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Exploring blockchain technology and recycling futures through speculative design

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Abstract

With the advancing of technologies, the world is still full of issues that we cannot yet resolve. Every day there are so many new applications and products evolving. I am curious to explore how we could go beyond the surface, if it possible to change our value and behaviour in the world to do better through the help of design and technology. This thesis starts from looking at blockchain technology, and the problem of sustainability, to be specifically among the recycling crisis the world is currently facing. Through case studies in sustainability and blockchain, in combination with speculative design as a method. The aim is to explore what are the possibilities to use blockchain technology for good. I hope we continue to dream bigger for a better future with the help of emerging technologies and design thinking.

Keywords: Blockchain Technology, Recycling, Sustainability, Circular Economy, Speculative Design, Human-Centred Design

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1. Introduction

According to UK research organisation Mintel, covid-19 pandemic from 2020 has increased consumers awareness of sustainability in the way they shop in fashion retail. The data shows it to be a higher influence factor to the younger generations, which indicates a culture change in our society. According to Baram (2020), there are 56% of people in the UK considering sustainability to be important when shopping from the high street. It is a welcome shift in today's environment, in my research there is evidence shows that valuing ecological sustainability of the planet has no longer be an option but a must have. Because we live in a world with limited natural resources, it plays a vital role in ensuring human as a society can survive. In the United Nation's recent reports, it shows if we continue the way we consume and produce, only if we have three planets that we can satisfy the current lifestyle by 2050. It highlights the alarming signs and its emergency to be addressed. In association with the world's growth in economy, we also consume more materials, a key issue in this is in how they are produced and disposed. If we do not treat this issue seriously, there will be one day we run out of resources and our survival will be at stake. With sustainability being the major driver of this research, I will focus on the topic of recycling. In this research, I will examine the way we recycle today, to discover the potential opportunities that blockchain can help.

Blockchain being an open sourced database, it allows us to trade without a third party because it is validated through each blocks in the software network. The technology is mostly common seen in cryptocurrency, and is also the technology behind the famous bitcoin. The vision of this thesis is to discover how could we use emerging technology to create better future. In light of the current challenges in the world, how could blockchain accelerate the changes we need to remain transparent and in-control while trading in a globalisation world? The thesis has been organised in the following way. The first section of this thesis will try to define blockchain technology, from the pros and cons I then research where it is currently at and what are the opportunities. So far, very little attention has been paid to the utilise the value of waste in technology. I am exploring the possibilities of blockchain technology in a circular economy to fulfil the life circle of production and waste. The concept of circular economy and value are crucial in my studies. A number of cross-sectional studies suggest an association between circular economy and value, which is vital in the exploration of blockchain technology for recycling. In the case study section, I will cover a varies of industries that allow me to review the callenges and opportunities in sustainability businesses. The main aim of the studies is to help further my imaginations, to better ask how can blockchain be useful to improve the current status of recycling.

Finally, I will use speculative design method, to organise my discovery from the aspect of blockchain, sustainability, and case studies, to build a proposal of design project through a series of scenarios. I understand there are still many skeptism around the technology and its safety and security, however, in this thesis we will use speculative design to try and overlook these issues. My purpose of this project is to dream and innovate for the future of recycling. Studies of Dunne & Raddy (2013) has shown that in emerging technology, there is a need for speculative design because of its ability to evoke viewers for discussions. This research project

aims to contribute to this growing area of research by exploring the possibilities of blockchain technology in recycling. The thesis does not engage with the discussion of whether blockchain is the best solution for the subject of recycling, rather it is focused on how and why. Another potential problem is that the scope of my thesis may be too broad, therefore it can still outline further with more details in studies and designs. This thesis attempts to show that speculative design is important in the future of recycling and blockchain. It requires further attention to think beyond whether blockchain can be the solutions for the world's environmental and social problems, to what may be the possibilities. Up to now, far too little attention has been paid to how we could use design thinking, to aid the development of emerging technologies. This indicates a need to understand the various perceptions of how to drive motivation in adopting new technologies. It is not merely a technical question, but a human one, the key here is to ask how we can fundamentally change our lives for the better.

2. Methodology

In this thesis, we will use a combination of literature review and case studies, to guide a speculative design exercise that allows the exploration of blockchain technology and better understand sustainability. This thesis will take into consideration of mass media, academic articles, and industry reports. The line of inquiry set out in this thesis started from a curiosity of whether blockchain is more than just cryptocurrency. Looking into opportunities and blockchain's research gap in applications, ideas why we do not use blockchain to solve the social and environmental issue for good.

I also focused on the areas I am most concerned in sustainability, to then realise it is actually one of the most desperate problems to be resolved. I find a connection of transparency, and value, in the blockchain and recycled business. Then I researched blockchain's weakness, such as the adoption issue, to use case studies in sustainability with the various industries trying to crack the code of how to run both blockchain and recycling like a business. I borrow these ideas, with consideration of the current challenges and limitation, but rather than trying to design something to fit into the technology restrictions. I use speculative design to help innovate, envision a world without single-plastic waste, and how we would like to design a solution for that future. To be a dreamer and imagine a world we would like to live in.

By using speculative design as a method to coordinate with research in blockchain technology, sustainability, and case studies. I can create a design project that uses the speculating practices, to explore possibilities for a radical change in the way we recycle. Firstly, I began by hoping to understand technology, to try to simplify emerging technology and grasp its core ideas. Firstly, this research project will study blockchain to understand its definition, basic technical concept, then understand what the current research and its gaps in the studies are, to be aware of in which area I can contribute to. Deep dive into the recycling process and what is its problem, to find if there is anything in common to both two very different things. Then research into the most urgent issues of sustainability, to focus on which we want to help inspire the discussion and ideas. I then borrow speculative design, to envision alternative future by dreaming and connecting two dots together. Finally, I hope the project concepts proposed in this thesis will spark conversation and imagine better futures with blockchain in it.

Because applied blockchain technology in sustainability sector is relatively new, I widen my search from collecting from different industries and not limited to specifically the use of this emerging technology. These case studies range from successful sustainability businesses in fashion retail and automobile, to a blockchain recycling startup. The goal is to observe consumer motivation for sustainability, as well as how it is possible make blockchain a profitable business beyond the use case of currency. Through the research, I wish to find success and applied what I learnt from different experts to support the speculative design project. According to

DiSalvo (2012), the speculative design uses design objects and representations to create imaginative realities that offers possibilities of alternative future and present.

Although of its characteristic and inventive nature, speculative design often has strong connection of the present reality. Which is why these design projects can be a mean to offer viewers a different perspective of current system, but through a new lense. Inspired by the project 'Designs for an overpopulated planted: Foragers' by Dunne and Raby (2009), and United Nations' quest for a waste-free environment. I began to imagine, inquire what would our future be in the world of recycling that is driven by blockchain. What if we could use blockchain to change the way we recycle and do it better? Foragers is developed in response to UN's concern on world starvation in 2050, Dunne and Raby developed a project under Design for an Overpopulated planted. And in this project, there's the concept of Foragers, in which the authors' explore alternative ways for people to digest and consume food.

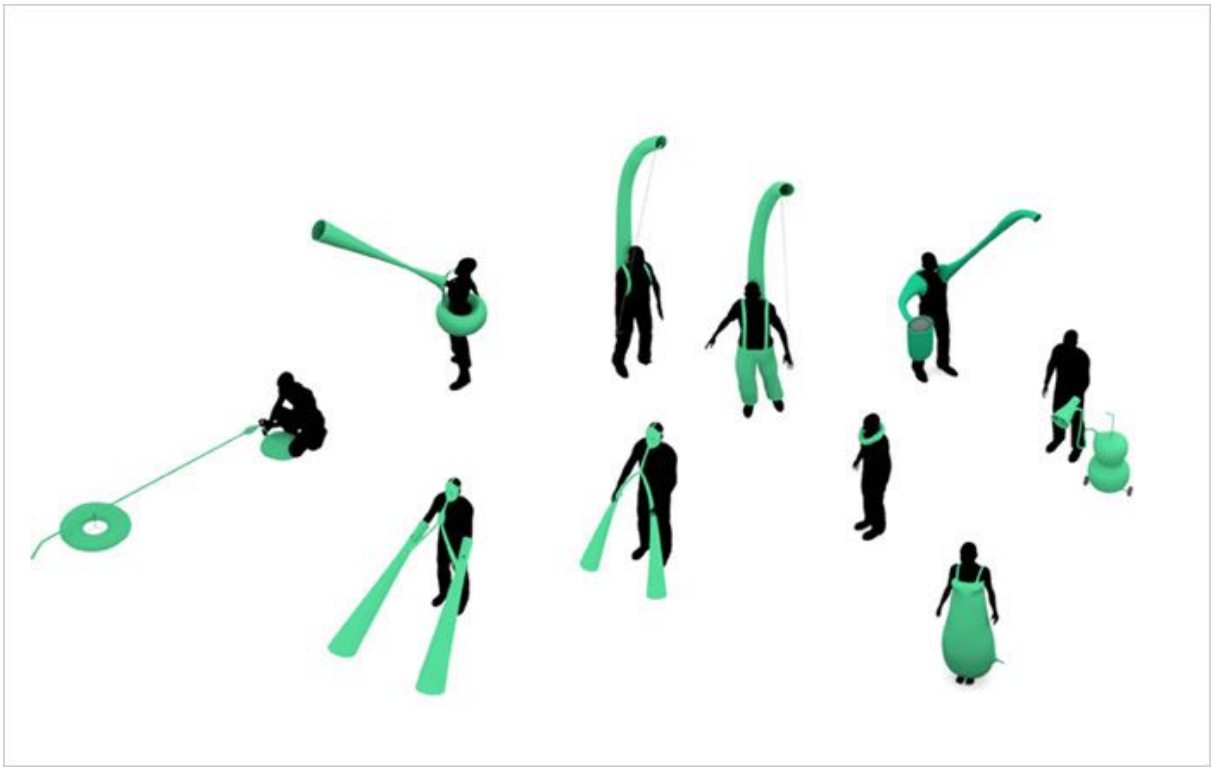

Figure 1. DESIGNS FOR AN OVERPOPULATED PLANET: FORAGERS, 2009[3]

3. Blockchain

Blockchain is a tricky technology to define. In this section, I will first discuss the various definitions of blockchain and follow this with a more critical assessment of the technology's strengths and weaknesses. From looking at the current status and research gap, I will also review the future opportunities and challenges.

3.1 Definition

3.1.1 Origin

Originating from the Bitcoin, which is a cryptocurrency proposed by Satoshi Nakamoto in the 2009 white paper 'Bitcoin: A Peer-to-Peer Electronic Cash System'. Blockchain is the technology behind it, which has been previously outlined in 1991 by Stuart Haber and W. Scott Stornett (Conway 2020). It is often described as a decentralised ledger on a peer-to-peer network. (Herweijer et al. 2018 & Finley et al. 2019). It is said by using this technology, transactions happen in the records do not require a third certifying authority (Herweijer et al. 2018 & Finley et al. 2019).

The name of blockchain, coming from the ledger being connected with many transactions' blocks[4]. Using cryptocurrency as a use case, everyone on the network stores an identical copy and no one can spend their coins twice (Finley et al. 2019). According to Nakamoto (2009), it prevents the double-spend problem, because each transaction is stored in blocks and will notify the entire blockchain network if any new information is added to the block. If it is already spent, the network will not accept this transaction. Double-spend problem, explained by Tapscott & Tapscott (2018) the internet we use now is the internet of information, everyone can make transactions of copies of digital assets but not the original. However, blockchain is to ensure there is only one copy and that is the original, similarly to the idea of banking. When one pound is transfer out, the bank makes sure there will be one pound deducted from your account, this is also the core idea of blockchain.

3.1.2 Internet of value

Tapscott & Tapscott (2018) described blockchain to be the internet of values, which is a new digital medium provides a peer-to-peer medium for value. The authors believe it is a breakthrough in technology after the invention of the internet, but recognise it is being rather hyped or feared by the public. To see beyond these phenomenon's, authors suggest if we limit our imaginations we might just miss seeing blockchain have a profound potential to affect our future. Compare to the globalisation world we live in today, it was easier to trade when the community was much smaller, people are more likely to trade with each other directly. Where you can verify, and to be closer the source of each transaction. But with the society grows and distance increase, we had to rely on institutions such as banks to help us facilitate and exchange value (Warburg 2016).

3.1.3 Simplify the idea

However, despite it being viewed as promising to the authors, the ideas of how blockchain technically works under the hood, might be often complex enough to keep an average user at bay, since it is still a relatively new technology from it was first mentioned by Nakamoto (2009) as the underlining technology of Bitcoin. In the documentation of Ethereum, one of the leading blockchain platform for cryptocurrency and decentralised applications, suggests the best way to describe blockchain is 'a public database that is updated and shared across many computers in a network'. To simplify, blockchain is an open source platform that can be used to store data with an immutable quality that cannot be amend.

3.1.4 Summary

Although the concept is a still a little bit difficult to grasp, Warburg (2016) argues that not everyone understands internet but almost everyone uses it. It is undeniable one of the most impactful technology we rely on heavily today, with 4.66 billion active users[5] in the world as of October 2020 which make 59 percent of the global population. Therefore, there is no reason why blockchain cannot become useful and widely adopt in many everyday use cases, despite it being hard to understand. I argue, solid use cases might be more important than users' ability to make sense of the theories behind it. There are increasingly more non-technical background experts began interested and to research in blockchain, and to influence to other non-technical users with hope to educate others and increase adoption. For example researcher Warburg (2016) from a nearly 4 million viewed Ted talk 'How the blockchain will radically transform the economy' is of a psychiatry background, and Tapscott & Tapscott (2018) author of 'Blockchain Revolution: How the technology behind bitcoin and other Cryptocurrencies is Changing the World', also a 5 million view Ted talk speaker 'How the blockchain is changing money and business' is from a business background. From here, it is observed as a shift of interests from computer science to a wider range of disciplines, similarly it is starting to attract broader consumers and viewers.

3.2 Positives

Difficulties in defining blockchain aside, it is possible to outline a few of its strengths and weaknesses. Novelty in blockchain has given us a new way to implement business model, to solve problems other than the original bitcoin to solve financial transactions. To remove the monopolies and given the power back to the people. I recognise the similar pattern, as in the world of recycling and sustainability, it is not always transparent and we have very little control over what are the so-called sustainable materials coming from, and where does our recycles go (Harrabin et al. 2019).

3.2.1 Transparency

Blockchain has ability to track and trace, its underlying value in transparency, all seem to align with the idea of circular economy and its importance to consumers (Macarthur 2020). Perkam (2018) even went ahead and call blockchain 'a potential game changer'. The author suggests what makes blockchain a potential game changer in the waste manage space, especially plastic and packages that most desperately need focus on. Reason being is that blockchain's core value of offering a trusted platform with non-reversible data and value. Similarly, Swan (2105) believes it can provide positive changes to the global environment. The authors may not be the only one believe in blockchain technology has the potential to change hard problems. Besides the technical leaders, there are also many believers that speak the benefits of the technology. It gives hope to offer radical changes to the broken system.

3.2.2 Trust

Trust is another important factor in the technology, and both sides have arguments in this discussion. Trust is also a benefit that being emphasised in this new digital infrastructure and is often described to be a trustless system (Tapscott & Tapscott 2018). It is suggested to be possible to remove power from the monopolies in industries, because of blockchain network can offer accurate information that is encoded and therefore cannot be changed. Because it removes the needs for a trusted third party organisations, and it avoids the power of monopoly such as banks (Warburg, 2017 & Daniel et al., 2019). Here we should be aware are trust being on the other side of the fence of its enhanced security, the trust in governance of a system cannot yet simply replaced by blockchain technology. There is still a difference between trust and verification (Schneier 2019).

3.3.3 Cost and efficiency

Di Francesco et al. (2020) state that because of blockchain's feature of traceability, and its ability to store immutable data. It can lower business cost of individual auditors and reduce the management the process of tracking products, which is a great motivation for companies to want to adopt blockchain into their system. It can also be a key feature to bring in a localisation-like trading, to the largely globalisation world, due to its easy traceability.

3.3 Negatives

Just as there are a lot of hypes around the technology, same as the amount of skeptism. Many are concerning it is a problem looking for a solution, and in result of solving fake problems. (Finley et al., 2020)

3.3.1 Technical barrier

A lot of people do not understand how blockchain actually works and how is it different with advanced programming. My assumptions are you do not need to understand technology to be able to use a product or services. Such as we have almost 4.57 billion active users of internet as of April 2020, but not everyone understand how it works. To this date, concept of internet is still complicated to many people's minds, but it does not stop people with minimum technology literacy to operate and communicate through the invention. If you look at blockchain, similar idea here is that while it can be a frustration, might not be a deal breaker for end users.

3.3.3 Security

Risks are a major concern to many people when it comes to blockchain technology, as hacks and attack still happens within the space of cryptocurrency. Because there are high hopes for the technology, the increasing hypes around the topic have also attracted scammers and hackers (Tapscott & Tapscott 2018). In 2016, $50 million worth of cryptocurrency Ethereum, due to a coding error had allowed an unknown individual to hack and bag these invested digital currency. Although blockchain can ensure each transaction being verified through its decentralised network, like many other technologies we cannot overlook human error (Finley 2019).

3.3.4 Energy consumption

Trapscott & Trapscott (2018) pointed out that the energy consumption of blockchain technology could be concerned as its impact of environment. Environmental impact in the technology itself is something we should be aware of. A more aggressive example would be the mining of Bitcoin, running computer algorithm to mine new cryptocurrency, which requires a lot of computer power. According to Ethereum's documentation, miner helps by solving computer to secure the network.

3.4 Current Status

Current discussion of blockchain technology, mostly are still economic related. It initially started centering around Bitcoin, which blockchain is used as a peer-to-peer decentralised payment system (Nakamoto 2009). Slowly, there are a lot more discussions around other applied use cases, such as voting, and music. (Tapscott & Tapscott 2018). Additionally, Big technology company such as IBM play a leading role in supply chain management, including waste supply chain. However, finance is still the strongest use-case of blockchain technology (Casino et al. 2019).

3.4.1 Blockchain 3.0 in the rise

According to Swan (2015), the blockchain 3.0 represents the technology's shift from cryptocurrency to applications beyond economy. It is possible to use such technology for all industries, although not apply for every situation, it is particularly useful where verification and some form of trading is required (Swan 2015). At present, supply chain management might be the next best use case. Some enterprises are already running prototype projects. Walmart has worked in collaboration with IBM for China's pork industry, to verify the source of pork in supply chain management (Glomann et al. 2020). There is also an increasing number of small startups running decentralised applications (Dapps[6]), on blockchain platforms such as Ethereum.

3.4.2 Blockchain for Good

> "While blockchain has the potential to become a powerful foundational technology used across different sectors to tackle a wide range of challenges and opportunities, if it is to be truly transformative for our global environment, it will need to be deployed in the right areas."
>
> (Herweijer et al. 2018: 16)

It has been undergoing researches in the areas of blockchain for good, which is what this thesis is particularly interested in. Many has claimed blockchain might be the revolutions the world needs. (Trapscott & Trapscott 2018). With for-profit institution such as Pwc, and other organisation including the United Nations (UN) and non-government organisations (NGOs), are investigating efforts into experiment and research in Blockchain technology for environmental and social good.

3.5 Research Gap

The danger of jumping in emerging technology, reverse the problem-solutions logic is that. There are a lot of problems do not exist, which is against how a product or services. We will use the research to valid the problems, and by talking to people we can understand how blockchain can help society to solve these tough problems. Or it is a problem that can be solved, even without the implementation of such technology. It is very interesting to use technology to solve fundamental issue in the world. Despite its promise of removing trust from the third party organisations, according to Schneier (2019) we could not trust on technology alone because there

are other aspect to trust than it simply being always right.

There is a lot of research within the field of economics but not as many applied blockchain with strong use case. Lack of research considering human factors, including usability, design, and HCI (Casino et al. 2019). Yli-Huumo et al. (2016) did not find any papers in usability from the developer's perspective, however there were some in regarding to the technology itself. I noticed there is a lot more research in the field of computer science, where the technological side of blockchain is still being discovered and studied. In terms of the usability, and how to adapt human error with the technology was not widely discussed. There was not enough analysis of how blockchain is being used currently, which might be because of it is still having trouble in mass adoption. To allow the technology being mass adopted in real use scenarios, there are also other aspect of the concept need to be discovered. Example of areas which are lack of research are: usability in blockchain applications; and blockchain from a HCI perspective. To put blockchain in the centre of human day to day activity, we will need to take closer look into how economy, value, trust, business model, are defined and functions, and we will explore multiple futures to explore possibilities of the technologies with speculative design. Beyond hype over how the technology would work and focus on the problem itself to put the technology to test.

4. Sustainability

Considering the current emergency on climate change, to think collectively for a sustainable future has become an unavoidable challenge we have to face as a global society. In this section, I will discuss the problem and opportunities in the context of recycling and waste management and why blockchain technology might just be what we need to make radical changes.

4.1 UN's Sustainable Development Goals

"By 2050, the equivalent of almost three planets could be required to sustain current lifestyles"

(United Nations, 2015).

According to United Nations, human have unlimited needs, but the challenge we are facing is that the plant also has limited resources to provide. The current plant would not have enough recourses, assuming the world's population rise to 9.6 billion by 2050. This problem is closely related with the way consumptions and produce. UN has proposed a covid-19 response, to consider the global crisis as an opportunity for the world to make radical changes, it is clearly an revertible ask for commitment of countries to collaborate to shift behavioural and social changes. It is also said that the needs of nature materials, will require a more sustainable economy and recycling to reduce its impact to the environment and people.

As a reflection to 17 sustainable development goals[7] adopted by United Nations (UN) on 25 September 2015, aiming to resolve urgent global issues of poverty, hunger, inequality, injustice, and climate change by 2030. This research project is inspired by goal 12[8] responsible consumption and production (See figure 2), to recycle paper, plastic, glass and aluminum. From UN's report in 2020, economic growth also contributes in the increase of material consumptions, mark a 17.4% increase from 2010 to 2017 which reach to an 85.9 billion metric for the world (See figure 2). It also shows that in 2015, in higher income countries was over 10 times larger than lower income countries. The report also shows electronic waste (e-waste) because of its short product life and not always possible to repair, and its slow rate in recycling contributes to pollution at the same time create wastage of nature resources that are limited in our environment.

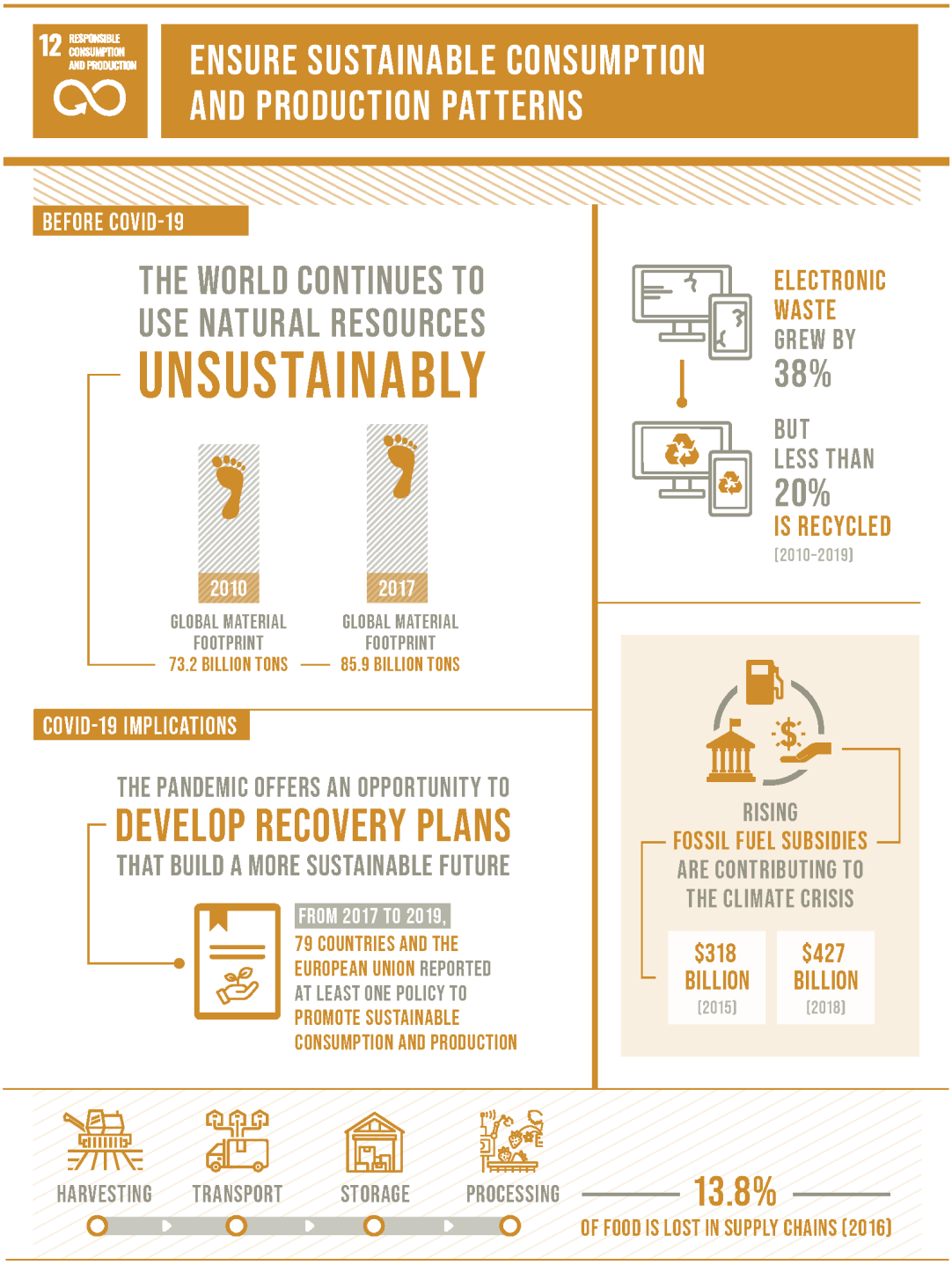

Figure 2. [Goal 12 infographic, source: https://unstats.un.org/sdgs/report/2020/](https://unstats.un.org/sdgs/report/2020/)

4.2 Waste Management and Recycling

Following research will discuss the current situation of waste management and recycling process, which is in response to recycling goal 12 from United Nation.

4.2.1 Complexity of recycling process

Incorrect recycling could slow down the recycling process[9], and with so many different types of materials, do we know how much of our recycled waste make it to the recycling process. See Figure N, it shows the reader just how many different types of waste materials there are and how each needs to be sorted and treated differently.

Figure 3. Recycling Centre in Barnet, North London (Sep 2020)

4.2.2 Where does it go

If we know the fact that by placing incorrect items into the recycling, will slow down the recycling process, or even reduce the rate of recycling. Will we still consider of doing it? But the truth is, most of us, do not understand the protocol of recycling,

recycling process, or where does the recycling go. Take plastics in the UK as an example, there are over 100,000 tones goes to Malaysia, and around 80,000 tons of plastic end up in Turkey between Nov 2017 to Oct 2018 along (See Figure).

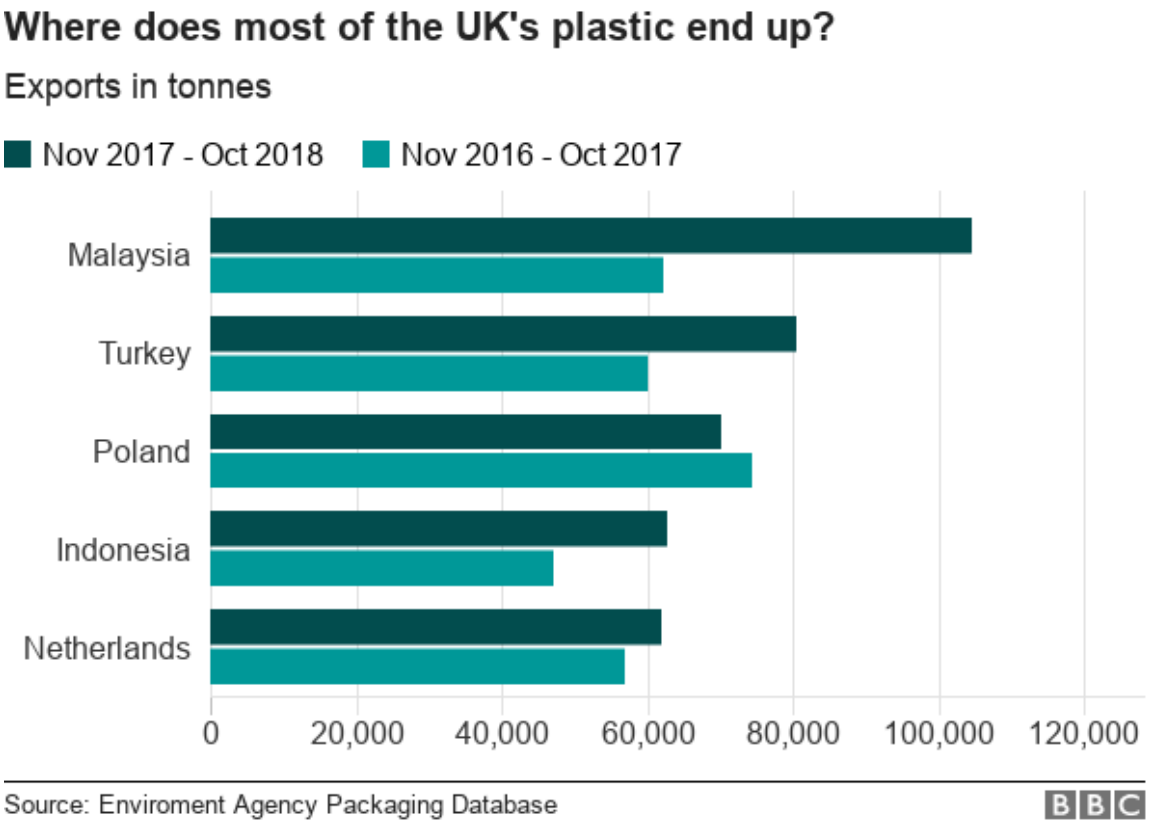

Figure 4. Where does most of the UK's plastic end up? (BBC[10] sourced from Environment Agency Packaging Database)

4.2.3 Recycling Crisis

From my observation in the research, there is too much recycled waste but not enough capacity to process them because of the cost. For developed countries including UK and US, it is often a solution to send these unprocessed waste to China, until its China's waste import ban in 2016. Since the needs of sending this waste is still a need. According to the diagram, it is reported to be sent out in other countries. People's good will to recycle their waste, similarly also an issue in the fast fashion industry, seen in The True Cost, discussed how in developed countries people donates overwhelming amount of clothes to charity shop. Ended up sent to African and eventually end up in landfill, but these subjects do not often be put in front of our eyes. Often people feels good recycling, but first they need to ask themselves the questions, 'is it really recyclable?', second, 'does it really get recycled? and are you confident it is not going to landfill?'

Figure 5. Recyclable waste in Seattle. Source: Your Recycling Gets Recycled, Right? Maybe, or Maybe Not https://www.nytimes.com/2018/05/29/climate/recycling-landfills-plastic-papers.html

4.2.4 Impact of China's waste import ban in 2016

Following with China's import ban of plastic waste in 2016 (See figure), there are many instances that waste from countries like the U.S. and Europe, has continuing issues emerging in news (Harrabin et al. 2019). For instance, Turkey has become the largest centre of plastic waste dumping in Europe. South east Asia such as Malaysia, has become another centre where the plastic waste gone to. Using UK as an example, Between 2016-2017. And 2017-2018, up to 100,000 tonnes plastic exported to countries from Malaysia, Turkey, Poland, Indonesia, and Netherlands. (Harrabin et al. 2019)

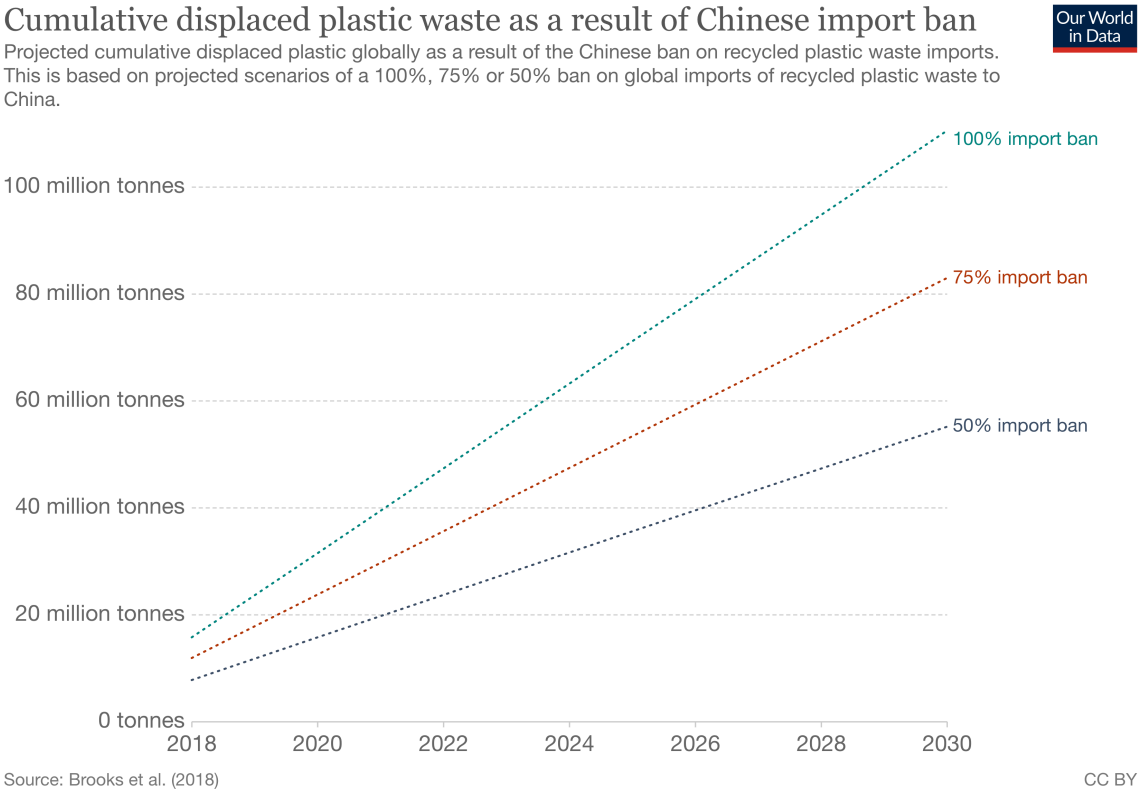

Figure 6. The Chinese import ban and its impact on global plastic waste trade (Brooks et al. 2018). Source: https://advances.sciencemag.org/content/4/6/eaat0131

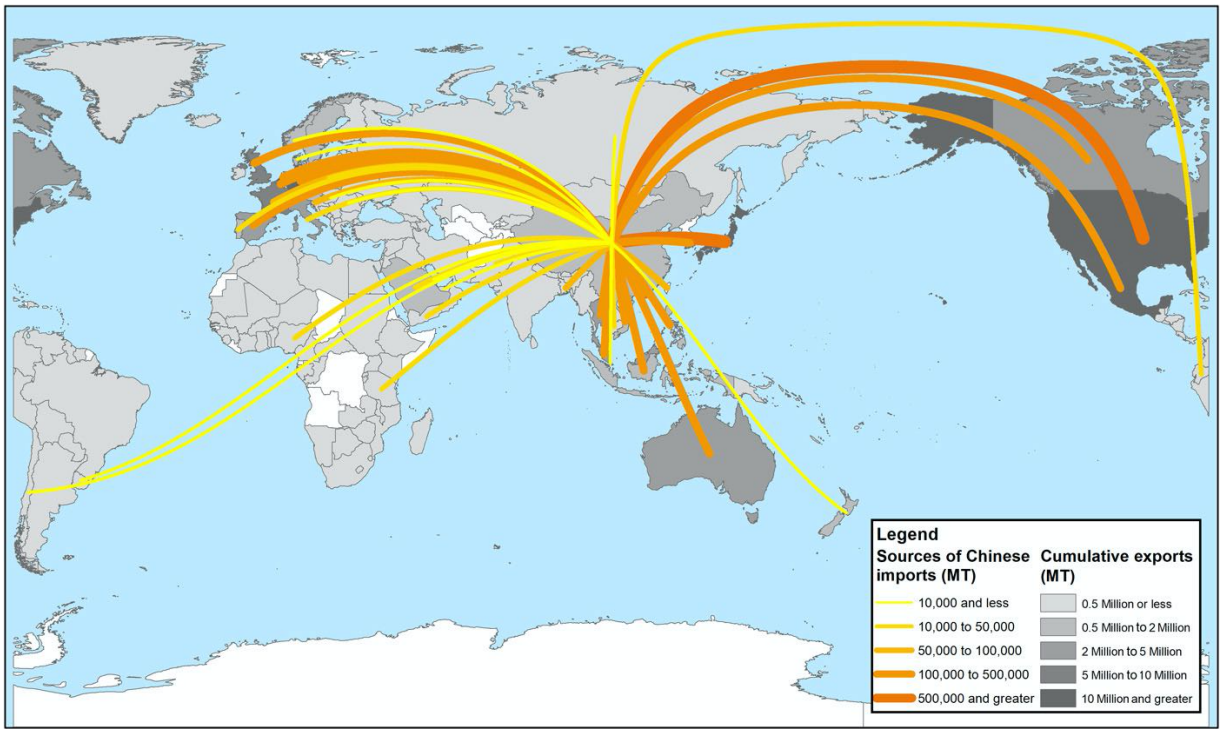

Figure 7. Sources of plastic waste imports into China in 2016 and cumulative plastic waste export tonnage (in million MT) in 1988–2016.

Source: Brooks et al. 2018

4.2.5 Single-use Plastic

It is not just all recyclable waste that causes issues. One waste is more problematic than the rest. To be even more precise on the topic of plastic problems. It is to say that single use of plastics, plastic packaging along are contributed to half of the plastic waste around the world. Plastic were invented to improve our quality of life, despite it is cheap to make, convenient, it can take up to thousand years to decompose, whilst it scatters in the environment or in the landfill. For these single-use plastics to go into landfill, is because plastic is not biodegradable for thousands of years (United Nation Environment Programme 2018).

4.3 Circular Economy

Recycling and the idea of circular economy both share a mutual goal to reuse and eliminate waste. In the section below, this research will discuss the concept of circular economy and why blockchain could reconnect trash with value in the supply chain.

4.3.1 Definition

To replace the traditional linear approach, every products or packaging have one life from produce, to use, then ultimately end up in landfill. Macarthur (2020) suggests moving away from the traditional linear 'take-make-dispose' approach will need the help of design. To move towards a circular system where it puts the resources back to economy again, following with growth in the economy and a better more sustainable environment. The author proposes this is a valid concept that both the business, people and environment will win. In a Circular Economy, we put the bond to be landfill material back to the economy. (Strategy for a Waste-Free Ontario 2017). The framework is discussed by many businesses, organisations, and governments around the world. Including United Nation (United Nation Environment Programme 2018) and European Union, as an ambitious response to tackle climate change. It is also not a new concept, according to Macarthur (2020), it can be traced back from the 1970s. This is also when the idea of 'Cradle to Cradle' has born, which is a design framework that promotes a workflow of industrial materials to be continuous use.

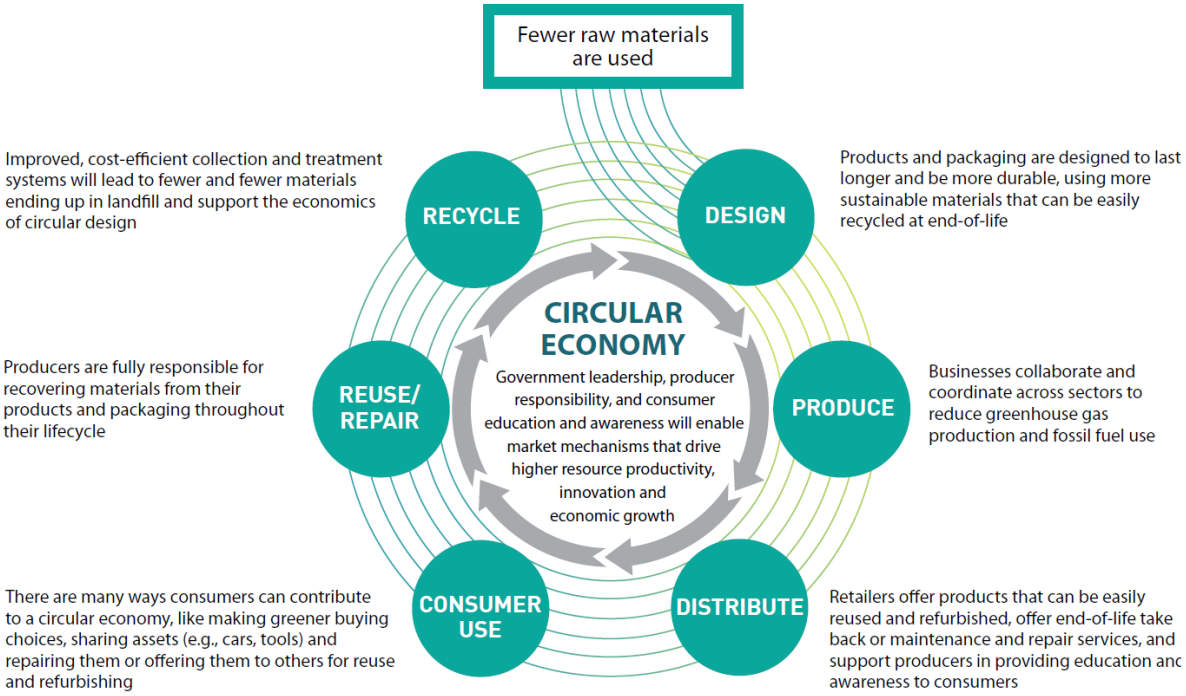

Figure 8. A graph presents how Circular Economy works in improving environment and less waste. Source: Sourced Strategy for a Waste-free Ontario Building the Circular Economy (2017)

4.3.2 Value of Trash

Circular Economy seems to be a win-win solution. However, it is still difficult to be applied in our current system. One of the reasons is because the cost of reprocessing, similarly to recycling, when it is the cost is high there will be little motivation to consider circular economy (Chidepatil et al. 2020). This is where the opportunity of blockchain, author suggests that by using such technology, manufacture can better access accurate information of recycled materials.

This trash was produced with value and this value should find their way to recover back to either recycled packaging, or new materials (upcycling) that retain value. For example, if a plastic bottle coast £0.2 to make, and £0.5 to sell, if we can reduce the cost of the ‘recycled ‘process to the minimum. These materials that were waste should be able to generate profit from only the cost of processing and storage? The idea of circular economy is to put the resources back from the waste, and in this research project I would like to explore this concept using speculative design.

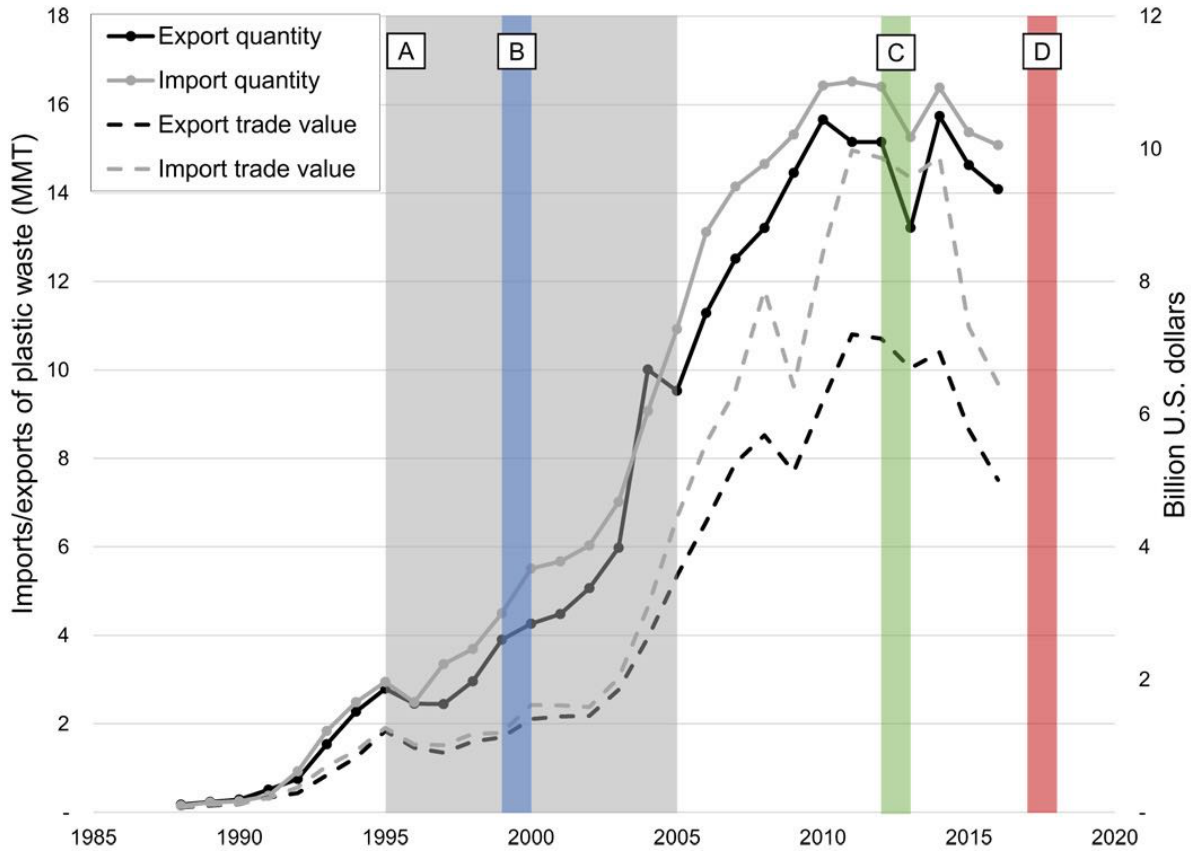

Figure 9. Quantity of import and export plastic waste. Trade of plastic waste in mass and trade value (UN Comtrade data). Cited from Brooks et al. (2018).

5. Case Studies

The issue of sustainability is closely tied to many industries and different technologies. It can be examined across fashion retail, automobile, and of course the waste management. In this section, we will use following case studies, to understand the different aspect of sustainable businesses in aid to understand how can we align consumer behaviour, in the sustainable goal of reuse, recycled, and reduce waste (The 3R[11]'s in waste management). Here I will discover insights of the trend and successful business models in relations to sustainability, and finally how blockchain is currently used to solve the environmental problem of waste and recycling, specifically plastic and packaging waste

5.1 Everlane: transparency

With the sustainable trend in fashion retail industry, the importance of transparency is often rise of awareness in the centre of consumer's mind (Baram 2020).

5.1.1 Background

During the research, it is made aware there are quite a few clothing companies with growing demands on clothing made from recycled material and to promote long-last design. Another successful brand is Veja[12], a French footwear retailer founded by Sébastien Kopp and François Ghislain Morillion, also with a strong focus on transparency, along with responsibilities in both social and environmental. They have a product line with wide use of recycled materials including plastic bottles. Finally, we cannot not mention out-door gear company Patagonia[13], founded in 1973 by Yvon Chouinard, a social and environmental impact before the recent wave of conscious buyers. In Mintel's research reported by Baram (2020), it shows companies like Everlane has a solid customer base. Which inspired many other companies to follow its steps. It is evident we should further explore the demands of recycling material and given the opportunities to truly disrupted recycling industry and made the profit accessible to everyone. If a cult-like royalty is what we need behind sustainable brands, we should investigate how their value proposition speak to their customers.

5.1.2 About

Everlane[14] is a clothing retailer manufacturing women and men's wear with an ethical vision. It is founded by Jesse Farmer and Michael Preysman in 2010, and is based in San Francisco, California, United States. They have many 'renewed' products made from recycled material such as plastic bottles. Their value propositions are transparency and sustainability. The brand is tackling the issue of traditional retail, especially fast fashion which was explored in documentaries such as *'The True Cost, Documentary, 2015*[15]*'* with the poor working condition and environmental cost behind the scene. The company's success has verified the customer's desire to understand where their garment is made, and the transparency

of pricing.

Yet, it is still not very clear how do they compare to 'traditional retailers. Stating on the company's official website could made up to 5-6 times. (*Everlane Official Website*[16]). Which I believe blockchain technologies track and tracing from the source of supply chain will add value in a use case like this. To give inimitable data regarding where the product is from, the material is sourced, and ultimately, which can help to validate Everlane's truth to be more than just marketing.

5.1.3 Material, supply and sourcing

Despite its effort to be an ethical brand, there is however no evidence of materials their supply chain use, how they pay the factory workers, beside their information on the website. Whether their ethical approach is genuinely going to make a difference, time will have to testify. Furthermore, this is where I believe blockchain might be able to make a difference in terms of immutable data to trace how a material is made during manufacturing.

5.1.4 Summary

Other than Everlane, we see the demands from the increasing brands promote their use of recycled material, or rebranding it being sustainable. These fashion retailers including H&M, Primark, although Everlane is still one of the leading brands in this field (Baram, 2020). In their winter 2020 collection, H&M[17] designed and manufactured the entire line made from waste. In short, we understand from this case study that sustainability is profitable business, there is a demand and recycled material (e.g. recycled polyester), a royal customer base for sustainable fashion retailer, and transparency is a void in customer's mind. But we still don't know where exactly Everlane buy their recycled material from, or the cost of these materials.

5.2 Tesla: carbon credit

Fossil fuel is also another concern related to the UN's goal of responsible consumption and production. Because of it being one of the major contributions to climate change, due to its large generation of greenhouse gas emissions, and it being an unsustainable energy.

5.2.1 Background

During the pandemic, Tesla's stock[18] price has been sky rocked. I wonder whether it has anything to do with people's quest of sustainable energy. There are also increasingly more common to see electronic cars in the market, traditional brands such as mini cooper[19] and Toyota[20] are producing electronic cars beside their regular gasoline powered cars.

5.2.2 About

Tesla[21] is a motor company developing fully electric vehicles, based in California, United States. Their products currently including 4 different models of electronic cars, as well as other green energy products as solar roofs and solar panels. Forbes[22] indicates the company is founded in 2003, by Jeffrey B. Straubel, Elon Reeve Musk, Martin Eberhard, and Marc Tarpenning. According to Tesla's official website, their mission is to 'accelerate the world's transition to sustainable energy.' According to Musk (2017), it is an inevitable trend for automobile to find alternative energy source because one day it will run out. The vision of Tesla is to accelerate of the shift of using electronic cars and make it mainstream. Therefore, other companies in the industry will likely to want to follow, which is the future that he wants to see. Sustainable energy is at the centre of the company's value. Besides electric cars, it also provides solar and clean energy products. Similarly, brands should not treat recycling, reuse or reduce waste as an afterthought, we need to put in the forefront of our mind.

5.2.3 Business model

Beyond recycling, I want to on the success on the electronic car manufacture Tesla. Through them to understand environmentally conscious customer, who love to see the change and there are still potential to grow. Besides producing great product, they also have a good business model and an attractive proposition offering electronic energy that is cheaper than fuel. Which is what still struggling to achieve in the industry of waste management. To investigate how sustainability, play into the successful brand, says the creator of Tesla. It is not just an electronic car, with the ability to use electricity replace fuel, what differentiate their products with other electronic cars on the current market, it an attractive design that adds value to the product, and a prestige proposition to make it desirable. Not only that, Tesla has exceeded its stock price during the challenge period of covid-19, with the desire of cars during the pandemic. It has potentially pushed the company even further, also helps electronic car to become more popular than ever before. As a leader in the market, it has increased the speed of electronic cars adoption in the market. The stock price has proven consumer's confidence in sustainable energy and interests in electronic vehicle becoming mainstream.

5.2.4 Regulatory credits[23]

I started by looking for a successful business Model. During our research of how Tesla becomes successful in their market and growth. An interesting finding, we came across is that how much regulatory credits contribute to Tesla's business. How does Tesla profit from regulatory credit and what is it? And what can recycle industry and blockchain learn from it? According to Duggan (2020), Regulatory Credit are an environmental emissions program that gives credits to electronic vehicle manufacturers, and because that is at the centre of Tesla's business they hold a lot of these credits that are desirable to trade with other automakers. The regulation runs in more than 13 U.S. states, and the motivation behind the purchase of these credit are to avoid penalty.

5.2.5 Summary

The reason why we started by looking at business model of automobile is because I wanted to learn what is the key that makes Tesla so successful. There are not many established businesses in blockchain besides cryptocurrency (Swan 2015). Blockchain, also a novelty technology compares to the use of electronic in cars. In the case study of Tesla, I was interested to know how it changed people's behaviour and their value. For example, why is that we must use sustainable energy, versus, why is that we need to care about sustainability and the environmental issue of waste. Tesla is a perfect example of how by changing our perception of an environmental issue, as a profitable business that can provide value that does good to the world. Finally, my discovery of regulatory credit has greatly inspired my speculative design project.

5.3 Empower: value of waste

In searching solutions for recycling systems, there are many blockchain-based applications. I have selected one of them as an example of how it may work, and what could be further improve.

5.3.1 Background

Peshkam (2019) states, beyond just Empower, there are many more blockchain startups trying to tackle the same problem around the world including Plastic Bank, Circularise, and Litterati. Rising in these startups has given us hope, that maybe blockchain could change the broken recycling system, and change the way people behave around waste collection and recycling.

5.3.2 About

Empower[24] is a for-profit recycling startup form Norway, using Stellar blockchain token EmpowerCoins (EMP) to get people around the world to cleanup waste. Companies can make donations for waste cleanups around the world (Peshkam 2019). Founded by Wilhelm Myrer, their goals are to encourage initiative in cleaning plastic waste in exchange of tokens using blockchain. Empower tackle problem of recycling and waste. Initially, the founder was focused on developing a use-case around banks before they brainstormed and the idea of an alternative blockchain recycling system was born. Their platform gives plastic waste a value through blockchain token, allowing everyone in the world to be paid by digital currency when they collect and recycle (Sheffield 2018).

The results are astonishing, according to Peshkam (2019) they have funded cleaned up 16,508,995-kilogram plastic as of 5 July 2019. As a for-profit business, Empower also shows us that there are huge market potentials in the value of plate waste. According to The Explorer,[25] an official marketplace for teen tech from Norway, there are more than USD 10 billion worth of plastic waste , and if all these

waste all turn into recycled materials that circular economy, would possibly create USD 50 billion of market value.

5.3.3 Fraction of a problem

As part of the 3R[26]'s in waste management, Empower has fulfilled the recycling side of the issue, however, there are other aspect of environment that are still require focus, to reduce or reuse. The amount of collection may be impressive, that also shows how much waste is there. A result of blockchain environmental startup starts to emerge is good, but can we think even further to challenge the current system, to push for ensuring everything we recycled are actually being processed and not end up going to be exported or landfilled?

5.3.4 Summary

From these case studies, we found that blockchain could be hugely beneficial in a market that Everlane trying to pursuit, of consumer's desire of transparency. Knowing where their goods are made from and understand the source of materials. Because of their have 'transparency' in common. Which I believe, is what we are going with the future. As for the credit use of Tesla, we realise that is it possible to utilise such regulation in the future of recycling. Together, with our understanding of other sustainable businesses, we visited one of the most hopeful blockchain application in the category of waste issue, Empower. I then narrow it down, using Empower as an example to show how blockchain is used to solve the problem of waste. From this case study, I learned that one of the desirable solutions to provide waste with a value. Ultimately, by looking at from far then close in, I have seen ideas I can borrow going forward in the speculative design project.

6. Designing for the Future

So far, I have looked at blockchain technology, sustainability, recycling and circular economy. I have also learned from case studies in varies sectors, to conquer potential challenges and seeking for new opportunities. To help us go further with these complex ideas, in this section I will explore and use speculative design to create a design project that can be built further.

6.1 What is Speculative Design

Dunne & Raby (2013) suggests that speculative design allow us to design as a tool to innovate, imagine or dream different futures. Which is beyond applications but rather to generate ideas and visions. In speculative designs, participants challenge and examines through design. To make something, you must first break it. Whereas different than science fiction, speculative design is often based on existing culture and explore what might be the future become using a taxonomy of futures.

The authors suggest a taxonomy of futures (See Figure 10) in design. Which is in consisted of cones of possible, plausible, probable, and preferable futures. These cones are represented by its likely hood of happening in the future, according to what is possible in the present. Future cones can be as a tool to help us challenge boundaries, from outside (possible) in (preferable). In this way, we are using design as a tool to better understand the present, which allow us to explore desirable futures, and at the same time, to discover what we might not want in the futures therefor have opportunity to avoid it now. They are not interested in predicting the future but to use this method to dream, especially in science and technology. It does not mean fantasy, rather to consult with experts in varies areas, including using what-if scenarios to explore an alternative system or model, which might not remotely seem possible at present moment.

The authors also illustrate the dilemma of design in twenty-first century, when designers goal is problem solving, and in many very desperately needed to change subjects. Includes which we are discussing in the thesis, the problem of sustainability and recycling that are tightly related to global warming. One of the most urgent issues that need to be resolved. However, even with the most advanced technology such as blockchain. It is unlikely to solve all our problems. Beyond merely create another new application, using emerging technology, according to Dunne & Raby (2013), we should go a step further to use design to inspire discussions of ideas and values.

Dunne & Raby (2013) suggest, there are many problems in our society today has become clear they are ‘unfixable’, and with losing our ability to dream, instead of hoping for the best, we could shift our focus on changing other areas other than the actual fact, such as values and behaviours. It is to our interests to find out, can adapting speculative design in our project, help us dream more and unveil any questions we might have about our present? Is it possible, that speculative design can be the missing possible of re-imagine futures they might change our value, beliefs, attitudes, and behaviour?

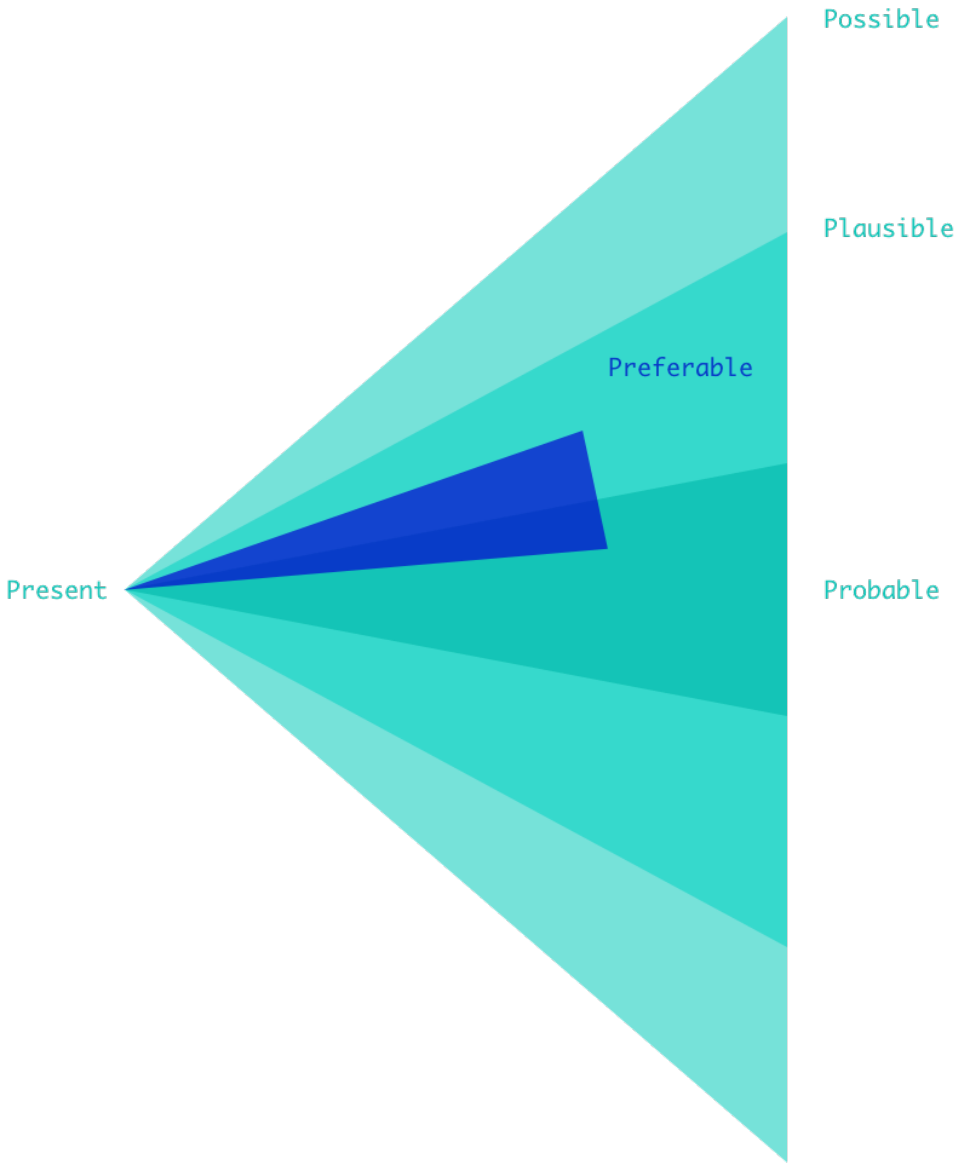

Figure 10. Illustrated by Dunne and Raby (2013: 5), reproduction[27].

6.2 Beyond the Probable

According to Dunne & Raby (2013), the aim of design speculation to think beyond what is predictable from the reality we have now. The authors used the term probable (see figure N.) to describe the most common way of design we see today. That is to produce probable futures that foreseen what will most likely happen, providing with the evidences and facts. On the other hand, there is also plausible futures (see figure N.), that is to imagine alternative futures using scenarios and to ask what if questions. This is how the design project began, through this method I can envision alternative futures. Through the lense of speculative design, instead of asking if blockchain is the best solution for recycling, I am more interested in how blockchain might be used in recycling. This has allowing my research to be open for

exploration and discovery.

In the future cones (See Figure 10), it also shown possible futures, that is on the edge of impossible but can still have connection with today's world. The goal is to encourage discussion and make people think again. The key here is that the scenarios still must be believable and scientifically possible, despite it being imaginary. Authors suggest that the aim here is not to make fictional stories, but to use speculative design as a method to avoid limitation to our options and maximise our chances of the best possible futures. Which open for discussions and gives better chances of reaching better futures, which might be different for everybody. From my observation, this approach focuses more on asking question rather than giving a solid answer. Instead of defining futures for people, the goal of speculative is to given opportunities for people to debate and given it a way for expert to imagine.

6.2.1 Global waste credit and Smart bin

To rethink of how people currently value and interact with waste, initiate with the smart bin ideas from my research. I want to elaborate the idea through speculative design, and by doing this I hope it can give a new light in the old issue. To reimagine the possible futures, we can have to change the way we behave, through existing devices.

6.2.1.1 'Cradle to cradle' Eco system

In response to the idea of circular economy, a cradle to cradle eco system allows each source of material is registered in the blockchain platform when it is first time being used. Every time it being produced it contains an initial value that only when it is being used again or recycled will release to the end consumer automatically. Consumer can choose to either use these credit (which ever information that the product stores) to pay bills, invest into their stock and share account with potential to increase value with time and can trade these credits with each other.

6.2.1.2 From produce to consumer

Beyond of being a currency, the fundamental concept of blockchain is that is holds a record of transactions of assets. Just it happens to be currency from the first white paper of Bitcoin published by, also the best use case to date from my research. These assets can be anything from currency, files, and metadata depends on the context of the application. Developed from the ideas seen in the supply chain industry. It is possible to create a blockchain platform that holds data of each product's detail information. For example, where it was made, by whom, the source of materials (including which is recycled), and cost to produce etc. When it is selling to wholesaler, retailers, or consumers. During the process of buying and selling, it also adds these details to the blockchain data base, but only the owner (e.g. when it is in the supermarket, they own the information) can view the information for security purpose, for others it is encrypted, and only when the owner agrees it can reveal to selected others. It is designed to enhance data security among these transactions. Because, according to our academia research that security can be one of the major

issues stop people from trusting the technology.

6.2.1.3 From consumer to another life

After each use of these product, if it is being reused or resell they credit will transfer to another owner, and when it is going to the smart waste bin, it reads the information and help to give feedback and sort the recycle material in the house. The smart device then can analyse what are these wastes, and with each consul have different regulation, it automatically matches where the registered waste centre. When they come and collect the waste, it is already being sorted, to maximise the best possible recyclable material. The smart bin, with information displayed on the interface, will be able to educate what is not yet recycled, and how sufficient is your waste. The council will sync each households data and validate the waste, they own the information now, however, the value that the waste can generate is belong to the location of the bin and therefore the household and the owner of each smart bin devices.

6.2.2 Waste passport

Each person will have a collection of data of their waste history, and it belongs to you. Everyone has a score of how much waste they produce, evaluate by how much of it going to landfill, how much it is recycled, how sustainable is one's shopping behaviour, these data because of blockchain are not changeable, but you can change your average score by changing your consuming behaviour. Furthermore, it can offer relief of the government tax, or charge government fee in different tier, which says the more sustainable and waste efficient you are, the more you are you can claim credit that can be cover for food and expense.

6.2.3 Waste credit

Similar to carbon credit that automobile needs to comply, manufacture also will have a waste credit, the more recycled material they use they get more credit. For example, Tesla uses renewable energy, so they have the carbon credit. Similarly, everyone also has waste credit, they can earn credit by being educated to reduce waste, reuse and recycle, buying more responsible produced product, or be a good waste handler.

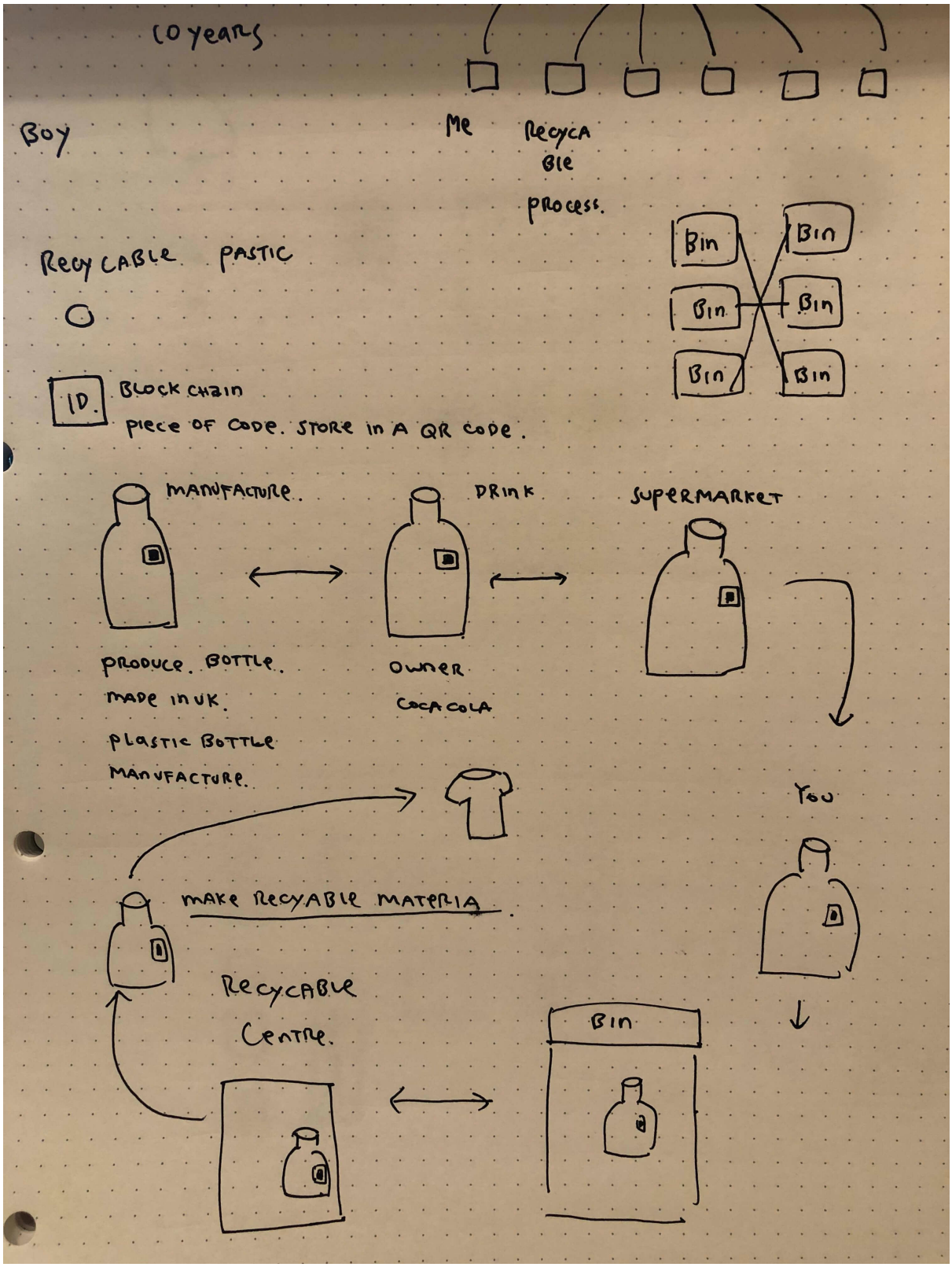

Figure 11. Blockchain Recycling Bin Concept

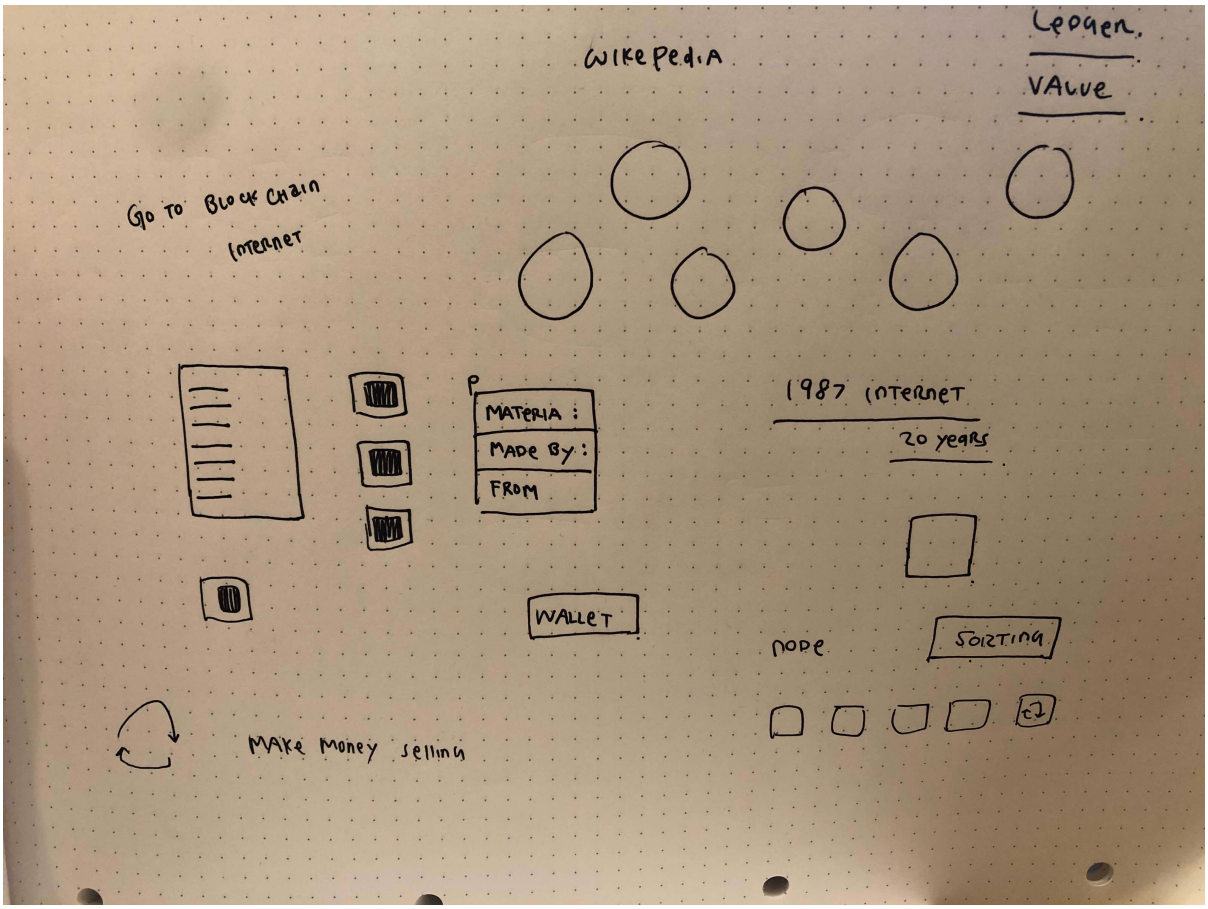

Figure 12. Blockchain Recycling Label Concept

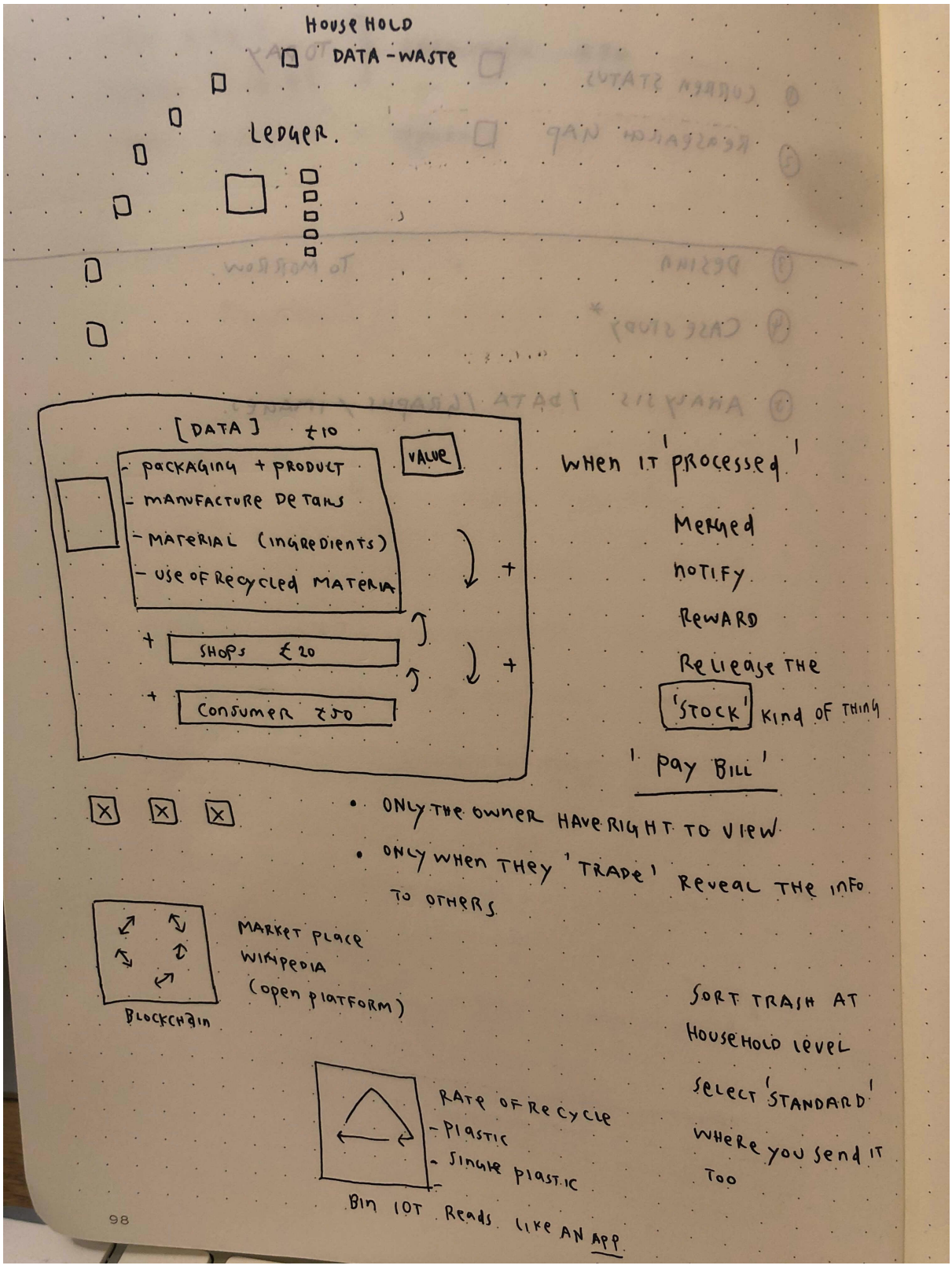

Figure 13. Blockchain Recycling System Concept

6.3 Design Project

To radically change best possible future (Dunne and Raby), in this research project will explore what are the possible scenarios can develop beyond the year of 2050.

6.3.1 Envision sustainable futures in 2050

Assuming blockchain can be widely adopted in our society, here are the solutions I have dreamt to be for possible futures. Using speculative design as a tool, and a design thinking method (Dunne & Raby 2013). Below I began by thinking of four possible scenarios in the order of A, B, C, and D for year 2050.

Scenario A: So now it is 2050, plastic is in the sea, it is everywhere, and pollutions and global warming are horrendous. What do we do with it?

Scenario B: So now it is 2050, we have solved the problem, we managed to recycle everything, and everything being recycled are processed and reused. It is because we have developed a way to use blockchain technology to trace our products. How?

Scenario C: So now it is 2050, we have zero waste, everything is made and use again, and again, how did we achieve this with blockchain?

Scenario D: In 2050, what if blockchain really have worked to solve recycling crisis, and it is now the real 'internet of value'?

6.3.2 Story board

To further develop above scenarios, I created a simple story board to imagine how the future of supermarket trip could be with blockchain implemented to all the products. This is not to say that it is a social theory where everyone share their resources, but instead using blockchain to give each product a value that is traceable from it being bought in the shop, to when it became waste. In the world of circular economy has been successfully executed, and possibly because of the implementation of blockchain it allows circular economy to be successful.

Extending from Scenario D: everyone is on the blockchain network, every product has been assigned a sustainable value (credit), and all transaction will be recorded through blockchain onto a measurement system. People can trade their credit, as well as buy and sale their credit (if they have minus credit - they will need to request to buy more things. e.g. holidays in offices.)

Scene 1. In supermarket, each product has a listing price and a price of sustainability (act as credit). For example, a sustainable packaged product might be more expensive on face value, but have high worth of sustainability, that your level of sustainability credit will grow when you buy it. It can be made of reused materials, minimum or responsive packaging. Others, if you buy a cheap made product that produces more waste, will cost you the sustainable credit you have saved.

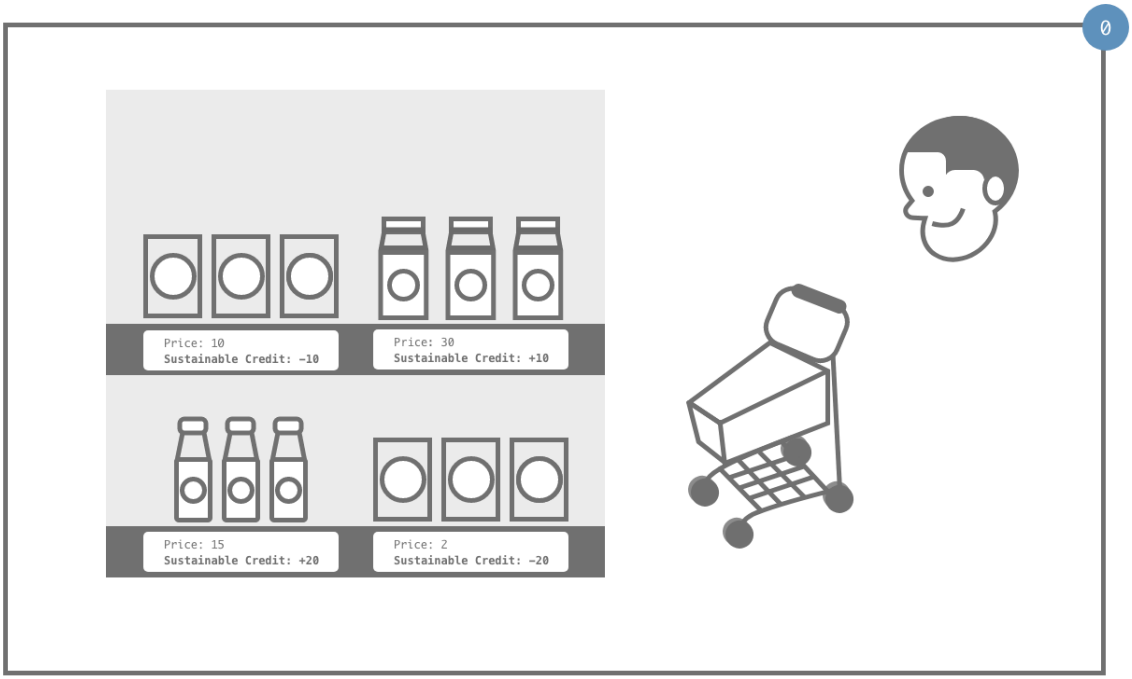

Figure 14. Storyboard 0: Products listed with price and sustainable credit

Scene 2. When checkout, you pay with an identity system that you use to pay as well as add a record of transition of your sustainability credit. Here each household can have a share account, similarly to a bank account, it has the exact same assets, but under both of your names.

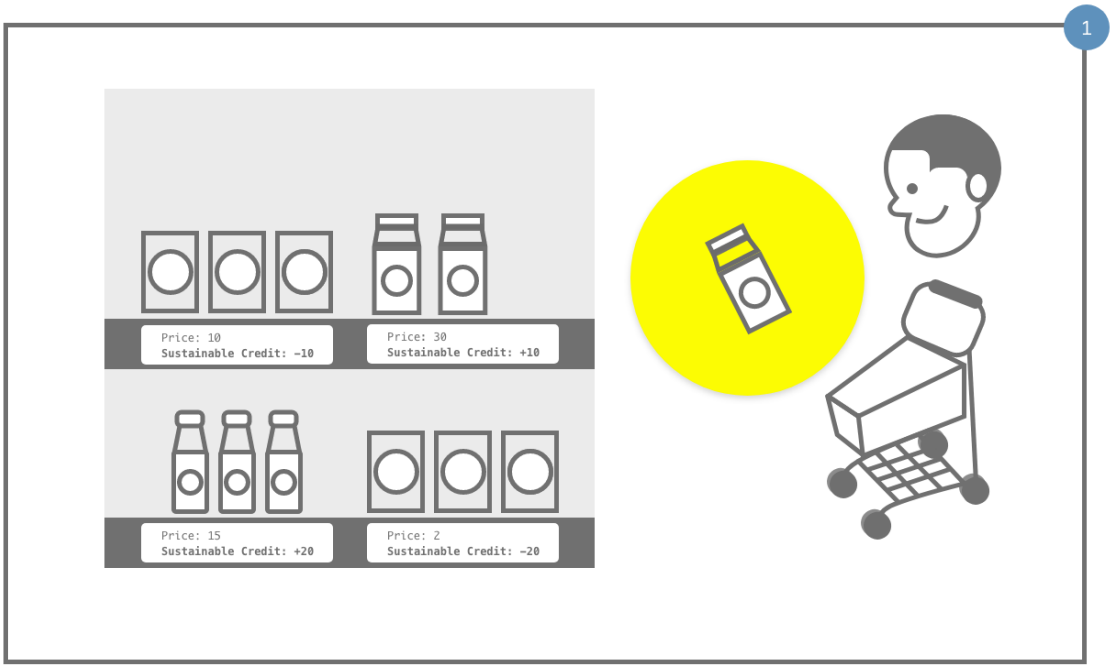

Figure 15. Storyboard 1: Self check out and sync with the blockchain network

Scene 3. When throw away trash it also records your rate of recycling, by charts etc.

to encourage you recycled and see what materials goes into the waste. Sync with your identity system.

Figure 16. Storyboard 2: Dashboard of Sustainable ID

Figure 17. Storyboard 3: How to gain positive credits

Scene 4. When you throw away trash outside, in a public space you'll have to sync your identity system to release the bin. It also records the waste sustainable rate to the system you have.

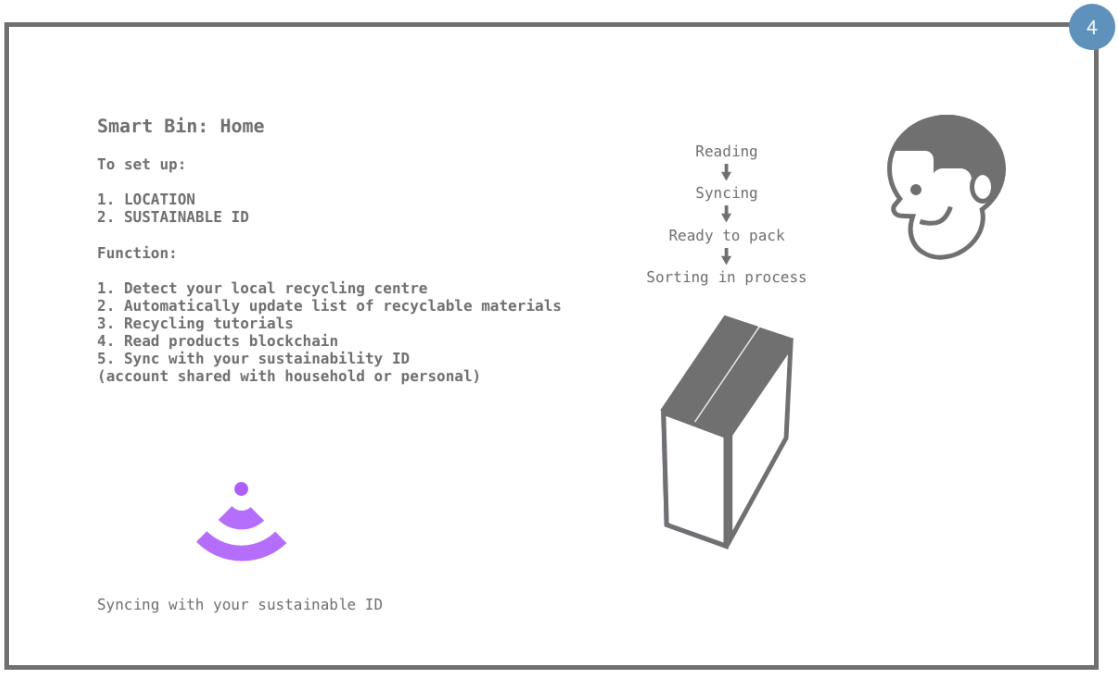

Figure 18. Storyboard 4: Smart bin at home

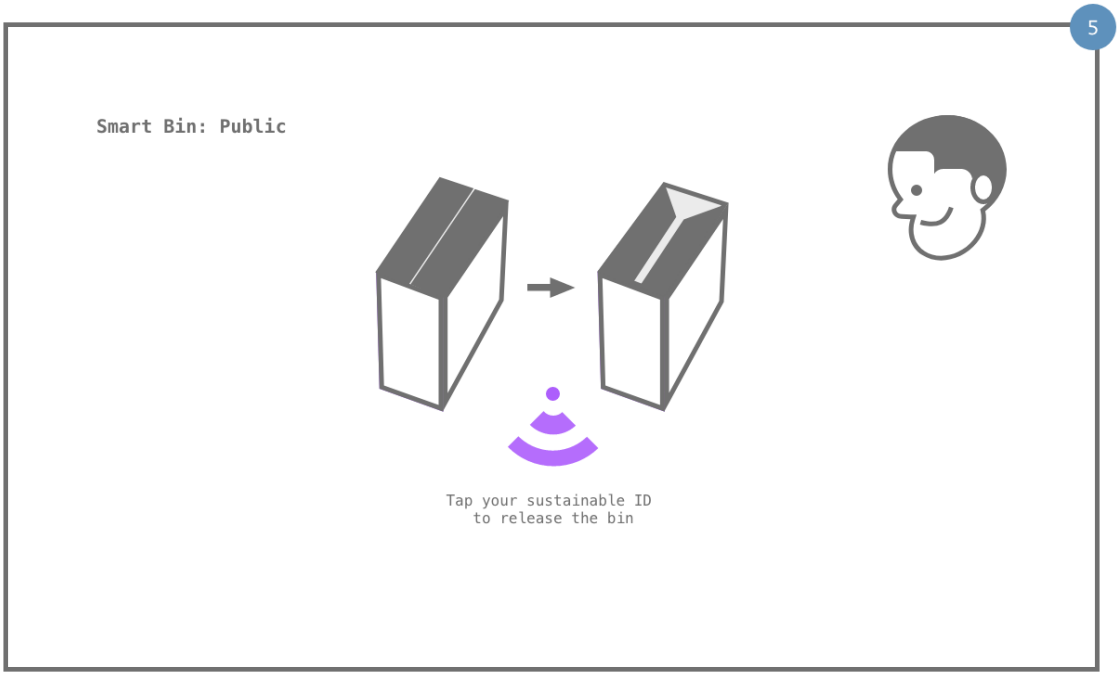

Figure 19. Storyboard 4: Smart bin in public

6.3.3 What can we do with this credit?

What if the idea of sustainable credit become part of the future regulation, as in which everyone must take part, and everything will be recorded through

blockchain? Similarly, to the carbon credit, each person needs to have positive credit to buy things. If not, you must trade with others. When one has too many credits, they can sale to others, or use it to pay for things like utility bills, rent, food, and other essentials.

In these scenarios. We have changed our value to sustainability to assign each product we buy with a sustainable credit. With hope it might be able to change our behaviour, to buy less, to think twice before we buy, to pay the price (credit) by buying products with low sustainability standard. Even if it is seemingly cheap at face value. When physically paying the price (credit) for the environment, we as consumer could possibly drive a top-bottom change of the market.

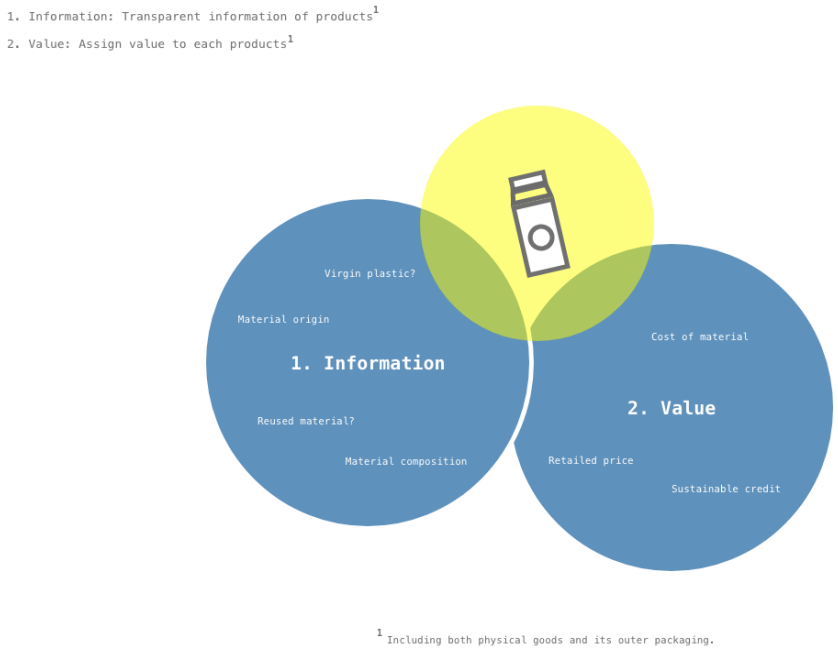

Figure 20. Product with blockchain information and value.

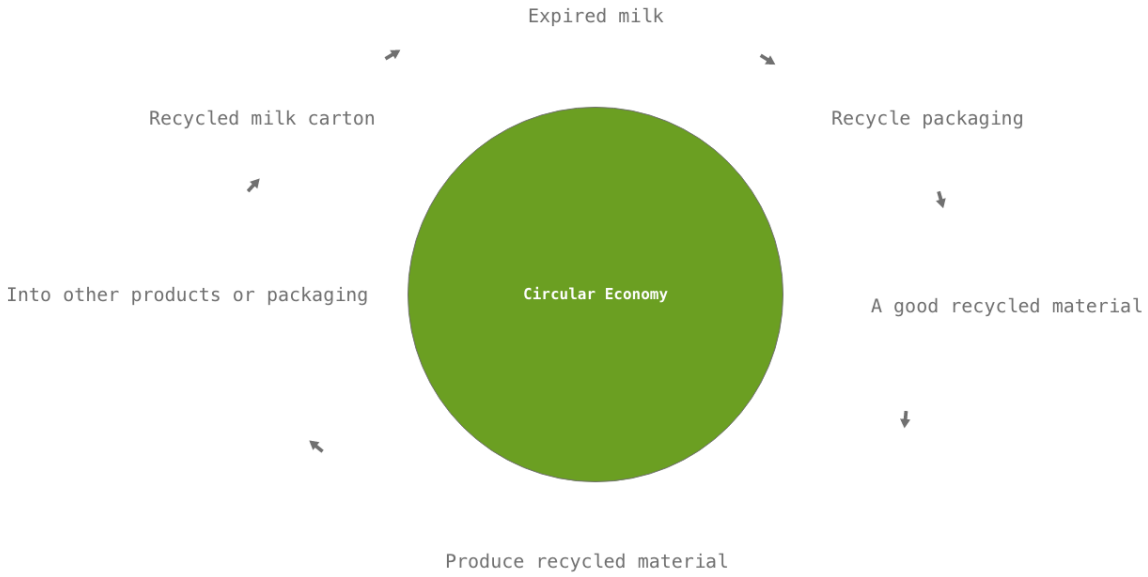

Figure 21. Circular Economy of a carton of milk

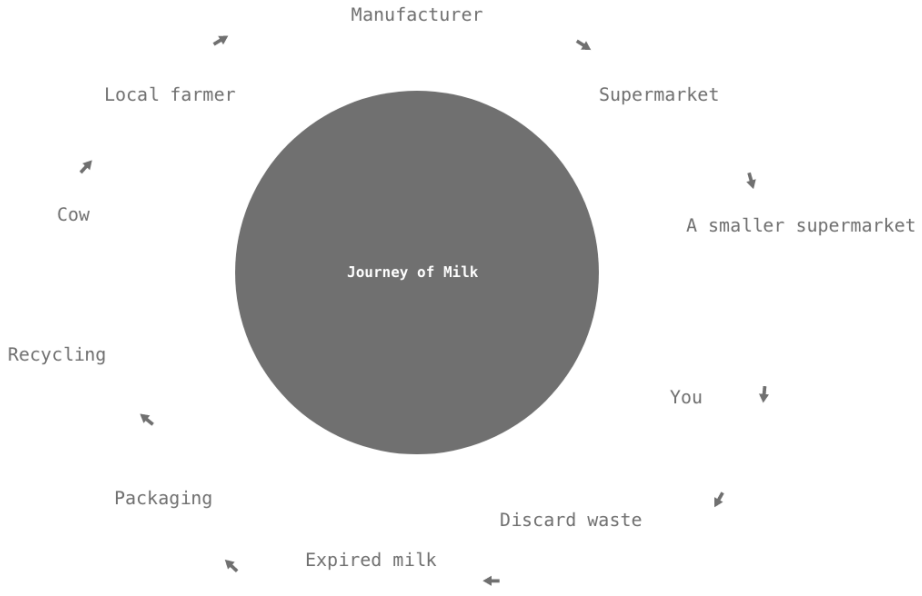

Figure 22. Life journey a carton of milk

6.4 Result

During my research of blockchain technology and the recycling issues, I came to realise that both the theory of blockchain and recycling is of high complexity and the ideal is quite far away from reality. Especially in blockchain, there is still a lot of unknown and more ambiguity to it, that we cannot yet understand in the thesis. However, I could use speculative design, to reimagine a future where blockchain is already mature and dream an ideal society without limitation of the technology which blockchain has currently. The reason I said currently, is that that with the advancing of technology's breakthrough, and when it becomes mass adopted, these concerns which stop us moving forward might no longer be an issue.

6.4.1 Designing for blockchain

When focusing specifically on the technical aspect of blockchain technology, it is easily ignored by how and why. Designing in blockchain for radical changes requires a lot of different expertise, depends on the problem it is trying to solve. Instead of giving it more limitation than it already has today, because it is not yet a mature technology and not widely adopted in everyday lives. When focusing specifically on the technical aspect of blockchain technology, it is easily ignored by how much different expertise is required to make a good use case. It has also given unnecessary limitation to a technology that is yet to need room for materiality. If we could go this direction, this way we can avoid asking what can blockchain do. Rather, what if we use the technology to solve these issues we currently facing? By asking what if, we could go much further with the imagination? Whether it is currently achievable or not. There are possibilities, blockchain technology might not be the answer to our problems, but there will be new technologies, whichever can solve our problem that is the goal. Not the technology itself. Same as speculative design in this context, it is of methods and not a solution. To help us get there, the future we envision today of 2050. In the design project, I have tried to implement the ideas learnt from the research. Includes envision scenarios of a value connected blockchain system in recycling. Although it is only part of the picture, there still room for further speculations in a more visually impactful way. According to Dunne & Raby (2013), to evoke discussions. It is still a gateway to possible futures that it is beyond the limitation of the technology.

6.4.2 Recycling with confidence

From my case study in Everlane, I realise companies can claim they are sustainable, however; it is still important for consumers to really understand how these materials are made from; it does not only encourage people to shop responsibly but also be smart enough to determine with valid information rather than plain faith. Similarly, in how we recycle as well. In my design project, I am hoping to use blockchain technology to verify and trace from supply chain management, all the way to recycling and waste management, in corresponds to the circular economy with cheaper cost and more efficiency in processing recyclable materials. Transparency in blockchain technology also means we could build an automation informative circle, from recycling to production and clearly see the benefit and the damage it can be to the environment. It may change people's behaviour and in the smart bin use case, the application can educate consumer through interfaces of information of things

(iot) to make recycling more precise.

6.4.3 Motivation through credit system

In a perfect world, everything we recycled will be made into useful products or other methods that are less harmful than landfill. But according to my research, the facts are far from it and not everything is recycled gets to have a second chance. The design project is built on human errors that are often overlooked, by that I mean it is not enough for us to feel good about recycling without knowing what exactly has happened to them. Blockchain in this instance has given us hope of transparency, and the ability to transition trash into value more efficiently. Through the credit system in my design, every product is assigned a value of sustainability. It does not only motivate consumers for the credit scheme but also helps us visualise the value of sustainability. Only if it is clearly understood what the price will be paid if we do not act, only if we understand the incorrect recycled materials does not help the process of recycling and knowing exactly where these recyclable materials go. We can confidently invest our time to improve the system in the right places, to work toward a better future. It is also clear, with help of blockchain technology, if we design to focus on the right areas that to motivate the circular economy by reducing the cost and make recycled materials more cost effective. It will eventually encourage the businesses because it is being profitable, beyond just being good to the world, although it is also key for consumers to have the desire to shop sustainably.

6.4.4 Further research

Considering where blockchain is now, in between experiments and mass adoption. I asked at the beginning of my research on how we get there? I learnt that speculative design is a very useful tool to help innovate emerging technology like this. Especially in social content, where the scenario is complex, there are factors such as government policies are involved, which might be out of our hand. In this thesis, I did not cover the roles regulations and play in the implementation of the design project, which I understand would be crucial in blockchain's development. I recognise there is further research required to make it a lot more specific. Including the scenarios in the designs, can still be speculating even more to other forms of design objects such as through videos, interactive prototypes, physical model and detailed storyboards to enable wider discussions.

7. Conclusion

Historically, it is easy to trade within a small village and when you hand-make tools to enable basic living. In the current world where we are far away from the manufacturing process, we need to use design thinking to resolve the environmental issue, by working together with emerging technology such as blockchain. It gave us the opportunity to shine the old issue in a new light. It is easy to fall into a trap of focusing on technical innovation alone. In this instance, the speculative design helped us to overlook that and rather on innovating itself, and furthermore, to address the key issue of redefining our value of waste in the society.

How design can help the development of blockchain

Whether overly hype, enthusiastic, positive, or skeptical, we need to really look into how and why we motivate to imagine a better future using speculative design or a hopeful technology like blockchain because there are opportunities and possibilities, we can find a solution to our most challenging and desperately needed to change problems. We should further invest our efforts in research, exploration, innovation, testing, and learning from other industries. In this thesis, I understand blockchain could give the trash problem another chance to shine under the spotlight, using what it does best, controversy and people's curiosity. By speculating it further, I was able to think outside of the box and to develop a project with the hope to enhance the discussion that we need as a society for the most desperate issues. The value of designing for recycling in the blockchain is not only a technical one. It has the potential to bring attention to the problem and speculative design was a helping hand in expending the inquiries. If we can discover more and get a little closer to find the right solutions, might it be blockchain to be the solutions or not, we will benefit and be grateful for a better future.

The evidence of circular economy

In the issue of recycling and waste management, the circular economy plays a crucial part in addressing the problems. Because of its similarity to blockchain's value of transparency, verification and immutability. From my research, it shows they allow consumers to trace the life cycle of materials and products in a more cost-effective way, especially for the businesses. However, to successfully implement the eco-system of the circular waste economy on the blockchain, it will require further efforts not only in engineering but also in exploring new business model, consumer behaviour, design, and to acquire the support of regulation and governments. In this research, I understood technicality is not the only thing to be considered in designing for blockchain and maybe other emerging technologies, especially when it is new and not yet been massively adopted. Finally, I came to a conclusion that even though there are still limitations in the technology itself, but through the design project I was able to open for further discussions of what may be the winning factors to make blockchain a success, and for the recycling business.

Endnotes

[1] Various Processing / Digesting Devices
'The world is running out of food we need to produce 70% more food in the next 40 years according to the UN. Yet we continue to over-populate the planet, use up resources and ignore all the warning signs. It is completely unsustainable.'
http://dunneandraby.co.uk/content/projects/510/0

[2] Reproduced by Ching-Yu Chiu

[3] Various Processing / Digesting Devices
'The world is running out of food we need to produce 70% more food in the next 40 years according to the UN. Yet we continue to over-populate the planet, use up resources and ignore all the warning signs. It is completely unsustainable.'
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