research method. In case study methods the subject is example of something larger phenomena. For this thesis the circular economy of labels is example of larger topic of the circular economy of disposal product and packaging product. For case study its typical to try to give versatile picture about the subject. (Vuori, tapaustutkimus, 2021)

For this thesis it has been decided to use mainly already existing literature and data also known as secondary data. The reason why this decision has been made is that research and case studies which concerns this topic are sufficient to answer the research questions in comprehensive. Secondary data for example LCA studies are better quality than primary data might have been. Primary data has been used only in chapter four as survey, when tried to understand the consumers willingly to recycle label waste. This survey has not been used to answer the research questions but to give ground data for further studies.

For qualitative research typical features are to doubt all given knowledge even when it would be classified as common sense and the use of empirical data, like interviews, surveys, and conversations, which describes the events of certain activity. Data is not commonly altered into numerical form, but it is explained open by words, even when numerical statistics can be used as data resources for the

research. Qualitative research is typical to be inductive, which means that research starts with empirical literature and results are risen from the text during research process. (Juhila, ominaispiirteet, 2021)

The theory of labels on chapter two act role as substance theory. This gives base and framework to research and research questions. Chapter two gives theory to the subject by answering what are labels and what challenges they have concerning to circular economy. Formal theories usually do not describe exactly about the subject of the research. They give more knowledge about the chosen topic by giving new perspectives to framework. In this thesis the chapters three: Packaging and chapter four: Circular Economy models are playing this role. They can be own individuals for some other research, but in this research, they complete the theory of self-adhesive labels and circular economy. (Juhila, tutkimus ja Teoria, 2021) The research and results have not been analysed as tight as factual methodology requires by assuming the data to be absolute fact, but it has been analysed by comparing results to other literature and research. Therefore, even then the theory chapters lean to substance theories it cannot said to follow completely this line.

The perspective which has been utilized in theory parts of this thesis is based on factual perspective. To this perspective its common that the focus of the research lean to facts and author stays external observer by using only substants theory and formal theories. The results and argumentation in this thesis have tried to understand in deeper level which refers that perspectives which has been used are more experience and constructivist perspectives. (Jokinen 2021)

Narrative literature research method has been used partly to establish the theoretical foundation and provide background information for the research question. Narrative literature research is used when main topic of research is to find out what is already known for certain topic and what are the main concept behind it. Narrative literature can be used for presenting the history and evolution of topic and present the wide overview on chosen topic. As the main idea is to understand the subject the knowledge of author grows during research process. This can cause the challenges that research methods and data collection can be random and subjected as research can modified the data collection methods during

research process. For these reasons narrative literature is seen to be more freely than other literature research methods. (Vilkka,2023,1.2.1) Vilkka (chapter 1.3) is mentioning that the data collection which are used in literature research is usually from

1. Peer-review research
2. Different kinds of publications made by research institutes or organisations (Ellen MacArthur foundation, Celab)
3. Public entities (Europa Commissions, Europa Union)

For this thesis the data has been collected from sources which are recognized to be good sources for literature research, but data has been collected also from free internet webpages of label professionals. Therefore, this thesis cannot be seen fully as narrative literature research, as it not follows the frames of reference which is normally used in literature research. Also, data analyse does not follow the principle of narrative literature research.

## **5. 1 Ethics**

Ethicality is important part of the thesis and research process. In this thesis the one of the ethical challenges is the reliability of the sources. Some of the sources used are quite dated, and the information may have changed over time. In these cases, the age of the sources has been clearly stated. If such information has been used for comparison, the corresponding data from the same year has also been included, ensuring the comparison remains valid.

One of the ethical issues in this study is objectivity concerning the actual need for labels at all. The information which is used in this thesis is mainly gathered from label professionals and label producers, case studies and articles about the topic were more label positive. Due this reason in this thesis has been briefly discuss the option if labels could be replaced completely, by printing the information to packaging. For this chapter as source has been used authors professional knowledge of label production.

When thinking objectivity, it needs to keep in mind that the main idea of this thesis is more label positive, the base idea behind this thesis has been how label production can continue in future world. And that`s why the questions about “can labels be replaced” or “are labels pointless” has not been explained with any case studies.

## 6. RESULTS

The research questions presented at the beginning was: *Can we expand the life cycle of self-adhesive labels, after it has been stucked to product?* and *Are self-adhesive labels circular economy -based product?*

In this thesis the printed literature data and technical publications of thesis were search by using Andor database and Google Scholar database, as well as browsing library bookshelves. Free internet pages, like Ellen MacArthur, Celab, Finat and labels producers' webpages came across by using google.

Used keywords were self-adhesive labels, pressure sensitive labels, circular economy, labels, bio adhesive, lignin and waste handling.

During research process the author has learned while doing and data has been collected and search based on that. For example, when learning that lignin can be used as raw material in bio adhesive, the used keywords were lignin AND bio adhesive. From the results were selected the literatures which fit the topic of the thesis.

Data has been analysed with quantitative approach with numeric data and results has been presented in table form by using theoretical foundation from chapter four: Circular economy business models. On figure 7 is presented the results which support the research question about extending the life cycle of self-adhesive labels, after label has been stucked to product and on figure 8 is presented the results which support the research question that are self-adhesive labels circular economy -based product.

In qualitative research analysing, the data is summarized and developed. For analysing data can have quite many methods. For this thesis is used qualitative content analyse approach, where data has been analysed by using different themes and larger topics. In content analyses the data is analysed with quantita-

tive and statistics analyse methods. Content analyse does not lay into any specific theoretical-methodological ideas, and therefore the analyse can be made more freely. (Vuori, laadullinen sisältöanalyysi, 2021)

On figure 7 the butterfly diagram from appendix 1 of biological and technical cycles is used to help identify the circular economy model.

Figure 7. Can we expand the life cycle of self-adhesive labels, after it has been stucked to product ?

Findings from research	How life cycle is extended	method
Using bio adhesives and bioplastics as raw material	Self-adhesive labels would be compostable	Biological cycle, back to nature
Using matrix waste recycling methods for label waste	Label waste would be re used to another product (construction films, Bio composite deck)	Technical cycle, waste would have new life as new product
Recycle of plastic- and paper face material	Label waste would be recycled to new film and paper material	Technical cycle, waste would be recycled back to the loop.
Burn label waste as energy	Instead of dumping waste into landfill, using it as the source of renewable energy	Technical cycle, re-manufacture waste to energy

On Figure 8 the circular economy principles presented in chapter four are used to identify the circular economy models for findings.

Figure 8. Are self-adhesive labels circular economy -based product?

Findings which verify the question	Circular economy model
Using the bioplastic over fibre -based material on right applications makes labels more durable	Life cycle of labels is longer --> circulate products and service to maintain its highest value
By using recycled materials in label production can affect the environmental impact of labels	Minimal use of virgin raw materials--> Natural renegeation
Using fibre raw materials over plastic as paper can be recycled	Minimal use of virgin raw materials--> Natural renegeation
Using wash-off adhesives in beverage industry	Recovery of recycled PET flakes is higher--> circulate products and service to maintain its highest value
Using bio adhesives over petrochemical adhesives has 22% lower environmental impact	Using renewable sources over fossil ones--> Nature renegeation
LISP adhesives have 0,8 kg CO <sub>2</sub> -e/kg lower global warming impact than fossil -based adhesives	Minimising the global warming --> eliminate waste and pollution
Release liner and matrix recycle	Minimal use of virgin raw materials--> Nature renegeation
Using label waste as energy source	Using renewable energy source--> Nature renegeation

## 7. DISCUSSION

The branding and advertisement of products are easy with labels as printing the information to label might be easier than print it to the product itself. Rebranding and special advertisements for example in holiday seasons are fairly easy way to elevate the product and make it to stand out. New innovations like QR codes and smart technology can be used in labels to give consumers more information and to elevate the product image (Grano).

From the result can be seen that based on this research, the research questions which were set at the beginning were able to answer. In the label industry has already done much concerning environment and circular economy. Label producers have desire to process on renewable energy and many of them have some kind of energy promise. Sustainable raw material option has launched to market and development for bio adhesive is ongoing process. The matrix and liner waste are already recycled back to circle. The main founding, which was discovered during the small target group survey was that consumers are willing to recycle the label waste if correct channels would exist.

Based on this thesis, self-adhesive labels can be circular economy –based product if correct raw materials are used. On chapter four the circular economy business models were presented. On that chapter was claimed that product follows circular economy idea if it can be returned back to nature. When using 100% bio gradable raw materials in face and in adhesive the label can be compost, which is giving it back to nature. This needs more research and implementation of bio adhesive to self-adhesive label production. LCA studies from bio adhesives showed that the load for environment is smaller when using bio adhesives than traditional petrochemical adhesives. So even when label would not be 100 % bio gradable, by using bio adhesive is better option and it follows circular economy idea by eliminating pollution.

By solving the recyclability of labels, the life cycle of labels can be further expanded from energy waste to actual new products. The matrix waste handling methods can help with that. Release liner and matrix waste are recycled already

and used for another products. One key solution for label waste could be by solving and creating one over the company lines solution for matrix waste. Now producers have their own recycling and handling process for matrix waste. This mean that they handle only their own waste. Consumer labels cannot be implemented to this as consumers cannot know the actual label producer behind the label and label producers does not want to handle competitor's waste.

One option would be that third party company would done the recycling process. The problem is that even when annual consumption of labels is 8,5 billion square meters, the amount is not much concerning recycle facilities, especially when recycling rate cannot reach to 100%. Let's make assumption that recycling rate of labels waste would be similar than for plastics. In EU level the recycling rate of plastic waste was 19 % based on European Parliament and plastic recycling rate in United States was 4,4% in year 2018 (United States Environmental protection agency). This means that only 0,3-1,6 billion square meter of label waste would be recycled. There could only be couple of recycling centres in world to make recycling plant profitability and we must take consideration the logistics cost for transport the label waste to recycling centre. Based on recycling habits the recycling should happen in EU.

If the matrix waste could be recycled in same recycling centre as label waste the case might be different, but then companies should give up on their own ideas. One idea could be that they sell the matrix waste to recycle centre and then purchase the granulate for their own purposes. All in the name of circular economy and zero waste thinking.

Never less consumers recyclability readiness towards label waste is surprisingly high. Based on the survey the willingness to recycle label waste was 51 %. But as in this thesis was presented, recyclability of labels needs deeper investigation, and this survey was held in Finland where recycling rates are quite high. The environmental knowledge of consumers is both challenge and the future of the self-adhesive labels. Consumers are demanding more environmentally friendly options, and they are aware of how environmental impact can be reduce (Murphy). This might increase the use of recycled materials and biobased plastics and –adhesives in label industry. On the other hand, based on the Instagram survey

consumers don't think about label waste handling options unless clear instructions and regulations say so.

The wash-off adhesive, where the adhesive can be washed off from the container might be one solution to help recyclability. If adhesive could be washed off also from label, the material could be recycled in paper and plastic recycling process. The challenge for this is that in self-adhesive labels the key thing is that adhesive stays stuck on label, and the adhesion is intensified with primers and corona-tion. There should be some kind of chemical solvent which wash the adhesive completely off also from label material.

On bigger picture the disposability and the poor recyclability of labels can increase environmental impact and the amount of waste to world. It might be hard to remove the label fully from the packaging and therefore the container may leave adhesive residues. This can increase the risk that packaging cannot be recycle. Other challenge in label recyclability is lack of needed infrastructure and recycling technologies. Burning label waste as energy rather than dumping it to landfill makes labels circular economy product in countries which uses mainly energy recovery as methods of handling municipal waste.

Global waste index showed that burning waste as energy is not that common. Label waste is mainly forest – and plastic based product. Paper and plastic are good sources for energy consumption, and like UN was presented using waste as energy source is considered to using renewable energy source as waste is renewable. So should we stop thinking waste as problem and bad thing and start discussing waste as one source of energy. Kierrätys.info is mentioning that most often the end use of plastic is energy recovery. In waste burning facilities waste is first crushed and all non-burnable material like metal and bio gradable material are removed from the mixture. Energy waste is used to heating and electricity of households and industry (Kierrätys.info). Like presented in global waste index report, lot of countries are still dump wastes mainly to landfills, and some countries don't have any waste burning facilities.

There is so much what we can do with waste handling all over the world. That will require resources and massive updates to infrastructure, first step would be increasing the rate of recycle and other waste handling methods. This would be completely own research which will not be solved in this research, so how life cycle of labels could be extend otherwise than solving global waste problem.

Increasing the use of bio adhesive and 100% bio gradable raw materials in label product could be one solution to minimise the label waste. In this method we would give raw materials back to nature, and there would be no waste left. 100% bio gradable labels could be utilized for example in food industry and applications where use of the label is short period of time and product are bio gradable itself. Case studies and articles about surgical tape was interesting and they might give some ideas to bio gradable adhesive development.

Unfortunate findings were that none of presented innovations expect burning labels into energy are not possible at the moment. The use of bio adhesive in label making is not yet widely used, and none of the big label producers advertise to have 100% bio adhesive applications on their portfolio. The applications with matrix waste cannot be implemented to label waste unless corporations start to work together and recycle all label -and matrix waste.

With this thesis the reader can have good basic knowledge of self-adhesive labels and challenges for circular economy point of view. Even when this study gave only brief overview of the hole subject it still can be used as base when start to think circular economy in self-adhesive labels. The results map fairly good the issues which should be focused on the future.

From this subject was not found so much other academic research with similar topic of self-adhesive labels as product and circular economy behind that. The other studies were more concentrated on small topics like lignin-based adhesive, recycled and biobased raw material use in label making. Therefore, this thesis gives overlook for the hole topic by combining the different studies into one larger entity. Key findings from other studies which concerns straight to circularity of labels were that the biggest environmental impact for labels does not come from

label waste but the production of labels and by using bio adhesive and raw materials over virgin once have better impact to environment.

As some of the collected data was from label professionals and free internet pages the reliability of data must keep in mind versus if all collected data would have been from technical publications and academic research. This assumption has been made because in academic research and publications the authors must think the ethically and reliability of their work. During this research process the reliability of sources has been one of the key questions which author has pondered when selecting the data, and for that reason the sources which have been used in this thesis are best possible which can be found.

At the beginning was informed that the aim of this research was to present the function of labels and solutions which has already done in self-adhesive labels as well as investigate the new innovations to make labels more circular economy –product. Based on the results, the questions that labels can be circular economy -based product was verified by using correct raw materials in face and correct adhesive in right applications and handling the label waste correct and circular economy way. Whether if the waste is liner waste, matrix waste or consumer label waste. The new innovations and applications were showed which can extend the life cycle of labels, once labels are considered to be waste.

The future of labels can be secured by answering the consumers call for environmentally friendly labels and develop the labels to be more sustainable product. The key element to reach more sustainable and environmentally friendly labels are education and co-operation between professionals and governments. By figuring out the recyclability of multilayered product, which labels are, the new business areas and entrepreneurs for label waste recycling and further processing may arise, this can generate jobs and increase the labour market, therefore national economy increases with the tax revenues and higher consumption.

For further studies the one idea could be modelling the label waste process in laboratory environment. There could be couple of sets using different kind of label faces and adhesives and this way could get deeper understanding for the circularity challenges of handling label waste. One idea would be trying to use label

waste for production of some other product like bio composite or construction films, where the matrix waste was presented to be used.

## 8. CONCLUSION

The aim of this study was to find out are self-adhesive labels circular economy – based product and how can we expand the life cycle of labels, after labels has been stucked to product surface. For both questions were able to answer in some level. With this report the reader can get good foundation of what are self-adhesive labels and what kind of functions and issues can come across when trying to combine circular economy mindset with disposal product.

Like presented before, labels can be circular economy-based product. By choosing recycled raw materials and bio adhesive, when possible, the environmental impact of label could be decrease. Using wash-off adhesives in beverage industry and plastic labels in challenging weather condition.

When trying to extend the life cycle of labels the recyclability of the liner- and matrix waste can give some answer. Matrix waste has same components than consumer label has, so if that can be recycle and reuse in new function, in theory label waste could be also used for same functions and use label waste as raw material of bio composite or construction films. The study of bio adhesive is on-going process and will give new steps for labels to be more sustainable product.

for further studies the recyclability of labels waste could be investigate by modeling the waste handling methods in laboratory conditions. Concerning the self-adhesive labels the developments need to focus on bio gradable and recyclability. By solving the recyclability issues of labels has multiple advances for economy. It can create jobs in recycling area, decrease the waste and environmental impact of the world and answer the consumers demands about more sustainable packaging product. Self-adhesive labels are above all tool for product branding and advertisement, and without labels there would not be ways for products to stand out.

## REFERENCES.

Ahire, J.P. Mousavi-Avval, S.H. Rajendran, N. Bergman, R. Runge, T. Jiang, C. Hu, J. Techno-economic and life cycle analyses of bio-adhesives production from isolated soy protein and kraft lignin. 04-2024. Journal of cleaner production. Vol.447. P 141474. Article 141474.

ScienceDirect. Read on 23.11

BioPak. 17.06.2021. Closing the loop on single use food packaging. Ellen MacArthur foundation. read on 5.10.2024. <https://www.ellenmacarthurfoundation.org/circular-examples/closing-the-loop-on-single-use-food-packaging>

Celab Europe. nd. read on 27.09.2024. <https://celab-europe.org/about-celab-europe/>

Celab. June 2021. LABEL FILMIC RELEASE LINERS. read on 27.09.2024, [https://celab-europe.org/wp-content/uploads/2021/08/CELAB-Technical-Paper-LABEL-FILMIC-RELEASE-LINERS\\_6\\_09-2.pdf](https://celab-europe.org/wp-content/uploads/2021/08/CELAB-Technical-Paper-LABEL-FILMIC-RELEASE-LINERS_6_09-2.pdf)

Celab. November 2020. LABEL PAPER RELEASE LINERS. read on 27.09.2024. <https://celab-europe.org/wp-content/uploads/2021/08/CELAB-Label-Paper-Release-Liners-Technical-PaperFIN.pdf>

Chu, J. 02.02.2022. Engineers develop surgical “duct tape” as an alternative to sutures. MIT News. read on 17.10.2024. <https://news.mit.edu/2022/surgical-tape-bioadhesive-sutures-0202>

Ellen MacArthur foundation. 16.2.2022. Circulate products and materials. a. read on 26.9.2024. <https://www.ellenmacarthurfoundation.org/circulate-products-and-materials>

Ellen MacArthur foundation. 16.2.2022. Eliminate waste and pollution. b. read on 26.9.2024. <https://www.ellenmacarthurfoundation.org/eliminate-waste-and-pollution>

Ellen MacArthur foundation. 16.2.2022. Renerate nature. c. read on 26.9.2024. <https://www.ellenmacarthurfoundation.org/regenerate-nature>

Ellen MacArthur Foundation. 03.03.2023. reusable packaging business models. d. read on 26.09.2024. <https://www.ellenmacarthurfoundation.org/reusable-packaging-business-models>

European bioplastics. nd. What are bioplastics?. read on 25.10.2024. <https://www.european-bioplastics.org/bioplastics/>

European Commission. nd. Waste and recycling. read on 26.09.2024. [https://environment.ec.europa.eu/topics/waste-and-recycling\\_en](https://environment.ec.europa.eu/topics/waste-and-recycling_en)

European environmental agency. 22.01.2024. Diversion of waste from landfill in Europe. read on 16.10.2024. <https://www.eea.europa.eu/en/analysis/indicators/diversion-of-waste-from-landfill>

European Parliament. 24.05.2023. Circular economy: definition, importance and benefits. read on 02.03.2024. a. <https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits>.

European Parliament. 21.11.2023. Pakkausjätteen vähentäminen EU:ssa. updated 24.04.2024. Read on 15.10.2024. b. <https://www.europarl.europa.eu/topics/fi/article/20231109STO09917/pakkausjätteen-vahentaminen-eu-ssa-info-grafiikka>)

European parliament. 19.12.2018. Muovijäte ja kierrätys EU:ssa. updated 10.07.2024. read on 15.10.2024. c. <https://www.europarl.europa.eu/topics/fi/article/20181212STO21610/muovijate-ja-kierratys-eu-ssa>)

Finat. nd. European label industry reports record growth in 2021 but faces volatile times in 2022. Finat yearbook 2022. read 5.10.2024. <https://www.finat.com/documents/1118/fyb22-024-027-029-industry-trends-market-statistics.pdf>

Finat. 06.2024. The role of self-adhesive labels in PET recycling. read on 22.10.2024. <https://www.finat.com/documents/1070/finat-whitepaper-self-adhesive-labels-enabling-pet-recycling-june-2024.pdf>

Forest Bio Facts. nd. learning path. recycled fibre and broke. read on 10.3.2024. need access. <https://forestbiofacts.com/learning-path-b-2/recycled-fibre-and-broke/>

Geneva Environment network. 01.08.2024. Earth overshoot day. read on 26.09.2024. <https://www.genevaenvironmentnetwork.org/resources/updates/earth-overshoot-day/>

Goldsberry, C. 07.08.2020. Avery Dennison Launches Matrix Recycling Program with RoadRunner Recycling. Plastics today. read on 10.10.2024. <https://www.plasticstoday.com/packaging/avery-dennison-launches-matrix-recycling-program-with-roadrunner-recycling>)

Grano. 15.11.2024. Elintarvikepakkaukset ja -etiketit – Ota nämä asiat huomioon pakkausvalinnoissasi. Read on 9.12.2024. <https://www.grano.fi/ajankoh-taista/elintarvikepakkaukset-ja-etiketit-ota-nama-asiat-huomioon-pakkausvalinnoissasi>

Herma. nd. sustainable self-adhesive materials. read on 25.10.2024. <https://www.herma.com/material/products/sustainable-self-adhesive-materials/compostable-self-adhesive-material/>

Huhtamäki. nd. Shrink sleeves. read on 25.10.2024. <https://www.huhtamaki.com/en/flexible-packaging/portfolio/labels/shrink-sleeves/>

Jokinen, A. 2021. Iadullisen tutkimuksen näkökulmat. Teoksessa Jaana Vuori, Laadullisen tutkimuksen verkkokäsikirja. Tampere: Yhteiskuntatieteellinen

tietoarkisto. Read on 10.12.2024. <https://www.fsd.tuni.fi/fi/palvelut/menetelmaopetus/>

Juhila, K. 2021. Laadullinen tutkimus ja teoria. Teoksessa Jaana Vuori, Laadullisen tutkimuksen verkkokäsikirja. Tampere: Yhteiskuntatieteellinen tietoarkisto. <https://www.fsd.tuni.fi/fi/palvelut/menetelmaopetus/>. read on 10.12.2024

Juhila, K. 2021. Laadullisen tutkimuksen ominaispiirteet. Teoksessa Jaana Vuori, Laadullisen tutkimuksen verkkokäsikirja. Tampere: Yhteiskuntatieteellinen tietoarkisto. <https://www.fsd.tuni.fi/fi/palvelut/menetelmaopetus/>. read on 10.12.2024

Jyväskylän Yliopisto. nd. Määrällinen tutkimus. Read on 28.11. <https://sites.app.jyu.fi/mehu/fi/menetelmapolku/tutkimusstrategiat/maarallinen-tutkimus>

Järvinen, P. 2000. Muovin suomalainen käsikirja. Bookwell Oy. Porvoo

Karkuketo, H. Seppälä, M. Törn, T & Viluksela, P. 2004. Kemiallinen Metsäteollisuus 3. Paperin ja Kartongin jalostus. second edition. Opetushallitus

Kierrätys.info. nd. read on 25.10.2024. <https://www.kierratys.info/energiajaete>

Kirwan, M. 2012. Handbook of Paperboard Packaging Technology. second edition. E-book. published as e-book nd. Ebook central. needs access. Read on 10.3.2024

Kosonen, M. Laaksonen, S-M. Rydenfelt, H & Terkamo-Moisio, A. 2018. Sosiaalinen media ja tutkijan etiikka. Media & viestintä. 41(1). <https://doi.org/10.23983/mv.69924>

McDevitt, J. Grigsby, W. Life Cycle Assessment of Bio- and Petro-Chemical Adhesives Used in Fiberboard Production. 2014. Journal of polymers and the environment. Vol.22 (4). p.537-544. read from Proquest on 23.11.2024

Medeiros, D. Braghirolli, F. Ramlow, H. Ferri, G & Kiperstok, A. Environmental improvement in the printing industry: the case study of self-adhesive labels. 05-2019. Environmental science and pollution research international. Vol.26 (13). p.13195-13209. Proquest central. read on 24.11

Muovien kierrätys. nd. Mekaaninen kierrätys. read on 15.10.2024. <https://muovienkierratys.wordpress.com/mekaaninen-kierratys/>

Murphy, C. 12.07.2022. The rise of single-use plastic packaging avoiders. Ellen MacArthur foundation. read on 9.12.2024. <https://www.ellenmacarthurfoundation.org/articles/the-rise-of-single-use-plastic-packaging-avoiders>

Neff, M. 12.07,2022. Label Adhesives: Permanent vs. Removable. Avery. read on 25.10.2024. <https://www.avery.com/blog/label-adhesives-permanent-vs-removable-labels/>

Polifilm. 08.07.2023. POLIFILM and HERMA resolve problem of recycling label matrix waste. read on 10.10.2024. <https://www.polifilm.com/press/polifilm-and-herma-resolve-problem-of-recycling-label-matrix-waste/>)

Stora Enso. nd. Ligniini. read on 05.10.2024. <https://www.storaenso.com/fi-fi/products/lignin>

Suomen pakkausyhdistys ry. nd. Pieni pakkausopas. read on 04.10.2024. <https://pakkaus.com/wp-content/uploads/2024/08/Pieni-pakkausopas-.pdf>

Testova-Färlin, L. 03.03.2023. Voiko kestävä ligniini mullistaa biotalouden?. Sweco. read on 05.10.2024. <https://www.sweco.fi/blog/voiko-kestava-ligniini-mullistaa-biotalous/>

The Cary Company. nd. In-Mold Labeling - What is IML. Read on 25.10.2024. <https://www.thecarycompany.com/insights/articles/in-mold-labeling>

Tilastokeskus. nd. Väestö tilastoina. Maailman väestönkehitys. Read 2.12.2024. <https://guides.stat.fi/vaesto-tilastoina/maailman-vaestokehitys#s-lg-box-16001804>

Ulrich, H & Schabel, S. 2012. Papermaking science and Technology. Volume 7. Recycled fibre and deinking,

United Nation. nd. Renewable energy – powering a safer future. read on 25.10.2024. <https://www.un.org/en/climatechange/raising-ambition/renewable-energy>

United states Environmental protection agency. March 2020. National Overview: Facts and Figures on Materials. Wastes and Recycling. Read on 16.10.2024. latest update 8.11.2024.

<https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials>

UPM Formi. nd. read on 12.07.2024. <https://www.upmformi.com/>

UPM Raflatac. nd. Permanent adhesives. read on 25.10.2024. <https://www.upmraflatac.com/products-and-services/label-products/adhesives/permanent-adhesives/>

Vilkka, H. 2023. Kirjallisuuskatsaus metodina, opinnäytetyön osana ja tekstiläijina. ellibs library reading program. Needs access. no page numbers available, chapters 1.2.1 Narratiivinen kirjallisuuskatsaus ja 1.3 kirjallisuuskatsauksen aiheisto.

Vukoje, M. Ivanda, K. Kulčar, R. & Dolovski, A. Spectroscopic stability studies of pressure sensitive labels facestock made from recycled post-consumer waste and agro-industrial by-products.12-2021. Forests. Vol.12 (12). P.1703. Article 1703. Proquest central. Read on 24.11

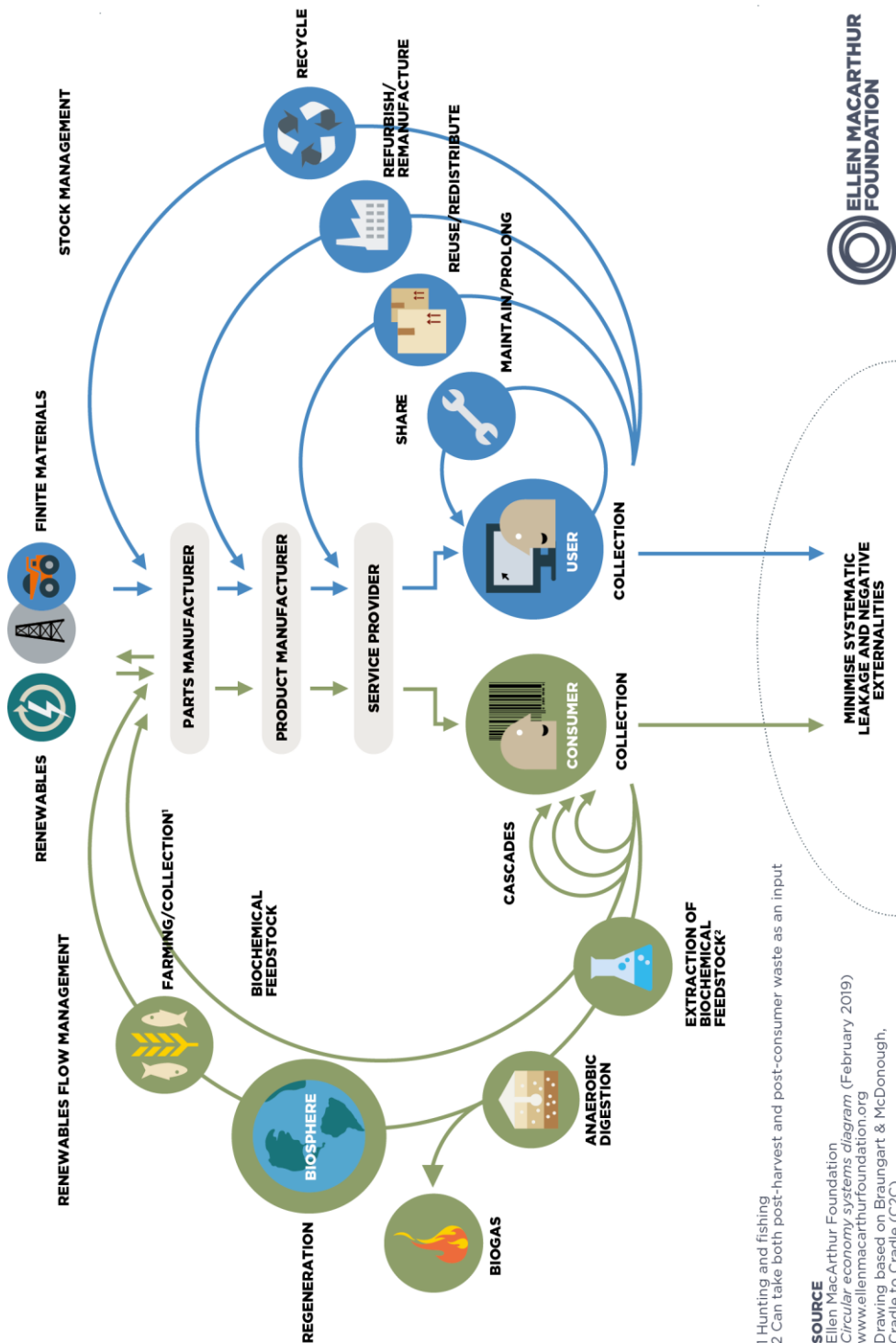
Vuori, J. 2021. Laadullinen sisältöanalyysi. Teoksessa Jaana Vuori, *Laadullisen tutkimuksen verkkokäsikirja*. Tampere: Yhteiskuntatieteellinen tietoaarkisto. Read on 10.12.2024. <https://www.fsd.tuni.fi/fi/palvelut/menetelmaopetus/>

Vuori, J. 2021. Tapaustutkimus. Teoksessa Jaana Vuori, *Laadullisen tutkimuksen verkkokäsikirja*. Tampere: Yhteiskuntatieteellinen tietoaarkisto. Read on 10.12.2024. <https://www.fsd.tuni.fi/fi/palvelut/menetelmaopetus/>

World bank. nd. Population total, New Zeland. Read on 2.12.2024. <https://data.worldbank.org/indicator/SP.POP.TOTL?locations=NZ>

APPENDICES

Appendix 1. Biological and Technical butterfly diagram



Etiketeillä  
tarkoitetaan  
tuotteiden kyljessä  
olevia tarroja  
(pesuaineet  
elintarvikkeet,  
hedelmätarrat,  
kierrätykseen  
sopimattomat pullot,  
pakettien  
osoitetarrat)

pois lukien  
kierrätyspullojen  
etiketit

# Tutkimuskysely

## ETIKETTIEN KIERRÄTYS

Teen maisterityötä (YAMK)  
liittyen etikettien  
kiertotalouteen  
ja suoritan pienimuotoisen  
kyselyn liittyen kierrätykseen.

Tulokset analysoidaan työssä  
nimettömänä käyttäen  
prosenttimenetelmää.

Olisi mahtavaa jos pystyisit  
vastaamaan oheisiin  
kysymyksiin  
kiitos, Liisa

Valitse sopivin vaihtoehto

## 1. Miten lajittelet etikettijätteen ?

Irroitaa etiketin ja lajittelet sen muovin/paperin keräykseen

Valitse sopivin vaihtoehto

## 1. Miten lajittelet etikettijätteen ?

En irroita etikettiä, vaan lajittelet sen purkin mukaan paperin/lasin/muovin keräykseen tai sekajätteeseen

Valitse sopivin vaihtoehto

## 1. Miten lajittelet etikettijätteen ?

Irroitat etiketin ja lajittelen sen sekajätteeseen

2. Jos etikettijätettä kerättäisiin kuten muovia, paperia, ser-jätettä.

Veisitkö etiketit lajittelupisteelle?